Cultural, Demographic, and Environmental Influences on Risk Perception and Mitigation in the Wildland-Urban Interface

Voravee Saengawut Chakreeyarat
Utah State University

CULTURAL, DEMOGRAPHIC, AND ENVIRONMENTAL INFLUENCES ON RISK PERCEPTION AND MITIGATION IN THE WILDLAND-URBAN INTERFACE

by

Voravee Saengawut Chakreeyarat

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Approved:

Mark W. Brunson Major Professor	E. Helen Berry Committee Member
Man-Keun Kim Committee Member	Peter D. Howe Committee Member
R. Douglas Ramsey Committee Member	Mark McLellan Vice President for Research and Dean of the School of Graduate Studies

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ABSTRACT

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by

Voravee Saengawut Chakreeyarat, Doctor of Philosophy

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Major Professor: Mark W. Brunson
Department: Environment and Society

Wildfire hazard is increasing in much of the United States, posing a threat to human communities and natural ecosystem services, especially in areas at the wildland-urban interface. There are steps people can take to reduce wildfire hazard, but often they are not used. Understanding and addressing human perceptions of wildfire risk and of risk-mitigating behaviors requires knowledge of both social and ecological systems. To better understand this complex issue, three types of factors must be addressed: social-cultural, demographic, and biophysical. This dissertation incorporates these three essential factors to intensively investigate the risk perception and behaviors of residents living in wildland-urban interface communities in three states (Arizona, California, and New Mexico).

The first study examines the effect that individual risk perceptions have on intention to mitigate wildfire risk by integrating two social-psychological theories, Theory of Planned Behavior and Cultural Theory, to investigate the causal relationship

and motivational factors that influence the intention to mitigate wildfire hazard. Results suggest that attitudes toward wildfire mitigation practices and perceived behavioral control play a significant role in the decision process. The effect of an individual's orientation toward nature is mediated by attitude and perceived behavioral control. It is important that these orientations are taken into consideration when designing strategies to increase incentives to mitigate fire risk.

The second study explores the linkage between property owners' perception of risk and scientifically measurable wildfire risks that vary across hazard zones in the three study locations. Individuals' perceptions of wildfire can be substantially different from each other and from reality. This study proposes that the perception of risk is formed in a multistage process (individual and community level). Results show that homeowners' worldview with respect to nature, length of residency, place-based influence, and attitudes about risk factors all are significant predictors for how residents of fire-prone areas perceive their risks. The variance in social and physical vulnerability associated with wildfire can explain, to a certain extent, the variation in individual perceptions of wildfire risk. The perception of risk is consistent with the level of exposure to fire hazards.

The third study investigates spatial relationships among social and ecological factors on private property. The biophysical characteristics of individual properties were extracted to observe wildfire risk and incorporated with information about social context from mail surveys. Results demonstrate that mitigation behaviors in the three study communities illustrate a spatial clustering pattern. Moreover, orientations toward nature

and physical attributes of property had an impact on decisions to undertake mitigation behaviors.

(163 pages)

PUBLIC ABSTRACT

Cultural, Demographic, and Environmental Influences on Risk Perception and Mitigation in the Wildland-Urban Interface

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Protecting human communities and natural environments from wildfire is growing more complex as more people move to fire-prone areas across the United States. This study integrates cultural, psychological, and environmental information to reach a better understanding of the linkages between perceptions of risk from wildfire and people's behaviors to reduce that risk. Through studies in fire-prone communities in Arizona, California, and New Mexico, I investigated factors that influence peoples' decisions whether to undertake wildfire hazard mitigation activities such as clearing dead vegetation around the house. The social and ecological characteristics of individual properties were investigated to understand how they are interconnected to affect property owner behaviors.

There are several factors affecting public responses to wildfire including local context, personal considerations, and experience with wildfire. I examined the influence of those variables upon an individual's decision regarding wildfire mitigation. Property owners residing in the wildland-urban interface understand the risk of wildfire, but their willingness to reduce risk varies based on the views people hold toward nature. I found that those who place a high value on nature perceived high risk from wildfire and were less likely to engage in mitigation. However, those whose perceptions of risk was based on fire managers and local authorities were willing to engage in mitigation behavior if

they have a positive attitude toward mitigating activities, and if they perceived that they felt they had control of the activity. In general, people often view that the risk from a natural hazard in their local area is lower than in other areas, known as being "unrealistically optimistic." I also investigated this issue in the wildfire context. I found that the same role applies with wildfire: People perceived a relatively lower risk in their local areas than at a broader scale such as a county or state. It is important to communicate wildfire risk at the community level to effectively help residents prepare for future wildfires.

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CHAPTER 1

INTRODUCTION

Wildfire risk perception plays an important role in a landowner's decision to mitigate wildfire hazards (W. E. Martin, Raish, and Kent 2010). Research on wildfire identifies three factors that influence individual responses to risk perception: socio-cultural background, socio-demographic characteristics, and biophysical setting of individual property (Figure 1.1). These three factors in wildfire management have an influence on individual response to wildfire risk as the arrows point into the person. The interconnections of three factors, depicted by the arrows and feedback loops incur to the demographics and biophysical setting. For instance, the biophysical components such as topography and vegetation cover that affect the objective risk can constraint risk-reduction behaviors (Daniel, Carroll, and Moseley 2007). These critical factors are not only interactive, but also inter-correlated across properties either privately or publicly owned in wildfire management. To better understand the influence of homeowners' risk perceptions on the intention of mitigation behaviors, this dissertation highlights a coupled human and natural system approach. The sociocultural background of the landowner was included to investigate its influence between individual responses to the factors of biophysical and social-demographic settings.

Understanding the multi-dimensional relationship of risk perception and behavior requires analyzing all three key factors simultaneously (W. E. Martin, Raish, and Kent 2010) because perception of risk does not directly lead to behaviors (Stern 1993). An emphasis on individual behavior is theoretically needed to identify factors that influence wildfire mitigation behavior and to derive measures to promote specific behavior. The

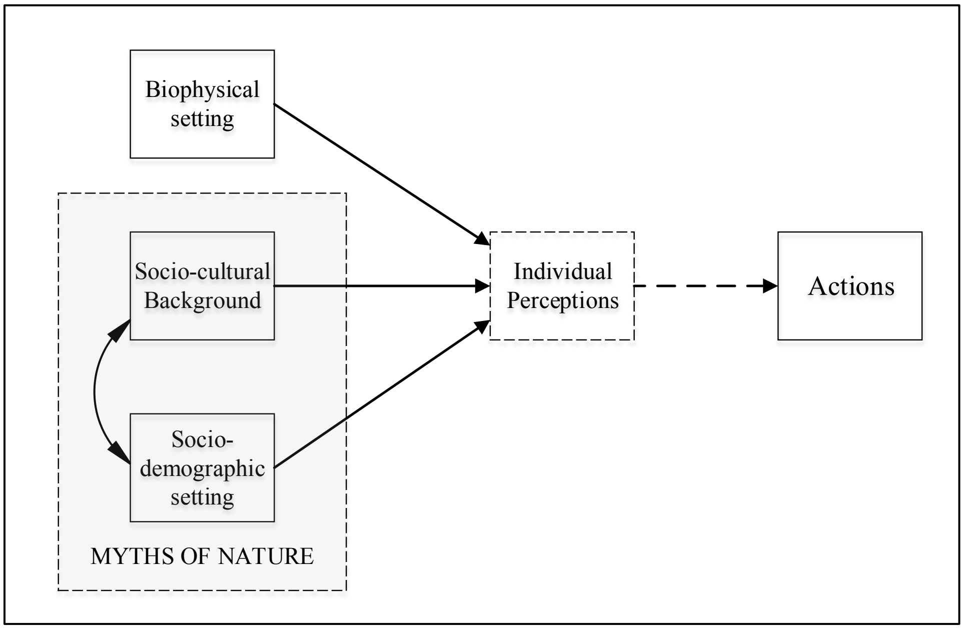

Figure 1.1. The conceptual framework of individual response to wildfire risk adapted from Daniel, Carroll, and Moseley (2007).

goal is to help promote efficient policy designs and outreach strategies, and to help wildland fire managers in developing risk mitigation programs.

Risk can be interpreted in different ways by different people depending on the risk characteristics of hazards (Lindell, Perry, and Greene 1980; Plough and Krimsky 1987; Flynn, Slovic, and Mertz 1994). The role of individual socio-cultural factors can be defined as an underlying psychological process in determining mitigation behaviors (Daniel, Carroll, and Moseley 2007). Perceived risk derives in part from social learning as people are influenced by others in choosing what to fear and how to fear it (Douglas and Wildavsky 1983). A systematic factor in how individuals perceive environmental risk is their adherences to culturally based “myths of nature” (Dake 1991). These myths of nature describe how individuals perceive risks imposed by nature. In other words, individuals use their own risk rationalities to decide how they undertake a preferred strategy to mitigate risk. The individual judgments about risk are a major role in how one decides to mitigate the risk and which strategies are appropriate for doing so.

The disconnection between risk perception and mitigation in a wildfire management context is known as the "risk perception gap" (Cohn, Williams, and Carroll 2008). Often the level of individual effort to mitigate risk does not reflect the actual actions that will be necessary to protect a person against the natural hazard (Slovic, Fischhoff, and Lichtenstein 1985; Sjöberg 2000). As such, although the general public understands the role of wildfire and fire management (Cortner and Gale 1990; McCaffrey 2008), it is not necessarily true that people who understand risk and have concern about it will take mitigation action to decrease their exposure to wildfire or other hazards (Mileti and Gailus 2005; Schulte and Miller 2010; Gordon et al. 2013). However, this connection may not be always true and it emphasized in this study. In general sense, it makes sense that individuals who live in hazard area, such as a fire-prone area, tend to have a high level of perceived risk; as a result, they are more likely to engage in risk reduction behaviors (Setbon et al. 2005; Lepesteur et al. 2008) while people living in low designated risk zones with a low objective probability of risk are less likely to implement such behaviors. People sometimes underestimate risk and neglect to comply with wildfire mitigation. Individuals express low wildfire risk perception when they have direct experience with other natural hazard such as a hurricane (Newman et al. 2014). Consequently, a perception of risk is a necessary but not sufficient as the sole motivation for hazard mitigation (Lindell and Prater 2000; McCaffrey et al. 2011).

Differences in risk perceptions and fire management responses are associated with differences in demographics and cultural worldviews, which shape underlying values and beliefs. For example, Native Americans were more likely to show concern about wildland and wilderness fires compared to other ethnicities in their state (i.e., Asian American, Black/African American, Latino/ Hispanic American, and White/Caucasian), and this group showed the highest shared values in fire management but the lowest trust in fire agencies (Winter and Cvetkovich 2010). In addition, different views of fire management may be related to more intangible factors such as social and culture related worldviews (Winter and Cvetkovich 2010). Recent work identifies cultural beliefs and values as associated with responsibility for behavior. Most homeowners feel responsible for mitigating fire risk and consider mitigations a shared responsibility by all landowners whether land is privately or publicly owned (Vogt, Winter, and Fried 2005; Cohn, Williams, and Carroll 2008; Brenkert-Smith 2011). Concern about actions on adjacent properties was specifically taken into account by property owners when trying to create effective defensible space (Brenkert-Smith, Champ, and Flores 2006; I. M. Martin, Bender, and Raish 2007; Paveglio et al. 2010; Schulte and Miller 2010; Winter and Cvetkovich 2010). However, this singular concern for defensible space does not ensure people will increase their mitigation behaviors on their own properties, so understanding individual differences in risk perception in relation to cultural factors can facilitate the development of more effective wildfire risk management strategies. In order to design a successful wildfire risk communication and mitigation strategy at a local level, characteristics of the target population beyond individual demographics should be taken, which would include taking into account identification of potential differences in risk perception across ethnic groups.

Theoretical Background

Numerous studies have provided insight into the behavior of homeowners in response to perceived wildfire risk. Some of this research has applied social-psychological models analyzing the relationship between cognitive factors and actual behavior in wildfire and fuel management (Brunson and Shindler 2004; Vogt, Winter, and Fried 2005; Bright, Newman, and Carroll 2007; Hall and Slothower 2009; Paveglio et al. 2010). In one typical example, to better understand risk perception researchers investigated the influence of psychological determinants of perceived risk to physical health on enacted behaviors intended to reduce risk and protect themselves from wildfire (Martin, Raish, and Kent 2010). By contrast, rather than seeing risk perception as a factor that directly leads to a property owner engaging in mitigation behavior, I examined the influence of risk perception on behavioral intention as affected by socio-cultural aspects. This socio-cultural influence was examined by two theoretical frameworks that originated in social science but have been applied successfully to natural resource management contexts.

Cultural Theory

According to Cultural Theory (CT), as proposed by Wildavsky (1987) and Dake (1991), people's perceptions of environmental risk are shaped by their social relations and underlying cultural biases, and these perceptions influence their understanding and actions to handle with risk by their preferred form of society (Douglas and Wildavsky 1983; Schwarz and Thompson 1990; Dake 1992). CT accounts for the social construction of environmental risk in terms of three domains: a) social relationships, b) cultural biases, and c) preferred behavioral strategies. The first domain describes the sorts of relationships people form and cultivate in order to maintain a preferred social life. Cultural biases refer to biases toward environmental risks in which shared values and beliefs reflect views on human nature, views on society, and risk perception, and so-called “myths of nature.” The third domain refers to the ways in which those relationships and biases are manifested in actual behavioral responses to risk. The three domains together are said to lead to four distinct cultural types, categorized as individualist, egalitarian, fatalist, and hierarchist. It is assumed that social relations are the origin of values, beliefs, perceptions, and policy preferences that result in maintaining those relations. These ways of life and value systems are supposed to address risk perception, risk judgments, and preferences for risk management strategies.

The idea of “myths of nature” originated in ecological science with Holling (1978) who defined it as the different beliefs about the vulnerability of nature. Michael Thompson later integrated the typology of social relations with the CT approach (Schwarz and Thompson 1990). The four ways of life identified above were found to be correlated with four specific myths of nature: nature benign (Individualist), nature fragile (egalitarian), nature capricious (fatalist), and nature perverse/tolerant (hierarchist) (Steg and Sievers 2000). As shown in Figure 1.2, the four myths of nature (sometimes known as views of nature or worldviews) present in a grid-group dimension. The grid-group dimension illustrates whether an individual is a member of bonded social units or absorbs a group’s activities, and the degree of solidarity people feel with each other or the degree to which an individual’s behavior is regulated or restricted by social context (Douglas and Wildavsky 1983). The grid dimension refers to the degree that a person externally imposes restrictions on action and behavior while the group dimension refers to the

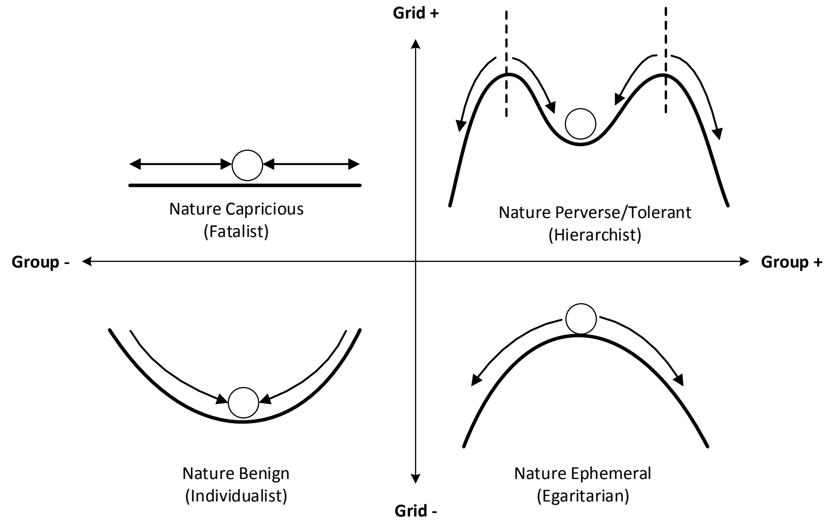

Figure 1.2. Four views of nature in the Cultural Theory adapted from Douglas and Wildavsky (1983) and Thompson, Ellis, and Wildavsky (1990).

degree that a person is tied to social units. A high grid indicates a strong interconnection with others that control an individual's actions while a low grid indicates more separation and independence from control of a group (Schwarz and Thompson 1990). A high group person exhibits high collective actions whereas a low group lifestyle exhibits intensively on self-sufficiency. In the diagram, the white ball represents environment-risky behavior and the shape of the landscape illustrates the vulnerability of nature, the interaction between ball and landscape (between human and nature). For each landscape, the ball stands on the equilibrium point. Each social construct of nature represents a transition of a ball on landscape. The graphic representation of the myth of nature captures each of the myth that sustain the four ways of life at the "stills" position after a sequence of interaction transformation between a ball and landscape has ended. The arrows presents the directions of a rolling ball. It is started from Nature Benign, Nature Perverse/Tolerant, Nature Capricious, and to Nature Ephemeral. If starting off position with a bowl-shaped landscape (Nature Benign) changes firstly to a depression of natural resources on a mesa, then to a flat landscape (Nature Capricious), and then to a upward bowl (Nature Ephemeral). The ball will land on a flat surface in the last situation when it only rests before begins another depression. This transformation cycle is completed.

CT describes the relationship of the four myths of nature to four corresponding ways of life (Douglas and Wildavsky 1983). (1) Fatalists view nature as capricious; they believe that nature and resources are limited and unpredictable, so their choices in life are dependent on and influenced by external forces. Thus, their rational risk management strategy is to cope with erratic events rather than to try to manage nature. This rational belief is presented by a ball landing on a flat surface with two-headed arrow which can roll in any directions. (2) Individualists adhering to nature benign believe that they have control over their own lives and even further other people's lives; therefore, they are able to recover from depletion of natural resources. They prefer a free market mechanism of managing natural resources and equal opportunity for managing risk situations; eventually new solutions will arise, such as new technology, to solve the problem. The ball will always find its equilibrium at the bottom. It is equivalent to the idea that no matter what happen, letting the system takes its own course without interfering. (3) Egalitarians view natural resources as limited and delicate, being ephemeral. Their view is opposite of the individualists' view, and they manage nature very carefully because they believe resources are being depleted, which may lead to disaster at any moment. They are risk averse and are very concerned about environmental problems; they seek for ways to allow everyone his or her share of a resource. In this belief, the ball lands on the peak of upward bowl landscape where this place has the least joint and is very easily to collapse. (4) Hierarchists view nature either as being perverse or tolerant. It is a robust system but only up to a certain point (tolerant); the ball remains within the equilibrium zone which is evaluated by the government or expert knowledge. Once the ball goes beyond the rim, natural resource falls apart (perverse), a policy that seeks for resilience and stability is a concern for this myth. Thus, people who hold a hierarchical myth of nature accept risks as long as the experts say so.

Cultural Theory has been applied in a variety of natural resource management contexts to explain the relationship between preferences of policy strategies and perceptions of nature. One foundation concept in ecological management explained that successful management of common property resources can be achieved by identifying a group's cultural biases (Buck 1988). By examining public grazing on lands in the southwestern U.S., Buck demonstrates that users with either egalitarian or hierarchist ideas of nature can successfully manage common property resources. Finding sustainable management of natural resources requires consideration of differences in cultural worldviews and perception of nature. Such consideration helps to engage stakeholder involvement (Billgren and Holmén 2008), promote participatory processes for forestry policy (Hoogstra-Klein, Permadi, and Yasmi 2012), and identify the environmental issues at specific locales (Lima and Castro 2005). In wildfire literature, CT has been used to examine discourses about wildfire management in the Pine Barrens of southern New Jersey and New South Wales (Danielson 2007). Using Q analysis and a mail survey, this study showed that risk perception strongly correlates with fire management and is influenced by fire exposures such as fire experience or living near forested areas; however, CT was not an effective tool for explaining the discourses on fire among New

South Wales and New Jersey residents' perspectives. Danielson points out that preferences and perceptions of respondents did not match up clearly into CT's groups because the set of individuals chosen may not have been representative. In addition, the controversial findings between two cases of study sites conclude that an accurate description of situation is critical to determining various individual's discourse about wildfire risk perception and different from region to regions.

Theory of Planned Behavior

The Theory of Planned Behavior (TPB) proposed by Ajzen (1991) is an evolution of an earlier work, the Theory of Reasoned Action (TRA) (Ajzen and Fishbein 1980). TPB explains that behavioral intention, the most immediate antecedent to human behavior, is influenced by attitudes (ATT), subjective norms (SBN), and perceived behavioral control (PBC) (Sutton 1998). The combination of these three components leads to the formation of a behavioral intention. Each immediate antecedent of intention is comprised of beliefs and evaluations. According to TPB, human behavior is planned around three kinds of beliefs: behavioral beliefs, which are beliefs about the likely consequences of behaviors; normative beliefs, which are beliefs about the normative expectations of important referents; and control beliefs, beliefs about the presence of facilitator or impeder factors to perform the behavior (Ajzen 2002). The respective aggregations of these beliefs produce a favorable or unfavorable *attitude toward the behavior*, perceived social pressures where one should or should not engage in a behavior or *subjective norm*, and perceived ease or difficulty of the performance of behavior or *perceived behavioral control.* In general, TPB assumes that the more favorable the attitude, subjective norms, and perceived behavioral control, the stronger should be an individual's intention to perform a certain behavior.

The conceptual framework of TPB is illustrated in Figure 1.3. A solid line at the end of the diagram from actual behavioral control to the line between intention and behavior is used to demonstrate that actual behavioral control might moderate the relationship between intention and behavior.

A dotted line is used to show the possibility of relations between influences. Background factors are assumed to cause variations in behavioral, normative, and control beliefs, and numerous variables have potential to influence the beliefs people hold. Although a connection between background factors and beliefs does not always appear, relevant background factors may influence given beliefs depending on the relevant behavior was asked in survey questions. In this study, we focus on cultural background factors as relevant to risk perception. The relative importance of attitudes, subjective norms, and PBC appears to differ for different target behaviors (e.g., managing landscapes or improving fire-safety constructions) and different target groups (i.e., groups differing in values and cultures).

TPB is one of the most commonly applied theories to predict human behavior developed in the socio-psychological field. It has been successfully applied to predict a diversity of environmental behaviors including wastepaper and curbside recycling (Guagnano, Stern, and Dietz 1995; Wan et al. 2012), pollution reduction preferences (Cordano and Frieze 2000), and forest owners' willingness to work toward reforestation (Karppinen 2005). Another line of research focuses on risk reduction

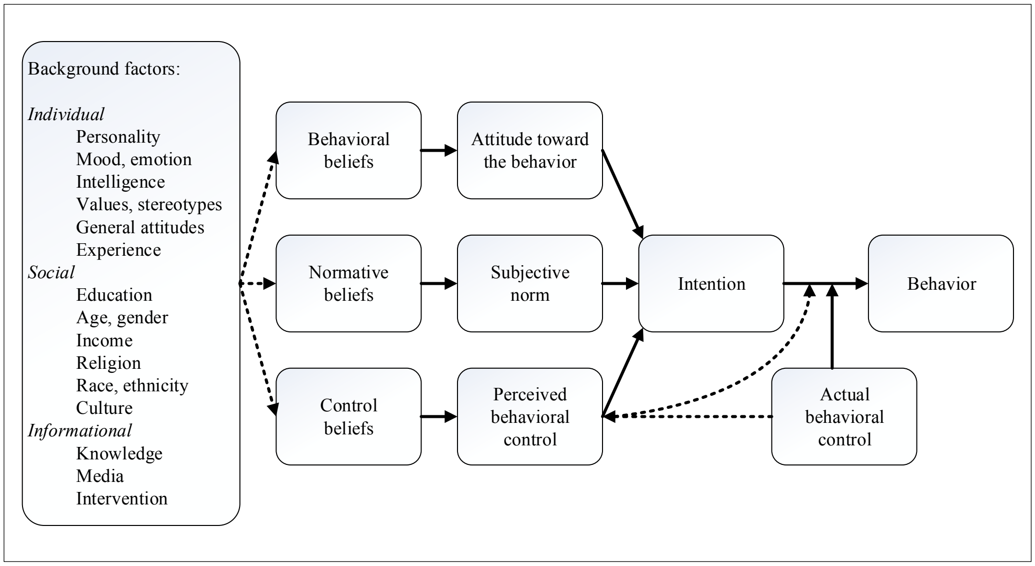

Figure 1.3. Behavioral model of the Theory of Planned Behavior (Fishbein and Ajzen 2005).

behaviors with respect to health-related issues such as quitting smoking and healthy eating (e.g., McEachan et al. 2011). In the field of wildfire and fuels management, beliefs about fuel management outcomes and attitudes and intentions for prescribed burning, mechanical thinning, and defensible space are tested using the TRA (Vogt, Winter, and Fried 2005). Under the TRA, authors investigated the need to understand home owners' attitudes and how attitudes impact behavioral intentions. Adding three variables, namely attitude, subjective norm, and perceived behavioral control, to the model provided a better prediction of an attitudes-intentions linkage and helped uncover personal importance as a significant predictor of attitudes toward a particular practice. Trust in an agency was also found to have a strong connection to intention in approving the use of fuel management approaches. In the same line of research, (Bright and Burtz 2006a, b) applied TPB to examine the differences in perceptions and behavior regarding creating defensible space in the wildland-urban interface (WUI). In this study, values and beliefs toward forest and fire management were compared across perceptions and behaviors which, in turn, showed variation in value-orientation groups for ATT, SBN, and PBC toward defensible space. Some studies on wildfire risk have extended the TPB along with protective behaviors (i.e., Protection Motivation Theory) to predict home owners' willingness to implement defensible space and their interests in consulting programs (Hall and Slothower 2009).

Objectives

The main objective of this dissertation is to understand the influence of different perceptions of wildfire risk on property owners' behaviors to mitigate wildfire hazards. It builds on prior wildfire research by examining the effects of cultural orientation of nature on risk perceptions. The dissertation is divided into three components:

1. Examining the relationship between risk perception influences (e.g., myths of nature and other culturally derived psychological processes), mitigation intentions, and preferred risk-reduction strategies for addressing wildfire hazard.
2. Examining the associations between landowner's risk perceptions and wildfire risk.
3. Examining the influence of neighborhood effects on the mitigation of property owners by determining the spatial interdependency of mitigation behaviors and how they are influenced by cultural orientations toward nature.

Study Area

Because Cultural Theory assumes that risk perceptions, behavioral intentions and policy preferences are shaped by social relations and underlying cultural biases, it is important to conduct this research in locations where residents with different cultural backgrounds live within the wildland-urban interface. Accordingly I chose communities in the American Southwest that have been identified by fire prevention officials as having significant wildfire risk and that also are shown by U.S. Census Bureau data as having ethnic and/or racial diversity.

As seen in Figure 1.4, the populations of California, New Mexico, and Arizona are highly diverse. This map shows the study areas (pink squares), that include high Diversity Index[1] scores (shaded in a dark blue), history of large wildfires[2], and the presence of a mitigation program. A high Diversity Index score indicates a high probability that two persons chosen at random from the same area belong to different races or ethnic groups. Population diversity continues to grow in most geographic areas of the U.S. In 2013 the national Diversity Index stood at 62.1, and it is projected to rise to 64.8 in 2018 (Reese-Cessal 2014). Specifically, the rate of change in diversity in suburban and rural areas increases annually at 1.5% and 1.4%, respectively.

The Firewise Communities Program (USA), started in 2002, and is one of many mitigation programs across the country that helps educate private landowners about wildfire prevention and engages them in taking responsibility for preparing their properties from wildfire disasters. This program is a significant part of the Fire Adapted

[1] The Diversity Index map, produced by the Environmental System Research Institute (ESRI), summarizes racial and ethnic diversity in the United States in 2013. The diversity score based on the 2010 U.S. Census was calculated to measure seven racial groups: White, Black, American Indian, Asian, Pacific Islander, Some Other Race, and Two or More Races. Two ethnic groups are also included: Hispanic and non-Hispanic, if an areas is ethnically diverse, the racial diversity is compounded. The index ranges from zero (no diversity) to 100 (complete diversity). The western U.S. is the most diverse region ranging from California (82) to New Mexico (76.7), Nevada (74.2), and Arizona (69.9).

[2] Note that a large wildfire in history refers to a fire size with greater than 100,000 acres.

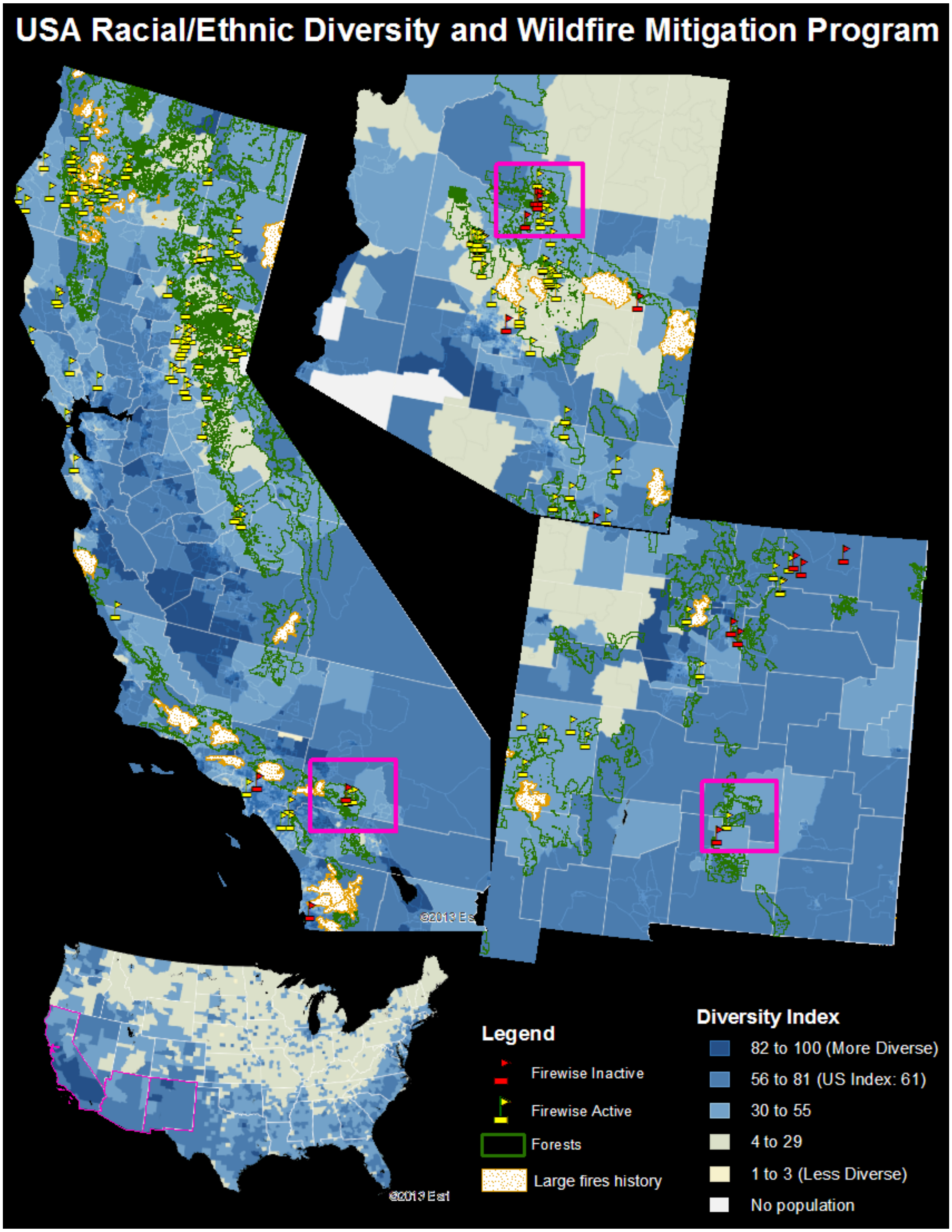

Figure 1.4. Study areas.

Communities organization funded by the U.S. Department of Agriculture Forest Service, the U.S. Department of the Interior, and the National Association of State Foresters. My purpose in using Firewise's geographic information[3] is to determine where people participate in mitigation programs relative to the level of racial and ethnic diversity in fire-prone areas. The geographic locations of each property may affect the level of participant in wildfire mitigation. One might presume that areas highly susceptible to wildfires would have a great number of Firewise communities because the local residents would recognize greater risk and therefore be willing to participate in a fire mitigation program. However, some communities have refused to continue participation in the Firewise program (red flag) even though large wildfires are a significant threat in their area. It is possible that in an area with higher racial and ethnic diversity, individuals may have widely differing knowledge of wildfire prevention and perceptions of risk. The difference in cultural background may influence how people perceive and response to risk. This situation may prevent the interface residents from seeking out wildfire prevention programs. Ultimately, my goal is to determine whether cultural biases may influence the risk perceptions and behaviors of private landowners with respect to protecting their properties from wildfire hazards in the following three study sites including Big Bear Lake, CA; Doney Park, AZ; and Ruidoso, NM.

The first study site is in California, in the San Bernardino County communities of Big Bear Lake and Big Bear City, which are located within the San Bernardino National Forest. The population in these two cities is in the middle of the diversity range (50-66). The proportion of Native Americans is high, a small proportion of individuals and

[3] Web link: http://firewise.org/usa-recognition-program/firewise-map.aspx

families are living below the poverty level, and about 22%[4] of residents have earned a bachelor's degree or higher (U.S. Department of Commerce Census Bureau 2011). San Bernardino County is the largest in the U.S. by area. While its western end is urban/suburban and quite populous, the remainder is made up of Federal lands surrounding private property with a slow rate of residential development. Grassland and shrubland dominate in this area, and the majority of the WUI is currently undeveloped (68%). San Bernardino County was ranked in the 90th percentile of western counties at risk of wildfire, based on the number of acres of undeveloped and forested private land bordering fire-prone public lands in 2010[5].

The second study site is Doney Park and Timberline, Arizona, which are major development subdivisions in Coconino County, near the city of Flagstaff. Located to the east of a famous scenic view of the San Francisco Peaks and Sunset Crater Volcano, Doney Park's population has a median income ($65,643) roughly the same as the national median, with only 15.9% of the population holding a college degree, and a medium to high diversity score of 56.8-70. According to the U.S. Census Bureau (2011), the indications of population growth and changing land-use patterns show an increase in the average number of residential homes per acre and a high possibility for residential development in the interface areas. The study area is surrounded by the Coconino National Forest, where the vast majority of the forest vegetation is ponderosa pine, pinyon-juniper woodland, and mixed conifer type, which is highly prone to crown fires.

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[4] The information on the demographic, physical characteristics and future wildfire potential of each study location is generated by the Economic Profile System-Human Dimension Toolkits (version 6.01) (U.S. Census Bureau 2011).

[5] Same as footnote 4.

Coconino County was ranked in the 84th percentile among counties in the West for wildfire risk.[6]

The third study site is the city of Ruidoso, located in southeastern New Mexico. Ruidoso has the second highest population diversity within the three states in the study at 68 and a median household income of $47,000. Ruidoso City is in Lincoln County, near the Lincoln National Forest, and has been designated as the third fastest growing city in New Mexico (U.S. Census Bureau 2011). The Mescalero Apache tribe owns resorts in this area although the Mescalero Reservation is located south of Ruidoso, almost entirely within Otero County. A high proportion of housing vacancies (59%) in Ruidoso are devoted to seasonal, recreational use in an area of montane scenic beauty, which suggests a higher than normal level of fuel-loading in the area. Nearly seventy percent of the WUI in Ruidoso is undeveloped. Most lands are privately owned and dominated by grass and shrub lands. Lincoln County was ranked in the 79th percentile among western counties for wildfire risk.

Sampling Method and Survey Design

Constructing a formative method for predicting behavior intention is not a single step approach. In this study, I gathered data primarily from mail surveys, which will factor prominently in all three sections of this dissertation. The mail survey was an applied because the majority of target population was located in the rural areas. To extract data that will be representative of risk perceptions of wildfires held by the

[6] The information on the demographic, physical characteristics and future wildfire potential of each study location is generated by the Economic Profile System-Human Dimension Toolkits (version 6.01). Data resources are from the 2013 U.S. Department of Commerce. 2013. Census Bureau, American Community Survey Office, Washington, D.C.

interface population, sampling will be structured to reflect the correct population proportions to those living in areas prone to these disasters where wildfire environment varies among sample population location and place. The concept of the relationship of cultural/human activities with the living environs links a particular social attribute to the respondent's perspective of their location (Johnstone 2004). The sampling technique is based on the socio-ecological perspective in which socio-economic and environmental characteristics of respondents and their properties are included to ensure a consistent representative sample over the study area.

To determine the population to be included in this sampling strategy, the target population was defined as those who own property in the WUI and those who spend most of their time living on their properties. On a broad scale (a regional-scale), we selected three southwestern communities according to the social attributes and race/ethnicity diversity (Diversity Index map) of the population and proximity to the wildfire initiatives (Firewise Community map). Figure 1.5 shows the process of spatial sampling using GIS-based data. The WUI[7] map (Radeloff et al. 2005), which provides both ecological and social aspects of the sampling procedure, is a base on which to construct the sample frame and define the spatial extent of the study area according to chosen interfaces. According to the authors, WUI in this study represents an area of both intermix and interface with at least 6.7 houses per square km and that is within 2.414 km. of an area with greater than 75% cover by wildland vegetation. Due to the fact that a longer

[7] Wildland-Urban Interface map (Radeloff et al., 2005) is produced by the Spatial Analysis for Conservation and Sustainability Lab, University Wisconsin-Madison. This GIS data is designed to support the effects of housing growth to inform both national and local policy assessment.

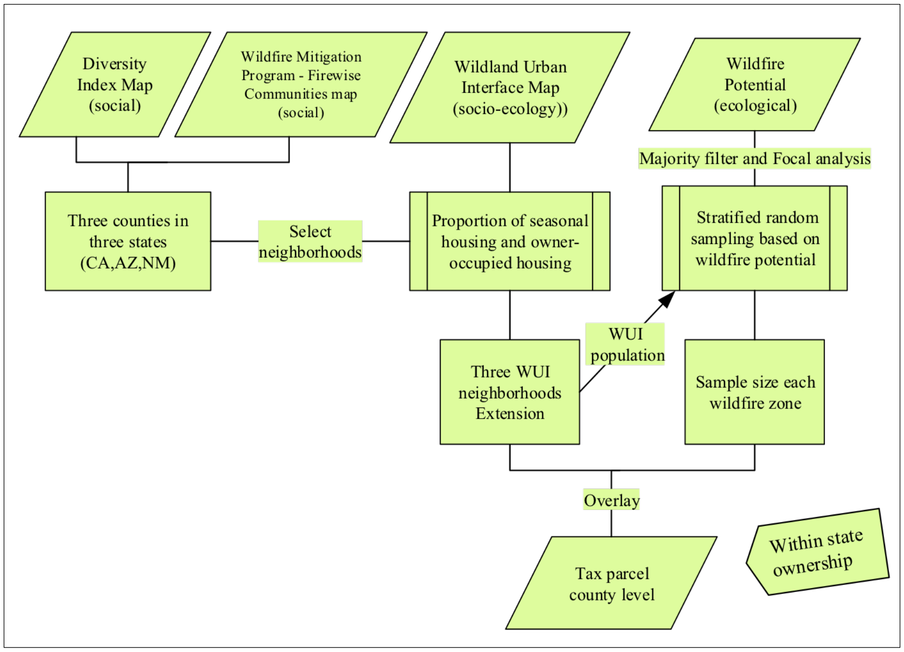

Figure 1.5. Socio-ecological sampling method (GIS-based).

term of residency implies significantly different effects on mitigation implementation and greater support for fire safety measure around one's home (Bright and Burtz 2006a, b; Collins 2008), this research focuses on all housing unit blocks with relatively high occupancy rates rather than those used for seasonal recreational or occasional use to ensure that we obtain a representative sample of respondents who are living year round in the area or who spend most of their time on their property.

On the finer scale (city-level), three neighborhoods in California, Arizona, and New Mexico were selected and used as a spatial parameter for the sample population. The WUI population can be estimated and the size of the final sample numbers can be determined using the spatial random sampling process of the Wildland Fire Potential

(WFP)[8]. The essential ecological variables associated with wildfires and the living environs affected by them were analyzed via a spatial sampling frame for this social survey. The WFP is a raster geospatial product that estimates burn probability and fire intensity levels for areas throughout the United States. The map represents a relative potential of five levels: very low, low, moderate, high, and very high probability of experiencing a high-intensity fire that may include torching, crowning, and other forms of extreme fire behavior. The majority filter and focal analysis[9] was applied to improve a classified raster in which larger and more generalized areas were included in the spatial sampling process. Specifically, five wildfire zones, or strata (1 = very low, 2 = low,…, and 5 = very high), were created.; then, the zones were used for sampling. Samples were assigned in proportion to both area of the strata and the relative wildfire potential, with equally weighted samples in each stratum. For example, it would be ideal to have a large sample set in a total of approximately 1,000 sample points with 200 points within each wildfire zone. In this case, the relative weight will be 1/5 for each zone. It was achieved by distributing these samples over the polygons (after converting a raster to a vector layer) based on the area of the polygon relative to the total area for the strata. For example, in the layer above, suppose one of the polygons in zone one has an area of 116.3 square km. and the total area of zone one is 192.5 square km. Therefore, the sample polygon should contain approximately 121 sample points ($200\times\left(\frac{116.3}{192.5}\right)$). In addition, the 200 samples, in this example, account for people living in the WUI within a certain

[8] The WFP map is produced by the USDA Forest Service, Fire Modeling Institute Dillion, "Wildland Fire Potential Map.". Its main objective is used as additional information for long-term strategic fuels management. Online links: http://www.firelab.org/fmi/data-products/229-wildland-firepotential-wfp

[9] The majority filter operates five successive times with HALF replacement threshold and the Median statistics is used for generalized data in Focal Analysis. Before precede sampling, the smoothed version of raster WFP data is converted to a vector layer.

hazard zone to avoid under-sampling of each zone. Consequently, a random set can be created using the sampling density based on stratified wildfire potential zones.

The stratified sample set was employed to build a frame for WUI individual selection which is linked to property tax records. Renters were excluded from samples to ensure that respondents would have equal incentive to mitigate wildfire risk. The parcel map was overlaid onto the established reference sample points of wildfire zones to select parcels and identify addresses of potential respondents. A property land parcel denotes the legal boundaries of each property and allows one to contact the owners; however, it is possible that potential respondents may be difficult to identify from residential parcels if they contain multiple addresses such as an apartment building. Thus, only parcels owned by individuals whose address was in the same state of study were selected to improve the chances of locating a long-term residence. The target population is mostly located in remote areas and education background varies from area to area, so a postal survey is an appropriate mode of survey for this study because this approach allow a survey respondents to read the complicate questions at their own paces (Dillman 2011). Mail surveys were also mailed to those who did not respond to the email inquiry within three weeks. Previous studies have suggested that mailing surveys improves response rates from 43% to 80%, rather than conducting telephone surveys, whether it is used as a lead mode or simply a follow-up (Dillman, Smyth, and Christian 2008).

To formulate the survey instrument, a pilot survey was conducted with participants from various ethnic background were selected from convenient targets, such as colleagues and friends of researcher. Participants were asked open-ended questions about their relevant beliefs. The most frequently mentioned responses to open-ended questions in the pilot portion of the study were incorporated into the final survey instrument as modal beliefs (behavioral, normative, and control beliefs). A survey instrument was constructed that included defining behaviors for each question that adhere to target, action, context, and time principles (Ajzen and Fishbein 2004). For example, "I (target) mowed (action) the lawn around my house and have kept the grass less than six inches (context) in the last two weeks (time)". In addition, participants' views of environmental risk relating to their perceptions of nature were also investigated using survey questions, developed for CT.

According to the Theory of Planned Behavior, self-efficacy and controllability factors are necessary components in Perceived Behavioral Control (PBC), so both must be obtained from respondents. Given a sufficient degree, PBC can be seen as a proxy for actual behavioral control (the mediator between intention and behavior, as shown in Figure 1.3) (Ajzen 2002) and can contribute to predictions of mitigation. Thus by obtaining precise PBC, we can gain insight into the foundation of TPB variables from perceived behavioral control by incorporating both self-efficacy and controllability factors.

Organization of the Dissertation

This dissertation is organized in a manuscript format with an introductory chapter summarizing the information that follows, three papers prepared for submission to refereed journals, and a final chapter summarizing and synthesizing results and describing overall conclusions and implications is also included. This introductory chapter provides background information and context for the remainder of the dissertation.

Chapter 2 describes and analyzes the survey results given to individuals in selected locations at the wildland-urban interface (WUI) to determine how sociocultural background, described as factors influence in response to risk perception (Danielson 2007), affects risk mitigation intentions. Surveys included questions designed to explore the beliefs and behavioral intentions of property owners about wildfire hazard mitigation. A set of survey questions on myths of nature (although not referred to as "myths" in the survey) was prepared to assess individuals' worldviews. Responses were analyzed for correlation between a particular worldview and individual immediate factors of TPB. The integration of CT (Wildavsky 1987; Dake 1991) and the TPB (Ajzen 1991b) was used as a framework to estimate the likelihood that participants will follow through on mitigation behaviors using Structural Equation Modeling (SEM). An SEM was constructed to estimate factor loadings assuming linear relationships among a set of indicators and latent variables. Items with greater weight were selected to represent strong factors and to test for the existence of mediating effects of social construct.

Through the lens of CT, people's views of environmental risks are seen as being shaped by their social interactions and underlying cultural biases, which can influence their understanding of and actions for handling risk by their preferred form of society (Douglas and Wildavsky 1983; Schwarz and Thompson 1990). CT categorizes the perception of environmental risk (myths of nature) into four groups depending on cultural background (cultural biases): Nature Benign, Nature Fragile, Nature Capricious, and Nature Perverse/Tolerant. Each of the four categories of CT was tested for strength of correlation with TPB elements: attitudes, subjective norms, and perceived behavioral control. The CT-TPB framework is displayed below.

The main objective of this chapter was to examine the relationship between myths of nature and intention to engage in risk-mitigation activities. The impacts of TPB variables were quantified. The role of worldviews regarding myths of nature was determined whether there exhibits the mediation effects of TPB variables as shown in Figure 1.6.

SEM was used to identify the causal relationships among variables in the CT-TPB framework and to determine the existence of the mediating effects of the construct. A set of questions to determine values was used to evaluate risk perception in this study. Furthermore, three key aspects of beliefs—attitudes, norms, and perceived behavioral control of the property owners —was quantified in order to estimate the likelihood of risk mitigation intentions and their relationship to individual values. The value types were isolated by factor analysis. Items loading with significant weight represent strong factors contributing to interpretation. An SEM was constructed to estimate factor loading, assuming linear relationships among a set of indictors and latent variables. Later, the

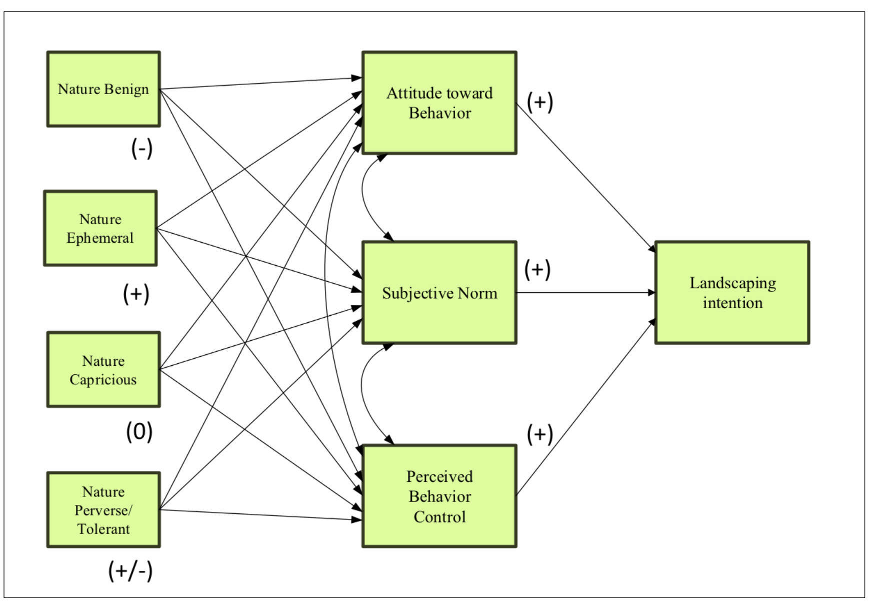

Figure 1.6. The conceptual framework of mitigation intentions.

structural model was linearly regressed to explore whether latent indicators are causally dependent. The general measurement model (Kaplan and Depaoli 2012) is expressed in *Equation 1.1*).

$$y = \alpha + \Lambda\eta + Kx + \varepsilon \qquad \text{Equation 1.1)}$$

where y is a vector of observed variables, α is the measurement intercepts, Λ represents a factor loading matrix, η is a vector of latent variables, K represents a matrix of regression coefficients , and ε is a vector of uniqueness with covariance matric Ξ assumed to be diagonal. The structural model can be expressed as

$$\eta = v + B\eta + \Gamma x + \xi \qquad \text{Equation1.2)}$$

where v represents a vector of structural intercepts, B and Γ are matrices of structural coefficients, and ξ is a vector of structural disturbances with a diagonal covariance matrix, ψ .

Chapter 3 examines a pattern of local risk perceptions. The goal was to test whether localized patterns of risk perception of wildfires are associated with actual scientific measurements of wildfire risk. My purpose was to improve understanding about the relationship between public perception and actual changes in wildfire risk. The "halo effect" concept is a theme to describe how individuals may be reluctant to ascribe high levels of risk to their own homes or neighborhoods. The explanation of halo effect is that people often believe that their setting location is surrounded by less harmful natural hazards and could result in lower risk perception such as hazard from wildfire (Vandeventer 2012).

The main objective for the third chapter was to examine a pattern of perceived wildfire risk across the study area (wildfire risk perceptions may not correspond to actual measured wildfire risk). More specifically, this study focuses on identifying individual characteristics and social context regarding risk perception that helps to explain variation in perception about wildfire hazard. I investigated whether an interface residents' likelihood to perceive of wildfire risk varies across communities. Then, I further investigate how community-level variables help explain variability in likelihood to form an individual-level perception. The multilevel modeling (ML) approach used in this chapter reflects the theoretical basis such that each individual respondent is independent and people from similar geographical locations share some common social and environmental settings which leads them to similar perceptions. This study uses a two-level model: individual-level and community-level (in different states). The model tests the hypothesis that individuals will perceive a lower risk to their homes or neighborhoods than at the broader-scales such as their county, region, or state overall.

The fourth chapter builds on the information discussed in the previous chapter. Its purpose is to estimate the effect of a neighbor's mitigation behaviors on a homeowner's intention to decrease wildfire hazards. By incorporating biophysical variables, the spatial interdependency of perception of nature held by homeowners on adjacent property mitigation was determined. The model assumes that if homeowners feel responsible for risk, they will undertake mitigation actions. Responsibility for mitigation is seen as shared by members of society and is related to the perceived risk to promote the acceptance of fire/fuel management. A spatial analysis was conducted to examine the role of adjacent properties' mitigation intention on homeowners' risk-reduction activities.

Beliefs and mitigations of respondents from neighboring properties were analyzed using a spatial-autoregressive probit (SARP) model to capture spatial interdependency of mitigating actions. This study posits that a landowner's willingness to mitigate wildfire risk will be influenced by perceived mitigation intentions of neighbors and their preferred risk-reduction activities.

This chapter incorporated Geographic Information System (GIS) for remote sensing to extract data for the biophysical features of each parcel. The extracted individual characteristics of landscape were later integrated with the data from surveys data. Raster images with fine resolution (e.g., 1-meter resolution images) were used to obtain spatial data for this study. Parcel data of fire adapted communities was obtained from each community's County Assessor Office. Topography data from the U.S. Geographical Survey (USGS) was separately estimated to determine fire risk indicators.

The final chapter concludes and synthesizes the findings of the three chapters. It provides implications of the research with a focus on the social-ecology perspective of the overall dissertation in the broader view of wildfire literature.

Each of the chapters contains important background information and specific analysis method within it but, when necessary, chapters refer to each other for more information.

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CHAPTER 2

INFLUENCE OF INDIVIDUAL WORLDVIEWS ON WILDFIRE MITIGATION DECISION PROCESSES

Abstract

The complex issue of public response to wildfire risks has become more of a challenge due to increasing numbers of people migrating closer to the wildland-urban interface. We utilized the Theory of Planned Behavior (TPB) and Cultural Theory (CT) to study the relationship between one's individual perspective toward risk and the decision to mitigate it. We examined the extent to which individual worldview as a measurement of risk perception influences an individual's intention to mitigate risk. Based on mail survey data from three fire-prone communities in the Southwest, we utilized structural equation modeling and mediation analysis to determine the antecedents of behavioral intentions for risk reduction and the relationships between individual risk perception factors. Our results indicated that the respondents fell into one of four types of worldviews which are predictive of mitigation intention. Positive attitudes toward practices and perception of having some control over mitigating wildfire risk increased mitigation intention. Decision (Cohen 1992) processes toward wildlife hazard mitigation depended somewhat on attitudes toward established mitigation activities.

Key Words: risk perception, mediation, SEM, survey methods, Theory of Planned Behavior, Cultural Theory

Introduction

Managers of public lands in the United States are under increasing pressure to reduce the risks and costs of wildfires, as exemplified in the latest version of the national fire plan, known officially as the National Cohesive Wildland Fire Management Strategy (Wildland Fire Leadership Council 2012). Of particular concern for wildfire management and policy is the landscape known as the Wildland-Urban Interface (WUI). This zone is estimated to have grown by 52% from 1970 to 2000 and is expected to cover more than 500,000 km^2 by the year 2030 (Theobald and Romme 2007). The need to protect lives and property in the expanding WUI has significantly contributed to the rising costs of fire suppression (Schoennagel et al. 2009). Accordingly, the comprehensive wildfire strategy emphasizes methods for reducing the threat of wildfires in the WUI. Among the plan's goals are to increase fuel management on both private and public lands and implement growth management, land development, and zoning laws that require the establishment of defensible space and wildfire risk-reduction activities in the WUI.

Protective measures taken on private lands that are not under federal jurisdiction require local consent to be implemented, either through permission granted from individual landowners or collective action within the community. It is vital, therefore, to understand how WUI landowners perceive wildfire risk and proposed actions that might reduce such risk. The perception of wildfire risk plays an important role in a landowner's decision to mitigate this potential hazard. Understanding the multi-dimensional relationship between risk perception and behavior requires the simultaneous analysis of social-cultural, demographic, and biophysical factors (Daniel, Carroll, and Moseley 2007) because perception of risk does not directly lead to behaviors (Stern 1993). The disconnection between perceived risk and actual behavior indicates that often the level of individual mitigation effort does not reflect the actual actions that will be necessary for protection against the hazard. For example, although the general public understands that fire management plays a role in preventing wildfires, it does not necessarily follow that people who understand the risk and are concerned about it will take action to decrease their exposure to wildfires or other hazards (McCaffrey et al. 2011). In reality, people sometimes underestimate risk and neglect to employ wildfire mitigation practices. Thus, individual behavior can be seen as a fundamental factor in wildfire management because individuals have a strong influence on collective action and policy decisions. This study investigated individual behavior in the WUI, individual risk perception communication, and the simultaneous interaction of these factors. The goal is to help promote efficient communication and outreach strategies in the event of wildfires and to help land managers develop appropriate risk mitigation programs that will appeal to a diverse constituency.

Numerous studies have focused on the response of landowners to perceived wildfire risk (McCaffrey 2004). However, relatively little is known about the relationship between cognitive factors and actual behavior with regard to wildfire and fuel reduction management. Within a risk perception framework, this study considered the interdependencies between the Cultural Theory (CT) and the Theory of Planned Behavior (TPB) to explain the complexity of behavioral intention behind wildfire risk reduction. According to the CT model, individuals behave based on core values or worldviews that are linked to risk perception, judgment of risk, and preferences for risk management (M. Thompson, Ellis, and Wildavsky 1990). Core values shape much of an individual's behavior, attitudes toward the world and the ways in which he or she orients/copes in complex situations. Four dominant worldviews represent different understandings of the nature of society and human's relationship to nature, which reflect how each group perceives risk. The TPB model proposes that an individual's behavioral intention, the most immediate antecedent to actual behavior, is influenced by attitudes toward the behavior, subjective norms about the behavior, and perceived behavioral control of the behavior. Although the combination of TPB and CT models has been recognized in climate change literature (Tikir and Lehmann 2011), it has not been applied to wildfire prevention. Several studies have attempted to explain the connection between risk perception and risk reduction behaviors in the context of wildfire; however, to the best of our knowledge, no studies in the wildfire prevention field have delved into the underlying psychological processes of forming attitudes, norms, and their link to perceived behavioral control.

The primary goal of this study was to determine how property owners' perceptions of nature are related to mitigation intention and self-reported behavior. More specifically, we aimed to investigate the strength of the interactions among attitudes, subjective norms, perceived behavioral control, and behavioral intention and whether this intention is predictive of actual behavior. We found that there was a significant connection between mitigation intention and self-reported behavior. In addition, we studied the possible mediating effects of worldviews regarding perceptions of nature on TPB constructs. We also analyzed the possible mediating effects of TPB cognitive variables on the relationship between individual perceptions of nature and mitigation intentions explicitly via multiple mediation analyses.

Theoretical and Conceptual Framework

Our theoretical framework, presented in Figure 2.1, draws from the integration of social-psychological theories to illustrate the interaction among aspects of risk perception and behavioral intention to mitigate the destruction of wildfires. Attitudes, subjective norms, and perceived behavioral control are predictors of the intention to perform a behavior described by the traditional TPB model. In this way, intention is the most immediate predictor of behavior (Ajzen 1991a). The antecedents of intention are composed of beliefs and evaluations of possible actions. Several factors can influence beliefs, such as personal and situational factors (Fishbein and Ajzen 2005) as well as one's cultural and personal values. The value-based approach utilizes individual risk

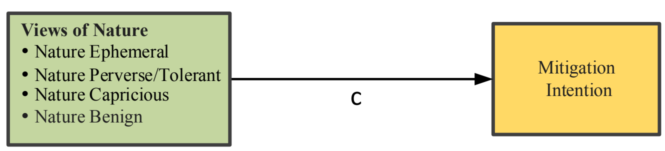

Figure 1a. Total Effects (unmediated) Model

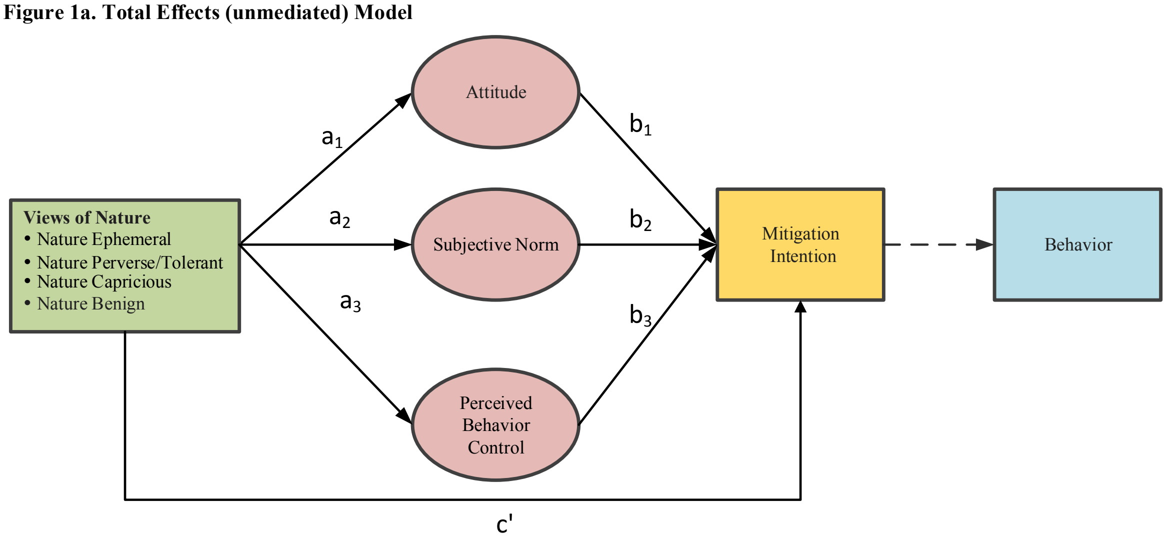

Figure 1b. Mediating Effects Model

Figure 2.1. Hypothesized integrative CT-TPB structural model of wildfire mitigation intentions.

perception because its role may indirectly affect behavioral intention. The perception of nature construct is included as an extension of the traditional TPB construct. To test the mediation effect of these TPB variables, the total (1a) and mediating effects (1b) are subsequently examined through a structural equation model, which will be discussed in the Methods section.

This conceptual framework extends the traditional TPB model to illuminate connections of risk perception as underlying factors of behavioral intention. Several value-based theories are commonly applied in environmental research. For example, the CT model is frequently used in risk perception analysis (Tikir and Lehmann 2011). According to this model, people's perceptions of environmental hazards are shaped by their social interactions, preferred form of society and underlying cultural biases, which can influence their understanding of risk and their behaviors to guard against it (Schwarz and Thompson 1990; Dake 1992)

This conceptual model, illustrated in Figure 2.1, assumes that TPB variables are robust predictors of intentions. In other words, the antecedents of intentions to mitigate wildfires have a strong positive relationship to the intention to reduce future forest fires. Therefore, a more positive variable leads to a greater intention for action (path b_1-b_3). This perceived risk-behavior examination extends the traditional TPB framework to include values as a possible motivational construct and beliefs, as a guide for choosing and evaluating actions (Schwartz 1977). With respect to the TPB model (Fishbein and Ajzen 2005), values, based on an individual's background, are assumed to affect TPB variables. Thus, individuals' differing perceptions of wildfire risk should be influenced by their values, attitudes, subjective norms, and perceived behavioral control.

The hypotheses regarding perceptions of nature associated with path a_1-a_3 are elaborated below:

- Egalitarians (hereafter called nature-ephemeral) see nature as fragile and have a positive attitude toward mitigation due to concern about the environmental impacts of wildfires. They would be very likely to participate in community-based fire management activities (e.g. become members of the Firewise community (a positive relationship to SBN)). They are concerned about environmental problems and frequently contribute to finding solutions by adapting their needs and behaviors, and try to motivate others to do so (positive relationship to PBC).
- Hierarchists (hereafter called nature-perverse/tolerant) may tend to have negative responses to some TPB variables because they place a high value on the decisions of government and experts. Hierarchists are likely to have a positive attitude toward mitigation because of their tendency to agree with experts' decisions. Since they view nature as being immune to human disturbance only to a certain degree, they believe that nature could be destroyed if human's demand for resources exceeds a certain limit. Thus, this view of nature is expected to have a negative relationship to PBC.
- Fatalists (hereafter called nature-capricious) are more random and less predictable in their thinking. Their preferences for isolation could result in a negative attitude toward mitigation attempts due to a perceived restriction on their freedom. As they are not active members of society, they would probably have a negative relationship to SBN or no relationship at all. Since the fatalists' view of nature is similar to that of a lottery, their decisions are not consistent; instead, they simply

cope with erratic events as they come. Thus, a zero or negative relationship to PBC would be expected.

- Individualists (hereafter called nature-benign) perceive environmental risk as normal. Because these people tend to be risk-seeking, we assume that they will not be very concerned about wildfire issues, because they believe that new technologies will solve these problems. For these reasons, they would likely have a negative attitude toward mitigation attempts. They prefer an isolated life (a negative relationship to SBN) and freedom to make their own decisions (positive to PBC). For example, individualists who reside in WUI areas would value the right to make their own decisions about trade-offs between safety and aesthetics or costs, so they would be unlikely to embrace behaviors that limit that freedom.

Finally, we hypothesize that the roles of cognitive variables in TPB theory (ATT, SN, and PBC) mediate the degree to which an individual's worldviews predict behavioral intentions (path c' in the mediating effects model). We assume that there is no correlation with path a and b.

Methods

Survey Sampling of the Study Area

Three communities in the Southwest (Big Bear Lake and Big Bear City, CA; Doney Park, AZ; Ruidoso, NM) were selected for the study. Each of these communities is in close proximity to national forest, has suffered a long history of devestating wildfires, and has been identified by fire prevention officials as having significant similar risks in the future. U.S. Census data suggest that respondents from these three communities exhibited diversity in such aspects as gender, level of education, and ethnicity. A stratified random sampling technique was implemented to include the socioeconomic and environmental characteristics of respondents and ensure a consistent representative sample across the study area. Because the Cultural Theory model assumes that risk perceptions, behavioral intentions and policy preferences are shaped by social relationships and underlying cultural biases, we tried to ensure that a wide variety of cultural backgrounds were represented in our study. Sampling was structured to accurately reflect the diversity of the wildland interface population and those living in proximity to areas with frequent wildfire disasters of all levels. The selected samples account for the wildfire hazard zones and social attributes of the WUI population (i.e., race/ethnicity diversity), as determined using a GIS-based data. Survey participants were finally selected from property tax records.

Socio-psychological indicators and demographic information were collected from property owners via a survey mailed in May 2014, following Dillman's tailored design method (Dillman 2011). Property owners were first contacted by postcards containing a brief introduction to our study and notifying them that a survey would be coming. A week later we sent 1,070 letters, including questionnaires and pre-paid envelopes. Eleven postcards were undeliverable. Three weeks later, we sent thank you/reminder postcards (1059), followed by a second wave of surveys (900) the following week. Two weeks after the second mailing, we received 220 returned surveys and the final dataset of 196 completed responses (response rate 20.8%; Doney Park = 71; Big Bear = 56; Ruidoso = 69). These results were tested for sample non-response bias. A set of one-proportional *Z*-

tests[10] detected significant differences in demographic variables (i.e., age, income, education and ethnicity) in these communities, but these findings would likely have little effect on our outcomes (see Table 2.1). We compared the mean measured variables, including views of nature, attitude, norms, perceived control, and mitigation intention, of the first responses to those of the subsequent mailing. We confirmed that there was no evidence of differences between two groups. In other words, the survey responses supported our belief that we had minimized nonresponse bias. The nonresponse bias test is shown in Appendix A.

While our sampling strategy attempted to draw from an ethnically and demographically diverse pool of residents, there was a bias within the respondent pool

Table 2.1. Descriptive statistics and measured variables

Community		Big Bear, CA	Doney Park, AZ	Ruidoso, NM
			Percent	
Socioeconomic Variables				
Age	Over 64 years old	33.8	55.6	61.2
Gender	Male	66.2	53.7	50.0
Education Level	College Degree	35.3	16.7	13.6
Ethnicity	White non-Hispanic	83.8	88.7	86.4
Income	$50,000 and up	52.2	47.2	35.4
Length of residency [a]	More than 5 years	14.0	14.0	15.0

Variables Considered in the TPB Model		Mean[b]	S.D.	Alpha
ATT	Attitude Toward Wildfire Mitigation	5.33	1.18	0.80
PBC	Perceived Behavioral Control	4.79	1.14	0.61
INTENT	Mitigation Intentions	6.20	0.79	0.92

[a] Median, a length of residence ranged from 9 months to 70 years. [b] Mean and standard deviation were calculated according to the factor score of each variable. Note that items measured in the subjective norm failed the reliability test of the model, measurement and were excluded from the further analysis.

[10] Appendix A, Table A-1

toward higher socioeconomic status compared to the population as a whole. The average respondents were white, age 55 years old and over, had attended college, and lived in a household in which the annual income was $50,000 and higher.

Survey Instruments

A questionnaire was developed to capture integrated socio-psychological indicators for assessing all theoretical constructs. Questionnaires were identical for all study areas except for references to location. In the CT model, items measure four perceptions of nature adapted and pre-tested from prior studies (Dake 1992; Sjöberg 2000; Rippl 2002; Oltedal et al. 2004; Lima and Castro 2005; Leiserowitz 2006; Hoogstra-Klein, Permadi, and Yasmi 2012). All were rated on a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). The 16 items measured four views of nature and were assessed for internal consistency and testing reliability before the indicator scores were extracted via factor analysis (Promax 4).

The items associated with TPB variables were initially elicited from a convenience sample of friends and colleagues of the author from three states (Arizona, Utah, and Washington) who were selected to represent varying ethnic backgrounds. They were asked questions on attitudes, norms, and perceptions regarding wildfire mitigation using open-ended online surveys. These surveys, along with propositions based on cultural theory, were used to guide construction of the survey instrument. For example, perceived norm items were designed to measure the opinions of important people in the respondents' lives (e.g. people who are important to me want me to manage my property, and most of my neighbors manage their property). In addition, mitigation behaviors were defined for each question that adheres to the target, action, context, and response time. The survey instrument was pre-tested later with the same group of participants.

Briefly, eleven items designed to measure TPB constructs on a seven-point Likert scale were examined via exploratory factor analysis (Principal Axis Factoring, Promax rotation) to ensure that items in each section conform to similar underlying constructs. The factor loading with value less than 0.5 was considered as an unsatisfactory reliability. In turn, the norm construct fell below a satisfactory reliability rate were excluded from further modeling[11]. A list of scale items for each CT construct is presented in the Appendix B.

Structural Equation Modeling Procedures

As depicted in Figure 2.1, structural equation modeling (SEM) was employed to test the hypothesized mediation relationship in a single model. An SEM involves a two-step approach. First, a measurement model was tested using confirmatory factor analysis (CFA) to confirm the relationship among latent constructs (attitudes, SNB, PBC and the four views of nature). The covariance structure was tested to determine if the observed variables reliably reflected the hypothesized latent variables. A common method bias (CMB) test was performed during CFA by including a common latent factor to capture a common variance among all observed variables in the model (Podsakoff et al. 2003). We confirmed that there was no evidence of a response bias from the unmeasured external factors in the model. In this study, the model fit measures were indicated by the Chi-

[11] The Cronbach's alpha of TPB variables: attitude =.78, subjective norms=.34, perceived behavioral control=.72, intention=.92, and behavior =.69. Behaviors activities include "removing dead vegetation from under deck and rook", "trimming back trees that overhang the house", and "pruning trees up to 8-15 feet above the ground".

square (χ^2 = 88.75, p < .001) test. The other five fit indices were used as a supplement for determining goodness of fit; the ratio of Chi-square to degree of freedom (χ^2/df = 2.07), the comparative fit index (CFI = .95), the goodness-of-fit (GFI =. 94), the standardized root mean-square residual (SRMR = .06), and the root mean square of approximation (RMSEA = .07). According to Hu and Bentler (1999), this measurement model would be a good fit for the data.

Second, the structural model was constructed to test hypothesized relationships. The SEM model simultaneously estimated the path coefficient and tested the significance of directional and non-directional association between variables (Byrne 2013). This analysis was performed via Amos Graphics 22.0 using the Maximum Likelihood (ML) method of parameter estimation. To determine whether the attitudes, subjective norms, and PBC significantly mediates property owners' mitigatation intentions upon the inclusion of individual worldviews into the model, the mediation effect was tested by combining the causal step approach of Baron and Kenny (1986) with the bootstrap algorithm. As shown in Figure 2.1, first we tested the significance of path c (1a), then determined the significance of direct effect path c' (1b) after the mediators were added into the model. The joint significance of path a and b were directly calculated in terms of the product of coefficients (ab) of path a and b (1b). This approach provided a validity measurement for indirect effect in each mediation model (MacKinnon, Fairchild, and Fritz 2007; Preacher and Hayes 2008; Hayes 2009; Zhao, Lynch, and Chen 2010). The significance of each indirect effect was determined by bootstrapped bias-corrected confidence intervals. This method accounts for an inconsistent mediation (when the coefficient of path a and b have the opposite sign) and provides more robust estimates given a small sample size (Shrout and Bolger 2002) in detecting the indirect effect (a size of mediation). In this study, the type of mediation effects were based on Zhao, Lynch, and Chen (2010)'s classification.

Results

Associations of Nature Views, Socio-demographic Variables and Mitigation

The categories into which the interface respondents were placed were predominately nature-ephemeral (29%) followed by nature-perverse/tolerant (26%), nature-capricious (23%) and nature-benign (20%). Although their perceptions of nature were not substantially distinct, female respondents were more likely to subscribe to the nature-perverse/tolerant and nature-benign philosophies, whereas the nature-ephemeral and nature-capricious were dominated by males (χ^2 (12,197) = 24.58, $p < 0.05$). In addition, the respondents with a professional degree seemed to view nature as being fragile, with a possibility of being thrown out of equilibrium if disturbed (nature-ephemeral and -perverse/tolerant). However, others perceived the natural environment as steady and unchanging (capricious and benign) (χ^2 (15,197) = 24.62, $p < 0.05$). We did not find any systematic relationship between views of nature and age, income, and race/ethnic background.

Wildfire mitigation activities[12] recommended by the Firewise program were used as target activities to observe. Not surprisingly, the respondents adhering to the nature-perverse/tolerant point of view reported engaging in many more mitigation activities than

[12] The list of wildfire mitigation activities described in Appendix C.

the other types. This could be because the mitigation activities are regulated by fire authorities and this group tends to place greatest faith in governmental structures. In contrast, the respondents who reported engaging in fewer mitigation activities were those associated with nature-ephemeral orientations. This may be because mitigating activities involve clearing vegetation, which may be distasteful to respondents with an ephemeral worldview who perceive nature as delicate and unstable.

The correlations of variables in the CT-TPB model were consistent with the theories, as shown in Table 2.2. The TPB variables were in accordance with the direction predicted by the TPB model. The TPB elements (attitude and PBC; $r = .468$ and $r = .563$, respectively) showed the strongest positive relationship to mitigation intention. Among the four perceptions of nature, the respondents associated with the nature-perverse philosophy exhibited the most positive relationship to TPB variables. The strongest positive correlation of CT factors involving views of nature were the nature-benign and nature-capricious groups ($r = .233$). Because these groups see nature as being able to re-establish itself and tend to be individualistic, they likely had a relatively low level of motivation to engage in mitigation activities. This significant negative correlation would be expected for the respondents who subscribe to the capricious view of nature ($r = -.117$). This makes sense because perceiving the environment as unstable and vulnerable leads them to be less involved in activities that they perceive as being disturbing to nature. On the other hand, the highest correlation of worldview and mitigation intentions was found in the group of respondents associated with the perverse/tolerant philosophy ($r = .197$).

Table 2.2. Correlation matrix of TPB variables and the worldviews on nature

	1	2	3	4	5	6	7
1. EPHEMORAL							
2.PERVERSE	.128**						
3.BENIGN	-.173**	.060					
4.CAPRICIOUS	-.080	-.055	.233**				
5.PBC	.002	.165**	.138**	-.058			
6.ATTITUDE	.008	.151**	.113*	-.042	.387**		
7.INTENTION	.013	.197**	.058	-.117*	.563**	.468**	
8.BEHAVIORS	.021	.100*	.072	.079	.082	.329**	.203**

Note: correlation coefficient is calculated by Kendall's tau with significant levels of ** *p*-value < 0.01; * *p*-value < 0.05

We evaluated our model, shown in Figure 2.1, via an SEM technique, as discussed in the Methods section. First, the baseline TPB model was tested (Figure 2.2). This model focuses on the relationships between the TPB variables (attitudes and perceived behavioral control) and intention and self-reported behaviors. The second iteration, which included the perceptions of nature, tested whether the TPB variables define the relationships to mitigation intention.

The baseline model results show that attitudes and level of perceived control have positive associations with the intentions to mitigate wildfires. The model fit indices confirm a good fit with our data supporting the hypothesized relationships. The standardized regression coefficients are .34 and .30 respectively. Although our model did not predict the mitigating behaviors, our results show that residents could be motivated to perform mitigation activities such as removing dead vegetation from under deck and roof of the house.

The next iteration incorporated the views of nature into the model. A few adjustments were applied to obtain the best-fitting model. The evidence during the confirmatory factor analysis (specifically, the common method bias) suggested that there

Mediation Effects of Individual Worldviews and Wildfire Mitigation Intentions

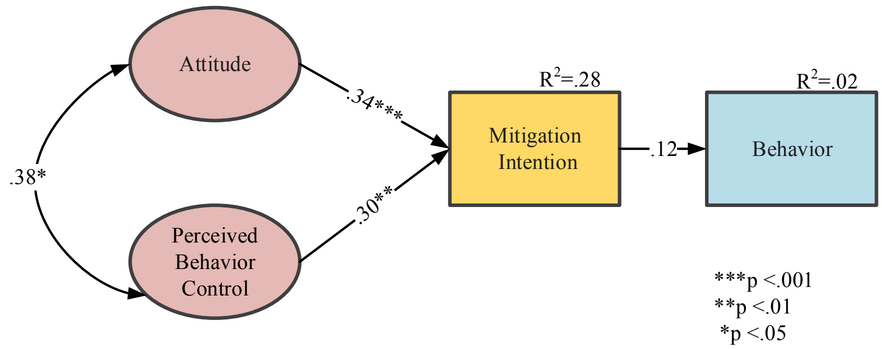

Figure 2.2. TPB path diagram with regression weights.

was instability caused by the components outside of the model. Thereby, the model was adjusted by removing the behavioral component, and the model as shown in Figure 2.3 was instead used to determine the mediation analysis. As a result, the attitudes and PBC for the intention shifted slightly and the explained variance in the intention increased from 28 to 34 percent. As expected, respondents associated with the nature-perverse point of view had more positive attitudes toward mitigation and should be expected to exhibit increased participation in activities to prevent wildfire damage. However, contrary to our hypothesis, this view of nature and the PBC had a negative association. It can be inferred that this group interpreted the risk of wildfire as being the responsibility of the government. As such, a high score for viewing nature as perverse leads to a positive effect on attitudes as well as the PBC. Likewise, the respondents subscribing to the nature-benign point of view have a positive effect on attitudes and PBC, even though the effect on attitude was contrary to our hypothesis. We found no association between the nature-ephemeral and nature-capricious orientations and TPB variables. Nevertheless, these associations of views on nature are in harmony with the CT model.

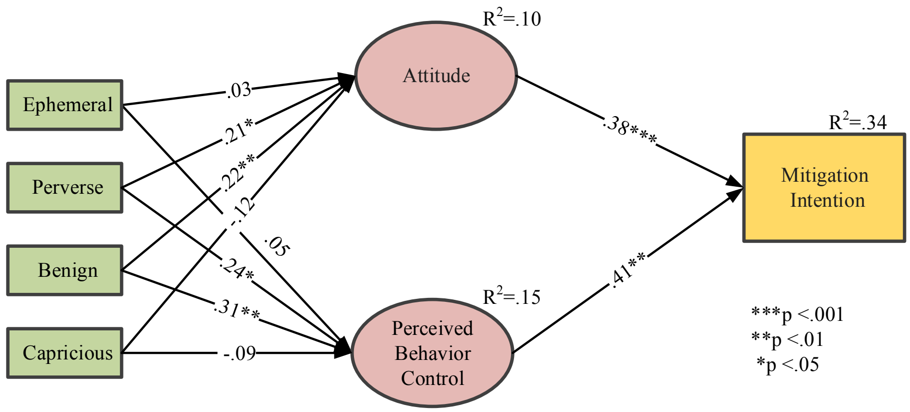

Figure 2.3. CT-TPB path diagram with regression weights.

Following Zhao, Lynch, and Chen (2010), the mediation effect was tested to determine whether cognitive variables (Attitude and PBC) mediate the relationships between individual worldviews and mitigation intention. The results of the mediation analysis, illustrated in Figure 2.3, confirmed the mediating role of attitudes and PBC in relation to perception of nature and wildfire mitigation intention. To establish the mediation effects, the statistically significant path of indirect effect (ab) was first determined using the bootstrap test. All parameters were simultaneously estimated to calculate the direct effects using SEM. The direct correlation between worldviews and the mitigation intentions (path c') were then examined followed by the determination of the significance of the direct (unmediated-path c) effect. In addition, the signs (+, -) of estimates were used to classify the type of mediation in the model. The analyses of the power of perspectives to predict mitigation intention, which included bootstrapped results of direct controlling for mediation and mediated effects, are presented in Table 2.3. In our study, the 95% confidence interval of the indirect effects was obtained from 5,000 bootstrapping samples (Preacher and Hayes 2008).

Table 2.3. Analysis of the direct (unmediated) and indirect effects of TPB variables on the association between the individual values on views of nature (IV) and wildfire mitigation intention (DV)

Independent variables (IV)	Mediator (M)	Direct effect of IV on DV (c) unmediated	Direct Effect with M (c')	Indirect effects (ab) BC[a] 95% CI
Ephemeral		-.019 (p=.06)		
	Attitude		-.040 (.05)	.010(.03) (-.04,.09)
	PBC		-.050 (.05)	.022(.05) (-.06,.13)
Capricious		-.148*(p=.05)		
	Attitude		-.087 (.05)	-.046(.04) (-.12,.02)
	PBC		-.078 (.05)	-.036(.05) (-.14,.04)
Perverse		.232**(p=.05)		
	Attitude		.105 (.05)	.082** (.04) (.02,.18)
	PBC		.072(.05)	.098***(.05) (.02,.24)
Benign		.005(p=.05)		
	Attitude		-.138**(.05)	.082*(.04) (.02,.18)
	PBC		-.188*(.05)	.125*(.05) (.02,.28)

Note that the standard errors are presented within the first parentheses; ****p < .001, **p < .01, *p < .05; (ns) = not significant*; [a] bias corrected bootstrapping confidence intervals in the second parentheses.

We found that viewing nature as perverse/tolerant (hierarchists) was mediated by attitudes and PBC. These mediations known as the indirect-only mediation[13] (Zhao, Lynch, and Chen 2010) suggest that attitudes and PBC were consistent with our hypothesized theoretical framework. The direct effect (path c') of possessing a perverse view and mitigation intention became insignificant when controlling for attitude (β = .103; p = .14) and similarly when controlling for PBC (β = .072; p = .35). In addition, the results confirmed the competitive mediation of attitudes and PBC variables in relation

[13] The indirect only mediation corresponds to Baron and Kenny, "The Moderator–mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations."'s "full mediation".

to viewing nature as benign (the individualist) and mitigation intention. The competitive mediation[14] presents the significance of indirect (positive) and direct (negative) effects with the opposite sign. This association suggested that the relationship between respondents adhering to the nature-benign view and mitigation intention was mediated with by attitude and PBC. However, the likelihood of an omitted mediator would positively affect the relationship indirectly. Taken as a whole, these mediation results indicated that attitudes and PBC are, in part, shaped by views of nature. Specifically, the respondents subscribing to the nature-perverse philosophy will have a positive attitude and PBC toward mitigation behaviors if others do not intend to reduce the risk of wildfires. In contrast, respondents adhering to the nature-benign perspective will have the opposite attitude.

Additionally, there was no evidence of mediating effects of attitudes and PBC on mitigation intentions for respondents adhering to ephemeral or capricious views of nature. However, the zero-order effect of the capricious view and mitigation intention was statistically negatively significant (β = -.148; p = .05). This result indicates the existence of direct effect path c as well as the insignificance of the indirect effect path ab known as the direct-only non-mediation (Zhao, Lynch, and Chen 2010). This pattern indicates that mediators are likely to exist, but they were not included in the model. In other words, to affect the mitigation intention, the other cognitive variable (i.e., norm in the sense of the TPB) may have a strong influence on the linkage for those who subscribe to the nature as capricious view.

[14] The suppression effect

Discussion

The purpose of our study was to examine the role of four alternative perceptions of nature on residents' intention to mitigate wildfire hazards in three WUI communities. We examined attitudes, subjective norms, perceived behavioral control, intention, and behaviors. Three important points can be made about the present research. First, since the subjective norm did not show sufficient internal consistency, it was removed from the measurement model. We also found that the opinions of neighbors were a relatively less important motivator than significant others and experts (i.e., family and local fire agency, forest service) in all communities. The subjective norm was found to be the least important predictor of the three TPB constructs of intention related to safety behaviors (Armitage and Conner 1999). In previous wildfire studies, the subjective norm plays a relatively small part in explaining the variations in behavioral intention involved with clearing activities around properties (Bright and Burtz 2006) and the intention to protect the environment against wildfires (Bates, Quick, and Kloss 2009). Some studies have excluded this element from the TPB model (Hall and Slothower 2009). Our study found that the motivation and desire to clear property among WUI residents was inconsistent and depended partly on peer pressure (McCaffrey et al. 2011). Thus, we believe that the absence of the subjective norm construct did not affect the predictability of the other two TPB constructs with regard to intention and behavior.

Second, we found that self-reported behaviors related to wildfire mitigation required more accurate measurements, which can be considered as a limitation of this study. In the TPB study, behavioral intention was hypothesized as the precursor of actual behavior Ajzen (2002) recommends conducting a follow-up survey in three month after the first questionnaire has been returned, then calculating the actual behavioral measurement from those responses. In this study we were unable to conduct a follow-up survey due to time and budget limitations. Participants should be also asked to report whether they consistently performed the behavior for three months. If information about the actual behavior is not available, the self-reported behavior can be used as a substitution (Ajzen and Fishbein 2004). For future research, a visual survey of each property in the field could help to provide information about the actual behavior. Since our responses were self-reported behavior, the bias associated with the reported responses could be concluded from the following evidence. We found no connection between intention and self-reported mitigation behavior in the baseline model. The bias was possibly caused by other unexplained factor included in the model. This bias may include the possibility that people respond to the survey in a way they think the researcher prefers, known as social desirability bias (i.e., performing any mitigation for being good in responsible for wildfire mitigation). To detect this bias, the test of unmeasured latent factors during the confirmation factor procedure was performed by adding the common latent factor (Podsakoff et al. 2003). As a result, the behavior construct was excluded from the model even when a positive intention and behavior was found.

Lastly, our findings were based on a quantitative approach and used a survey-based test of individual's perceptions of nature, which can be seen as a possible limitation in this study. Some scholars in CT research argue that because the CT includes a large number of features, it is more difficult to fairly test though surveys (Rayner 1992). However, a combination of survey and case study research can account for the specific characteristics of lifestyles, in particular social setting (Verweij, Luan, and Nowacki

2011). The authors posit that the CT stands on as a good theory as it raises new questions, presuming those are solvable, even though it is more challenging toward quantitative analysis. Future research should consider incorporating qualitative field research as a means of better understanding the connection between the nature perceptions of WUI residents and their preferred methods of wildfire risk management.

Conclusion

Our study found that mitigation intentions regarding the risk of wildfire can be predicted by the TPB model. A positive correlation between self-reported mitigation behavior and intention was found, even though, the self-reported behavior was insufficient to determine intention. Our findings suggest that a stronger positive attitude toward wildfire mitigation and a stronger PBC increases the respondents' intention to engage in risk reduction behaviors. This result is in line with other wildfire studies that made use of the TPB model (Vogt, Winter, and Fried 2005; Bright and Burtz 2006; Bates, Quick, and Kloss 2009; Hall and Slothower 2009).

Regarding the role of CT, our results indicate that the preeminent value of perceptions of nature influenced how mitigation behavior is perceived through attitude and PBC. For instance, if one has a tendency to perceive nature as perverse/tolerant, wildfire mitigation is perceived more positively. Information about risk-reduction on wildfires will be processed in positive way via attitude and perceived behavioral control. In addition, the perception of experts and local fire agencies as trustworthy and the perceived fairness of regulations are important factors for residents to be willing to comply with the risk-reduction rules (Vogt, Winter, and Fried 2005). In contrast, the respondents adhering to the nature-benign philosophy believe in the power of nature to re-balance itself and technological solutions. Therefore, they believe that performing mitigation is unnecessary. From a theoretical perspective on mediation, the competitive mediation effect suggests that the increased positive indirect effect from attitude and PBC could possibly strengthen the relationship to wildfire mitigation. Fire managers could improve this connection by increasing the positive attitude and self-efficacy such that the benefits of reducing wildfire risk are valuable to the residents. In addition, the direct only effect suggested that other mediators besides attitude and PBC could intensify the relationship to mitigation intention for residents subscribing to the nature capricious perspective. The nature-capricious perspective is inconsistent with other cultural type' decisions and actions, but they comply with rules established by the institutional system to a certain extent. Hence, increasing peer pressure and incentivizing regulations could influence people to engage more actively in mitigating wildfire risk.

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CHAPTER 3

LOCALIZED RISK PERCEPTION OF WILDFIRE HAZARD

Abstract

Individual perceptions of wildfire can be substantially distinct from one person to another and/or from reality of wildfire risk. This distinction of wildfire risk perception can result in inconsistent responses to wildfire mitigation at the individual and community level. Although several studies in wildfire risk perception have found that subjective risk is shaped by both personal and social considerations, exploring various undiscovered key factors is necessary for identifying a reliable formation of risk perception in a multistage process. In this study, I examined the interconnection between individual and social-contextual characteristics related to wildfire risk, such as views of nature, place-based influence, and vulnerability. Using a mail survey, the findings show that the risk perception of wildfire is formed at the individual level as guided by psychological factors. In addition, it is substantially influenced by social context. With a better understanding of those influences, the communication efforts to promote wildfire protection can significantly strengthen community engagement in wildfire management.

Keywords: vulnerability, place-based influence, cultural theory, multilevel analysis, survey study

Introduction

The need to protect lives and property in the expanding wildland-urban interface (WUI) across the American West increases the pressure to reduce risks of wildfires. As the threat of wildfires continues to rise, state and federal agencies and local fire departments are challenged to establish a risk reduction program for local areas, either through individual landowner decisions or collective action within the community. A community's perception of exposure to wildfire risk plays an important role in a landowner's decisions to protect private property. However, in order for community members to be mobilized against wildfire hazards they must first acknowledge that a risk exists. In this chapter, I explore the link between landowners' perception of risk and scientifically quantified wildfire risks that vary across hazard zones in three states (Arizona, California, and New Mexico). I employed a spatial stratified random sampling based on respondents' hazard zone and proximity to the WUI to ensure a consistently representative sample of perceived risk relative to objective risk over the study area. By utilizing a multilevel response model from community public opinion surveys combined with a map indicating areas of potential wildfire risk, I investigated the relationship between the patterns of risk perception and individually perceived wildfire risks at multiple scales. Results suggest that perceptions of the residents in wildfire zones were aligned with the actual fire danger. The respondents in at-risk areas tend to be more optimistic about their situation when compared to the general population. Not surprisingly, the more conscientious respondents are about protecting their properties; the more likely they are to perceive a higher level of risk.

Model Specification

<u>Wildfire Risk Perceptions</u>

"By reflecting the spatial dynamic of risk perception, research has shown that homeowners tend to assess the risk of wildfire for the general area as higher than that for their individual homes."(McCaffrey 2008) The study of wildfire risk perception is not new; however, its complication and its link to homeowners' decisions to attempt to mitigate risks is a relatively recent and critical aspect of this field. Objective risk of a potential disaster is calculated as a function of probability and magnitude of loss from a disaster, whereas individual perception of risk, known as subjective risk, focuses on understanding and direct experience on an individual level. Social-psychological variables such as personal values, spiritual beliefs, and worldviews influence individuals' risk perception from natural disasters (Slimak and Dietz 2006). The assessment of individual perceived risk also accounts for attitude, sensitivity to risk (Sjöberg 2000), and a feeling of control over the situation (Rachman 1990). In addition, when disastrous events occur frequently, individuals are more likely to underestimate the associated risks, while the dramatic character of striking and rare events tends to cause an opposite response (Lichtenstein et al. 1978). It is the role of experts to understand and cope with the objective risks while the public interprets the situation by personalizing the objective risk and other factors. The various individual assessments and responses to these risks could become a challenge to local fire authorities to communicate risk.

In this chapter, I study the relationship between the perceived and scientific measurement (e.g., fire occurrence, severity) of wildfire risk. This insight is essential as wildfires have become more frequent and devastating with the expansion of the interface between urban and wildland (WUI) areas. However, people living in the WUI do not always respond to an increase in public awareness and response to wildfire safety. Every fire season, federal agencies are confronted with protecting the million acres of public lands from wildfires. Public land managers are well aware of the dangers and have strongly encouraged methods of mitigating the damage. On the contrary, some residents of WUI areas refuse to believe that the wildfires could actually cause damage to their properties (Steelman 2008). Risk tolerance, or the trade-off between facing risk from wildfire and benefit of living in the forest, is taken into personal considerations in responding to wildfire (Daniel, Carroll, and Moseley 2007). The research founds that the perceived risk was decreased after recent fires had consumed vegetation fuels in the wilderness.

For this reason, they believed that another fire in the near future would be less likely to occur (Cohn, Williams, and Carroll 2008).

This disconnection between perceptions and degree of exposure to wildfire has increased the need for more extensive wildfire research and its relationship to psychological factors. This psychological phenomenon is often referred to as unrealistic optimism (Sjöberg, 2000). Therefore, unduly optimistic risk judgments for residents in wildfire zones are to be expected (Kumagai, Carroll, and Cohn 2004). Researchers have discovered inconsistent positive relationships between risk perceptions and exposure to wildfire risk (McCaffrey 2004; Arvai et al. 2006; Martin, Martin, and Kent 2009; McGee, McFarlane, and Varghese 2009). Recent research has found that community involvement is related to perceived risk and consequences of a past wildfire (Brenkert-Smith et al. 2013). For example, homeowners perceive the danger from fires as higher when they believe their neighbor's properties to be overrun with dense vegetation. Thus, the psychological variables related to wildfire are important to address in order to determine how individuals perceive risk from wildfires.

Social-Cultural Constructions of Risk Perceptions

Extensive research on risk perception has found that responses to fire threat are shaped by a number of social and cultural processes. Cultural Theory (CT) explores the sociological aspects of risk. Individuals' risk perception is said to be rooted in their interpersonal relationships and "ways of life" – their values, beliefs, and preferences (Sjöberg 2000). For example, one's perception of wildfire risk is associated with whether one believes nature to be benign or capricious. Four categories of risk perception have been identified through Cultural Theory: *nature capricious* (fatalist), *nature perverse/tolerant* (hierarchist), *nature ephemeral* (egalitarian), and *nature benign* (individualist) (Schwarz and Thompson 1990). Although the use of CT in the wildfire context is limited, research concerning environmental risk perception has shown important concepts that are similar to basic tenants of this theory (Steg and Sievers 2000; Lima and Castro 2005; Tikir and Lehmann 2011). The CT states that individuals adhering to the nature ephemeral (egalitarian) view have the highest tendency to attempt to preserve the environment. Those who hold the nature benign (individualists) view believe that nature is always in balance, and technology is the only solution for environmental problems. However, individuals who hold the capricious (fatalist) view believe that risk is unpredictable, as is nature, and the quantity of resources is limited. On the other hand, the nature perverse/tolerant (hierarchist) group will rely on experts' opinions about hazards of nature. Thus, understanding aspects of the CT, such as individuals' primary values as they relate to perceptions of nature could yield a deeper understanding of perceptions of wildfire risk. Note that the term "views of nature" will be used through the rest of this study referring to this perception.

The role of place-based influence is beyond a simple setting of human environment; rather it has a social meaning for risk perception. Brenkert-Smith, Champ, and Flores (2006) found that attachment to place (or place-based influence) shapes the decision-making process when individuals choose whether to participate in a wildfire risk reduction plan. The emotional attachments and environmental conditions related to place may influence perceptions of how much would be lost in the event of wildfire, but may also increase reluctance to change environmental conditions associated with sense of place. Residents with strong feelings of attachment to their place tend to be the most inclined to engage in mitigating wildfire to protect their properties (Kyle et al. 2010). Gordon et al. (2013) showed that risk perception is influenced by the disruption of a shared place-based influence in which the changing social and environmental conditions affects residents' attitudes about potential disasters and subsequent mitigation behaviors. However, the reality of hazard exposure could be biased by knowledge and memory about places. For example, in Australia, one's memory of one's place appears to play an important part in one's tendency to underestimate the risks and ignore fire safety measures (Reid and Beilin 2014).

Another aspect discussed in the literature is that social and geographical vulnerability affect local residents' perception about the risks of facing wildfires. Wisner et al. (2004) defines social vulnerability and biophysical hazards as key components that indicate a risk of impending environmental disaster. Social vulnerability is an understanding as being:

"…essentially about the human ecology of endangerment…and is embedded in the social geography of settlements and lands uses, and the space of distribution of influence in communities and political organization" (Hewitt 2014).

In general, social vulnerability has placed attention on the role of socioeconomic status, such as income and poverty levels, in the capability to recover and in the ability to access resources for mitigating hazards. Low-income and part-time residents are among the most vulnerable groups to wildfire exposure as the high implementation costs and marginal income critically limit their capabilities to protect themselves from hazards (Collins and Bolin 2009). From a geographical perspective, hazard vulnerability rests on the human-biophysical relationships in which people's susceptibility to harm and loss influences their capacity to prepare for, respond to, and recover from hazard events (Wisner et al. 2004). As such, in local areas with rapidly changing socio-demographic characteristics, residents tend to have conflicts with believing in the threat of hazards and the pleas of fire managers (Gordon et al. 2010). In this study, I explore how the predictability of factors indicating hazard vulnerability from wildfire would influence individual's perception of wildfire.

Multi-Level Modeling to Measure Wildfire Risk Perception

This research is an examination of risk perception related to wildfires within complex social and environmental contexts (Figure 3.1). The purpose of multilevel modeling (MLM) in the field of risk research is to integrate single and aggregate samples of risk perception for analysis. Because the connection is indeed inherently hierarchical, in theory, incorporating multiple levels of influential components into the study will improve the explanation of both individual mitigation behaviors and the societal-environmental reaction to them. As such, individual attitudes, perceptions and behaviors could be established within a community. In other

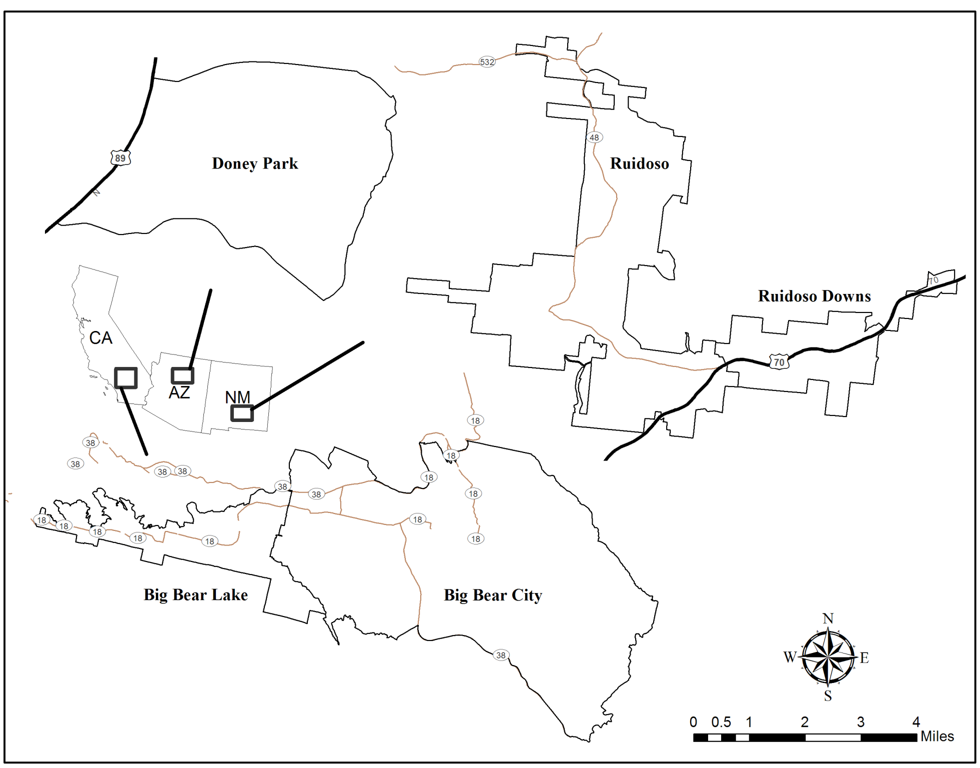

Figure 3.1. A map of the study areas.

words, I assume that although individuals responded to our survey independently, each one shares similar common social and environmental settings, which result in somewhat similar perceptions. In order for community members to mobilize against wildfire hazards, they must acknowledge that this risk exists. My research focused on identifying both individual characteristics and contextual factors that help to explain variations in perceptions formation about wildfires in various spatial domains. More specifically, I investigated whether an interface resident's likelihood of acknowledging the existence of wildfire risk varied across communities. Then, I further investigated how community-level factors help explain variability in forming an individual-level perception. Thus, MLM allows us to consider higher (community-level) factors to explain lower (individual-level) proposition without committing ecological errors about data structure (Snijders and Bosker 1999). This study employed a two-level model: individual-level and community-level (in three different states).

Hypotheses

This study tested the following four hypotheses:

H1: Individuals perceive their homes or neighborhoods to be at a lower risk than those in broader areas, such as the county, region, or state.

H2: There are two aspects to the variations of wildfire risk perception: the variation among individuals and that among communities. People who live in the same community tend to have similar perceptions about wildfire hazards and are more homogenous in terms of perception. Therefore, people living in different communities are likely to have more heterogeneous perceptions about wildfire risk to their communities.

H3: Individuals' perception of the threat of wildfires is influenced by their worldview and level of preparedness to protect their properties. After controlling for socio-demographic characteristics (e.g., age, income, education, length of residence), the greater a person will be averse to risk (i.e., having an ephemeral worldview), and the higher the likelihood he or she will perceive wildfire as a risk. The degree of preparedness for protecting properties is positively related to risk perceptions. Similarly, the perceiving risk factors for wildfires caused by human activities is positive to risk perception.

H4: Community wildfire risk perceptions on average are influenced by the community's general geographic characteristics and social vulnerability such as housing density in the WUI, scientific measurements of wildfires, and poverty level. Wide spacing of houses in the community leads to a lower perceived risk from wildfires. The negative relationship between perception and scientific measurement is expected, whereas the greater the exposure to wildfires (indicated by poverty level), the more negative the perception will be.

Methods

Measurement

The dependent variable for this study was the degree to which respondents believe wildfires in their local area are a serious problem. Respondents were asked to rate such questions as, "Within the next 10 years, what is the probability that a wildfire will damage your home?" on a scale from 1% - exceptionally unlikely, to 99% - virtually certain. The independent variables are based on the relevant factors of local risk in multiple-scale data. The individual level (level-1) included each respondent's demographic information and length of residency. I applied Cultural Theory's perception of the environment typology as it relates to wildfire management. Respondents were asked to rate the importance of possible causes of wildfires in their community, such as discarding cigarettes, burning debris, and arson. The mean score of these ratings was used to determine the residents' opinions on the level of human responsibility for causing wildfires (human risk factor). The degree of home protection from wildfire hazards was measured using a preparedness index, determined by responses to a series of items asking if respondents were undertaking certain landscaping activities. The place-based influence associated with a perception of wildfire risk was measured at different spatial scales, such as the community and state. The community-level variables included the scientific measurement of risk (i.e., wildfire hazard zone), socioeconomic characteristics related to physical characteristics (i.e., housing density), and social vulnerability to wildfire (e.g., poverty rate). These variables and descriptions are illustrated in Table 3.1.

View of Nature Cluster Analysis: The Cultural Theory

According to Douglas and Wildavsky (1983), individuals are not necessary adhere into one cultural type. The relations of social structure described by CT have shared some similarity and dissimilarity of four types. It is possible that people adhere to more than one cultural type. Thus, to reflect this idea, a cluster analysis was used to group respondents with similar responses on cultural adherence (Oltedal and Rundmo 2007). A *K*-means cluster analysis was conducted to classify respondents' view on nature. The results found a heterogeneous distribution of values which are not indicative of any particular cultural type. Factor scores of items measured to determine the view of nature were used in the analysis to minimize computational complexity and achieve the iteration convergence. Although differences between the distribution of indicators can be found, the pattern of distribution can be distinguished by the levels of

Table 3.1. Description of variables in the multilevel statistical model

Variables	Descriptions	Mean	S.D.
Dependent variable			
Risk perception	Self-reported risk perception rating from 1 to 7, ranging from very unlikely (=1) to very likely (= 7).	0.93	0.68
Independent variables			
Level-1: individual level			
View of Nature	Indication of the role of environmental worldviews using 16 items related to the Cultural Theory	1.60[a]	0.63[b]
Preparedness	Likelihood of undertaking Firewise-suggested landscaping activities (alpha=0.69)	0.44	0.25
Human risk factor	The importance of human related factors in creating a wildfire hazard (alpha = 0.67)	3.3	0.55
Place-based influence on wildfire risk			
Probability of a home burning in the community	Self-reported risk perception rating from 1 to 7, ranging from very unlikely (=1) to very likely (= 7).	1.19	0.67
Probability of a home burning in the state	Self-reported risk perception rating from 1 to 7, ranging from very unlikely (=1) to very likely (= 7).	1.36	0.82
Independent variables			
Level-2: community level			
Scientific measure *of physical vulnerability variables*	Wildfire risk potential zones, low (=0), moderate, and high(=1)	1.22	1.03
Housing density	WUI housing density units per square km. in terms of a log transformation	2.38	0.61
Socioeconomic vulnerability variables Poverty level	Percent of total people below the poverty level in 2012	17.17	4.04

Note that all variables are grand-mean centered; [a] and [b] are calculated from the distance of each response from its classification cluster center.

homogeneity, accumulation, and concentration. The determination criteria of the number of clusters were based on the significant *F*-value of the cluster, minimum cluster size, and the unique characteristics with distinctive variables.

As Figure 3.2 shows, the mean of each indicator within the final cluster, plays an important role within the different combinations of the other three worldviews. The clusters of the four views of nature are labeled based on the dominant indicators.

For a simpler overview of the nature value groups, we can distinguish the dominant characteristics from preferred management style into three general degrees of risk: risk averse, risk taking/or tolerant, and risk neutral. The ephemeral view of nature is associated with risk aversion in the sense that adherents are concerned with the depletion of environmental and natural resources. The greater the loading on this view, the stronger aversion to risk will be. Clusters 1 and 2 have greater risk aversion than the other two groups, while cluster 1 is more risk averse than cluster 2. Those who hold to the benign view of nature are likely to be closely associated with risk-taking due to a belief in a resilient ecosystem. Those of the perverse view also share similar beliefs, but they perceive that resilience has limits. Cluster 3 represents a group of respondents who are more prone to risk taking than other worldview groups. Cluster 2 and 3 share a similar cluster which present a risk-taking view. Lastly, the capricious viewpoint is the most prominent in cluster 4. Persons holding this viewpoint are not very concerned about erratic events because they believe that you cannot be concerned about what you do not know is coming; therefore, as Figure 3.2 illustrates, cluster 4 is closely related to the risk neutral group. Clusters 1-4 represent the following: risk aversion, risk taking, and risk neutral.

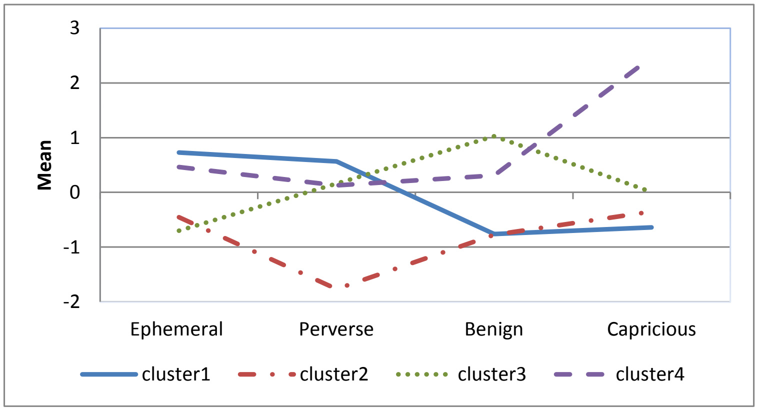

Figure 3.2. A cluster of the views of nature.

Wildfire Hazard Zones

To scientifically measure the wildfire risk, I applied a single standard measurement acquired from the Wildland Fire Potential map[15]. The WFP is a raster geospatial map that estimates burn probability and fire intensity levels for areas throughout the United States. The map represents the relative probability of five levels, very low, low, moderate, high, and very high, of experiencing an intense fire that may include torching, crowning and other forms of extreme fire behavior. I applied the majority filter and focal analysis[16] via ArcGIS 10.1 to obtain more specific raster which would only include larger and more generalized areas. Specifically, three wildfire zones, (1 = low, 2 = moderate, and 3 = high), were created.

[15] The WFP map is produced by the USDA Forest Service, Fire Modeling Institute (2012), Online links: http://www.firelab.org/fmi/data-products/229-wildland-firepotential-wfp

[16] The majority filter operates five successive times with HALF replacement threshold and the Median statistics is used for generalized data in Focal Analysis.

Multilevel Statistical Analysis Procedure

Multilevel statistical modeling is designed to handle hierarchically structured data. Variability at individual levels (lower level) can be partially explained by variation at the group level (higher level). Individuals in the WUI are members of their communities; therefore, I analyzed the risk perception of individuals by simultaneously considering variation within and between communities. Since I used the categorical responses of wildfire risk perceptions from low, moderate, and high risk, ordinal regression models were ideal for minimizing underestimation and standard error bias within the parameters (Muthén and Kaplan 1985). In addition, the ordered categorical variables represent the difference in quantity for measuring variation from nominal outcomes (Azen and Walker 2011).

The functional form of this multilevel model was adapted from (Hedeker and Mermelstein 2011). If Y denotes the individual wildfire risk perception response with a probability of $\pi_{ijc} = P(Y_{ij} \leq c)$ for individual *i* within each community-level *j*, we have the ratio of the probability of risk perception being at or below the c^{th} category where $c = 1, 2, \ldots, C$. I applied cumulative probabilities to the applied complementary log-log link function to estimate the ordinal model.

$$\eta_c = \log[-\log(1-\pi_{ijc})] = \gamma_c - X'\beta_c \qquad \text{Equation 1)}$$

where c represents the c categories of risk perception outcomes from 1,2,…, c-1

X denotes the vector of explanatory variables, including the intercepts

γ_c refers to threshold which reflects cumulative odds when $X = 0$.

The complementary log-log transformation is recommended for the ordinal model when categories are not equally distributed (Heck, Thomas, and Tabata 2013) yielding a very small or large probability (i.e., most individual responses fit into specific categories). The odds ratio is simply the exponent of the estimate's coefficient.

The sequential modeling process begins with the unconditional model (no independent variables), which assumes that each community has a random average that may reflect the respondent's perception of wildfire risk. If a significant amount of variance of random intercept occurs, this suggests a total variance in risk perceptions as a result of the differences in community means, the second level. Next, the independent variables, including the individual level (level-1), are introduced in the second model where the community intercepts are allowed to vary from each other, and the community-level variables (level-2) are introduced into the model. The sequential procedure was based on (Hox 1995), which consists of five progressive specifications:

(1) Begin with an unconditional model, including only the intercepts and threshold coefficients
(2) Add level-1 fixed individual explanatory variables
(3) Add level-2 random community-level explanatory variables
(4) Add cross-level interaction explanatory variable.

The intraclass correlation coefficient (ICC) is used to estimate the proportion of variance among group (higher) levels, ranging from 0 to 1. The ICC was calculated from a community-level variance ($\sigma^2_{between}$) relative to a total variance ($\sigma^2_{between} + \sigma^2_{within}$). The variance of a complementary log-log link function, σ^2_{within}, is equal to $\frac{\pi^2}{6}$, or approximately 1.645[17]. All the analyses were performed using the IBM SPSS statistical package. The receiver operating characteristics

[17] http://data.princeton.edu/wws509/notes/c3s7.html#f:links.

(ROC)[18] analysis was used to determine a goodness-of-fit of the subsequent models in this study. The ROC value, which varies between 0.5 and 1, is close to 1, indicating a model with an ability to discriminate between categorical cases of the outcomes, whereas the value close to 0.5 indicates that the group is classified randomly.

Results

Effects of Multilevel Driving Factors on Wildfire Risk Perception

All models measure two levels of risk perception: random effects and fixed effects for fire prone communities (Table 3.2). Model 1 is the unconditional (intercept only) constraint for examining the variations in subjective risk of wildfire, assuming that each community has a random community average that could reflect residents' perceptions about this risk. The variance of the random intercept was 1.01 (z-test = 4.912, $p < .001$), which suggests statistical significance across communities. The total variance in wildfire risk perception is calculated by determining the differences in community means. Thus, this evidence confirms that the multilevel approach can explain the multilevel association of subjective risk and the location of the community where the respondents reside. The intraclass correlation coefficient (ICC) of model 2, the individual level variables, shows that 42% of the total variance can be attributed to the community level (level-2), indicating higher clustering of risk factors associated with the threat of wildfire at the community level (Table 3.2). Controlling for the ICC, higher levels of

[18] ROC is originally applied partly in the signal detection analyses to decide whether a blip on radar screen is a signal or a noise. The ROC is a common approach to evaluate the Generalized Linear Model for categorical outcomes Smithson and Merkle, *Generalized Linear Models for Categorical and Continuous Limited Dependent Variables*..

Table 3.2. Multilevel statistical models for wildfire risk perception

	Model 1 Null model	**Model 2** Fixed Level-1 variables added	**Model 3** Random slope added	**Model 4** Cross-level interaction
Fixed effects				
Threshold 0: Pr(< 10%)	0.44***	0.36**	3.71***	3.64***
Threshold 1: Pr(~33-50%)[a]	-1.81**	2.34**	6.74***	6.70***
Level 1				
cluster 1- risk averse		-0.02	0.07	0.12*
cluster 2- risk taking		-0.08	-0.27**	-0.24**
cluster 3- risk-taking[b]		-	-	-
Residents over age 65		0.50**	0.57**	0.54**
Length of residency		-0.03***	-0.03**	-0.03**
Human risk factors index		0.73***	0.67***	0.68**
Preparedness		-0.20*	-	-
Place-based influence vs. wildfire risk				
Community				
High probability of home burning > 60%		1.14***	2. 81***	2.74***
Moderate [c] ~33-50%		-0.13	1.16**	1.07**
State level				
High probability of home burning > 60%		-1.16***	-0.15	-0.13
Moderate[d] ~33-50%		-0.97**	-0.04	-0.06
Level 2				
Wildfire risk zones				
High exposure			0.88**	0.83**
Moderate exposure[e]			0.15	0.08
Density of housing[f]			0.67**	0.67**
Poverty level			0.07**	0.09***
Interaction				
Poverty × cluster1 – risk aversion				-0.05*
Poverty × cluster2 – risk taking				-0.07*
Variance Component/ Random Effect				
Intercept variance	1.01***	1.92***	1. 07***	1.09***
ICC	0.38	0.54	0.39	0.40
AIC	8,034.05	26,777.95	10,305.96	10,271.68
BIC	8,039.12	26782.98	10,310.98	10,276.70
ROC	.739	.770	.887	.890

Note that all continuous variables are grand-mean centered.
*** $p < 0.001$; ** $p < 0.05$; * $p < 0.10$;
[a-e] other = 0 responses used as reference including pr(burning > 60%), age < 65, pr(burning <10%), and low exposure; [f] the housing density is logarithm transformed.
Also note that due to the inverse relationship between the ordered outcome categories and the direction of the predictors, the software (IBM SPSS) restores the direction of the regression coefficients such that the positive coefficients increase the likelihood of being in the highest category and vice versa (Hox 2010).

risk perception in model 2 are significantly associated with most individual-level variables except for views of nature. In addition, preparedness and cluster 1 of nature views did not have independent effects on risk perception. The model was rerun without these two variables to yield model 3 and the subsequent analyses. The ICC of model 3 dropped from 54% to 39% at the community level, and it only was very slightly altered after the cross-level interaction between the cluster 2 view of nature and poverty level was introduced, which resulted in model 4. The ROC analysis indicated that the multinomial complementary log-log models are a very good fit.

Variables such as percentage of respondents over 65 years of age, the degree to which wildfire could be caused by human factors, risk perception at the community level, and risk perception of wildfire were found to be positively related by Model 2. Conversely in the same model, the length of residency, degree of preparedness, and risk perception at the state level were found to be negatively related. Specifically, when all other variables are constant, the predicted odds of perception wildfire risk versus perceived moderate or low probability of home burning were decreased with greater length of residency. The degree of preparedness for wildfire protection decreased with respondents' perception of moderate or low wildfire risk. This implies that the respondents who are long term residents and are less prepared for a wildfire also have a low perceived probability of a wildfire occurring in their local areas.

In addition, perceived risk at the state level affects perceived probability of wildfire risk at the local level. For a subjective risk at the state level, respondents perceived a chance of their homes being damaged from wildfire at the local in the opposite direction to perceiving their home damaging from wildfire at state level. The negative relationship of perceived probability of wildfire at state level supported the hypothesis that people are more optimistic about wildfire in their neighborhoods than broader areas. These effects (moderate and high chance of home burning) were reduced by a factor of exponent (-1.16 and 0.97), when other factors are constant. However, view of nature did not significantly explain the factor of risk judgments in the context of wildfire threats in model 2.

All three community-level variables in Model 3 were found to have a significant correspondence to the differences in community-level means. The estimated slopes associated with all variables were significantly positive, which implies a significant association between the average community perception of wildfire risk and housing density, poverty level, and the exposure proximity of wildfire hazard. This association confirmed that as housing density and poverty levels in the community increase, the perceived risk of wildfire also increases. Similarly, the residents' perceived risk was consistent with their proximity to hazard zones.

Moreover, the incorporation of complex structures and the cross-level interaction between both levels are presented in the model 4. It explores the combined effects of poverty level and low risk-taking perception (cluster2) on the general perception of risk. Note that the risk-aversion group (cluster1) that was statistically insignificant became significant only when cross-level variables were examined in the more complex model. The results of cross-level effects indicate that the interaction of respondents adhering risk aversion and risk taking is statistical significant. This interaction is also known as a moderating effect (Azen and Walker 2011) where the strength of a relationship between two variables is affected by a third variable. In this case, these interactive effects are associated with poverty level. It should also be noted that the average effects of views of nature upon perceiving a risk aversion (B= -0.05, $p < .10$) or risk taking (B = -0.07, $p < .05$) are significantly negative. In other words, the direction and strength of the relation between perceived wildfire risk at local and views of nature adherents is affected by poverty level. For example, because poor individuals are less likely due to mitigate wildfire risk due to reduced access to resources (financial and time), the effect of their views of nature on perceived risk is dampened when compared to higher-income individuals.

Discussion and Conclusion

The findings confirm a majority of our hypotheses about individuals' perceptions of risk. The first model shows a significant amount of variance (39%) in perception with regard to wildfire risk across the communities. The intercept predicts a positive correlation for all four models, which explains the relationship to the reference groups, when other variables are held constant. In model 2, age, length of residency, attitude about risk factors, and level of preparedness were all found to be significant predictors of risk perception. The positive association hypothesized with regard to attitude about risk factors of wildfire hazards was confirmed. A person who is more concerned about the threat of wildfires is more likely to acknowledge higher risk factors caused by human activity. In contrast, length of residency and preparedness were found to have unexpected associations with risk perception on the level of the individual home. This could possibly be explained by the significant role of place attachment variables. Our findings extend the knowledge found by (Brenkert-Smith 2006) in the sense that the feeling of place attachment decreases the perceived risk from wildfires. Wildfire risk perception is relatively higher at broader scales - community and state level than the perceived risk closer to home. Specifically, respondents typically perceive probability of fire damage in the community similarly to how they perceive it at the home level, whereas the opposite result was found about perceptions at the state level. In other words, the relatively higher risk perception is reserved for wildfire damage on a broader scale (state-level) compared to the more local scale of (home and community). This discrepancy could be due to what risk researchers call optimistic bias (Weinstein 1989), or it may simply reflect the higher probability that a wildfire will occur somewhere in each state during any given year.

As the intra-community difference shows various levels of significance, all three community-level variables show the expected positive associations with perceived fire risk at the home level. Respondents' perception of risk was consistent with their level of hazard exposure. As the higher house density and poverty level increase, the higher risk was perceived. The same relationship was found with the poverty level. The view of nature becomes a significant predictor; however, it was not found to be significant at the fixed effect level (model 2). A risk aversion and risk taking have negative associations with perceiving risk of fire damaging their home. Another important finding appeared in Model 5, examining evidence of cross-level interaction between the individual and community levels. It confirms that random-slope variations can be accounted for by community-level effects. In this case, the poverty level as an indicator of social vulnerability at the community level is significantly related to individuals' perception of wildfire damaging their homes.

In conclusion, this study illustrates that a WUI homeowner's worldview with respect to nature, length of residency, place-based influence, and attitudes about risk factors are significant predictors for how residents of fire-prone areas perceive their risks. The variance in social and physical vulnerability associated with wildfire can explain, to a certain extent, the variation in individual perceptions of wildfire risk. The perception of risk is consistent with the level of exposure to fire hazards. These findings have useful implications in many aspects for public policy and improvement of hazard communication and education. For instance, given the significant associations indicated between attitude toward hazard mitigation and risk, environmental views and individual characteristics, a "one-size-fits-all" policy is likely to be less efficient to communicate the complexities of risk than a strategy of policy making and planning aimed at certain groups or residents. Additionally, acknowledgement of the differences in wildfire risk perception in term of individual and community level will help fire-prone communities or adjacent states become motivated to play a part in implementing wildfire risk reduction strategies. Although the adjacent landscape shares geographic similarities, the same rules may not apply to each local social dynamic. The study of wildfire risk perceptions should inspire fire managers or community leaders to identify gaps between biophysical conditions and social values and awareness about wildfire risks in their areas.

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CHAPTER 4

SOCIAL-ECOLOGICAL LINKAGES TO WILDFIRE MITIGATING BEHAVIORS ON PRIVATE LANDS

Abstract

Private property owners in wildland-urban interfaces areas face risks from wildfire every year. The decision to undertake mitigation takes into account the condition of neighboring properties. The influence of neighbors' behaviors in mitigating wildfire is an important connection to determine the behaviors of private property owners. Social and biophysical variables of each property are included in the models to investigate the influence of reducing risk behaviors. Findings from spatial analysis suggest that mitigating behaviors in all communities indicate a spatial clustering pattern. Survey results demonstrate that property owners' value of nature and property characteristics have an impact on wildfire mitigating behaviors. Results show that the likelihood of mitigating behaviors and a person's worldview (i.e., perceiving risk in a certain limit and protecting nature) were found to be negatively correlated. The mail survey respondents are unlikely to mitigate for wildfire around their houses. Biophysical characteristics of property have an influence on mitigating behaviors and their effects are statistically significant difference depending on community.

Keywords*:* wildfire, risk perception, spatial analysis, mitigation, wildland-urban interface

Introduction

This study was built on the information discussed in the previous chapter. Its purpose is to estimate the spatial interaction of a neighbor's mitigation activities on a property owner's decision to decrease wildfire hazards. By incorporating biophysical variables, I investigated the spatial interdependency of neighboring property and social factors such as motivation to participate in mitigation. Concerns about mitigating actions on adjacent properties strongly affect individuals' decisions to undertake wildfire mitigation. The mitigating behavior, such as creating defensible space, often falls short of adoption by landowners. Defensible space has a relatively low value when the neighboring properties are untreated (Brenkert-Smith 2011).

Data from mail surveys in three wildland-urban interface communities were examined to determine the effects of neighboring land characteristics. I investigated mitigation behaviors of private owners to find whether neighbors' mitigating behavior is a necessary condition for owners to increase action. The effects of property traits and risk perception indicated by worldview are examined for their influence on mitigating behaviors. Spatial analysis was conducted to examine the role of neighbors' property mitigation on homeowners' risk-reduction activities. This study posits that a landowner's willingness to mitigate wildfire risk will be influenced by mitigation behavior of neighbors and their preferred risk-reduction activities.

Empirical Model

Spatial Processes in Wildfire Mitigation

The decision to mitigate wildfire risk is complex, involving multiple elements to demonstrate how property owners commit to the behavior. The linkage between mitigating behaviors and individual perceptions of risk can be described by a process of spatial connection through a neighboring property. Mitigating behaviors on neighboring property place great concern on private owners' decisions to mitigate wildfire. According to the wildfire literature, because risk is seen as shared among members in a community, responsibility in mitigating wildfire is recognized beyond the ownership borderline (Paveglio et al. 2010). Property owners primarily feel responsible to protect their homes, but they also feel responsible for neighbors' fire safety (McCaffrey et al. 2011). In this study, I investigated whether the neighbors' mitigation has influence on private owners' mitigation. It is possible that some neighbors have perceived risk and nature in similar way, and we do not know whether neighbors' risk perception would influence the effort of private owners to mitigate wildfire.

In contrast to the evidence above, wildfire risk is described in terms of externalities when homeowners have to decide whether creating defensible space to protect their homes is cost effective (Shafran 2008; Taylor, Chrisman, and Rollins 2013). These authors indicate that a decision on defensible space investment depends on whether similar mitigation is undertaken by neighbors. Homeowners perceive more benefit in an investment as their neighbors increase their defensible spaces. Therefore peoples' concern about wildfire safety and decision to engage in an activity may increase when the mitigation is first adopted by their neighbors. In this study, I hypothesized that individuals would be willing to engage in mitigation even if an adjacent neighbor failed to do so, as long as the majority of neighborhood residents engage in mitigating behaviors and the risk of fire spreading is reduced. This model assumes that:

I. If homeowners feel responsible for risk, they will undertake mitigation actions.

II. Property owners' willingness to mitigate wildfire risk will be influenced by perceived mitigation intentions of neighbors and their preferred risk-reduction activities.

III. A term of neighbor is defined by distance-based weights. It is not necessary that an influential neighboring property must always share property boundaries.

IV. Property owners regularly update their information about their neighbor's landscape conditions before making any decisions about whether or not to engage in risk mitigation (This assumption makes it possible to omit a time dimension during the analysis of decision-making that occurs in a dynamic process).

The objectives of the study are to:

1) Estimate the effect of spatial interdependency of property owner's mitigation in the neighborhood.
2) Identify the magnitude and relationship of spatial autoregression on the views of nature.
3) Determine the influence of biophysical characteristics of properties associated with behaviors in reducing risk from wildfire.

Data

Two main sources of data were used to analyze spatial effects in this study. The first was from a mail survey of U.S. wildland-urban interface residents. Survey design and mail distribution followed Dillman's approach (Dillman, Smyth, and Christian 2008). The 7-page survey received a 20.8% response rate after deleting undeliverable mailings (196 completed surveys received from an initial mailing of 1059 deliverable surveys). Respondents were asked to report on what wildfire mitigation actions they undertook in the current and previous year. Potential actions included nine landscaping activities taken from the Firewise program and Adapted Communities program checklist for homeowners. Responses indicating that the activity was not applicable were removed from the dataset. These clearing activities aim to reduce fuel-loading around a house, in which each activity is associated with space adjacency and attachment to the house. The decision to perform wildfire mitigation was defined as a dummy variable and a function of social interaction variables, including the perceived views of nature and attitudes on neighbors' wildfire mitigation. Perceived views of nature were measured using a set of questions based on Cultural Theory adapted from the literature (Marris, Langford, and O'Riordan 1998). Cluster analysis results from Chapter 3 were included to determine the effects of risk perception indicated by value of nature. Attitudes about neighbors' mitigation actions were measured using the average level of agreement in response to a seven-point rating scale. Respondents were asked, for example, the extent to which they agreed with the statement: "Working together with my neighbors has impact on reducing wildfire risk to my property." More information about the mail survey was included in previous chapters.

A GIS database was another important source that provided biophysical characteristics, which vary from one respondent's property to others. It was derived using data from the National Agricultural Imagery Program (NAIP). NAIP[19] imagery constitutes a high-resolution (i.e., 1-meter), multispectral dataset in which 1-meter resolutions are appropriate sources of spatial data for this study (Read et al. 2003). The 4-band raster image provides key elements in analyzing a level of vegetation on each property. The normalized difference vegetation index (NDVI) represents the level of canopy vegetation density on each property. The value of NDVI was adjusted for the bare soil reflectance, especially in communities with relatively low canopy cover. Moreover, the National Elevation dataset from the U.S. Geological Survey was obtained; specifically, topography data from the digital elevation model was used and later extracted for slope and aspect of each property. These determinants indicate a potential of wildfire that each property faces. As such, increased slope is associated with increased fire risk. The aspect of property was measured in degrees, assuming zero for north-facing slopes and values increasing in a clockwise direction. Properties with south-facing slopes tend to receive more sunlight; they are likely to be drier and more prone to ignition. Parcel data in the three study communities (Big Bear Lake, CA; Doney Park, AZ; Ruidoso, NM) were obtained from each community's County Assessor Office. The parcel size and boundary was calculated using parcel tax records. The size of a parcel decreases the likelihood of wildfire burning due to the house-to-house propagation effects. It can also reflect willingness to undertake mitigation in terms of physical power and effort.

[19] Aerial photos were taken on the same day in each community: 12/1/2013 (AZ), 11/2/2014(CA), and 13/1/2014(NM).

The process of extracting information about biophysical determinants was performed in several steps: first, houses of respondents were manually digitized and associated with the address of survey recipients. Second, information about the area surrounding each property was recorded, such as house location and road width. Third, parcel data for each community was overlaid on the raster images to extract data about each property, including parcel size (*Parcel*), distance from the house to the national forest (*Forest*), to the fire station (*Fire*), vegetation cover (*NDVI*), and topography *(Elevation, Slope,* and *Aspect)*. Finally, survey data of the particular community in each house location and empirical data were transformed into a shape file and later joined with parcel data. All analysis on GIS-based data was performed in ArcGIS 10.2. More information on variables and summary statistics are described in Table 4.1.

Statistical Analysis Procedure

The spatial interdependency of undertaking risk-reduction was estimated by a spatial autoregressive probit model (SARP) that captures the spatial effect of neighbor risk mitigation on property owners. According to LeSage and Pace (2009), the SARP can be expressed in the equations below:

$$y = \rho W y + \alpha n + X\beta + \varepsilon \qquad \text{Equation 4.1)}$$
$$\varepsilon \sim N(0_n \times 1, \sigma^2 I_n)$$

In which y represents a binary dependent variable (if $y = 1$, this indicates that the property owner is undertaking mitigation and would be 0 otherwise); X represents explanatory variables; W is the spatial weight matrices with ρ spatial autoregressive

Table 4.1. Summary descriptive statistics and variable definitions

Variable Name	Description	Big Bear Lake		Doney Park		Ruidoso	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Worldview	Value on nature dummy variable = 1, if ephemeral and perverse	0.41	0.50	0.34	0.48	0.32	0.47
Neighbor	Attitudes about Neighbor mitigation	4.77	1.13	4.22	1.16	4.66	1.21
Road	Road width measured from the outer edges of the road to residence entryway (feet)	25.83	5.47	27.09	8.23	25.62	8.81
Fire	Distance to the national fire station (meter)	2,348.80	1,385.93	5,302.16	3,053.97	1,881.42	1,139.82
Forest	Distance to the national forest (meter)	438.43	373.70	982.00	854.55	795.36	886.95
Parcel	Tax property size in sq. meter	1,510.09	1,994.41	7,517.49	6,814.72	6,459.22	1,9635.89
Elevation	Elevation of parcel measured from the average sea level (Meter)	2,109.41	63.04	2,040.22	56.02	2,073.39	110.77
Slope	Percent change in elevation measured in percent rise	6.28	4.61	3.56	2.66	3.97	2.28
Aspect	Aspect of parcel measured in degree	178.46	110.81	148.08	68.37	172.35	99.46
NDVI	Indicates canopy cover ranged between -1 and 1	0.16	0.09	0.05	0.05	-0.08	0.07
Remove	Removing dead vegetation from under deck and roof	0.66	0.48	0.49	0.50	0.57	0.50
Trim	Trimming back trees that overhang the house	0.54	0.50	0.35	0.48	0.46	0.50
Wood	Locating firewood stack away from building	0.38	0.49	0.32	0.47	0.32	0.47
Prune	Pruning trees up to 8-15 ft. above the ground	0.45	0.50	0.28	0.45	0.43	0.50
Mow	Mowing the lawn regularly	0.50	0.50	0.56	0.50	0.64	0.48
Water	Watering landscape as necessary to maintain succulent vegetation	0.66	0.48	0.56	0.50	0.42	0.50
Plant	Planting low-growing and less flammable species that are free of reins, oil and waxes	0.34	0.48	0.21	0.41	0.26	0.44
Thin	Thinning dense tree groups	0.57	0.50	0.44	0.50	0.54	0.50
Compost	Piling compost debris away from building	0.23	0.43	0.34	0.48	0.36	0.48

parameter. ρ represents the effect of the neighborhood's share of mitigation responsibility. A Bayesian Markov Chain Monte Carlo (MCMC) method was used to estimate the spatial autoregressive probit. The MCMC technique and Gibbs sampling provide sequential algorithm sampling from the conditional posterior distributions of the model parameters. The statistical process in the spatial interaction was to first observe the spatial dependency in which two states of dependency may be present: spatial lag process and spatial error process. The existence of spatial autocorrelation indicates that an observation's mitigation has partial influence on neighbor's mitigation. The Moran's I was used to determine this spatial dependency. For instance, under the wildfire mitigation setting, a spatial lag dependence implies that the likelihood that an owner of property *i* performs mitigation is a function of whether the owner of property *j* performs mitigation (including all other property in the relevant spatial neighborhood). The existence of a spatial lag process and evidence from wildfire literature in observing spatial interaction suggests that use of the spatial autoregression model is appropriate in this study.

The spatial weight matrix (W) was specified prior to estimating the model. The weight matrix describes the spatial process between the observations (i.e., w_{ij} quantifies the influence neighbor *j* has on observation *i)*. The matrix of elements w_{ij} has zeros on diagonal and was a row-standardization. There are several styles of defining weight matrices. A review of specifications on weight matrices in relation to wildfire context applied the weight on the distance basis (Donovan, Champ, and Butry 2007; Shafran 2008; Taylor, Chrisman, and Rollins 2013). In this study, weights were defined based on distance. Two formations were applied, including the inverse distance (W_1) and inverse distance within an average proximity to have at least one neighbor[20] (W_2). The houses further away than the average proximity have a weight of zero. I believe that the strength of relationship in neighborhoods attenuates with distance. The analogy is that the effect of a property owner's mitigation behavior on a neighbor's decision to mitigate is likely to be most influential for the most immediate neighbors and to decline with increasing distance between properties. It is because the closer properties are more visible, so that the closer neighbors are more likely to pay attention on wildfire mitigation. Weight was given in order to have at least one nearest neighbor and to help reduce the presence of zeros in the matrix. Spatial weight matrices were generated by ArcGIS 10.2. The SARP models performed using the R statistical package version 3.2.1[21].

Since the three communities are located in different states, the preferred weight matrix that best represents weighing neighbors varies across communities. The analysis was conducted separately for each community. The spatial weight matrix was first specified and selected to estimate the spatial correlation for all nine fuel reduction activities. Mitigation behaviors showing the existence of a spatial relationship proceeded in examining the spatial interaction in the SARP model.

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[20] The mean Euclidean distance between all house centroids was determined to ensure that every entity has at least one neighbor. The results of mean distance are 440, 1460, and 285 meters for communities in Big Bear Lake, Doney Park, and Ruidoso, respectively.

[21] R script was adapted from Wilhelm and Godinho de Mato (2013), "Estimating Spatial Probit Models in R."

Results and Discussion

The spatial autocorrelation analysis examined whether spatial dependency existed. Table 4.2 shows that the mitigation behavior undertaken can have a spatial relationship in all communities; however, the type of mitigation affected differs across communities. Evidence confirms that the spatial process exhibits the clustering pattern of mitigation behaviors. Property owners residing in Big Bear Lake are spatially correlated with respect to removing dead vegetation around the house and locating firewood away from the building. Spatial patterns were found for property owners in the Doney Park area, where trimming back trees that overhang the house and mowing a lawn illustrated a strong significant clustering (*Z*-score = 0.95 and 0.58, respectively). Similarly, a pattern of trimming and pruning trees for property owners in Ruidoso show significant clustering (*Z*-score = 0.14 and 0.13). The results suggest the existence of spatial correlation in mitigating wildfire hazards. In other words, one's risk-reduction behaviors partly influence a neighbor's mitigation behavior. The influence of spatial correlation drops off dramatically as proximity of neighboring property increases.

The SARP estimation for mitigation behaviors shows that the spatial interaction captured by ρW was small and insignificant in all three communities. The SARP model might have omitted other drivers that explain spatial interaction in risk-reduction behaviors. An additional test, the Lagrange Multiplier (LM) test, can assist in identifying whether an errors process exists in the spatial correlation. That process occurs when regression residuals are spatially correlated and may occur when the error term is spatially autocorrelated (Anselin and Bera 1998). In addition, the result from the LM test

Table 4.2. Test for spatial autocorrelation

		W1		W2	
Community	Activity	I-index	Z-score	I-index	Z-score
Big Bear Lake, CA					
	Remove	0.1611	2.227	1.999**	2.038
	Wood	0.125***	2.231	0.910	0.937
Doney Park, AZ					
	Trim	0.028	0.647	0.952**	2.044
	Mow	0.049	0.965	0.133	0.310
Ruidoso, NM					
	Trim	0.137**	1.970	0.160	0.722
	Prune	0.128**	1.863	0.056	0.293

Notes: I- index is the Moran's I, Z-score is the Moran I statistic standard deviate; Remove refers to removing dead vegetation from under deck and roof; Mow refers to moving the lawn regularly; Prune refers to pruning trees up to 8-15 ft. above the ground.
***p-value <.001; **p-value <.05; *p-value <.1

determines whether a spatial error model or spatial lag model is the appropriate choice. Although a series of tests was performed on the spatial autocorrelation, which indicated statistical significance for Moran's I, the specification may fail in case of a small sample size. Thus, I focused on the determinant of mitigation behaviors by using a nonspatial probit model and then compared the results with the spatial models. Only mitigating behaviors that exhibit significant spatial autocorrelation are discussed and compared with the estimates in normal probit models. In probit estimation, the sign of coefficient indicates the direction of their influence on the dependent variables. To compare the magnitude of influence, coefficients have to be described in terms of the marginal effect.

Results of the probit models show that the biophysical characteristics and social factors explained variation in the mitigation behaviors of owners in Doney Park and Ruidoso. In the Doney Park area, trimming and pruning trees are the prominent mitigation behaviors. Physical characteristics of property illustrate the statistical significant relationship with landscaping behaviors. The results as shown in Table 4.3 indicate that the distance from one's house location to a fire station is negatively related to the mitigation behaviors. It is possible that owners feel less motivation to mitigate because they have better access to an emergency response. In addition, the risk factor including the aspect of property illustrates the risk of wildfire related to mitigating behaviors namely trimming back tree and mowing a lawn.

The aspect of a property is positively correlated to mitigation behaviors. If a property is located on a drier ground surface and is more prone to ignition, owners are more likely to undertake wildfire mitigation. Although respondents placed relatively low value on nature, a negative correlation with the vegetation-clearing activities is present,

Table 4.3. SAR probit estimates vs. probit estimates for Doney Park, AZ

	Trim				Mow			
	SARP		Probit		SARP		Probit	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Intercept	-15.4*	8.82	-13.7400	8.53	-4.2700	7.80	-3.5280	7.32
Worldview	-0.559	0.38	-0.5111	0.37	-0.4580	0.36	-0.4416	0.35
Neighbor	0.302*	0.16	0.2838*	0.16	-0.2030	0.15	-0.1882	0.15
Road	-0.0237	0.03	-0.02024	0.03	-0.0090	0.02	-0.0070	0.04
Fire	-0.00029**	0.00	-0.00026**	0.00	-0.0001*	0.00	-0.00013*	0.00
Forest	-0.0003	0.00	-0.0003	0.00	-0.0002	0.00	-0.0002	0.00
ParcelSize	0.0000	0.00	0.00003	0.00	0.0001*	0.00	0.0001*	0.00
Elevation	0.0073	0.01	0.00648	0.01	0.0028	0.01	0.0024	0.00
Slope	-0.00795	0.08	-0.00425	0.07	-0.0107	0.07	-0.0119	0.07
Aspect	0.0058*	0.01	0.00543*	0.03	0.0055*	0.01	0.0049*	0.01
NDVI	5.2800	3.97	4.77900	3.79	-6.52*	3.51	-6.11*	3.44
Spatial lag parameter (rho)	0.0542	0.57			0.0250	0.57		

***p-value <.001; **p-value <.05; *p-value <.1

as expected. The largest group of respondents in Ruidoso believed that nature is fragile and they are very protective of nature, so it is perhaps not surprising that they are less motivated to clear natural vegetation. Significant positive influences of neighbors' behaviors were illustrated only by property owners who reported regularly trimming back trees that overhang their houses. Perhaps this activity is a less labor-intensive behavior, so that the incentive to match neighbors' activities is less likely to be offset by drawbacks of undertaking.

Another finding of a variation in mitigation behavior was for mowing the lawn. This clearing activity is significantly and negatively correlated with vegetation density index (NDVI). The opposite correlation implies that the properties with fewer trees and shrubs are more likely to have a lawn that needs mowing. It is particularly true because properties with high vegetation cover, especially in ponderosa pine forests, tends to have cone litter that inhibit grass growth. In contrast to the vegetation density, a size of property and mowing the lawn have positive and significant correlation. The larger the property is, the higher the probability that property owners will mow the lawn.

Table 4.4 illustrates the finding in the Ruidoso wildland interface. I found that none of the social predictors were related to the likelihood of mitigation behavior in this area. In addition, the relationship with mitigations presents that views of nature had a negative relationship while attitudes about neighbor mitigation had a positive relationship to mitigation behavior.

The biophysical characteristics of property show an important association. The proximity of property to the National Forest is associated with the likelihood of an

Table 4.4. SAR probit estimates vs. probit estimates for Ruidoso, NM

	Trim			
	SARP		Probit	
	Coefficient	S.E.	Coefficient	S.E.
Intercept	13.13**	4.576	12.02**	4.3630
Worldview	-0.240	0.397	-0.2125	0.3839
Neighbor	0.028	0.148	0.0137	0.1427
Road	-0.012	0.031	-0.0070	0.0293
Fire	-0.0002	0.000	-0.0002	0.0002
Forest	.001*	0.000	0.0005*	0.0002
ParcelSize	-	-	-	-
Elevation	-0.007**	0.002	-0.0059**	0.0020
Slope	0.079	0.081	0.0635	0.0753
Aspect	0.00053	0.002	0.0004	0.0017
NDVI	0.061	2.831	0.0000	2.7540
Spatial lag parameter (rho)	-0.007	0.573		

****p*-value <.001; ***p*-value <.05; **p*-value <.1

owner's use of mitigation practices. The closer the distance, the higher the probability that owners will take action to mitigate wildfire hazard. In addition, elevation is negatively significant to mitigation behavior. This relationship makes sense because the lower elevation forest in Ruidoso has higher-density ponderosa pine stands, which are associated with increased high fire risk. Owners are more likely to perform mitigation activities accordingly. Estimates are displayed in Table 4.4. There was no evidence in the Big Bear Lake area that proposed determinants can explain mitigation behavior; thus, it was not presented here. Table 4.5 presents the average marginal effect of mitigation behavior predictors which indicate the average magnitude of each predictor.

Conclusions

This study examines whether wildfire mitigation behaviors on privately owned properties affect behaviors on neighboring properties in three WUI communities. There

Table 4.5. Marginal effects

	Doney Park		Ruidoso
	Trim	Mow	Trim
Intercept	-4.1348	-1.1912	4.0224
Worldview	-0.1538	-0.1491	-0.0711
Neighbor	0.0854	-0.0635	0.0046
Road	-0.0061	-0.0024	-0.0023
Fire	-0.0001	-	-0.0001
Forest	-0.0001	-0.0001	-0.0002
ParcelSize	-	-	-
Elevation	0.0019	0.0008	-0.0020
Slope	-0.0013	-0.0040	0.0212
Aspect	0.0016	0.0017	0.0001
NDVI	1.4380	-2.0626	-
Percent correctly predicted	0.68	0.68	0.43
Pseudo R-squared	0.17	0.22	0.17

Conclusions

This study examines whether wildfire mitigation behaviors on privately owned properties affect behaviors on neighboring properties in three WUI communities. There are three caveats to the analysis in this chapter. First, the primary goal is to indicate the spatial effects of neighbors and whether those can explain the decision by property owners to engage in mitigation behaviors. Spatial correlations with mitigation behaviors were found in all three communities. These included removing dead vegetation from under the deck and roof, locating firewood stacks away from the building, trimming back trees that overhang the house, mowing a lawn regularly, and pruning trees up to 8-15 ft. above the ground.

Spatial parameters failed to capture spatial effects on neighbor's mitigation behaviors in the SARP models. Performing an additional test, the Lagrange Multiplier, provided a better alternative model to examine this spatial correlation. The nonspatial probit model was a complementary model to the SARP model for indicating the influence of neighborhood, views of nature, and biophysical characteristics of private property.

Second, I found that in the Doney Park and Ruidoso communities, the worldview variable is not significantly correlated to private property owners' mitigation behaviors. However, the worldview or value of nature strongly affected property owners' mitigation behaviors (i.e., removing dead vegetation) in the Big Bear Lake area. Although the value of nature is high for them, they are willing to compromise that value to reduce from wildfire. In all, to promote a level of participation in mitigation behaviors of private owners in interface areas, it is important to illustrate that damage from wildfire to the natural environment, including their own properties, will be minimized if recommended mitigations are undertaken. The consequences of ignorance and lack of participation in mitigating can cause more substantial disaster for all.

Third, property location and its biophysical attributes play a role in private owners' decisions to undertake mitigation. In this study, the wildfire risk was specified in each individual property and measured by a topographic variable and vegetation density index. The wildfire risk factors are significantly associated with owners' mitigation behaviors. The strength of these relationships varies by location of community. In the Doney Park area, if a property is located close to a fire station, owners tend to lack motivation to undertake mitigations even though the property faces wildfire risk on south-facing slopes. However, the elevation of a property presents a significant effect on mitigation behaviors in the Ruidoso community. This being said, more detailed analysis about adaptation of property to reduce risk of wildfire, and its relationship to owners' perceptions of landscape-scale pattern, would help to make these results more useful to promote the mitigation programs successfully. This study may offer a fruitful avenue for future research questions. Moreover, since this study explored many various variables across different study sites, some effects such as that of proximity from fire station on the likelihood of mitigation were present only in one community and not at the others. As this was an exploratory study, future research in more and different communities could identify which variables are typically influential and which findings from this study may be anomalous.

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CHAPTER 5

CONCLUSIONS

Due to the fact that the human and biophysical dimensions of the environment are interconnected, both must be addressed to fully understand and deal with the complexity of wildfire management (Daniel, Carroll, and Moseley 2007). Without an integrated framework, wildfires will never return to an ecologically resilient state in these ecosystems, and human communities will continue to give rise to adverse consequences for these ecosystems. We must integrate three key elements—the socio-cultural, socio-demographic, and biophysical settings of individuals—to understand the inherent human-wildfire relationship. The coupling of the social and ecological dimensions of wildfire as an approach to understanding an individual's risk perception can be divided into three aspects as presented in this dissertation. We focused on three wildland-urban interface communities in the western U.S. (Big Bear Lake, CA; Doney Park, AZ; and Ruidoso, NM) because these populations have a higher than typical level of ethnic diversity for areas with a high potential for wildfires. This study specifically focused on the reported hazard mitigation activities of private property owners because they have jurisdiction over their land. I am most interested in the motivational factors that drive decision-making in regard to mitigation behaviors. We conducted a mail survey within the three communities and incorporated the biophysical characteristics of each property using Geographic Information Systems.

The first study investigated social-psychological factors that influence residents' intentions to reduce wildfire hazards. Since wildfire risk perception is not always directly linked to behaviors that can mitigate risk (McCaffrey et al. 2011), there are several factors that shape how individuals respond to risk from wildfires and influence mitigating behaviors, such as social context, institutional, and psychological variables (Thompson 2014). The main objective of this research was to explore the influences upon intentions to perform mitigation, as intentions are the most immediate links to human behaviors (Ajzen 1991). The study focused on investigating whether risk perception directly affected intention to mitigate wildfire risk. The conceptual framework utilized the integration of two socio-psychological theories: the Theory of Planned Behavior (TPB) and Cultural Theory (CT). The risk perception measures included variables designed to measure one's worldview and uncover four distinct perceptions of nature. A model to predict mitigation intention was developed based on the TPB, which measures attitudes toward behavior, social norms, and perceived behavioral control. The causal relationship of nature views and mitigation intention was demonstrated using structural equation modeling. The essential findings included that respondents held a perverse/tolerant perception of risk whereby nature is seen as balanced and stable as long as it remains within the limits set by the experts and authorities. They also had a more positive attitude and perception of behavioral control toward intention to reduce risk from fires. Consistent and open communication can provide an effective venue for local fire agencies to achieve greater support for fire management. Such a relationship includes perception of shared values and norms (McCaffrey and Olsen 2012).

The second aspect of understanding the coupled social-ecological system of wildfire risk in this dissertation was to determine property owners' perception of wildfire risk in the local areas and at the broader scale of one's county and state. This research investigated human behaviors related to wildfire as to the extent that the perception of risk is formed in a multistage process (individual and community level). The rationale for this approach was based on the fact that social and environmental contexts are inherently hierarchical in certain geographical locations. In other words, people who live in similar social and environmental settings are more likely to have similar perceptions about wildfire risk. The goal of this study was to identify both individual characteristics and contextual factors that help explain variations in formation of perception about wildfires. We observed how community-level factors help explain variability in forming individual-level perceptions. Risk perception is determined at two different levels. At the individual level, risk perception is a function of an individual's perception of nature, place-based influence, and wildfire risk factors caused by human and demographic factors. At the community level, social and physical vulnerability play a part in determining an individual's perception about wildfire risk. The results illustrated that one's view of nature, length of residency, place-based influence and attitude toward fire risk are significant predictors of perceived risk for respondents. People's perception of wildfire risk is consistent with their level of exposure to these risks. The variability in social and physical vulnerability associated with wildfire can explain, to a certain extent, the variation in an individual's perception of wildfire risk. I recommend that policies and regulations at the local level be put in place to improve communication about hazards and to expand education, which must emphasize the perceptions of nature, human risk factor, and individual characteristics.

The final aspect of understanding wildfire risk from a coupled systems perspective focused on spatial relationships including the effects of mitigating actions taken on neighboring lands. Our observation of the outcome of changes in a neighbor's behaviors provided insight into the factors that influence property owners' decisions to engage in protecting their lands from wildfires. Fire protection responsibilities are considered to be shared because private owners are responsible for mitigating the risk to their property while public agencies are responsible for managing public lands and educating residents about hazards (Nelson, Monroe, and Johnson

2005; Bright and Burtz 2006). Nevertheless, there are many effects of untreated private lands in mitigation decisions (McKee et al. 2004; Brenkert-Smith, Champ, and Flores 2006), which may lead to action or inaction regarding mitigation risk (McCaffrey and Olsen 2012). This paper used spatial analysis to determine whether the mitigation behavior of neighbors is a necessary condition for private owners to increase action. Although the spatial lag parameter in the initial model failed to capture the neighborhood effect, significant results were observed when the initial model was replaced by substitute models. I found that mitigation behaviors in all communities reflected a spatial clustering pattern. For example, trimming back trees that hang over houses and mowing the lawn were the most reported behaviors, and these were spatially correlated. I also found that the extent to which property owners' value nature and property characteristics of the property itself had a significant effect on wildfire mitigation behaviors.

This study has extended previous wildfire research in several aspects, including decision-making influences, hierarchical perspectives of risk perception, and spatial relationships on mitigation behaviors for reducing risk. The growing diversity of populations in the wildland-urban interface community increases the complexities of social values, norms, and risk-related behaviors to enhance wildfire risk management. Three WUI communities in this study can be used as examples of growing communities that face a threat from wildfires. The individuals' values were highlighted as an essential factor affecting risk perception and mitigation behaviors. The influences of such values on behaviors are shaped by socio-cultural and environmental aspects of individuals. WUI respondents in this study perceived wildfire risk as controllable by public agencies; however, they also were concerned about environmental depletion and the need to protect natural resources. On the other hand, some residents felt that it did not make any difference to mitigate risk if the hazards are extreme or out of control. They expected that it was the responsibility of the authorities to inform them of the intensity of potential wildfires. In terms of multistage processing of risk perceptions, the consistency of perceived exposure to risk was relevant. Interface residents seemed to be more optimistic about their risk of wildfire exposure in their local areas when compared to those in broader areas. Given these results, it is not surprising that some mitigation behaviors were found to be spatially clustered within each community. It can be implied that perceiving risk from wildfire does transform into action taken by property owners to protect their property. The level of effort may vary by sociocultural and community norms so that a dynamic process of social networking may help to spread out the effectiveness of mitigation. It may take time for individuals to accept this process and adopt effective mitigation practices. Thus far, the results suggest that we cannot put all processes into a "one method fits all" plan. Social values, cultural, norms, and individual perceptions are interconnected through space and have a significant influence on the risk perception-behavior relationship.

Opportunities for Future Research

This study provided an additional perspective on risk perceptions of wildfire hazard for the residents in the wildland-urban interface. While the resulting mitigation implications for communities of this study are of immediate benefit, the results could be applied to more detailed exploration of fire-prone communities that are like those that exist in the three surveyed areas. Such an exploration would be likely to focus on determining the effects of variation on risk perception, such as the difference across cultural groups and the relation to other natural hazards such as flooding. The results from such exploration would help fire managers communicate preferred procedures. Having an accurate understanding of social dynamics also helps not only in maintaining ecosystem health but also increases cost effectiveness for future fire management.

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APPENDICES

APPENDIX A

NONRESPONSE BIAS TEST RESULTS

Table A-1. Nonresponse bias test

Community		U.S. Census 2012*	Representative Sample	Z-test *p*-Value	Z-test Effect Size
Doney Park CDP,AZ					
Population/sample size		6,075	348		
Gender	Male	49.5%	64.7%	<.001††	.03
	Female	50.5%	35.5%	<.001††	.03
Age	35-64	42.1%	61%	<.001††	.04
	65&over	5.6%	35.3%	<.001††	.06
Ethnicity	Amr Indian	15.5%	3.1%	<.001††	.04
	Asian	0.2%	1.5%	<.001††	.09
	White	70%	86%	<.001††	.04
	Other (Hispanic)	12.3%	9.2%	.35	.01
Education	Some college	25.7%	23.1%	.55	.01
	College graduate	15.9%	35.4%	<.001††	.05
	Graduate/Professional	9.7%	20.0%	<.001††	.04
Income	50,000 – 74,999	22.3%	21.9%	.81	.00
	100,000 – 150,000	17.0%	15.6%	.71	.00
	>150,000	5.5%	6.3%	.73	.00
Big Bear Lake, CA					
Population/ sample size		5,085	360		
Gender	Male	50.66%	52.8%	.66	.00
	Female	49.34%	47.2%	.67	.00
Age	35-64	43.4%	45.3%	.70	.00
	65&over	15.3%	55%	<.001††	.11
Ethnicity	Amr Indian	1.2%	1.9%	.52	.01
	Asian	0.8%	3.8%	.12	.02
	White	80.3%	88%	.05†	.02
	Other(European, Hispanic)	8.7%	5.8%	.30	.01
Education	Some college	25.7%	37.7%	.01†	.03
	College graduate	15%	17%	.58	.01
	Graduate/Professional	10.7%	26.4%	<.001††	.05
Income	50,000 – 74,999	17.5%	15%	.51	.01
	100,000 – 150,000	6.8%	15%	<.001††	.03
	>150,000	3.4%	13.5%	<.001††	.06
Ruidoso, NM					
Population/ sample size		8,055	368		
Gender	Male	48.14%	50%	.71	.00
	Female	51.22%	50%	.81	.00
Age	35-64	38.8%	36.4%	.62	.00
	65&over	22.4%	63.6%	<.001††	.10
Ethnicity	Amr Indian	3.1%	-		
	Asian	0%	-		
	White	68.4%	85.1%	<.001††	.04
	Other (Hispanic)	25.2%	12%	<.001††	.03
Education	Some college	31.3%	24.6%	.15	.01
	College graduate	22.3%	15.4%	.10	.02
	Graduate/Professional	9%	32%	<.001††	.08
Income	50,000 – 74,999	20.3%	12.5%	.05†	.02
	75,000-99,999	11.6%	14%	.45	.01
	100,000 – 150,000	7.3%	7.8%	.85	.00

* Economic Profile System – Human Dimensions Toolkit (EPS-HDT). (2011). Headwaters Economics. www.headwaterseconomics.org/eps-hdt.

† Significant level $p < .05$, †† Significant level $p < .001$

APPENDIX B

PRINCIPAL COMPONENT ANALYSIS FOR WORLDVIEWS

Table B-1. A list of scale items for Cultural Theory constructs; reliability, Method: Principal axis factoring estimates, Promax rotation with 6 iterations convergence

Measurement items	Factor loadings			
	EPHEMERAL	PERVERSE	BENIGN	CAPRICIUOS
Cronbach's Alpha	0.77	0.65	0.62	0.64
The balance of nature is very delicate and easily upset- E3	.815	-.072	-.054	.020
Forest environments are fragile, and human interference can cause unexpected disasters-E2	.735	.118	-.017	-.075
Wildfire disasters can only be avoided if people radically change their behavior-E4	.617	-.011	.232	-.010
If things continue on their present course, we will soon experience a major ecological catastrophe-E1	.578	-.054	-.241	.113
During the last years much has been done to protect the forest from wildfire danger-H3	-.075	.699	-.100	.145
The Forest Service does a good job of considering my concerns about wildfire risk-H2	-.056	.686	.037	-.078
To avoid wildfire disasters it is necessary to pay more attention to the advice of experts-H4	.147	.513	.064	-.073
We do not need to worry about environmental problems because in the end, science and technology will be able to solve these problems-I4	-.022	-.060	.675	-.002
Humans will eventually learn enough about how nature works to be able to control it-I1	.133	.104	.609	.063
Human beings were meant to rule over the rest of nature-I2	-.107	-.056	.525	.059
It is no use worrying about what happens on public lands; I can't do anything about them anyway-F3	-.042	.046	.007	.741
The future is too uncertain for a person to make serious plans-F2	.079	-.035	.097	.600
Extraction Method: Principal Axis Factoring.				
Rotation Method: Promax with Kaiser Normalization.				

a. Rotation converged in 6 iterations.

APPENDIX C

WILDFIRE RISK PERCEPTION MAIL SURVEY

SECTION 1 WILDFIRE RISK MITIGATION ACTIVITIES

1. In the **past years**, have you done any of these following activities at this residence/property? (Please check all that apply)
   ☐ Removing dead vegetation from under deck and roof within 10 feet of house
   ☐ Trimming back trees that overhang the house
   ☐ Locating firewood stacks away at least 30 feet from buildings
   ☐ Pruning trees up to 8 to 15 feet above the ground
   ☐ Mowing the lawn regularly keep less than 6 inches
   ☐ Watering landscape as necessary to maintain succulent vegetation
   ☐ Planting low-growing and less flammable species that are free of resins, oil, and waxes
   ☐ Thinning dense tree groups and removing brush and dead needles, leaf litter, and other plant debris within 75 feet of your house
   ☐ Piling compost debris at least 100 feet away from buildings

2. Which of the following activities that currently undertaking on your property? (Please check all that apply)
   ☐ Removing dead vegetation from under deck and roof within 10 feet of house
   ☐ Trimming back trees that overhang the house
   ☐ Locating firewood stacks away at least 30 feet from buildings
   ☐ Pruning trees up to 8 to 15 feet above the ground
   ☐ Mowing the lawn regularly keep less than 6 inches
   ☐ Watering landscape as necessary to maintain succulent vegetation
   ☐ Planting low-growing and less flammable species that are free of resins, oil, and waxes
   ☐ Thinning dense tree groups and removing brush and dead needles, leaf litter, and other plant debris within 75 feet of your house
   ☐ Piling compost debris at least 100 feet away from buildings

SECTION 2 BELIEFS ABOUT WILDFIRE RISK AND HUMAN IMPACTS

Instruction: Please rate to what extent you agree or disagree with each of the following statements by checking in the appropriate circle. For example, if you *feel strongly agree* with the statement, you will check on *Strongly Agree*

1. No matter what we do, it is impossible to predict when or where a wildfire will occur.

2. The future is too uncertain for a person to make serious plans for

3.It is no use worrying about what happens on public lands; I can't do anything about them anyway

4. Public land managers should do more to build trust in the local community

5.Humans will eventually learn enough about how nature works to be able to control it

6. Human beings were meant to rule over the rest of nature

7. Forests are quite adaptable and will recover from any damage caused by humans

8. We do not need to worry about environmental problems because in the end, science and technology will be able to solve these problems

9. It is possible to avoid wildfire disasters in populated areas if human behaviors are regulated by laws or ordinances.

10. The Forest Service does a good job of considering my concerns about wildfire risk.

11. During the last years much has been done to protect the forest from wildfire danger

12. To avoid wildfire disasters it is necessary to pay more attention to the advice of experts

13. If things continue on their present course, we will soon experience a major ecological catastrophe

14. Forest environments are fragile, and human interference can cause unexpected disasters

15. The balance of nature is very delicate and easily upset

16. Wildfire disasters can only be avoided if people radically change their behavior

SECTION 3 PERCEPTIONS OF WILDFIRE RISK

1. The next three questions ask about the probability of wildfire damage in the next 10 years. Please check the number that reflects your opinion using the following scale: **1:** exceptionally unlikely (about a 1% chance); **2:** very unlikely (10% chance); **3:** unlikely (33% chance); **4:** about as likely as not (50% chance); **5:** likely (66% chance); **6:** very likely (90%); **7:** virtually certain (99% chance).

To what extent do you believe that wildfire will damage your home?

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

To what extent do you believe that wildfire will damage homes in your community?

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

To what extent do you believe that wildfire will damage homes in your state?

1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

2. Please rate the importance of these factors in creating a risk of wildfire in your community

	Not At All Important	Slightly Important	Moderately Important	Very Important
Lightning	☐	☐	☐	☐
Discarded cigarettes	☐	☐	☐	☐
Debris burning or other intentional fires that get out of control	☐	☐	☐	☐
Arson	☐	☐	☐	☐
Sparks from railroads and motor vehicles	☐	☐	☐	☐

SECTION IV BELIEFS ABOUT WILDFIRE RISK MITIGATION

Instruction: Please answer the following questions whether or not you currently are using mitigation practices. For the following questions, please circle the number that best describes your opinion, as shown in the sample question below:

I feel scared when I see smoke around my neighborhood	definitely false:	1	2	3	4	5	6	7	: definitely true

As an example, if you always feel scared when you see smoke around your neighborhood, then you would circle the number 7, as follows:

definitely false: 1 2 3 4 5 6 (7) : definitely true

*Please do not circle more than one number on the same scale

1. I believe that managing my property regularly to reduce risk from wildfire hazard is
unpleasant: 1 2 3 4 5 6 7 : pleasant

2. I believe that managing my property regularly to reduce risk from wildfire hazard is
extremely difficult: 1 2 3 4 5 6 7: extremely easy

3. I believe that managing my property regularly to reduce risk from wildfire hazard is
tiring: 1 2 3 4 5 6 7 : energizing

4. I believe that managing my property regularly to reduce risk from wildfire hazard is

extremely worthless: 1 2 3 4 5 6 7: extremely valuable

5. People who are important to me want me to manage my property on a regular basis
extremely unlikely: 1 2 3 4 5 6 7: extremely likely

6. Most of my neighbors manage their property on a regular basis

extremely disagree: 1 2 3 4 5 6 7: extremely agree

7. I feel in completely control whether I manage my property to reduce risk of wildfire hazard on a regular basis

completely false: 1 2 3 4 5 6 7: completely true

8. I am confident that I could manage my property to avoid wildfire hazard on a regular basis extremely disagree: 1 2 3 4 5 6 7: extremely agree

9. I intend to manage my property to mitigate risk from wildfire hazard on a regular basis
extremely disagree: 1 2 3 4 5 6 7: extremely agree

10. I will make an effort to manage my property to reduce risk from wildfire hazard on a regular basis completely false: 1 2 3 4 5 6 7: completely true

11. I will try to manage my property to reduce risk from wildfire hazard on a regular basis definitely will not: 1 2 3 4 5 6 7: definitely will

12. Managing my property for wildfire hazard reduction on a regular basis will help reduce the chance of wildfire damaging my property

extremely unlikely: 1 2 3 4 5 6 7: extremely likely

13. Reducing a chance of wildfire damaging your property is

extremely bad: 1 2 3 4 5 6 7: extremely good

14. Managing my property for wildfire hazard reduction on a regular basis will create a nice appearance to my property

extremely unlikely: 1 2 3 4 5 6 7: extremely likely

15. Creating a nice appearance for my property is

extremely bad: 1 2 3 4 5 6 7: extremely good

16. Managing my property for reducing wildfire hazard on a regular basis will take a lot of time extremely unlikely: 1 2 3 4 5 6 7: extremely likely

17. If mitigating wildfire risk around my property required a large time commitment, it would be extremely bad: 1 2 3 4 5 6 7: extremely good

18. Mitigating wildfire risk for my property on a regular basis will cause me to spend a lot of money extremely unlikely: 1 2 3 4 5 6 7: extremely likely

19. Spending lots of my money to manage my property from wildfire hazard is

extremely bad: 1 2 3 4 5 6 7: extremely good

20. Managing my property for reducing wildfire hazard on a regular basis will take a lot of physical effort

extremely unlikely: 1 2 3 4 5 6 7: extremely likely

21. If reducing risk from wildfire hazard on my property require a lot of physical effort it would be

extremely bad: 1 2 3 4 5 6 7 : extremely good

22. My neighbor thinks that I should manage my property to reduce risk from wildfire hazard on a regular basis

extremely unlikely: 1 2 3 4 5 6 7: extremely likely

23.With regard to wildfire hazard mitigation, I want to do what my neighbor thinks I should extremely disagree: 1 2 3 4 5 6 7: extremely agree

24. My family thinks that I should manage my property to reduce risk from wildfire hazard on a regular basis

extremely unlikely: 1 2 3 4 5 6 7: extremely likely

25. With regard to wildfire hazard mitigation, I want to do what my family thinks I should extremely disagree: 1 2 3 4 5 6 7: extremely agree

26. The local fire department or the Forest Service thinks that I should manage my property to reduce risk from wildfire hazard on a regular basis

extremely unlikely: 1 2 3 4 5 6 7: extremely likely

27. With regard to wildfire hazard mitigation, I want to do what the local fire department or the Forest Service thinks I should

extremely disagree: 1 2 3 4 5 6 7: extremely agree

28. How often do you feel that you do not have enough knowledge on managing activities for reducing wildfire risk?

very rarely: 1 2 3 4 5 6 7 : very frequently

29. Not having enough knowledge on management activities for reducing wildfire risk would make it for me to manage my property

more difficult: 1 2 3 4 5 6 7 : easier

30. I don't have enough money to manage my property from wildfire hazard

extremely unlikely: 1 2 3 4 5 6 7: extremely likely

31. I found that it requires unanticipated demands on my time to manage my property away from wildfire hazard

very rarely: 1 2 3 4 5 6 7 : very frequently

32. If I have less spending than I hope for, it would make it.....for me to reduce wildfire hazard on my property

more difficult: 1 2 3 4 5 6 7 : easier

33. Unanticipated demands on my time would make it much more.....for me to manage my property away from wildfire hazard

more difficult: 1 2 3 4 5 6 7 : easier

34. How often do you feel that you do not have enough physical ability on managing your property to reduce wildfire hazard?

very rarely: 1 2 3 4 5 6 7 : very frequently

35. How often do you feel that working together with your neighbors on wildfire-related issues has an impact on your property?

very rarely: 1 2 3 4 5 6 7 : very frequently

36. Working together with my neighbors would make it … for me to manage my property to reduce the risk of wildfire.

more difficult: 1 2 3 4 5 6 7 : easier

SECTION V DEMOGRAPHIC INFORMATION

Instruction: Please answer some basic information about yourself. The questions in this section are used for statistical analysis only and all responses are strictly confidential.

1. How old are you?
- ☐ 18-25
- ☐ 26-34
- ☐ 35-54
- ☐ 55-64
- ☐ 65 or over

2. Are you …?
- ☐ Male
- ☐ Female

3. Do you consider yourself …?

☐ American Indian
☐ Asian
☐ African American
☐ Native Hawaiian or other Pacific Islander
☐ non-Hispanic white
☐ Other ____________________

4. Please indicate the highest level of education you have completed.

☐ Did not finish high school
☐ High School or equivalent
☐ Vocational/Technical School (2 years)
☐ Some College
☐ College Graduate (4 years)
☐ Graduate or Professional Degree

5. How long have you lived at your current property? (Please specify either in months or years)

____

6. Please indicate your current household income in U.S. dollars

☐ Under $10,000
☐ $10,000 - $19,999
☐ $20,000 - $29,999
☐ $30,000 - $39,999
☐ $40,000 - $49,999
☐ $50,000 - $74,999
☐ $75,000 - $99,999
☐ $100,000 - $150,000
☐ Over $150,000
☐ I would rather not say

APPENDIX D

DESCRIPTIVE STATISTICS

Table D-1. Comparisons of mitigation activity to reduce wildfire risk (past years)

Past years	Doney Park (N= 71)	Big Bear Lake (N=56)	Ruidoso (N=69)	Total* (N=196)	Test**	Sig.
Removing dead vegetation from under deck and roof	33.5%	31.1%	35.4%	83%	χ^2=5.54	.236
Trimming back trees that overhang the house	29.3	35.0	35.7	72.2	χ^2=16.96	.002
Locating firewood stacks away from buildings	42.3	25.8	32.0	50.0	χ^2=5.14	.274
Pruning trees up to 8-15 feet above the ground	24.3	34.0	41.5	54.6	χ^2=17.53	.002
Mowing the lawn regularly	37.3	22.2	40.5	64.9	χ^2=12.39	.015
Watering landscape as necessary to maintain succulent vegetation	33.9	34.8	31.3	59.3	χ^2=6.54	.162
Planting low-growing and less flammable species that are free of resins, oil, and waxes	36.9	33.8	29.2	33.5	χ^2=3.58	.467
Thinning dense tree groups and removing brush and dead needles, leaf litter, and other plant debris	32.6	32.6	34.8	69.6	χ^2=7.37	.118
Piling compost debris away from buildings	40.8	21.1	38.2	39.2	χ^2=6.51	.164

Notes: NS = not significant;

* total is not equal to 100 because it is calculated from the sum of "Yes" response in all locations and divided by total responses in all performing activity (196)

**Test for sig correlation/association between variables; thus; NS means there is an association between variables

Table D-2. Comparisons of mitigation activity to reduce wildfire risk (current year)

Current year	Doney Park (N=71)	Big Bear Lake (N=56)	Ruidoso (N=69)	Total (N=196)	Test	Sig.
Removing dead vegetation from under deck and roof	31.8%	33.6%	34.5%	56.7%	χ^2=5.33	NS
Trimming back trees that overhang the house	29.1%	34.9%	36.0%	44.3	χ^2=8.18	.085
Locating firewood stacks away from buildings	35.4	32.3	32.3	33.5	χ^2=1.88	NS
Pruning trees up to8-15 feet above the ground	27.0	33.8	39.2	38.1	χ^2=10.09	.039
Mowing the lawn regularly	36.0	25.2	38.7	57.2	χ^2=11.58	.021
Watering landscape as necessary to maintain succulent vegetation	37.7	34.9	27.4	54.6	χ^2=7.23	NS
Planting low-growing and less flammable species that are free of resins, oil, and waxes	28.8	36.5	34.6	26.8	χ^2=6.09	NS
Thinning dense tree groups and removing brush and dead needles, leaf litter, and other plant debris	31.3	32.3	36.4	51.0	χ^2=4.33	NS
Piling compost debris away from buildings	38.7	21.0	40.3	32.0	χ^2=4.62	NS

Table D-3. Questions eliciting views of nature related to wildfire risk

Percent	Doney Park (N= 71)	Big Bear Lake (N=56)	Ruidoso (N=69)	Total (N=196)	Test	Sig.
1. No matter what we do, it is impossible to predict when or where a wildfire will occur					χ^2=17.21	.028
Strongly disagree	57.1	14.3	28.6	3.6		
Disagree	60.9	26.1	13.0	11.9		
Neutral	25.0	37.5	37.5	8.3		
Agree	37.7	18.8	43.5	35.8		
Strongly agree	28.2	37.2	34.6	40.4		
2. The future is too uncertain for a person to make serious plans for					χ^2=10.98	NS
Strongly disagree	43.5	27.4	29.0	32.6		
Disagree	33.0	28.9	38.1	51.1		
Neutral	26.3	52.6	21.1	10.0		
Agree	37.5	12.5	50.0	4.2		
Strongly agree	50.0	0	50.0	2.1		
3. It is no use worrying about what happens on public lands; I can't do anything about them anyway					χ^2=10.90	NS
Strongly disagree	37.3	23.7	39.0	30.3		
Disagree	39.6	30.8	29.7	46.7		
Neutral	34.8	39.1	26.1	11.8		
Agree	15.8	26.3	57.9	9.7		
Strongly agree	66.7	0	33.3	1.5		

4. Public land managers should do more to build trust in the local community					χ^2=11.41	NS
Strongly disagree	0	50.0	50.0	1.0		
Disagree	45.5	27.3	27.3	5.8		
Neutral	50.9	21.8	27.3	28.8		
Agree	25.6	34.6	39.7	40.8		
Strongly agree	35.6	26.7	37.8	23.6		
5. Humans will eventually learn enough about how nature works to be able to control it					χ^2 =11.28	NS
Strongly disagree	36.4	28.8	34.8	34.2		
Disagree	41.2	28.2	30.6	44.0		
Neutral	31.8	36.4	31.8	11.4		
Agree	17.6	29.4	52.9	8.8		
Strongly agree	0	0	100.0	1.6		
6. Human beings were meant to rule over the rest of nature					χ^2 =11.90	NS
Strongly disagree	43.0	28	29	51.8		
Disagree	22.8	35.1	42.1	29.5		
Neutral	31.3	31.3	37.5	8.3		
Agree	44.4	11.1	44.4	9.3		
Strongly agree	50.0	0	50.0	1.0		
7. Forests are quite adaptable and will recover from any damage caused by humans					χ^2 =4.36	NS
Strongly disagree	36.7	32.7	30.6	25.3		
Disagree	31.6	28.4	40.0	49.0		
Neutral	45.5	31.8	22.7	11.3		
Agree	40.9	22.7	36.4	11.3		
Strongly agree	50	16.7	33.3	3.1		

8. We do not need to worry about environmental problems because in the end, science and technology will be able to solve these problems					χ^2 =8.21	NS
Strongly disagree	39.1	23.9	37.0	47.2		
Disagree	34.4	35.6	30.0	46.2		
Neutral	36.4	18.2	45.5	5.6		
Agree	0	0	100	1.0		
Strongly agree	0	0	0	0		
9. It is possible to avoid wildfire disasters in populated areas if human behaviors are regulated by laws or ordinances.					χ^2 =5.43	NS
Strongly disagree	46.4	21.4	32.1	14.4		
Disagree	35.6	30.1	34.2	37.6		
Neutral	35.1	27.0	37.8	19.1		
Agree	29.2	35.4	35.4	24.7		
Strongly agree	62.5	12.5	25.0	4.1		
10. The Forest Service does a good job of considering my concerns about wildfire risk.					χ^2=8.50	NS
Strongly disagree	53.8	7.7	38.5	6.7		
Disagree	40.0	20.0	40.0	15.4		
Neutral	40.3	29.9	29.9	34.4		
Agree	28.6	33.8	37.7	39.5		
Strongly agree	37.5	37.5	25.0	4.1		
11. During the last years much has been done to protect the forest from wildfire danger					χ^2=12.46	NS
Strongly disagree	23.1	15.4	61.5	6.7		
Disagree	14.6	11.5	13.8	18.0		
Neutral	32.5	40.0	27.5	20.6		
Agree	41.8	27.6	30.6	50.5		
Strongly agree	50.0	37.5	12.5	4.1		

12. To avoid wildfire disasters it is necessary to pay more attention to the advice of experts					χ^2=14.30	NS
Strongly disagree	66.7	0	33.3	1.6		
Disagree	11.1	22.2	66.7	4.7		
Neutral	33.3	20.5	46.2	20.2		
Agree	36.1	34.4	29.5	63.2		
13. If things continue on their present course, we will soon experience a major ecological catastrophe					χ^2=15.75	.046
Strongly disagree	22.2	33.3	44.4	4.6		
Disagree	29.4	29.4	41.2	17.5		
Neutral	28.3	35.0	36.7	30.9		
Agree	35.6	27.1	37.3	30.4		
Strongly agree	65.6	18.8	15.6	16.5		
14. Forest environments are fragile, and human interference can cause unexpected disasters					χ^2=5.47	NS
Strongly disagree	0	33.3	66.7	1.6		
Disagree	48.0	24.0	28.0	13.1		
Neutral	28.6	32.1	39.3	14.7		
Agree	34.1	31.9	34.1	47.6		
Strongly agree	43.2	25.0	31.8	23.0		
15. The balance of nature is very delicate and easily upset					18.49	.018
Strongly disagree	33.3	66.7	0	1.5		
Disagree	55.2	6.9	37.9	14.9		
Neutral	20.9	44.2	34.9	22.1		
Agree	34.4	27.8	37.8	46.2		
Strongly agree	46.7	26.7	26.7	15.4		

16. Wildfire disasters can only be avoided if people radically change their behavior					11.27	NS
Strongly disagree	28.6	0	71.4	3.6		
Disagree	30.6	34.7	34.7	25.3		
Neutral	33.3	35.7	31.0	21.6		
Agree	38.6	22.9	38.6	36.1		
Strongly agree	50.0	30.8	19.2	13.4		

Note: q. 1-4 measure nature capricious (Fatalist), q.5-8 measure nature benign (Individualist), q.9-12 measure nature perverse/tolerant (Hierarchist), and q.13-16 measure nature ephemeral (Egalitarian)

Table D-4. Perception of wildfire risk

	Doney Park (N= 71)	Big Bear Lake (N=56)	Ruidoso (N=69)	Total (N=196)	Test*	Sig.
Probability of wildfire damage in the next 10 years						
Mean responses on scale of 1(Exceptional unlikely) to 7 (Virtually certain)						
Wildfire will damage your home	2.96	3.68	3.74	3.44	F=6.79	<.001[a]
Wildfire will damage home in your community	4.80	4.55	5.28	4.90	F=4.68	.01[b]
Wildfire will damage home in your state	6.39	6.07	6.01	6.17	F=1.81	NS

* One way ANOVA, Ho: means from different groups are Not different [a, b] Between-subjects effects are .06 and .046 respectively (small size)

Percent	Doney Park (N= 71)	Big Bear Lake (N=56)	Ruidoso (N=69)	Total (N=196)	Test	Sig.
Probability of wildfire damage in the next 10 years						
Wildfire will damage your home					χ^2=24.71	.016
1%	8.5%	7.1%	10.3%	8.7%		
10%	29.6	14.3	8.8	17.9		
33%	31.0	21.4	20.6	24.6		
50%	22.5	32.1	32.4	28.7		
66%	5.6	16.1	16.2	12.3		
90%	2.8	3.6	8.8	5.1		
99%	0	1.5	1.0	2.6		
Wildfire will damage home in your community						
1%	0%	1.8%	0%	0.5%	χ^2=18.96	NS
10%	2.8	8.9	1.5	4.1		
33%	22.5	26.8	25.0	24.6		
50%	12.7	10.7	7.4	10.3		
66%	33.8	26.8	19.1	26.7		
90%	19.7	12.5	22.1	18.5		
99%	8.5	12.5	25.0	15.4		
Wildfire will damage home in your state					χ^2=15.71	NS
1%	0%	1.8%	2.9%	1.5%		
10%	0	0	1.5	0.5		
33%	2.8	1.8	0	1.5		
50%	2.8	14.3	10.3	8.7		
66%	8.5	8.9	10.3	9.2		
90%	23.9	14.3	22.1	20.5		
99%	62.0	58.9	52.9	57.9		

Table D-5. Beliefs about wildfire risk mitigation – direct measurement on TPB variables

Mean responses on scale of 1(lowest) to 7 (highest)	Doney Park (N= 71)	Big Bear Lake (N=56)	Ruidoso (N=69)	Total (N=196)	Test	Sig.
Attitude toward wildfire mitigation activities						
Pleasant	5.24	5.52	5.60	5.45	F=1.47	NS
Difficulty	4.65	4.98	4.96	4.85	F=1.13	NS
Tiring	4.52	4.87	4.79	4.72	F=0.99	NS
Valuable	6.27	6.45	6.34	6.35	F=0.53	NS
Subjective norms						
People who are important to me want me to manage	5.03	5.33	5.20	5.17	F=0.53	NS
Most of my neighbors manage their property regularly	4.35	4.93	4.38	4.53	F=2.50	NS
Perceive behavioral control						
I feel completely in control on managing my property to reduce risk	4.49	4.46	5.12	4.70	F=0.92	NS
I am confident that I could manage my property to avoid fire hazard	5.07	5.61	4.99	5.19	F=2.70	NS
Behavioral intention						
Intend to manage	5.99	6.45	6.28	6.22	F=4.59	.01
Will make an effort to manage	6.08	6.39	6.34	6.26	F=2.08	NS
Will try to manage	6.20	6.57	6.41	6.38	F=3.80	.02

Table D-6. Beliefs about wildfire risk mitigation – indirect measurement on TPB variables (belief-based)

Mean responses on scale of 1(lowest) to 7 (highest)	Doney Park (N= 71)	Big Bear Lake (N=56)	Ruidoso (N=69)	Total (N=196)	Test	Sig.
Behavioral beliefs on managing property for wildfire hazard						
Likely to help reduce the chance of wildfire damaging property	5.75	6.05	5.78	5.85	F=0.86	NS
Create a nice appearance for my property	6.11	6.32	6.32	6.25	F=0.88	NS
Take a lot of time	4.90	4.93	5.16	5.00	F=0.74	NS
Spending a lot of money	3.42	3.61	4.28	3.77	F=5.11	.007
Take a lot of physical effort	4.91	5.28	5.39	5.18	F=2.01	NS
The importance of each reference groups on (motivation to comply)						
My neighbor	3.16	4.09	3.63	3.59	F=3.59	.03
My family	4.35	5.27	4.85	4.78	F=3.01	.02
The local fire department or the Forest Service	5.61	6.06	5.60	5.73	F=2.11	NS
Strength of controllability on managing property for wildfire hazard (control beliefs) on the subjects to						
insufficient knowledge	2.61	3.16	3.04	2.92	F=1.58	NS
not having enough money	2.99	3.13	3.71	3.28	F=3.04	.05
not having enough time	3.06	3.31	3.63	3.33	F=1.71	NS
working together with neighbors	3.79	4.33	4.58	4.22	F=2.72	NS

Table D-7. Evaluations on factors of mitigation beliefs

Mean responses on desirable scale of lowest (-3) to highest (+3)	Doney Park (N= 71)	Big Bear Lake (N=56)	Ruidoso (N=69)	Total (N=196)	Test (F)	Sig.
Outcome evaluation on behavioral beliefs on mitigation actions						
Reducing a chance of wildfire damaging my property	2.55	2.41	2.24	2.40	F=1.62	NS
Creating a nice appearance for my property	2.27	2.48	2.29	2.34	F=0.76	NS
Requiring a large time commitment	0.57	0.75	0.38	0.37	F=3.50	.032
Spending lots of my money	-0.19	-0.18	-0.16	-0.17	F=.00	NS
Requiring a lot of physical effort	0.40	0.87	0.63	0.61	F=1.89	NS
Strength of reference groups on managing property for wildfire hazard (normative beliefs)						
My neighbor thinks that I should manage my property	-0.33	0.60	0.41	0.19	F=3.83	.023
My family thinks that I should manage my property	0.65	1.35	1.20	1.04	F=2.69	NS
The local fire department or the Forest Service thinks that I should manage my property	1.63	2.50	2.19	2.07	F=5.21	.006
Having the following factors help on performing mitigations easier						
insufficient knowledge	-.83	-.98	-1.44	-1.08	F=2.77	NS
not having enough money	-.21	.09	.00	-.05	F=.463	NS
not having enough time	-1.07	-.41	-.99	-.85	F=3.81	.024
working together with neighbors	1.01	1.26	1.38	1.21	F=1.05	NS

Table D-8. The importance of risk of wildfire rating

Percent	Doney Park (N= 71)	Big Bear Lake (N=56)	Ruidoso (N=69)	Total (N=196)	Test	Sig.
Lightning					χ^2=12.25	NS
Not at all important	0%	1.8%	0%	0.5%		
Slightly important	9.9	1.8	6.0	6.2		
Moderate important	25.4	26.8	11.9	21.1		
Very important	64.8	69.6	82.1	72.2		
Discarded cigarettes					χ^2=4.94	NS
Not at all important	2.8	0	0	1.0		
Moderate important	8.5	8.9	9.0	8.8		
Very important	23.9	17.9	22.4	21.6		
Slightly important	64.8	73.2	68.7	68.6		
Debris burning or other intentional fires that get out of control					χ^2=8.58	NS
Not at all important	1.4%	7.1%	4.4%	0.5%		
Slightly important	14.1	7.1	4.4	8.7		
Moderate important	29.6	37.5	26.5	30.8		
Very important	54.9	55.4	69.1	60.0		
Arson					χ^2=9.63	NS
Not at all important	2.8	0	3.0	2.1		
Slightly important	14.1	10.7	23.9	16.5		
Moderate important	29.6	21.4	26.9	26.3		
Very important	53.5	67.9	46.3	55.2		
Sparks from railroads and motor vehicles					χ^2=4.70	NS
Not at all important	7.0	1.8	4.5	4.6		
Slightly important	33.8	26.8	38.8	33.5		
Moderate important	36.6	42.9	32.8	37.1		
Very important	22.5	28.6	23.9	24.7		

Table D-9. Demographic statistics

	Doney Park (N= 71)	Big Bear Lake (N=56)	Ruidoso (N=69)	Total (N=196)	Test χ^2	Sig.
% Age					χ^2=20.65	.002
18-25	-	-	-	-		
26-34	2.8%	0%	1.5%	1.6%		
35-54	36.6	14.8	10.4	21.4		
55-64	26.8	29.6	26.9	27.6		
> 65 years old	33.8	55.6	61.2	49.5		
% Male	66.2%	53.7%	50.0%	57.0	χ^2=4.05	NS
% Ethnicity						
American Indian	4.4%	1.9%	1.5%	2.7%	χ^2=24.54	NS
Asian	1.5	3.8	0	1.6		
African American	-	-	-	-		
Native Hawaiian or other Pacific Islander	-	-	-	-		
White non-Hispanic	83.8	88.7	86.4	86.1		
Other (Hispanic)	10.3	5.7	12.1	9.6		
% Education					χ^2=14.40	NS
Did not finish high school	1.5%	1.9%	4.5%	2.7%		
High School or equivalent	14.7	13.0	18.2	15.4		
Vocational/Technical School (2 years)	4.4	3.7	4.5	4.3		
Some College	23.5	38.9	25.8	28.7		
College Graduate (4 years)	35.3	16.7	13.6	22.3		
Graduate or Professional Degree	20.6	25.9	33.3	26.6		
Length of residency (year)						
Mean	16.02	17.61	18.70	17.38	F=.63	NS
Median	14.0	14.0	15.0	14.67		
%Income distribution						
Under $10,000	3.0%	0%	1.5%	1.6%	χ^2=24.54	NS
$10,000 - $19,999	1.5	7.5	10.8	6.5		
$20,000 - $29,999	4.5	5.7	6.2	5.4		
$30,000 - $39,999	7.5	7.5	7.7	7.6		
$40,000 - $49,999	10.4	7.5	4.6	7.6		
$50,000 - $74,999	20.9	17.0	12.3	16.8		
$75,000 - $99,999	10.4	1.9	12.3	8.6		
$100,000 - $150,000	14.9	15.1	7.7	12.4		
Over $150,000	6.0	13.2	3.1	7.0		
I would rather not say	19.4	22.6	30.8	24.3		

CURRICULUM VITAE

Voravee Saengawut Chakreeyarat
3530 Old Main Hill, Utah State University
Logan, UT 84322-3530
voravee.cha@aggiemail.usu.edu (509-5923945)

EDUCATION

Ph.D. Human Dimensions and Ecosystem Management Science, (2012 - current)
May 2015. Defense April 24, 2015.

M.Sc. Economics and Statistics, Utah State University (2010 - 2011)

M.Sc. Resources and Applied Economics, University of Nevada, Reno (2008 - 2010)

M.Sc. Environmental and Natural Resources Economics
Chulalongkorn University Bangkok Thailand (1998 - 2000)

B.E. Khon Kaen University, Khon Kaen, Thailand (1995-1998) Honor

PROFESSIONAL EXPERIENCE

PhD Candidate, Department of Environment and Society, Utah State University, 2014 - 2015.

Develop three research projects as part of my dissertation including mail survey.

MS Student

Research Assistance, Applied Economics department, Utah State University (2010 - 2012)

Projects under guidance of Assoc. Prof. Kynda Curtis including input Cooperative Extension classes evaluation, In-person survey on Farmer's Market for summer 2011.

Project under guidance of Assoc. Prof. Paul Jakus: Utah waterfowl Hunting Study

Grader for Business Statistics (STAT 2300), Department of Mathematics and Statistics (Fall, 2010)

Research Assistance, Resource Economics department, University of Nevada, Reno (2009-1020). I developed equations which consist of the model and estimate parameters under the guidance of Dr. Kim Man-Keun. The project is funded by Food and Agricultural Policy Research Institution (FAPRI)

Faculty of Management Science Department, Khon Kaen University Thailand (2003 - current). Lecturer position

Faculty of Graduate Studies program (MBA), Suan Dusit Rajabhat University, Bangkok Thailand (2000-2002)

PUBLICATIONS

Author (Preparation)
Chakreeyarat, Voravee S., and Brunson, M. W. (2015). Influence of individuals worldviews on wildfire mitigation decision processes. Manuscript in prep for submission to *Society and Natural resources*

Coauthor

Curtis, K., V. Chakreeyarat, and I. Yeager, (2012). “Potential for Farmers’ Market Season Extension: Grower and Market Manager Viewpoints.” Utah State University Extension Fact Sheet, Applied Economics/2012-22pr.

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Curtis, K., V. Chakreeyarat, and I. Yeager, (2012). “Farmers' Market Manager Perspectives on Season Extension Potential.” Utah State University Extension Fact Sheet, Applied Economics/2012-26pr.

Curtis, K., V. Chakreeyarat, and J. Dominique Gumirakiza, (2012). “Community Supported Agriculture Programs: A Sustainable Approach to Local Foods.” Utah State University Fact Sheet, Applied Economics/2012-25pr.

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RESEARCH EXPERIECE

Illegal Dumping Mitigation (Term paper, 2010)

Environmental Kuznet’s curve and Economics Growth of Thailand (2008)

Economics and Social Impact Assessment of Disaster in the northeast Thailand (2009)

Fishery Impact of Dam: A case study of Pak Moon irrigation (Thesis, 2000)

AWARDS AND HONORS

Teaching award: Principle of Economics (2003), Natural Resources Economics (2004)

Appreciation as volunteer in promoting "Sustainable Ecotourism in Thailand" seminar organized by Ministry of Tourism and Sport of Thailand and Chulalongkorn University Thailand (2000)

Undergraduate honor degree award (1998)

INVITED PRESENTATIONS

International Association Wildland Fire April 20-22, 2015

PROFESSIONAL MEMBERSHIPS

Society and Natural Resources

International Association of Wildland Fire

Science in Society

Society of Risk Analysis

International Society for Ecological Economics

Agricultural Applied Economics Association

Associations of Americans Geographers

SKILLS

Proficient in geographical software: ArcGIS

Proficient in statistical software programs: R, Python, IBM SPSS, IBM AMOS, MATLAB

Proficient in Microsoft products: Word, Excel, Visio, PowerPoint