Spring 2018

Understanding Colorado’s Wildland-Urban Interface: Assessing Risk Perception and Wildfire Mitigation in Post-Wildfire El Paso County

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Understanding Colorado’s Wildland-Urban Interface: Assessing Risk Perception and Wildfire Mitigation in Post-Wildfire El Paso County

By
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A thesis submitted to the
University of Colorado at Boulder
In partial fulfillment
Of the requirements to receive
Honors designation in
Environmental Studies
May 2018

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Abstract

The wildland-urban interface (WUI) of the conterminous United States is becoming increasingly important for both private and government land managers due to the increased wildfire risk. Private landowners within the WUI are responsible for wildfire mitigation on their own property, but not all landowners adopt or conduct sufficient measures. This study attempts to clarify factors that influence wildfire mitigation, using the WUI of El Paso County, CO as a case study. Social determinants, such as age, retirement status, and political affiliation were not found to be related to more frequent mitigation. Place dependency variables, such as local employment and duration of residence, were also found to have no association with mitigation, contrary results in preexisting literature. How residents perceived the wildfire risk was found to be an important determinant of more frequent mitigation, suggesting the need for education programs that help WUI residents more accurately evaluate the risk to lower the need for additional government firefighting resources in the event of a wildfire. Insurance policies requiring mitigation were sparse across the study area, and the requirements varied between companies. This study highlights the need for more comprehensive collaboration between private and public land managers, and an increased effort from federal agencies to educate landowners about wildfires in the abutting WUI.
Preface

This project came to me when evaluating the possibility of a controlled burn as a land management tool when working for a city conservation office. The outcry from neighboring property owners over the possibility of the fire spreading onto their land led to the line of questioning that would eventually become this thesis. This project would not have been possible without the guidance of my advisors Dale Miller, Steven Vanderheiden, and Michael Dwyer – thanks for sticking with me throughout the near constant delays and setbacks during this process. A special thanks to Gregory Simon and Dalton Dorr, who helped me with the initial stages of this project, and Andrea Feldman, who helped me see it through to completion. Thanks to the El Paso County Sheriff’s office and their Wildland Fire Division for giving me a better understanding of my study area. Finally, many thanks to the residents of northern El Paso County for allowing me for their time and input – without them, this project would not have been possible.
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**Introduction**

In 2013, the Black Forest fire burned 14,280 acres and destroyed or damaged over 511 homes in northwestern El Paso County, Colorado ("Black Forest Fire", 2013). Most people and land affected by this disaster lived in the area known as the wildland-urban interface (WUI), which is the area where human structures and development meet or intermix with undeveloped wildlands. The WUI has been a focal point in recent decades for researchers from many fields examining society-environment conflicts, particularly regarding wildfires. With the expansion of the WUI, especially in the American West, more people and structures come within proximity of wildfire-prone wildlands. As a result, The United States Forest Service (USFS), and to a lesser extent the Department of the Interior (DOI), are having to spend increasingly more of their budgets on both wildfire mitigation and wildfire suppression within and around the WUI. In fact, the portion of the USFS budget devoted to wildland fire management more than tripled – from 16% to 52% - between 1995 and 2015 (USDA, 2015). Private landowners within the WUI are responsible for protecting their own properties, and properly mitigated properties lessen the need for additional government resources in the event of the wildfire, but not all landowners engage in hazard mitigation.

In this thesis I focus on the effects of the WUI on government wildfire management spending, how this is influenced by private WUI landowners not undertaking adequate fire mitigation activities, and what determinants influence WUI residents to undertake wildfire mitigation. I explore household determinants of wildfire mitigation within the WUI through a household survey conducted in northern El Paso County, CO - an area with large tracts of federally-owned wildlands bordering extensive forested residential developments.
Background

A wildfire is any unplanned fire, human-ignited or not, which affects either wildlands or lands with human development (NIFC, 2017). In fire-adapted ecosystems, semi-regular fire regimes can contribute to better overall ecosystem health and reduce the potential for future fires by reducing fuel loads (Veblen, Kitzberger, & Donnegan, 2000). However, wildfires also pose a major threat to human structures and lives and have the potential to derail livelihoods and communities (Bracmort, 2012). The Western United States is particularly prone to wildfires, damaging public and private timber stocks and watershed functionality, among other valuable natural resources (Westerling et al., 2006).

In the western United States, wildfires have been increasing in both intensity and frequency since the mid-1980s (Westerling et al., 2006). Climatic shifts in the region have led to rising temperatures, less precipitation, and earlier snowmelt; and these conditions presently contribute to a heightened risk of wildfire ignition, as well as future changes to regional fuel types (Flannigan et al., 2009). These factors, especially the lower precipitation, can also increase the flammability of standing fuel loads, a problem that has been exacerbated by decades of forest mismanagement.

Before 1995, forest policies in the United States vastly underrated the role of fire in various ecological processes (USDA, 1995), and pressed for wildland fire policies that were oriented towards protecting the existing forests for future human use, whether it be industrial, recreational, or otherwise (Graves, 1910, as cited in Stephens and Ruth, 2005). Large fires, like those experienced in the Rocky Mountains in 1910, led to significant losses of timber stocks, and were used as the justification for total suppression of fires in support of the then-highly profitable timber harvesting industry (Pyne, 2017). This is the point where the responsibility for managing fire regimes in the U.S became that of the federal government in the form of the United States
Forest Service, as opposed to more localized land managers (Collins, 2008). These policies led to a massive buildup of fuels in western forests over the course of the 20th century (Johnson, Miyanishi, and Bridge, 2001). Forests that were previously dominated with mature ponderosa pine trees and low amounts of ground cover turned into dense stands of ponderosa pine, with little separation between individual trees as well as low amounts of separation between ground cover and the canopies (Fulé et al., 1997; Moore et al., 1999; Schoennagel et al., 2004). The resulting fire regime allowed for fires that are significantly larger in both scale and intensity (Schoennagel et al., 2004). The increased density of stands, along with the deeper ground cover from decades of accumulation, allow fires to burn across greater areas due to a more continuous distribution of fuel. The shorter distance between the younger trees' canopies and the ground means that wildfires that would previously have raged only on the ground can spread more easily upward, creating canopy fires that burn with greater intensity and with an increased chance of tree mortality.

**The Wildland-Urban interface**

The WUI is an area where residential homes or developments intermingle within or are located around areas of undeveloped, vegetated areas (Stewart, Radeloff, Hammer, & Hawbaker, 2007). This area (See Fig 1; Radeloff, Hammer, Stewart, Fried, Holcomb, & McKeefry, 2005) is generally the focus of the majority of wildfire-related policy makers because it contains the majority of the population at risk of being exposed to the wildfire hazard. The interface between private and public lands creates a division of responsibility for the wildfire hazard with both private and public elements, although most of this responsibility currently lies with the United States Government in the form of the United States Forest Service (Gorte, 2013).

**Fig. 1:** The 2010 WUI of the conterminous United States (Radeloff et al., 2005)
The area that became the wildland-urban interface previously consisted of economies that were predominantly based on resource extraction and livestock grazing, depending on the specific region (England and Brown, 2003). This lasted from the introduction of railroads to the western U.S. in the late 19th century until the second half of the 20th century, when the maturation of the postwar baby boomer generation led to the rapid growth of the rural amenity economy (Gosnell and Abrams, 2011). The current wildland-urban interface began to form during the "rural rebound" of the 1990s, when unprecedented growth occurred in many rural regions across the United States (Johnson, 1999).
Amenity-driven migration towards the urban periphery is a phenomenon perpetuated mainly by the retiring baby boomer generation, along with younger couples seeking the perceived slower lifestyle of suburban life (Theobald & Romme, 2007; Radeloff, Hammer, Stewart, Fried, Holcomb, & McKeefrey, 2005; Hammer, Stewart, & Radeloff, 2005). The cultural values instilled by the environmental movements of the 1960s and 1970s led to the expansion of the amenity economy to the point where it became more influential than resource extraction, leading to rapid changes in regional land uses (Riebsame, Gosnell, & Theobald, 1996). Western states in particular have shown a strong correlation with certain amenity values such as forested area or elevation change with increased rates of growth, and contain extensive rural amenity economies that are still attracting more potential WUI residents (McGranahan, 1999).

How Wildfire Management is Funded
The majority of wildfire protection costs are borne by the United States Forest Service and the Department of the Interior, both of which are funded by Congress. In accounts these are typically divided between wildfire suppression, preparedness, fuel reduction, and site rehabilitation (Gorte, 2013). Wildfire suppression makes up the largest portion (Avg. $962m FY2002-FY2012) of federal fire-related spending (Gorte, 2013). Funds are used to combat wildfires that ignite on, spread from, or threaten federal land, and can be supplemented by emergency appropriations from Congress (Gorte, 2011). The amount of these emergency funds fluctuates greatly from year to year, depending on the length and severity of the fire season. Preparedness funds, making up the second largest account (Avg. $964m FY2002-FY2012), are utilized for firefighter training and equipment. Fuel reduction funds (Avg. $522m FY2002-FY2012) are used for preventative and mitigating actions in fire-prone federal lands, affecting
the long-term ability of federal resources to effectively contain and prevent wildfires, as well as reducing future fire suppression costs (Gorte, 2013). Site rehabilitation makes up the smallest portion of federal wildfire spending (Avg. $48m FY2002-2012), although federal agencies like the USFS often divert funds from other accounts for land rehabilitation (Gorte, 2013; Gorte, 2011).

Local and state departments, who are responsible for wildfires igniting on private and local public lands, are funded locally, although this funding is again coming from all local public taxpayers, not just WUI residents or others who live in fire-prone areas. Many locales with significant populations in the WUI will find rural fire protection districts with mill levies-in addition to having access to state and county emergency preparedness funds. Some local wildfire management accounts are further supplemented by federal wildfire assistance funds, the majority of which come in the form of funding passed on from federal agencies to states, and by states to local agencies for wildfire suppression and protection efforts. The Clarke-McNary Act of 1924 was the first major legislation that authorized the federal government, then in the form of the Secretary of Agriculture, to provide monetary and technical assistance to states for wildfires. The assistance provided at the time was geared towards the expansion and protection of the public and private forestry industries, as well as water sources in western regions (Agee, 1998). This assistance was usually provided in the form of matching grants, wherein the states must match the funds provided by the federal government. The Clarke-McNary Act was more recently revised in the Cooperative Forestry Assistance Act of 1978, which expanded the scope and range of the assistance that can be provided to states, again with the intention of expanding the security and profitability of forest-related natural resources on both public and private lands. Because of the revisions, the USFS can now allow, at its discretion, for additional funds to be appropriated
to a state, so long as the total federal funds do not exceed the total amount spent by the state for their own forest resources program. Since this act considers many expenditures unrelated to the fire, this allows the USFS to allot additional funds to a state for any natural resources management activity they deem necessary, so long as the total funds sent to the state do not exceed the state's own total forest-related expenditures.

The Healthy Forests Restoration Act (HFRA), signed into effect in 2003, was an effort to extend the abilities of the USFS and the Department of the interior to conduct more proactive wildfire management strategies on federal lands (Healthy Forests Restoration Act, 2003). However, this act included a provision that at least 50% of fuel treatment budgets be allocated to fuel reductions within the wildland-urban interface (Healthy Forests Restoration Act, 2003). This stipulation leads to both the under protection of lands outside the WUI, and increases the potential for private landowners to free ride on fuel treatments in their area (Crowley, Maliki, Amacher, & Haight, 2009; Busby & Albers, 2003). By forcing land managers to conduct mitigation within the bounds of the WUI, the HFRA increases the non-WUI public liability for private values and forces land managers to in effect subsidize fire mitigation at taxpayer expense (Busby and Albers, 2010).

**Wildfire Management Expenditures are Increasing**

Wildland fire management expenses have been rising since the mid-1990s, with USFS spending on wildfire suppression alone increasing from $721,663,268 USD in 1990 to $2,130,543,000 in 2015 (National Interagency Fire Center, 2015; controlled for inflation). When examining what is contributing to increased wildfire suppression spending, researchers have focused on three major causes (Gude, Jones, Rasker, & Greenwood, 2013):
1. There is a greater frequency and intensity of fires, due to changes in both the climate and local ecosystems.
2. A higher demand for trained firefighters and more advanced equipment
3. Increased residential development in the WUI

The overall number of wildfires in the American West has been increasing since the mid-1980s (Westerling, Hidalgo, Cayan, & Swetnam, 2006), in addition to longer wildfire seasons, more burned, and a greater frequency of large (>400 ha; Westerling et al., 2006) fires. Climatic shifts have led to warming temperatures, more frequent and prolonged drought conditions, and decreased precipitation in areas that have had traditionally moderate fire regimes (Westerling 2016; Heyerdahl, Brubaker, & Agee, 2002). These conditions, and the climatic shifts themselves, are further exacerbated by human influences. Federal and state policies of strict fire suppression beginning with the inception of the national forest system in the early 20th century have led to a build-up of fuel loads in the American West (Busenburg, 2004). Denser tree stands and accumulating deadfall provide the fuel sources needed for fires to spread faster and over larger areas, especially near centers of human habitation where fire suppression policies were most strictly implemented (Stephens & Ruth, 2005).

To combat the increased wildfire threat, Federal, State, and Local governments have needed to spend more money on equipment, training, and wildfire research (Gorte, 2011). Most of the equipment and training spending comes from the USFS (Ellison, Mosely, Eversm & Nielson-Pincus, 2012), who also provides technical assistance and further training to smaller more localized departments. This is especially so in more rural forested areas, where in many cases residential development of the WUI has surpassed the wildfire management and protection capabilities of the often volunteer local fire districts (Hammer, Stewart, & Radeloff, 2009).
The expansion of the WUI indirectly increases the costs associated with wildland firefighting for federal agencies. More homes in fire-prone areas mean more human structures that need protection (Liang et al., 2008). The WUI of the conterminous United States consists of 9.4% of the total land area and contains roughly 38.5% of all housing units (Radeloff et al., 2005). The current state of the WUI is mostly the result of recent rural migration trends, having experienced a 52% increase in land area since 1970 (Theobald & Romme, 2007). The majority (~89%; Theobald et al., 2007) of this land is privately owned, meaning that a notable portion of wildfire management in the United States is the responsibility of private landowners.

Despite the WUI being majority privately owned (Theobald et al., 2007), the USFS and DOI have need to devote an increasing amount of money and resources to wildfire management in the WUI to protect human structures there. Any WUI that abuts large tracts of federally owned land is dependent on wildfire management actions taken on abutting federal lands for wildfire safety. This is because federal agencies are responsible for wildfire suppression when the fire’s ignition happens on federal lands, and the safety of abutting residential areas must be prioritized. As the WUI has continued to expand, there are increasingly more residential developments that are at increased risk of exposure to wildfires stemming from nearby federal forests that need protection. But as demand for federal wildfire mitigation on federal lands that abut the WUI increases, so too are the number and size of wildfires. Since the majority of wildfire management funds are now being diverted to pay for wildfire suppression, the needed mitigation in the larger WUI cannot be feasibly paid for or conducted. Because of this, individual homeowners whose land borders public forests must conduct their own mitigation to reduce their own risk of wildfire exposure.
How Individual Mitigation Reduces Firefighting Costs

Even though the federal government is required to use at least 50% of its fuel treatments in the WUI, this only applies to government-owned lands, with only a few minor exceptions (Gude et al., 2013). Private landowners are responsible for protecting their land and their structures by conducting wildfire mitigation actions on their own property. However, in most states mitigation by private landowners is voluntary. Some states, like California, do have mitigation enforcement built into WUI building and zoning codes (Gude, Hansen, & Jones, 2007). Other states, like Arizona and Colorado, are “Local Option States”, where it is up to county and municipal governments to develop and enforce their own mitigation laws, if at all (Burton, 2013).

Properly mitigated properties reduce the need for additional firefighting personnel, equipment, and time, meaning that those resources can be used elsewhere in the event of a wildfire. However, the fire safety of a property is directly influenced by any abutting properties (Brenkert-Smith, Champ, & Flores; 2006). In small plots, where a house or structure is close to a property line, the recommended defensible space for a house (usually >30ft) may cross over into an abutting plot. If the abutting landowner does not conduct mitigation measures on this portion of their property, they increase the wildfire risk of their neighbors, and the need for additional firefighting resources to defend that house in the event of a wildfire (Shafran, 2008). The same applies to federal properties; federal properties bordering tracts of unmitigated private WUI land are at greater risk of wildfire damage, and vice versa. However, federal land managers do not have the ability to enforce wildfire mitigation on nonfederal properties. Enforcement, if there are local policies that require mitigation, in the WUI is the responsibility of local and state authorities, who are also the authorities responsible for allowing and furthering residential development these areas.
What Influences Individual Wildfire Mitigation

When faced with uncertain risks, such as wildfire, risk-adverse individuals will attempt to protect themselves and their property in accordance to their valuation of that risk (Winter & Fried, 2000). Looking from the outside, there appears to be a moral hazard problem within the WUI associated with government wildfire protection and wildfire insurance. If the government is subsidizing their protection, or if a private landowner has a comprehensive fire insurance policy, these could be incentives for private landowners to reside in more risky areas or conduct less (or no) mitigation. However, recent literature indicates that this is not the case and that WUI residents simultaneously allocate resources towards mitigating risks and ensuring against them (Talberth, Berrens, McKee, & Jones, 2006). In addition, wildfire insurance appears to not influence individuals to live in more risk-prone areas, such as the WUI (Rasker, 2016).

Individuals moving towards the wildland-urban interface are predominantly driven there by the perceived amenity values, and often do not factor the wildfire risk into their decisions (Donovan, Champ, & Butry, 2007; as cited in Rasker, 2016). However, the amenity values of a property are an important determinant of wildfire mitigation on a property. Mitigating actions may be perceived by the landowner as detrimental to the amenity values on their property (Winter & Fried, 2000), and may not be carried out as a result.

While the study of demographic influences on natural hazard mitigation is relatively well documented, the relationships between demographic characteristics of specifically WUI residents and the rate at which they conduct proactive mitigation for wildfires is somewhat lacking (Collins, 2008). Previous studies have offered mixed results when looking at characteristics such as income (Brenkert-Smith, Champ, & Flores, 2012), where results have shown both strong correlations (Collins, 2008) and weak or no correlations (Schute and Miller 2010). Other characteristics, like duration of residence, and whether the resident is an owner or renter of a
property, have had significant measurable impacts on whether a WUI resident will conduct mitigation (Collins, 2008; Biasi, Colantoni, Ferrara, Ranalli, & Sacati, 2015). While increased age has been shown to be associated with a smaller likelihood of mitigating actions (Fischer, 2011), retirement status has shown to be associated with higher levels of household mitigation (Collins, 2008). In one study political party was shown to have an impact on mitigation (Talberth et al., 2006), with a negative correlation being drawn between Republican Party affiliation and mitigation efforts.

Recent studies have focused on how wildland-urban interface residents view the efficacy of mitigation actions and the perceptions of the wildfire risk (Winter & Fried, 1997). Certain actions, like prescribed burns, are commonly regarded as dangerous and unnecessary by WUI residents, who may at the same time not regard mechanical fuel removal as worthwhile due to its considerable time and labor considerations. Environmental beliefs and knowledge have often been cited as factors that influence hazard mitigation (Paton, Sagala, Okadam Jang, Burgdt, & Gregg, 2010). However the degree to which mitigation is affected varies depending on the individual (Paton, 2006, as cited in Paton et al., 2010). WUI residents who possess strong environmental values will often engage in hazard mitigation measures that they regard to be environmentally-friendly (Paton, 2006; Winter & Fried, 2000), while simultaneously shying away from, or even actively preventing, wildfire mitigation measures they deem detrimental to the environment (Paton, 2006; Winter & Fried, 2000; Blanchard & Ryan, 2007). Mitigation strategies like prescribed burns are particularly susceptible to negative public opinions, especially since they also perceived as relatively uncontrollable and unsafe (Fischer, 2011; Paton, 2006).
Those who consider wildland fires themselves to be an uncontrollable hazard consequently believe that investments in wildfire mitigation are limited in their effectiveness or even inconsequential (Winter & Fried, 2000). In addition, previous wildfire exposure can have differing impacts on how an individual, or a community, perceives that risk. Previous exposure, in the case of wildfires, can be interpreted as anything from a wildfire burning an individual's property to having to evacuate from a proximate fire. Past literature indicates that the type of impact and exactly how it affects the perception of that risk can vary greatly based on numerous factors (Slovic 1987; Paton and Johnston, 2001). Exposure to wildfire can lead individuals to believe that the risk is more frequent or probable and may lead them to make future decisions regarding that risk based on the psychological stress experienced during or after exposure (Martin et al., 2007). However, this may just be a short-term effect, meaning that over time the influence of exposure on perception fades (Martin et al., 2007). Exposure to a disaster may also lead to the hazard being perceived as out of the resident’s control, leading to them conducting less mitigation measures and becoming more dependent on government or community intervention (Gorte, 2013).

**Hypotheses**

The literature review revealed that social variables, place dependence, and risk perception are all associated with wildfire mitigation. Ecological knowledge has been studied as a determinant of mitigation in more recent literature, but missing from these studies is a look at how WUI residents understand the human nature of wildfires. Collins (2008) suggests that future studies should look at a WUI resident’s knowledge of how humans are partly to blame for the current number of wildfires’ relationship with wildfire mitigation. If the WUI resident understands the extent to which humans (and themselves) are responsible for the current amount of exposure to wildfires (84% of ignitions are human-caused; Balch, Bradley, Abazoglu, Nagy,
Fusco, & Mahood, 2017), it is reasonable to predict they will mitigate against the hazard. This lead to the first hypothesis that I decided to test, that: wildfire mitigation will be related to knowledge of the human nature of wildfires.

Anecdotal assumptions of a moral hazard problem within the WUI rely on the assumption that WUI residents believe that the government is mostly, if not wholly responsible for protecting their property from wildfires. However, past studies have indicated that residents of the WUI have a strong sense of personal responsibility for protecting themselves and their own property against wildfires (Winter and Fried, 2000). Because of this, I wanted to ask whether WUI residents in my case study areas believed that government wildfire suppression and mitigation measures enable them to live where they do, hypothesizing that WUI resident’s opinion on whether government wildfire management measures enable their residence will conduct more mitigation measures.

In studies focused on determinants of household risk mitigation in the WUI, generalizable results across regions are hard to come by. Peer-reviewed articles have conducted quantitative studies in the WUI of California (Collins, 2005), Arizona (Collins 2008), Michigan (Winter & Fried, 2000), and Colorado (Brenkert-Smith et al., 2006; Martin et al., 2007). However, the cases utilized in Colorado have focused on areas with strong homeowner’s associations or wildfire safety prevention groups with high levels of community participation (Brenkert-Smith et al., 2006). To have results that could be compared to other WUI studies, I will also be including the following hypotheses: that social variables will be related to wildfire mitigation, place dependency will be related to wildfire mitigation, and that risk perception will be related to wildfire mitigation.
Methods

To gain a better understanding of what variables influence frequency of mitigation, I collected data through a household survey administered in Black Forest and Monument. I developed a 21-question survey instrument to test my hypotheses (see appendix A), which also included other possible determinants that would be related to wildfire mitigation. Over the course of five days (Feb 17th, 18th, 20th, 24th, and 25th), I administered surveys on a handheld tablet using the Qualtrics online platform by going door to door in the WUI of the study communities; an area determined utilizing maps from the Colorado State Forest Service (CSFS). I chose every 5th house for attempted survey administration, however, many properties had either a fence with gates or no trespassing signs, which often forced me to choose households more infrequently than 1 in 5. A total of 104 surveys were administered in person. In my survey, I did not make the distinction between Black Forest and Monument, instead including the two towns as a way to include populations both with and without experience with wildfires, as Black Forest was directly subject to a wildfire and Monument had only proximate exposure to some fires in the El Paso County Area.

The Study Area

Colorado’s WUI (see Fig. 2; Radeloff et al., 2005) consists of roughly 6.6 million acres, occurring disproportionately within the Front Range Region. The Front Range of Colorado consists of 16 urban counties that span the eastern slope of the Rocky Mountains and is home to more than 85% of Colorado’s population (Haas, Calkin, & Thompson, 2015). The Front Range of Colorado has been experiencing population growth rates that have ranged from double to triple national averages since the late 1980s, particularly in the WUI (Baron et al., 2000). This is likely a result of the amenity-driven migration trends, facilitated by both an increase in
environmental values, as well as access to emerging technical industries. Colorado shows a strong correlation between certain amenity values, such as elevation change or forested area, and growth rates in areas in proximity to those areas (McGranahan, 1999). The moderate fire regime in the area consists of wildfires every 2-7 years, due to the ponderosa pine and prairie grass habitats that are particularly well adapted to fire (Veblen et al., 2000). Decades of fire suppression policies have led to denser stands of the ponderosa pine and Douglas fir, meaning fires in the front range have a greater capacity to burn more intensely and spread to greater areas (Graham, 2003).

**Fig 2.** Colorado’s WUI, with study area marked in black (Radeloff et al., 2005)
I decided to focus my study area further to El Paso County (see Fig. 3; CSFS CO-Wrap), which in contemporary wildfire impact models has the highest percentage of population exposed to wildfires stemming from ignitions on federal lands compared to other Front Range counties (Haas, Calkin, & Thompson 2015). This is most likely due to the combination of dense residential developments surrounding Colorado Springs, along with a high concentration of federal landholdings. The county contains portions of Pike and San Isabel National Forests, along with several Department of Defense (DOD) properties, including the Air Force Academy and Peterson Air Force Base. Fires ignited on DOD lands in El Paso County are predicted to affect the greatest amount of people, taking into consideration that they border the residential sprawl of Colorado Springs as well as containing their own inhabitants (Haas et al., 2015). The area has also been subject to several of Colorado’s largest and most destructive wildfires in the state’s history, including the 2002 Hayman Fire (55,750 ha burned, 600 structures destroyed), the 2012 Waldo Canyon Fire (7,384 ha burned, 346 structures destroyed; NIFC, 2017; Waldo Canyon Fire Update, 2012), and the Black Forest Fire (5,780 ha burned, 511 structures destroyed; NIFC 2017). The Hayman Fire was the largest fire by area in the state of Colorado, and the Black Forest Fire is the most destructive fire by homes and value of structures destroyed. Both the Hayman and Black Forest fires were the result of human ignitions. These fires occurred during periods of dry and windy conditions, in areas with high fuel densities that facilitated quick fire spread, conditions that are becoming increasingly common on the Front Range (Graham, 2003; Fire Data and Statistics, 2010 - 2017).

I wanted to sample areas that are representative of the WUI, while reflecting the socioeconomic and ecological conditions of Colorado’s Front Range and El Paso County. I further narrowed my study area to the communities of Monument and Black Forest, both located
in the northern portion of the county. Due to Black Forest’s 2013 wildfire experience, Monument was included as a way of getting survey responses from WUI residents without past wildfire experience, which was predicted to influence mitigation. Monument, CO, is a town in the north of El Paso County, with a population of 5,742, located 15 miles to the northwest of Black Forest (U.S Census Bureau, 2012). Fire protection services in the area are provided by the Tri-Lakes Monument Fire Protection District, which will provide fire mitigation home assessments in concordance with federal Firewise guidelines at the homeowner’s request. Monument borders large tracts of federal land, including the Pike and San Isabel National Forests, as well as having Air Force Academy land nearby to the south.

Fig. 3: WUI of northern El Paso County with study areas highlighted retrieved from https://www.coloradowildfirerisk.com/map/Public
Black Forest, CO is an unincorporated census-designated place (CDP) located in north of Colorado Springs in El Paso County, with a population of 13,116 as of 2010 (U.S. Census Bureau, 2012). Almost the entirety of Black Forest is considered WUI, and the vast majority of the land is owned by private individuals. From June 11th to June 20th, 2013, Black Forest was subject to the most destructive wildfire in the history of the State of Colorado. It burned 14,280 acres and 511 homes over its duration, and cost over 5.2 million dollars to suppress (STAFF, 2013). Not only was there significant damage to Black Forest’s human structures, but also to the forests which the town's name was derived. Private forest owners experienced a significant loss in both timber and amenity value on their properties, causing a significant temporary drop in real estate values in the area. While the forested area in the community has significantly decreased, the area is still wildland-urban interface that is at risk of wildland fire. Unlike Monument, Black Forest does not border any large tracts of federal land, and as a result receives less attention from federal land managers looking to perform or fund wildfire mitigation actions. However, Black Forest’s majority-volunteer fire rescue has been particularly active in expanding and improving its services. Most of the department’s funding comes from local taxpayer money, with applications filed for matching grants when larger projects need to be undertaken or equipment replaced. Black Forest also has a comprehensive community wildfire protection plan (CWPP), which expands upon El Paso County’s CWPP for unincorporated places and includes more proactive and comprehensive wildfire mitigation and prevention measures for homes located in wooded areas.

**Results**

Out of the total surveys collected (n=104), only one was deemed unusable due to the absence of almost all answers, leaving 103 total survey responses. Some questions utilized in the
survey instrument were deemed unusable, which I describe in detail in discussion, as they contained unusual and confusing wording. However, I found that most of the data was still usable (See Table 1) for the purposes of testing my hypotheses. Both the descriptive statistics and the chi-squared tests were conducted using the Qualtrics online platform, with the exception of the median values, which were calculated using RStudio.

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<td>Mitigation frequency</td>
<td>2.59</td>
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<td><strong>Independent Variables</strong></td>
<td></td>
</tr>
<tr>
<td>Human Responsibility</td>
<td>2.74</td>
</tr>
<tr>
<td>Government Enable</td>
<td>3.78</td>
</tr>
<tr>
<td>Insurance Requires Mitigation</td>
<td>1.84</td>
</tr>
<tr>
<td><strong>Social Variables</strong></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>2.59</td>
</tr>
<tr>
<td>Retirement Status</td>
<td>2.40</td>
</tr>
<tr>
<td>Political Affiliation</td>
<td>2.31</td>
</tr>
<tr>
<td><strong>Place Dependency</strong></td>
<td></td>
</tr>
<tr>
<td>Local Employment</td>
<td>1.54</td>
</tr>
<tr>
<td>Residential Tenure</td>
<td>3.24</td>
</tr>
<tr>
<td>Tenure Type (Own/Rent)</td>
<td>1.89</td>
</tr>
<tr>
<td><strong>Perceived Risk</strong></td>
<td></td>
</tr>
<tr>
<td>Perceived Risk</td>
<td>2.81</td>
</tr>
<tr>
<td>Concern about wildfires endangering property</td>
<td>2.38</td>
</tr>
<tr>
<td>Past Exposure</td>
<td>1.61</td>
</tr>
</tbody>
</table>
I utilized chi-squared tests of independence to determine whether relationships exist between the individual variables and frequency of mitigation, since all variables in this study were categorical. If necessary and possible, I merged columns and/or rows in the contingency table to ensure that expected frequency counts were at least five in every cell to ensure the chi-squared values were accurate. For all tests, a significance level of 0.05 was used to test the hypotheses.

**H1) Wildfire mitigation will be related to knowledge of the human nature of wildfires**

The chi-squared test of association indicates that the extent to which the respondents believed humans are responsible for the current amount of exposure to wildfires is not statistically associated (p=0.75) with the mitigation frequency (See Table 2). Worth noting is that only one respondent surveyed believed that humans are not at all responsible for the current amount of exposure to wildfires. As some expected values were less than five, the “not at all” and “somewhat” columns were merged, along with the “mostly” and “completely” columns to get a more accurate chi-squared value. However, this also did not yield statistically significant results or a more accurate chi-squared value.

<table>
<thead>
<tr>
<th>Extent to which humans are responsible for exposure to wildfires</th>
<th>Mitigation Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>Less than once a year</td>
</tr>
<tr>
<td></td>
<td>Once a year</td>
</tr>
<tr>
<td></td>
<td>Twice a year</td>
</tr>
<tr>
<td></td>
<td>More than twice a year</td>
</tr>
<tr>
<td>Somewhat</td>
<td>Less than once a year</td>
</tr>
<tr>
<td></td>
<td>Once a year</td>
</tr>
<tr>
<td></td>
<td>Twice a year</td>
</tr>
<tr>
<td></td>
<td>More than twice a year</td>
</tr>
<tr>
<td>Mostly</td>
<td>Less than once a year</td>
</tr>
<tr>
<td></td>
<td>Once a year</td>
</tr>
<tr>
<td></td>
<td>Twice a year</td>
</tr>
<tr>
<td></td>
<td>More than twice a year</td>
</tr>
<tr>
<td>Completely</td>
<td>Less than once a year</td>
</tr>
<tr>
<td></td>
<td>Once a year</td>
</tr>
<tr>
<td></td>
<td>Twice a year</td>
</tr>
<tr>
<td></td>
<td>More than twice a year</td>
</tr>
</tbody>
</table>

*Note. \( \chi^2 = 5.89\), df = 9. Numbers in parentheses indicate column percentages. *p < .05

**H2) WUI resident’s opinion on whether government wildfire management measures enable their residence will conduct more mitigation measures**
The chi-squared test of association (see Table 3) indicates that respondent’s opinions on
the statement "Government wildfire mitigation and suppression measures enable me to live
where I do" and mitigation frequency were not statistically associated (p=0.49). Since some of
the expected frequencies were less than five, the chi-squared statistic may be inaccurate. To
remedy this, I merged the columns “strongly agree” with “somewhat agree”, and “strongly
disagree” with “somewhat disagree”, and the rows “twice a year” with “more than twice a year”,
along with “less than once a year” and “once a year”. However, this also did not yield an
accurate chi-squared value (1.09*) or statistically significant results (p=0.58) as expected
frequencies less than five remained.

Table 3

<table>
<thead>
<tr>
<th>Mitigation Frequency</th>
<th>Strongly agree</th>
<th>Somewhat agree</th>
<th>Neither agree nor disagree</th>
<th>Somewhat disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than once a year</td>
<td>0 (0.00%)</td>
<td>5 (29.41%)</td>
<td>11 (52.38%)</td>
<td>7 (43.75%)</td>
<td>16 (38.10%)</td>
</tr>
<tr>
<td>Once a year</td>
<td>0 (0.00%)</td>
<td>5 (29.41%)</td>
<td>11 (52.38%)</td>
<td>7 (43.75%)</td>
<td>16 (38.10%)</td>
</tr>
<tr>
<td>Twice a year</td>
<td>2 (66.67%)</td>
<td>7 (41.18%)</td>
<td>5 (23.81%)</td>
<td>5 (31.25%)</td>
<td>19 (45.24%)</td>
</tr>
<tr>
<td>More than twice a year</td>
<td>1 (33.33%)</td>
<td>1 (5.88%)</td>
<td>2 (9.52%)</td>
<td>1 (6.25%)</td>
<td>1 (2.38%)</td>
</tr>
</tbody>
</table>

*\( \chi^2 = 11.45^* \), df = 12. Numbers in parentheses indicate column percentages.

*\(p < .05\)

H3) Social variables will be related to wildfire mitigation

Age, which needed to be merged into the categories of 18-54 years and 55 years or older
(see table 4), was determined to not have a statistically significant relationship with mitigation
(p-value=0.34), wherein the rows “twice a year” with “more than twice a year”, along with “less
than once a year” and “once a year” were again merged. Notably, the majority of WUI residents
surveyed fell into the 18-54 range. This, combined with fact the 60.19% of respondents who
responded that no adults in their household were retired, indicates an oversampling of younger
WUI residents.
Table 4

*Results of Chi-square Test and Descriptive Statistics for Mitigation Frequency by Age*

<table>
<thead>
<tr>
<th>Mitigation Frequency</th>
<th>Age Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than once a year, once a year</td>
<td>18-34 years, 35 to 54 years</td>
</tr>
<tr>
<td>Twice a year, more than twice a year</td>
<td>35 (81.40%)</td>
</tr>
<tr>
<td></td>
<td>44 (73.33%)</td>
</tr>
</tbody>
</table>

*Note.* $\chi^2 = 0.91$, df = 1. Numbers in parentheses indicate column percentages.

*p < .05*

Originally my question querying about household retirement status had three options: All adults in this household are retired, some adults in this household are retired, and no adults in this household are retired. As only a small percentage of respondents indicated the all adults were retired, the two retired categories were merged for the chi-squared analysis (see table 5). The chi-squared test revealed that retirement status had no statistically significant relationship with mitigation frequency (p=0.19).

Table 5

*Results of Chi-square Test and Descriptive Statistics for Mitigation Frequency by retirement status*

<table>
<thead>
<tr>
<th>Mitigation Frequency</th>
<th>Retirement Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than once a year</td>
<td>All adults in this household are retired, some adults in this household are retired.</td>
</tr>
<tr>
<td>Once a year</td>
<td></td>
</tr>
<tr>
<td>Twice a year, more than twice a year</td>
<td>No adults in this household are retired.</td>
</tr>
</tbody>
</table>

*Note.* $\chi^2 = 3.33$, df = 3. Numbers in parentheses indicate column percentages.

*p < .05*
I determined mitigation frequency to be independent of political affiliation (p=0.06), although the chi-square approximation may be inaccurate, as the expected frequency of democrats conducting mitigation twice a year or more was less than five (see table 6). The table’s columns could not be merged further without skewing the results. Worth noting is the large portion of respondents that identify with either the Republican party (47.57%) or consider themselves an independent (41.75%).

Table 6

<table>
<thead>
<tr>
<th>Mitigation Frequency</th>
<th>Political Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Democrat</td>
</tr>
<tr>
<td>Less than once a year</td>
<td>7 (63.64%)</td>
</tr>
<tr>
<td>Once a year</td>
<td></td>
</tr>
<tr>
<td>Twice a year, more than twice a year</td>
<td>4 (36.36%)</td>
</tr>
</tbody>
</table>

Note. $\chi^2 = 5.79^*$, df = 2. Numbers in parentheses indicate column percentages. *p < .05

H4) Place dependency will be related to wildfire mitigation

Question 6 on the survey asked whether any person in the household being surveyed was currently employed in the same community they reside in. Using a chi-squared test (see Table 7), I determined that local employment was independent of mitigation frequency (p=0.30). Some of the total respondents (n=21) chose to not answer this question, leaving only 82 responses.

Table 7

<table>
<thead>
<tr>
<th>Mitigation Frequency</th>
<th>Local Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Someone in household is employed locally</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. $\chi^2 = 0.43^*$, df = 1. Numbers in parentheses indicate column percentages. *p < .05
Duration of residence, with the categories merged into five years or less or greater than five years (see Table 8), was determined to be independent of mitigation frequency (p-value=0.45). Most respondents who took the survey indicated that they had lived in the same area for at least five years (n=80). While the results were not significant, there was a visible trend in that respondents who lived their communities longer often conducted less frequent hazard mitigation.

Table 8

<table>
<thead>
<tr>
<th>Mitigation Frequency</th>
<th>Residential Tenure Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than once a year, once a year</td>
<td>19 (82.61%)</td>
</tr>
<tr>
<td>Twice a year, more than twice a year</td>
<td>4 (17.39%)</td>
</tr>
</tbody>
</table>

Note. \( \chi^2 = 0.58 \), df = 1. Numbers in parentheses indicate column percentages. *p < .05

Whether the resident was an owner or renter of the property was determined to have no relationship with mitigation frequency (p-value=0.24). For this test, I found that it was not possible to merge different categories in a way that yielded an accurate chi-squared value (see Table 9). Since only one resident who was currently renting their property conducted mitigation twice a year or more, the expected frequencies for that cell were far below the threshold needed for an accurate chi-squared test.

Table 9

<table>
<thead>
<tr>
<th>Residential Tenure Type</th>
<th>Results of Chi-square Test and Descriptive Statistics for Mitigation Frequency by tenure type</th>
</tr>
</thead>
</table>

Note. \( \chi^2 = 1.05 \), df = 1. Numbers in parentheses indicate column percentages. *p < .05
**Mitigation Frequency**

<table>
<thead>
<tr>
<th>Less than once a year, once a year</th>
<th>Rent</th>
<th>Own</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twice a year, more than twice a year</td>
<td>10 (90.91%)</td>
<td>69 (75.00%)</td>
</tr>
</tbody>
</table>

Note. $\chi^2 = 1.39^*$, df = 1. Numbers in parentheses indicate column percentages. *p < .05

**H5)** **Risk perception will be associated with wildfire mitigation**

I determined that respondent’s risk perception (p-value = 0.04) is not independent from their frequency of mitigation, indicating a relationship exists between the two variables (see Table 10). Interestingly, resident’s answers to the Likert-scale prompt “I am concerned about wildfires endangering my property” had no relationship.

Table 10

Results of Chi-square Test and Descriptive Statistics for Mitigation Frequency by perceived risk

<table>
<thead>
<tr>
<th>Mitigation Frequency</th>
<th>Political Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lowest risk, low risk</td>
</tr>
<tr>
<td>Less than once a year</td>
<td>20 (55.56%)</td>
</tr>
<tr>
<td>Once a year</td>
<td>12 (33.33%)</td>
</tr>
<tr>
<td>Twice a year, more than twice a year</td>
<td>4 (11.11%)</td>
</tr>
</tbody>
</table>

Note. $\chi^2 = 10.17$, df = 4. Numbers in parentheses indicate column percentages. *p < .05

However, there was determined not to be a relationship between respondent’s agreeing or disagreeing with the statement: “I am concerned about wildfires endangering my property” and frequency of mitigation (p-value=0.97). However, rows and banners could not be merged in a way that gave an accurate chi-squared value (see table 11).

Table 10

Results of Chi-square Test and Descriptive Statistics for Mitigation Frequency by Wildfire Concern
<table>
<thead>
<tr>
<th>Mitigation Frequency</th>
<th>Strongly agree, somewhat agree</th>
<th>Neither agree nor disagree</th>
<th>Somewhat disagree, strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than once a year, once a year</td>
<td>53 (55.56%)</td>
<td>8 (80.00%)</td>
<td>18 (78.26%)</td>
</tr>
<tr>
<td>Twice a year, more than twice a year</td>
<td>16 (23.19%)</td>
<td>2 (20.00%)</td>
<td>5 (21.74%)</td>
</tr>
</tbody>
</table>

Note. $\chi^2 = 0.06^*, df = 2$. Numbers in parentheses indicate column percentages. *p < .05

Discussion

Risk perception’s relationship with mitigation frequency was the main statistically significant finding from my analysis. Homeowners who perceived a greater risk often conducted more frequent wildfire mitigation. I found that my results mirrored those found in other studies (Brenkert-Smith et al., 2006; Champ et al, 2016; Cohn et al., 2008; Collins, 2008; Martin et al., 2009; McGee et al., 2003), risk perception continues to be an important determinant of wildfire, and more generally risk, mitigation. Policymakers and other wildfire-related officials and organizations need to understand how their specific WUI constituents perceive the wildfire risk, to develop more effective education programs that can target any common misperceptions. Education programs that increase WUI resident's perceptions of risk, or more accurately evaluate that risk, have a strong likelihood of increasing wildfire mitigation within a community, and can reduce the overall resources needed to defend that community in the event of a wildfire.

Through my statistical analysis, I determined that the social variables utilized in my survey had no relationship with mitigation frequency. I found that both age and retirement status had no bearing on frequency of wildfire mitigation. Interestingly, of those surveyed, only 24 respondents were age 55 or older, and only 41 households had a retiree living in them. This may indicate a sampling error, or that the WUI of El Paso County in the towns surveyed is not
primarily composed of retirees or those who are soon to be retired. Other studies focusing on the WUI (Collins, 2008; Winter & Fried, 2000) have noted that the region is composed predominantly of retiring amenity seeking baby-boomers, but the data collected in my study area indicated otherwise. While this may be a generalizable trend over the entirety of the WUI in the United States, future studies may want to take a closer look at the differences between WUI areas in different regions.

One of the Likert-scale questions utilized in the survey had respondents agreeing or disagreeing with the statement: “it is primarily my responsibility to conduct wildfire mitigation measures for my property”. I found that a large majority of respondents agreed (86.41%) to some extent that it was primarily their responsibility to mitigate the wildfire risk on their own property. Of those who agreed, 58.25% indicated that they “strongly agreed”, which meshes with other literature on wildfire risk reductions within the WUI. McGee and Russel (2003) found that residents of Australia’s WUI accepted personal responsibility for conducting proactive protection actions against wildfires, and Martin et al. (2009) who in the WUI of the United States found locus of responsibility to influence mitigation mediated by risk perception. Like Martin et al. (2009) noted, western United States cultures regarding self-reliance were often expressed by WUI residents, specifically those the strong sense of resistance to government interventions on private property.

In my study I made no differentiation between direct wildfire experience and proximate wildfire experience within the survey instrument (See Appendix A), meaning that it was up to the survey respondent to answer the question using their interpretation of what "past exposure to a wildfire" meant. Some studies in the past, like Martin et al. (2009) also did not make the distinction, and like my study did not find a significant relationship between mitigation and past
fire experience. There are two likely explanations for this: That a disaster subculture has developed within these areas due to repeated disaster exposure, or that exposure to the wildfire hazard has led WUI residents to believe that they are at a lessened risk due to the absence of potential fuels. Disaster subcultures emerge when communities are subjected to a risk, like wildfires, frequently enough that residents accept that risk as an inevitable part of residing in a fire-prone area (Dynes, 1994). El Paso County, being home to three of Colorado’s largest wildfires, is an area where disaster subcultures would likely exist. If this is the case, the perception of wildfires as a way of life will lead to lessened wildfire mitigation. Part of the area surveyed in Black Forest was within the bounds of the 2013 wildfire, which replaced the formerly dense stands of ponderosa pine with short grasses native to Colorado’s Front Range. Residents surveyed within this area often felt that they did not have much to mitigate, as the fire had burned any fuels tall and dense enough to cause a crown fire. While the previous fire did burn away most trees, and creates open defensible space around structures, these are areas that are still at risk of wildfire. Past exposure to wildfires, and natural disasters in general, is still a variable that should be targeted by future risks and hazard studies. It may be worth differentiating between different types of exposure (i.e. fire burned structure, family was evacuated, family was put on evacuation watch, etc.), and what effect it has on both risk perceptions and adoption of mitigation strategies.

With my survey instrument, I asked WUI residents whether their insurance company required them to conduct wildfire mitigation measures on their property. Only 36.63% (n=37) of respondents indicated that their insurers required them to undertake mitigation measures, with the type of measure and strictness of enforcement varying between companies. Neighboring property owners can be held to different mitigation standards, which can lessen the effect of
mitigation measures by an individual through the increased fire transmission rates on the neighboring property. The lack of uniform standards between insurance companies certainly contributes to the variance in adoption of mitigation measures. However, since insurance companies cannot collaborate to enact uniform policies, the solution to this issue most likely lies with government intervention. Gorte (2013) suggests that a national wildfire insurance program could be implemented and required for WUI residents. More uniform regulations and requirements could improve overall WUI wildfire safety and remove the variance in required mitigation actions.

Place dependency variables, which are often cited (Collins 2008, Winter & Fried, 2000, Martin et al, 2009) as determinants of mitigation, were not found to have significant relationships with mitigation frequency. Duration of residence and whether the resident is an owner or a renter of the property both had insignificant chi-squared test results. This is most likely due to methodological problems (elaborated upon below), as place dependency variables are consistently found to be important determinants of wildfire mitigation (Collins, 2008; Collins, 2009; Flint & Luloff, 2005). Those who have invested more into their properties and communities may be exposed to more social vulnerability than those who are less “place dependent”, which can lead them to mitigate more against potential threats to preserve their total “investments” in their community (Flint & Luloff, 2005; as cited in Collins 2009).

It may be worthwhile for government land managers and wildfire professionals to seek methods of engaging WUI residents who are less “place dependent” for participation in community wildfire groups. Areas with large concentrations of renters (or even new developments), especially those with preexisting community organizations or homeowner’s associations, should be targeted for outreach. Wildfire education programs in areas such as these
may lead to greater overall adoption of mitigation measures, as opposed to targeting more “place dependent” communities that may have already have higher base rates of adopting mitigation measures.

Local employment, which includes those who work from their houses or within their communities, has been theorized to increase adoption of mitigation measures (Collins, 2008). While my data indicated that there was no relationship with mitigation frequency, this variable should not be dismissed as a nonfactor. In Black Forest, many of those who worked from home or within the community lived within the burn scar area. Their infrequency in mitigation could most likely be attributed to the perception of a lessened or inevitable risk, which would mediate the effect of local employment or even their tenure status. The absence of statistical significance for these variables, as with most of my independent variables, is most likely due to the weakness of mitigation frequency as a dependent variable.

Mitigation frequency was chosen as the way to measure wildfire risk mitigation for this study. However, I determined post-survey administration that mitigation frequency was an inadequate way of quantifying risk mitigation. Wildfire mitigation is a constant process that consists of many different actions undertaken over a long period of time. By lumping all types of wildfire mitigation into one category, I considered all mitigation actions to have equal efficacy, despite this not being the case. The option chosen most frequently (n=41) by survey respondents was “less than once a year”, followed by “once a year” (n=38). The option “less than once a year” is somewhat problematic, as it lumps those who undertake infrequent mitigation on their property, without considering their reasoning for doing so, with those who undertake no mitigation on their property. Undertaking wildfire mitigation actions less than once a year is also not necessarily a bad thing; trimming branches on trees and cleaning up deadfall are no
mitigation strategies that need to be done every year for them to be effective. For example, removing trees that are too close to a structure is an expensive one-time action that is not represented by using mitigation frequency as a measure of wildfire mitigation. Despite mitigation frequency not being an ideal variable, 54 of 94 respondents (see Table 2) took some type of mitigation more than once a year.

I recommend that future studies utilize more comprehensive measures of wildfire mitigation, perhaps similar those utilized by Martin et al. (2009) or Collins (2008), where mitigation was broken down by different strategies, and respondents could indicate whether and when they had done each. In addition to measuring wildfire mitigation more accurately, this provides a continuous variable that can be used to build more accurate models of how WUI residents conduct wildfire mitigation.

The results of my study support the need for more outreach and education programs within the WUI. Increased and more accurate risk perceptions are associated with more frequent mitigation, which can lessen the need for government firefighting resources in the event of a wildfire. These programs are in the best interest of federal land managers in charge of areas bordering large residential developments (i.e. El Paso County, CO), whose departments (and the federal taxpayer) must pick up the tab if a fire on federal land spreads into residential developments. This can be aided by the implementation of a national WUI fire insurance program, which, in conjunction with local building and mitigation codes, can increase wildfire mitigation (as a requirement for coverage). To solve the issue of WUI-related fire spending cutting into USFS and DOI budgets, this program should be implemented outside of these departments, and funded by those who live within the fire-prone WUI, to avoid the externalities associated with wildfire insurance risk-pooling.
While my study does not provide any particularly new insights into determinants of wildfire mitigation, it highlights the importance of risk perception and the need for more Government authorities need to act soon due to the increases in number and intensity of wildfires near the WUI. Education programs that focus on providing accurate risk information to private landowners who abut federal lands have potential to reduce firefighting costs in the event of a wildfire event. The USFS, DOI, and other government agencies whose budgets are increasingly being diverted to wildfire management would benefit from increased research on determinants of household mitigation.
Bibliography


"Waldo Canyon Fire Update 6-30-12 Pm". InciWeb. Retrieved 2012-07-01.


Appendices

Appendix A: Survey Instrument

Survey Instrument (Implemented Through Qualtrics Online Service)

1. What is your age?
   1= 18 to 34 years
   2= 35 to 54 years
   3= 55 to 74 years
   4= 74 years and older

2. How long have you lived in your current community?
   1= Less than 2 years
   2= 3 to 5 years
   3= 6 to 10 years
   4= More than 10 years

3. Do you own or rent the place where you live?
   1= Rent
   2= Own/Bought

4. What race or ethnicity do you consider yourself?
   1= White, Caucasian, or European
   2= Hispanic, Mexican-American, or Latino
   3= Asian or Pacific Islander
   4= Black or African American
   5= Native American
   6= Other: (Fill In)

5. Are all adults in your household retired?
   1= Retired
   2= Not retired

6. Is your or anyone in your household’s place of work in the same community that you live or reside in? (If retired/unemployed, please answer no)
   1= Yes
   2= No

7. What was your household’s average income over the past 12 months (before taxes)?
   1= Less than $25,000
   2= $25,000 to $34,999
   3= $35,000 to $49,999
   4= $50,000 to $74,999
   5= $75,000 to $99,999
   6= $100,000 to $149,999
   7= $150,000 to $199,999
   8= $200,000 or more

8. In politics today, do you consider yourself a:
1= Democrat  
2= Republican  
3= Independent  
4= Other

9. Have any of your current or past residences been exposed to a wildfire?  
   1= Yes  
   2= No  
   3= Unsure  

For the purposes of this survey, a wildfire mitigation action is any action taken by an individual or community that is aimed at lowering the risk of wildfire on their property or in their community. These actions can be done before, during, or after a wildfire. This includes actions like mechanical brush removal, constructing a fire line, or a prescribed burn.

9. In the event of a small localized wildfire, do you believe community firefighting resources will be sufficient to prevent any damage to your property?  
   1= Yes  
   2= No  
   3= Unsure  

10. Does your household insurance company require you to take wildfire mitigation measures on your property?  
    1= Yes  
    2= No  
    3= Unsure  

11. To your knowledge, what level of formal or informal government ultimately pays for the majority of fire suppression and mitigation?  
    1= Federal (United States Forest Service, Department of Interior, etc.)  
    2= State (Colorado State Forest Service, etc.)  
    3= Local (Municipal Fire Departments)  
    4= Local Informal (Community fire organizations, Homeowners associations, etc.)  
    5= Other (Please Specify)

12. In your opinion, what level of formal or informal government do you believe should pay for the majority of fire suppression and mitigation?  
    1= Federal (United States Forest Service, Department of Interior, etc.)  
    2= State (Colorado State Forest Service, etc.)  
    3= Local (Municipal Fire Departments)  
    4= Local Informal (Community fire organizations, Homeowners associations, etc.)  
    5= Other (Please Specify)

13. How often do you conduct or pay for fire mitigation measures, of any type, on your own property?  
    1= Less than once a year  
    2= Once a year  
    3= Twice a year  
    4= More than Twice a year
14. Has your household donated or participated in community wildfire prevention groups or programs, such as those with Firewise certifications?
   1= Yes  
   2= No  
   3= Unsure

15. On a scale of 1-5, To what extent are humans responsible for the current amount of exposure to wildfires? (With 1 being entirely human and 5 being entirely natural)
   (1-5)

16. On a scale of 1-5, with 1 representing low risk and 5 being the high risk, how at risk do you believe your home is from wildfire?
   (1-5)

The following section will consist of several statements, which you can choose to agree or disagree with on the following scale:
   Strongly Disagree
   Disagree
   Neutral / Undecided
   Agree
   Strongly Agree

17. “I am concerned about wildfires endangering my property”

18. “It is primarily my responsibility to conduct wildfire mitigation measures for my property”

19. “It is primarily the government’s responsibility to conduct fire mitigation measures for my community”

20. “Government wildfire mitigation and suppression measures enable me to live where I do”

21. “It is primarily my community’s responsibility to conduct fire mitigation measures in my community”