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Wildfire Risk Perception and Homeowner Mitigation: Evidence from Montana

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WILDFIRE RISK PERCEPTION AND HOMEOWNER MITIGATION:

EVIDENCE FROM MONTANA

By

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Fire prevention managers find that homeowners often do not perform mitigation actions that could reduce the damage and spread of wildfire. There is widespread belief among these fire professionals that one of the primary reasons that homeowners do not perform mitigation actions is that homeowners misperceive the risk that wildfire poses. Thus, a significant component of fire prevention programs' focus on increasing homeowner awareness of the risk. However, it is possible that homeowners are aware of the fire risk but choose not to mitigate because of a variety of reasons, to include the costs of mitigation, limited monetary liability that they have after they insure the property, or doubts about the benefits of mitigation. I combine survey data obtained from Montana property owners with simulated fire probabilities for their parcels to test whether homeowners who report greater concern about the risk of fire conduct more mitigation activities. Using an instrument variables approach, I find that increased homeowner concern about the risk of wildfire causes them to conduct significantly more mitigation activities.

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1. Introduction

In recent years, large wildfires have scorched millions of acres of land across the United States, leaving ash and destruction in their wake. Many of these fires burned adjacent to populous urban areas, resulting in substantial direct and indirect losses. Efforts to suppress wildland fires in 2017 exceeded $2 billion—the most expensive year on record for fire suppression (United States Department of Agriculture 2017). These losses can be minimized when homeowners mitigate. With so much at stake, fire professionals struggle to explain why many homeowners living in high-risk areas opt not to take actions to mitigate their risk for catastrophic loss due to wildfire (Crowley 2009). One common hypothesis is that if a homeowner chooses not to take action on their property, it must be because the homeowner does not have an accurate perception of their risk (Martin 2008). Under the assumption that when homeowners perceive a higher risk they will mitigate more, current public fire prevention programs attempt to motivate action by increasing awareness and heightening perceived susceptibility to wildfire (Brenkert-Smith et al. 2012).

An examination of the current literature related to wildfire risk demonstrates that the nature of the relationship between risk perceptions and risk mitigation is uncertain. Furthermore, much of the existing literature presents correlational findings without causal implication. Few studies exist that address the causal relationship between wildfire risk perceptions and mitigation behaviors, and even fewer account for the simultaneity of perception and behavior (Champ et al. 2013). Some empirical analyses have indicated that risk perceptions do have positive effect on mitigation behaviors (Fischer et al. 2014, Martin et al. 2009, Brenkert-Smith et al. 2012, McCaffrey 2002, McFarlane et al. 2011), supporting current field tactics of increasing risk awareness among landowners living in fire-prone areas. Still, frustrated educators may not be surprised to hear that other studies have determined that increased perceptions of risk do not translate to increased mitigation behaviors (Champ et al. 2013, Hall and Slothower 2009, Collins 2008, Brenkert-Smith et al. 2006). Studies that fail to find an effect of homeowner wildfire concern on mitigation point toward the possibility that homeowners are making tradeoffs and rationally choosing to mitigate at a lower level.

This paper specifies the relationship of homeowner concern about wildfire and mitigation actions using an instrumental variable approach that allows me to make causal conclusions that are not adequately present in the current literature. By using location-specific objective estimates of wildfire risk as an instrumental variable to isolate the estimated effect of risk perceptions, the results can indicate the presence or lack of a causal effect, without the endogeneity present in correlational studies. Additionally, this instrument is unique in that it strips out the effect of severity on concern and uses only variation in concern that is driven by variation in burn probability to estimate the effect on mitigation behaviors.

In this paper, I use new data from a 2016 mail survey of Montana landowners to test whether homeowner's perceptions of wildfire risk have a causal impact on their propensity to perform certain actions to mitigate wildfire risk on their property. The results of this analysis provide crucial information to fire professionals and government agencies, as well as inform the development of effective methods to induce fire-safe behavior. My findings indicate that homeowner concern about wildfire causes an increase in the number of mitigation behaviors completed. Having enough money and perceived efficacy of action also resulted in higher levels of homeowner mitigation.

The first section of this paper introduces the dimensions of wildfire that have led to its emergence as an exigent, interdisciplinary matter.

1.1 Increasing Threat of Wildfire

Periodic wildfire is necessary for the survival of nearly every natural ecosystem (Corace et al. 2015). In many areas, land management crews will even prescribe controlled burns to remove excess vegetation and spur plant regeneration. However, despite the essential role wildfire plays in natural processes, it can also have catastrophic effects where wilderness abuts developed land.

Intense fire seasons in recent years have raised concern that wildfires will occur with greater frequency and severity. Changing weather patterns and climate trends have resulted in higher temperatures and decreased moisture, conditions that promote more frequent ignition events and more rapid spread of fire (Abatzaglou et al. 2016, Fried et al. 2004, Westerling et al. 2006). If climate conditions continue to follow this trajectory, natural disasters, particularly wildfires, may continue to worsen (Committee on Stabilization Targets 2011).

Additionally, increased fire suppression efforts and reduced timber extraction to preserve land for recreation and wildlife habitat on public lands throughout the 1900s have created potentially hazardous conditions that allow fires to spread more rapidly and burn more intensely (United States Forest Service 2015, Husari 2006, National Wildfire Coordinating Group). These suppression efforts have only delayed wildfire, as wildland forests have accumulated decades-worth of combustible biomass (Husari 2006). Under these conditions, even a small fire can quickly erupt to set the entire forest ablaze. Comprehensive fuel management practices are evolving but, as it stands, fuel loads remain elevated in forests (Husari 2006).

As more people opt to reside in the densely vegetated outskirts of urban areas, also known as the wildland-urban interface (WUI), both the threat to human safety and the potential for material loss are amplified. In the WUI, it is common for landowners nestle their structures amongst trees and other vegetation for aesthetic appeal (Brenkert-Smith et al. 2006, Martin et al. 2009). Fire prevention specialists promote fuel management by private landowners living in these fire-prone areas (Champ et al. 2013). In addition to using noncombustible materials to build structures, experts recommend (1) limiting forest density, (2) landscaping to reduce vegetation and remove other potential fuel sources, and (3) maintaining a defensible space around structures (Barkley et al. 2005). These are examples of wildfire "mitigation behaviors", or actions that can be performed by homeowners to reduce their structure's risk of destruction from wildfire. When owners do not comply with recommendations, the heavy fuel loads surrounding structures on these properties present the greatest opportunity for catastrophic losses from wildfire (Evans et al. 2015).

1.2 Consequences of Wildfire

In the continental United States, the threat of large wildfire is greatest in the sparsely populated Western States. The arid climate frequently experiences drought conditions and the region's steep topography is conducive to the rapid spread of fire. Each year, the American West braces for "fire season" when low precipitation and high temperatures leave the vast expanse of forests and grasslands particularly vulnerable to fire. Wildfires are a staple of summer in the West, and blazes can be relatively unimpactful if the fire is remote or well-contained. In recent years, however, fire seasons have had a wide range of serious impacts.

The 2017 fire season was particularly unrelenting, damaging communities and landscapes alike. The devastation from uncontrolled fires in California, Oregon, and Montana captured the attention of national news networks. Late summer wildfires erupted quickly and surprised Californians, tragically killing more than 40 people (Daniels 2017). The blazes forced the evacuation of over 100,000 people, and damaged or destroyed an estimated 14,700 homes (Daniels 2017). In Oregon, a teenage vandal provided the spark that went on to scorch tens of thousands of acres of revered scenic wilderness in the historic Columbia River Gorge (Brettman 2017). Even communities far from the reach of flames were engulfed in a thick haze of smoke.

Though the California wildfires captured the most media attention in 2017, Montana experienced its worst fire season in decades. Throughout the state, fires consumed over one million acres of land and the economic impact of the fires was severe (Northern Rockies Coordination Center 2017). Efforts to control the fires accrued $74.2 million dollars in expenses, over double the state's two-season $32.3 million-dollar fire response appropriation (Legislative Fiscal Division 2017). Funds allocated to prevent and fight next year's fires have already been completely exhausted. At the community level, menacing fires and thick plumes of smoke drastically deterred tourism. In particular, businesses in Seeley Lake were devastated when smoke from a nearby fire settled over the community and caused a closure of its popular lake (Kidston 2017). Two months of crucial tourism income was lost, prompting the state government to subsidize grants and loans to local business owners (Erickson 2017). Economic losses of this magnitude are unsustainable, and the state economy would quickly cripple if larger-than-usual fires continue to plague Montana year after year (Legislative Fiscal Division 2017). Clearly, the adverse effects of wildfire can be far-reaching. Efforts to reduce wildfire, particularly on privately-owned residential lands, can lessen the threat to human safety. Not only will residents be less vulnerable on a fire-wise property, but mitigation efforts make it safer for firefighters to defend a property in the event of fire. While mitigation actions cannot guarantee protection, these actions may also greatly reduce the public costs associated with defending the property in case of fire, drastically reducing the strain on state budgets and federal disaster aid funds.

In the next section of this paper, the current literature related to wildfire risk perceptions and related mitigation behavior is presented. Section 3 discusses the details of the original survey data used in this analysis. Section 4 proposes an econometric model using an instrumental variable to specify the relationship of mitigation behaviors as a function of risk perceptions and a vector of explanatory variables.

2. Review of Current Literature

2.1 The Gap Between Homeowner and Expert Assessment of Risk

It is well documented that private landowners are not mitigating wildfire risk at the level recommended by fire professionals (Brenkert-Smith et al. 2011). One explanation for this is that homeowners' assessment of risk differs substantially from expert assessments. Quantitative studies support this claim that homeowners tend to underestimate their property's risk for wildfire (Champ et al. 2013, Meldrum et al. 2015). A survey of homeowners living in Colorado's fire-prone Rocky Mountains found that while only one percent of homes were in the lowest risk category, twenty-one percent of respondents indicated that they believed their home was in the lowest risk category (Champ et al. 2013). Another survey of Colorado landowners discovered that 67% of respondents did not know that their home was in a high-wildfire risk area until after they had already moved in (Champ et al. 2009). Meldrum et al. (2015) compared public assessments of risk to an aggregate, weighted measure of wildfire risk compiled by fire experts based on ten property attributes. Even when the questions posed to the homeowners were specifically worded to make them consider the same attributes as risk factors as the professionals used in their valuation, a clear pattern emerged: 53% of respondents underrated the wildfire risk compared to the professional assessment (Meldrum et al. 2015). Studies like these demonstrate dissonance between public and expert assessment of even the simplest determinants of wildfire risk.

Research suggests several reasons for this discrepancy in risk perception. Despite stochastic factors such as weather patterns and ignition events, fire scientists use land attributes, geospatial interactions, and historical data to estimate burn probability for a given parcel of land (Finney et al. 2011). Uniform methodology that excludes subjective factors yields estimates that approach the true burn probability for a given location. While not infallible, models from fire scientists yield reliable, research-based estimates that are used as the probabilistic component when calculating overall wildfire risk (Meldrum et al. 2015).

Homeowners, however, rely on their personal knowledge and assumptions in order to make a judgment regarding the probability of an event (Slovic 1999). When combining their assessment of the probability with the expected consequences, homeowners implicitly apply their own subjective weighting system, resulting in the potential for drastically different estimates (Martin 2008, Meldrum et al. 2015). Researcher Sarah McCaffrey asserts that these judgments are also more likely to rely on visceral responses as opposed to the mathematical calculations used in expert analysis (McCaffrey 2008). Individual appraisals of risk may also be subject to inconsistency over time. One survey found that, in 2010, respondents rated the probability of a wildfire event as less likely than they had rated it in 2007 but rated the consequences as more severe (Champ et al. 2016).

Additionally, social science suggests that human nature limits the capacity of homeowners to accurately calculate probabilities (Tversky and Kahneman 1974). The overall quality of an individual's assessment can be evaluated based on two criteria: the extent and accuracy of the homeowner's knowledge related to wildfire incidence, and the homeowner's ability to accurately translate that knowledge into a burn probability (Noonan and Fitzgerald 1991). Humans tend to overrate their scientific knowledge and systematically miscalculate the probability of rare events, all while discounting the human error present in their assessment (Tversky and Kahneman 1974). This concept is supported by a study demonstrating that people tend to overrate their expertise in a variety of situations (Alba and Hutchinson 2000).

This human error can arise as a result of various heuristics employed to reduce the mental strain of evaluating a multifaceted problem such as wildfire occurrence (Tversky and Kahneman 1974, Noonan and Fitzgerald 1991, Martin 2008). Heuristics allow an individual to efficiently make judgments by focusing on certain aspects of an issue while ignoring others. A phenomenon known as anchoring suggests that humans rely strongly on the first piece of knowledge they learn, then insufficiently adjust to new information (Wright and Anderson 1989). They may also resort to all-or-nothing strategies such as denial or "attributing complete protection to adjustments" (Martin 2008). When assessing wildfire likelihood on their property, a homeowner may heavily weight the influence of precipitation, while ignoring the impacts of vegetation and topography. While these shortcuts can ease the mental burden of making the appraisal, they compromise the integrity of the evaluation (Tversky and Kahneman 1974).

Homeowners converge on an estimate of wildfire risk very differently than fire experts, and though they may consider information provided by fire experts, they ultimately rely on subjective influences to form their perception of wildfire risk.

2.2 Wildfire Mitigation Behaviors

Property management can be an effective method to minimize the risk of wildfire. Conditions in the HIZ (Home Ignition Zone) are the primary focus of effective wildfire risk mitigation. Minimizing combustible material in the 100- to 200-foot perimeter surrounding the structure greatly increases the chances that the structure survives in the event of a wildfire (Department of National Resources 2008, Cohen 2000). While weather patterns and other ignition events are relatively random, homeowners do have control over the “ignitability” of the home and surrounding vegetation (Cohen 2000, Barkley et al. 2005, Brenkert-Smith et al. 2012, Champ et al. 2016). Performance of property-level mitigation behaviors can reduce the destructive impacts of wildfires by reducing fire intensity (DNR 2008), and they can generally be classified as vegetative or structural (Brenkert-Smith et al. 2006, Dickinson et al. 2015). Vegetative mitigation involves “the removal or modification of vegetative fuels”, such as thinning trees or bushes (Federal Emergency Management Agency, Brenkert-Smith et al. 2006). Structural mitigation is any action taken to modify a structure to be resistant to ignition, such as installing a metal roof or covering vents.

Increasing vegetative and structural mitigation behaviors by private homeowners is the primary objective of wildfire outreach programs, but both qualitative and quantitative studies alike reveal that even concerned homeowners do not always choose to mitigate. Particularly, qualitative studies have provided important insights into the decision-making process that homeowners use when choosing how best to manage wildfire risk on their property. Brenkert-Smith et al. (2006)

conducted in-depth interviews of Colorado residents and found that many residents in the WUI chose not to alter the vegetation on their property for aesthetic purposes, even though they were aware of the fire hazard they posed. These residents were more likely to favor structural modifications that reduced probability of home ignition and tended to complete these efforts in phases as finances allowed (Brenkert-Smith et al. 2006). If residents of the WUI have chosen to live in forested areas intentionally, asking them to thin the forest and remove vegetation around their home may prove problematic (Martin et al. 2009). A majority of WUI homeowners interviewed stated that they "did not want to alter their landscapes unnecessarily" (Brenkert-Smith et al. 2006).

2.3 The Economist's Perspective of Mitigation

Clearly, homeowners in the WUI perceive a cost associated with mitigation actions. Expected Utility Theory suggests that decision makers choose between uncertain options by comparing the expected utility for each outcome, weighted by the probability of the outcome. A homeowner weighs the expected costs of mitigating (time, money, preference) with the expected benefits of their increased protection and will choose to mitigate only if the expected benefits outweigh the expected costs. Insurance significantly reduces the expected monetary costs of wildfire. If a home is insured, the homeowner must choose how to address the moral hazard, as they would not incur the financial loss of the home if the home did burn.

Prospect Theory suggests that people would rather take a gamble at a large loss than accept a smaller, sure loss (Kahneman and Tversky 1979). Mitigation behaviors are a form of "probabilistic insurance", which is a protective action "where one pays a certain cost to reduce the probability of an undesirable event-without eliminating it altogether" (Kahneman and Tversky 1979). Probabilistic insurance tends to be an undesirable option for decision makers, which may explain why homeowners don't eagerly accept the costs associated with wildfire mitigation (Kahneman and Tversky 1979). Isolating what concerned homeowners are actually willing to do to reduce wildfire risk is extremely important in the process of successfully promoting mitigation.

2.4 Role of Risk Perceptions on Mitigation

Given that homeowners are comparing the costs and benefits of mitigation (both monetary and nonmonetary), increasing awareness of the risk may not sufficiently alter the decision calculus to affect mitigation behaviors. In the wildfire mitigation literature, the effect of homeowner risk perceptions on mitigation behaviors is not decisive. Some studies find that mitigation increases with higher risk perceptions (Fischer et al. 2014, Martin et al. 2009, Brenkert-Smith et al. 2012, McCaffrey 2002, McFarlane et al. 2011), while others do not (Champ et al. 2013, Hall and Slothower 2009, Collins 2008, Brenkert-Smith et al. 2006). Meldrum et al. (2015) propose that perceived risk is a necessary, but insufficient condition for the performance of mitigation behaviors.

Few studies recognize the potential for reverse causality between risk perception and mitigation behaviors. While those with a higher level of perceived risk may be more likely to perform actions to mitigate that risk, it may also be the case that a homeowner is less concerned about the possibility of a wildfire on their property because they have taken mitigation actions to reduce the risk of losing their home in a fire. In addition to reverse causality, there may be unobserved factors or characteristics of homeowners that affect both their risk perceptions and their mitigation preferences. For example, a particularly anxious homeowner may have high perceptions of risk, as well as a higher tendency to mitigate. On the other hand, homeowners with insurance may be less likely to be concerned about wildfire and less likely to mitigate because their home is insured. This would be a source of endogeneity, producing biased estimates.

Recognizing that risk perception and mitigation behaviors may be jointly determined, Champ and colleagues use homeowner awareness of whether their home was located in an area of risk at the time of purchase as an instrument for perceived risk (Champ et al. 2013). They determine that perceived risk does not have a statistically significant effect on the number of risk-mitigating behaviors undertaken by a homeowner.

2.5 Additional Determinants of Risk Perception and Mitigation

Beyond the factors described above, differences in homeowner backgrounds and characteristics will result in a wide array of attitudes towards wildfire risk and risk mitigation. The literature on wildfire risk has identified many potential factors that influence individuals' risk perception and mitigation choices but has yet to reveal a clear consensus.

Demographic characteristics have been shown to affect wildfire risk perceptions and behavior. Age, gender, and education are all factors that may influence an individual's perception of wildfire risk, as well as their resulting response.

Although, Martin et al. (2009) did not find an effect on wildfire risk perception or risk mitigation for any demographic factors.

Direct experience with wildfire can have an ambiguous effect on both wildfire risk perception and on willingness to perform mitigation behaviors. Two possible outcomes of experience with wildfire can be summed up as postexposure wakeup call or postexposure letdown (Champ et al. 2016, Arvai et al. 2006). While experience with a wildfire may make a person feel more susceptible to the hazard, they may also feel that having already experienced a wildfire may make them less likely to experience in the future, thus reducing their perceptions of risk. The latter phenomenon is consistent with the adage that "lighting does not strike twice in the same place" (Martin et al. 2009, Champ et al. 2016). Beyond this, even if a homeowner's awareness and feelings of vulnerability to the hazard increase, they may see the hazard as uncontrollable and random, and that efforts to reduce the risk will not be effective (Winter and Fried 2000). Research has shown that risk perceptions after an experience are only influenced in the short run, as the effect of the experience fades out over time (Martin 2009). They also may have realized that the negative outcomes of their previous experience were not as bad as they had expected. Some studies that have explored the impacts of experience have found an effect on mitigation behaviors (Brenkert-Smith et al. 2012, McCaffrey et al. 2011), but many are unable to find statistically significant effects, likely due to the competing effects described above (Martin et al. 2009, McGee et al. 2009).

Knowledge about wildfire risk can be an important determinant of risk perception and mitigation. Some studies found that receiving wildfire information from local fire departments did not have an effect on perceptions of risk (Champ et al. 2016). Others have found the opposite, that information from experts did act to increase their perception of wildfire risk (Brenkert-Smith et al. 2012). Knowledge about available mitigation options could also influence likelihood of mitigation. Additionally, beliefs about the effectiveness of measures taken to mitigate wildfire risk, perceived “efficacy of action”, are an important driver of perceived risk and mitigation. Martin and colleagues found that a belief in one’s ability to reduce risk was associated with lower levels of perceived risk (Martin et al. 2009). Perceived efficacy of action can also be expected to increase mitigation, as homeowners may be more inclined to perform actions they view as effective, however Brenkert-Smith et al. (2012) did not find a statistically significant effect of perceived efficacy on mitigation.

The research also identifies additional factors that may contribute to the formation of individual risk perceptions and drive the decision to mitigate. Even members of families living on the same parcel of land can have different levels of perceived risk (Brenkert-Smith et al. 2006). The implicit cost-benefit analysis by homeowners may contribute to variation in risk perceptions. Beliefs that living in the WUI provided high benefits were also accompanied by lower perception of risk (Martin 2008, Collins 2008). Homeowners also tend to have a concept of interdependence of risk (Dickinson et al. 2015, Martin 2008). Qualitative interviews revealed that people found their efforts to mitigate risk on their own property may be futile if their neighbors were not also making efforts to mitigate (Martin 2008). Additionally, risk perception is greater when a homeowner believes a neighbor's property is densely vegetated (Dickinson et al. 2015).

Determining whether current tactics to induce risk mitigation among private landowners are well-directed is of extreme importance to many federal, state and local agencies (Martin et al. 2009). Fire experts hope that by aligning homeowner perceptions of risk with their objective estimates of risk, homeowners will be more inclined to perform mitigation behaviors on their property.

3. Data

The data used in this analysis comes from a mail survey conducted by Human Dimensions Lab in the W.A. Franke College of Forestry and Conservation at the University of Montana in early 2017, and a publicly available geospatial product from the Fire Modeling Institute that estimates wildfire hazard potential (Short et al. 2016).

3.1 Study Area

The responses used for this analysis were collected from residents of the land-locked, western state of Montana. While Montana is the fourth largest state, its population barely tops one million. Only three cities boasted populations above fifty thousand in 2016, and sixty-four percent of Montanans live in rural areas (USDA-ERS 2016). The state's expansive area allows for a wide range of geographical and climatic attributes. The Northern Rockies run through the western third of the state, which is heavily forested. East of the Continental Divide, the state is mostly vast prairie. Temperatures and precipitation levels vary greatly across the state, but the overall climate is characterized by low precipitation and low humidity.

Wildfire is a potential concern throughout the state, often incurring tens of millions of dollars in containment and suppression costs annually. Total expenditures on fire suppression in the 2018 fiscal year were estimated at $74.2 million (Legislative Fiscal Division 2017). The severity and extent of the fires in Montana led the Federal Emergency Management Agency (FEMA) to approve a federal disaster aid grant that would cover 75% of the costs associated with the state's firefighting expenses (Voltz 2017, Dettman 2017).

3.2 Survey Instrument

The survey instrument was designed to provide a better understanding of homeowner response to various threats facing their property[1]. Questions on the survey gauged homeowner perceptions and inquired about their property management strategies. The selection of a random sample of landowners was facilitated through the use of Montana's publicly available cadastral data. The state cadaster contains ownership records and value information from county assessors for every parcel of land statewide. Montana is one of the few states with free access to comprehensive statewide cadastral data (von Meyer 2013).

In order to qualify as an eligible parcel, the parcel had to be privately owned, lie outside of city limits, and be larger than 0.5 acres and smaller than 6,000 acres. From those qualifying parcels, a random sample of 4,424 properties was drawn, split evenly between three regions (Figure 1). The three regions were created by collapsing the 7 statewide Fish, Wildlife & Parks (FWP) regions into three larger regions (East, Central, and West), to account for potential differences in ecosystem function in different parts of the state.

[1] Wildfire risk reduction, weed management, and human-bear conflict reduction are salient issues for landowners in the WUI. Additionally, they share the condition of interdependence of outcome: one landowner's practices contribute to the outcomes on adjacent properties. The segments of the survey related to wildfire risk perceptions and behavior were used.

Figure 1: Regions of Montana

Selected addresses were confirmed with the USPS NCOA database. In early 2017, surveys (along with prepaid return postage) were mailed to the addresses of the chosen parcels. Respondents also had the option to complete the survey online. After two weeks, a reminder postcard was sent to those who had not yet responded. Two weeks later, a follow up survey was sent to non-respondents. A second follow up survey was sent two weeks later to the remaining non-respondents. Overall response rate was 29.7%, which was slightly lower than surveys used in similar studies. Non-response bias checks were performed by the survey team and found no significant differences between those who responded to the survey and those who did not.

3.3 Relevant Variables

Measures of Homeowner Risk Perceptions

Homeowners' perceptions of the wildfire risk were measured with a series of questions that asked them to rate their level of concern about four types of wildfire risk using a Likert scale that ranged from one to five (1=Very Unconcerned and 5=Very Concerned). Figure 2 is a screenshot of how the questions were presented to the homeowners.

5. How concerned or unconcerned are you that a wildfire will? Please use the 1 to 5 scale, where 1 is "Very Unconcerned" and 5 is "Very Concerned."
   (*For each row, please circle only one number or N/A.*)

	Very Unconcerned	Unconcerned	Neither	Concerned	Very Concerned	No Structure
Burn in the area in the next 5 years	1	2	3	4	5	
Cause damage to your land	1	2	3	4	5	
Cause damage to neighboring properties	1	2	3	4	5	
Cause damage to structures on your property	1	2	3	4	5	N/A

Figure 2: *Indicators of concern survey question*

The explanatory variable of interest is perceived risk of wildfire, which will be directly measured by these survey responses. Perceived risk encompasses both the probability of a wildfire and the consequences (Champ et al. 2016, Martin 2009, Papakosta et al. 2013). While concern is not exactly the same as perceived risk because it does not account for value and the relative influence of probability and consequence, it can still be used as a measure relative levels of perceived risk.

Table 1: Summary Statistics of Concern Indicators

	Mean	Std. Dev.	Min.	Max.
Burn Concern (1-5)	3.37	1.31	1	5
Damage Concern (1-5)	3.34	1.31	1	5
Neighbor Concern (1-5)	3.42	1.29	1	5
Structure Concern (1-5)	3.42	1.38	1	5

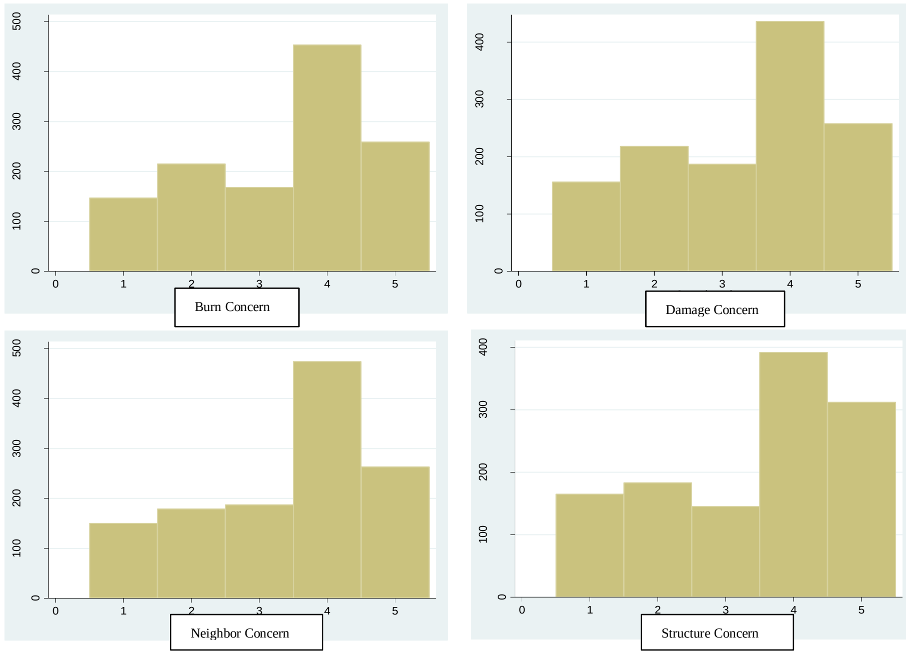

Figure 3: Frequency of responses to concern indicators

The first indicator, *Burn Concern*, will be used as the key independent variable in the model. This measure of concern about whether fire will burn *in the area* is not likely to be influenced by any individual actions completed by homeowners, while the concern about damage to land or structures is more likely to be mediated by mitigation. Table 1 and Figure 3 show that there was not much average difference in how respondents rated the different indicators of concern.

Measures of Homeowner Mitigation Activities

Homeowners were asked whether or not they had performed each of 12 vegetative and structural mitigation behaviors that fire professionals recommend to mitigate wildfire risk on individual properties, as depicted in Figure 4. The questions referenced three zones (Figure 5): six questions related to behaviors in Zone 1 (0-5 feet from home), and three questions each related to behaviors in Zones 2 (5-100 feet) and 3 (100+ feet). All three zones are located within the larger Home Ignition Zone. The result is a binary variable for each action, equal to one if the homeowner indicated that they had completed the action, and equal to zero if they had not.

7. Have you taken any of the following actions on your property in the past 5 years? (*For each row, please check only <u>one</u> box.*)

Zone 1	Yes	No	Not Applicable
Installed non-combustible material (rock landscape, composite decking, rock skirting, metal roof)	☐	☐	☐
Moved flammable material (firewood, patio furniture, lighter fluid, rags, propane cylinders)	☐	☐	☐
Cleared flammable debris (leaves, pine needles, grass)from under decks	☐	☐	☐
Cleaned out your gutters (leaves, pine needles)	☐	☐	☐
Covered vents with wire mesh or screens	☐	☐	☐
Removed flammable vegetation (trees, shrubs)	☐	☐	☐
Zone 2	Yes	No	Not Applicable
Removed trees to increase spacing	☐	☐	☐
Pruned tree branches up 10 feet	☐	☐	☐
Reduced ground vegetation (grass, shrubs, dead vegetation, branches or trees)	☐	☐	☐
Zone 3	Yes	No	Not Applicable
Removed trees to increase spacing and/or thinned forest	☐	☐	☐
Pruned tree branches up 10 feet	☐	☐	☐
Reduced ground vegetation (grass, brush, dead vegetation, branches, trees)	☐	☐	☐

Figure 4: *Mitigation behaviors survey questions*

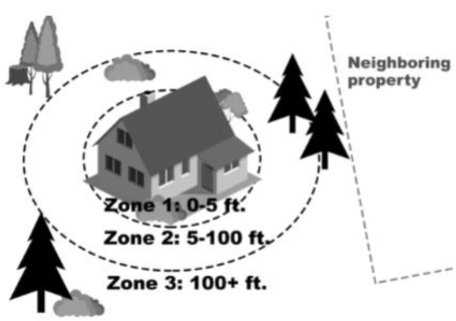

Figure 5: *Zones around home*

Other Variables

Based on evidence from the existing literature, age, gender, and responses to questions regarding their experience with and attitudes toward property management are used as controls. Homeowners rated the degree to which they felt they had enough money to mitigate on a Likert scale from 1-5 (with 5 indicating they felt they had enough money to mitigate). I expect having enough money to be a significant factor in the choice to mitigate, as many forms of mitigation have related monetary costs. I also expect whether or not homeowners believe their actions will be effective in reducing wildfire to be an important control. Respondents rated their perceived efficacy of action by indicating on a Likert scale of 1-5 how confident they were that taking action would reduce their property's risk of wildfire (with 5 corresponding to the highest degree of perceived efficacy). A dummy variable, "Expectations of Neighbors", is used to control for potential social pressures based on homeowners' response to a question asking whether most people in their area believed homeowners should be taking action on their properties to reduce wildfire. Table 2 displays summary statistics of relevant controls. The mean age of 64.6 is much higher than the national median age of 51 for rural Americans, though it may be comparable to the average age of rural landowners who tend to be much older (United States Census Bureau 2016). In fact, ninety-five percent of the sample was 40 or older. About seventy percent of the respondents were male.

Table 2: Summary Statistics of Covariates

	Mean	Std. Dev.	Min.	Max.
Enough Money (1-5)	3.22	1.15	1	5
Efficacy of Action (1-5)	4.04	0.90	1	5
Satisfaction with area efforts to reduce wildfire (1-5)	3.35	0.81	1	5
Willingness to contact local FD (1-5)	3.39	0.91	1	5
Gender (male = 1)	0.69	0.46	0	1
Age	64.60	12.92	18	97

Wildfire Probability Estimates

The survey data are combined with a measure of wildfire hazard potential. The Fire Modeling Institute of the USDA Forest Service creates a national product that contains estimates of burn probability and intensity (Short et al. 2016). Estimates of wildfire probability are derived using the Large Fire Simulator, a fire modeling software. A map of the contiguous United States is rasterized into cubic pixels 270 meters wide. The software accounts for the specific attributes of each 270-meter pixel, including vegetation information obtained from LANDFIRE, topography, and current fuel management practices (Finney 2006). The software then incorporates potential weather patterns and fire history to run thousands of simulations, each representing one hypothetical fire season. Tens of thousands of permutations are needed to form a sample size appropriate for statistical analysis. In each of these permutations, stochastic ignition events occur and algorithms predict the spread and intensity of the resulting wildfires. Physical attributes of the land in a certain pixel determine the behavior of fire if it reaches that pixel.

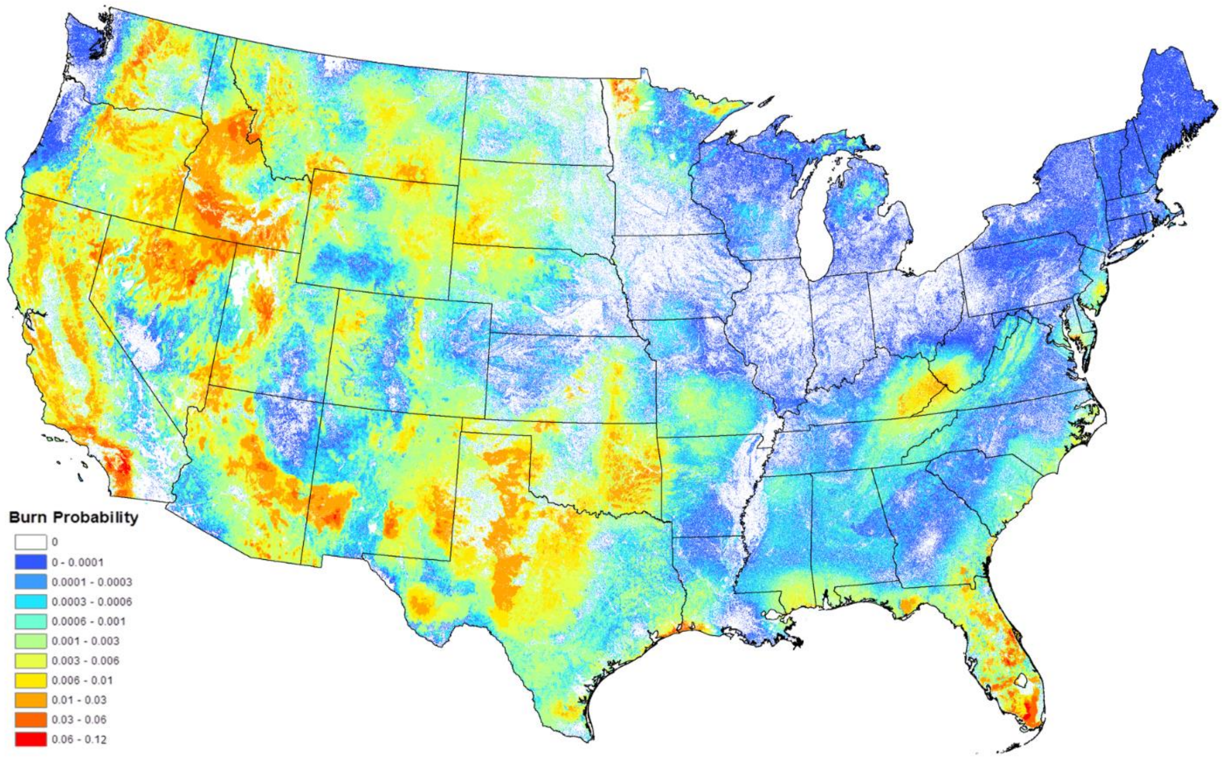

Figure 6: *Burn probability in the contiguous United States*

A burn probability (BP) is calculated for each pixel based on the frequency of fire occurrence in that pixel during the simulation (Finney 2006). For example, a pixel that experienced a fire in 500 out of 10,000 modeled scenarios would have a burn probability of five percent. A map of burn probabilities across the United States is pictured above in Figure 6. The burn probabilities in Montana range from zero to six percent statewide, and within the sample the highest burn probability is just shy of three percent (Table 3). This makes sense, as areas with the highest burn probability are likely heavily forested areas with steep topography impractical for building homes.

Each time a fire occurs in a simulation, it is classified into one of six fire intensity (FI) classes measured by flame length. A conditional probability for each intensity level is calculated by using the proportion of total fires that burned at the given intensity level. The most common intensity level for modeled fires in Montana is level 2, which includes fires with a flame length of 2 to 4 feet.

Table 3: Burn Probability and Intensity Indicators of Sample

	Mean	Std. Dev.	Max.
Overall Burn Probability	0.1704	0.2187	2.8554
Probability of a Small Fire (Intensity Levels 1-2)	0.0936	0.1541	2.5259
Probability of a Large Fire (Intensity Levels 3-6)	0.0768	0.1216	1.3678
Fire Intensity Level 1 - Flame Length less than 2 ft.	9.4969	20.8850	100
Fire Intensity Level 2 - Flame Length 2-4 ft.	48.5347	28.2776	100
Fire Intensity Level 3 - Flame Length 4-6 ft.	29.0885	21.2241	100
Fire Intensity Level 4 - Flame Length 6-8 ft.	8.3554	11.8914	55.5556
Fire Intensity Level 5 - Flame Length 8-12 ft.	3.5280	9.3060	90.9091
Fire Intensity Level 6 - Flame Length greater than 12 ft.	0.9964	5.4006	77.7778

There are seven objective measures of wildfire risk: overall burn probability, and six conditional probabilities corresponding to six levels of fire intensity, measured by flame length. The probability of a fire of given intensity level is the overall burn probability multiplied by the conditional probability of a fire of that intensity (Equation 1). The probability of a small fire (levels 1 and 2) and the probability of a large fire (levels 3-6) sum to the overall burn probability on that parcel (Equation 2).

Equation 1: $$P(FI_k = i) = bp_k * P(FI_k = i \mid burn=1)$$

Equation 2: $$probbigfire_k + problittlefire_k = bp_k$$

The output is intended for use in long term projections and is not descriptive of fire conditions in any given year (Dillon et al. 2015).

3.4 Matching Spatial Data

Each respondent is assigned a unique survey ID to identify the observation. Each respondent's address lies on a lot. Using ArcGIS, the centroid of the lot is calculated, and the latitudinal and longitudinal coordinates at that point are used as the location of the address. Those angular coordinates lie within a 270x270 meter pixel with a given burn probability and intensity estimate from the Wildfire Hazard Map. Those probabilities are extracted and matched with the respondent.

4. Econometric Model

Prior studies exploring the relationship between wildfire concern and mitigation behavior find evidence that they are jointly determined (Martin 2008, Champ et al. 2013). While higher perceptions of risk are hypothesized to increase risk mitigation behaviors, there is also a potential for reverse causality when an individual who has performed mitigation behaviors reports a lower level of concern as a result. Thus, the indicator of concern from the survey data actually reflects a homeowner's true concern of the threat of wildfire, minus the unobserved mediating effect of any mitigating behaviors they have completed. Thus, the use of these reported measures of concern to estimate an equation (Equation 3) to predict mitigation behaviors would be inappropriate and would result in biased coefficients. The coefficient estimates from Equation 3 may also be biased due to unobserved characteristics of a person, such as personality or temperament, that affect their level of concern as well as how likely they are to perform mitigation behaviors.

Equation 3: $$mitigation = \delta_0 + \delta_1 concern + \delta_2 X + u$$

As a result, the covariance of concern and the error term is not equal to zero (Equation 4), and coefficient estimates of δ_1 will be biased. I expect these estimates to be downwardly biased due to the effects of reverse causality. The expected bias of any endogenous unobserved characteristics will depend on the omitted variable.

Equation 4: $$Cov(wildfire\ concern,\ u) \neq 0$$

4.1 The Instrument

To address both econometric issues, an instrumental variable approach is utilized. In particular, objective wildfire probability is used as an instrument for homeowner wildfire concern. I consider three instruments. The first is burn probability (*bp*), which is the objective probability of a burn in a parcel. However, it may be that homeowner concern responds differently to the threat of large fires than to the threat of small fires, so I also use the probability of a large fire (*probbigfire*) and probability of a small fire (*problittlefire*) as instruments. The variable *problittlefire* is the probability of occurrence of a fire of intensity levels 1 and 2, while *probbigfire* is the probability of occurrence of a fire of intensity levels 3 through 6.

A valid instrument must satisfy two conditions (Cameron and Trivedi 2009). First, an instrument must satisfy the condition of instrument relevance, meaning that the instrument and the endogenous variable must be correlated. It must also satisfy the exclusionary condition. That is, the instrument must not belong in the model for the dependent variable (and is therefore uncorrelated with the error term).

Objective probability of wildfire on a property and homeowner concern are expected to be positively correlated. Relatively higher levels of objective wildfire probability will be associated with relatively higher levels of concern about wildfire, and vice versa. As such, objective wildfire probability will likely satisfy the condition of instrument relevance (Equation 5).

Equation 5: $Cov(objective\ wildfire\ probability,\ wildfire\ concern) \neq 0$

The instrument, objective wildfire probability, also satisfies the exclusionary condition for the six actions in Zone 1. For these six mitigation actions, observed objective wildfire probability is unlikely to be correlated with an unobserved determinant of mitigation (Equation 6). That is, objective wildfire risk can only affect these six mitigation behaviors through its impact on concern. Additionally, fire experts voice that Zone 1 is the most important zone in which to take action, as it is the most vulnerable to ignition from embers (Barkley et al. 2005, National Fire Protection Association 2018).

The instrument also addresses the problem of reverse causality because the completion of mitigation actions in Zone 1 will not change the objective wildfire probability of the parcel. Any effect on mitigation as a result of variation in objective risk must be caused by a change in perceived risk.

Equation 6: $Cov\ (objective\ wildfire\ probability,\ u) = 0$

The remaining six actions (in Zone 2 and 3) are unlikely to satisfy this exclusionary condition. Because the overall vegetation on a plot of land is one of the inputs used to determine the objective wildfire probability for that plot, the vegetative mitigation actions described for Zones 2 and 3 could effectively change the objective wildfire probability for a given parcel. Because of this, only mitigation actions in Zone 1 will be used as outcome variables.

Upon the satisfaction of these conditions, an instrumental variable model can be estimated in two stages (Equations 7 and 8).

Equation 7: $$concern = \alpha_0 + \alpha_1\, Obj\, risk + \alpha_2 X + v$$

Equation 8: $$mitigation = \beta_0 + \beta_1\, (\widehat{concern}) + \beta_2 X + \varepsilon$$

4.2 Modeling Multiple Binary Mitigation Behaviors

The literature provides a few methods to analyze multiple binary outcome variables. Each method has strengths and drawbacks.

One approach is to treat mitigation as dichotomous. Fischer et al. (2014) used this method by approaching fuel treatment as a binary dependent variable that takes the value of zero if the homeowner had completed no actions, and one if the homeowner had completed one or more actions. While it does specify a nonlinear relationship within the appropriate range, this approach would treat an individual who had performed one mitigating behavior the same as someone who had performed six behaviors. This method only provides insight about what makes people move from no mitigation to some mitigation; it says nothing about what might move people to mitigate more than they already are.

A second method creates classifications by categorizing the number of actions into low, medium, and high levels. While Brenkert-Smith et al. (2012) use this method for the intuitive appeal of having low-, mid-, and high-mitigators, a drawback is that the cutoffs for the classifications can seem arbitrary.

Modeling the number of mitigation actions as a count exploits more variation than the previous approaches. This approach accounts for the ordinal nature of number of mitigation behaviors by using either a Poisson model, or an ordered probit or logit model. With the assumption that performing M+1 behaviors is superior to performing M behaviors, Champ et al. (2013) and Collins (2008) both use this method to predict number of mitigation behaviors. This technique provides insight to the factors that make homeowners perform more mitigation behaviors. The drawback of this strategy is that it treats all mitigation behaviors as commensurate (Brenkert-Smith et al. 2012).

I construct a count of the six actions in Zone 1 because fire scientists have indicated that focusing most mitigation efforts on the home and the immediate surrounding area can reduce the potential for home loss (Cohen 2000). Using a count is the most appropriate method because it best indicates which homeowners are taking the most action on their property to prevent home ignition. Ordinary Least Squares (OLS) estimation is not appropriate for this type of data. First, OLS assumes that the data is normally distributed. Under a normal distribution, the mean is equal to the median and the mode, which is not the case for this data. Additionally, the count data cannot take values less than zero, but OLS can result in negative estimates for predicted number of mitigation actions. The Pearson chi-squared test indicates that the distribution of the count data of the first 6 actions is not statistically different from a Poisson distribution

(p=.544). A likelihood ratio test for overdispersion determines that the overdispersion parameter alpha is not statistically different from zero (p=.500).

One problem with this count variable is that it requires that a homeowner responded either "yes" or "no" to every mitigation action. When a person selects "N/A" for a question, a count cannot be constructed without deciding how to treat the nonapplicable responses. Using only observations for which a *count6* can be constructed leaves only 623 observations of the original sample of 1306, which is not desirable. I confront this problem two ways. First, I construct a variable, *count6na*, that treats all of the "N/A" responses as "no". Second, I construct a variable, *prop6*, that is a proportion of the applicable actions that a homeowner completed. This

Table 4: Mitigation behavior (Zone 1) frequency of responses

Mitigation Action	**Yes**	**No**	**N/A**	**Total N**
Installed non-combustible material	550	485	188	1223
Moved flammable material	567	392	258	1217
Cleared debris from under decks	644	239	333	1216
Cleaned out gutters	640	192	389	1221
Covered vents with wire mesh or screen	361	498	351	1210
Removed flammable vegetation	549	414	254	1217

method treats "N/A" responses as truly not applicable. Thus, if a person responded that they completed 3 actions, did not complete 2 actions, and one action was not applicable, they would be assigned a proportion of three out of five (0.6). Due to the high number of actions that were marked as "N/A" (Table 4), I believe that this approach is insightful.

In addition to the analysis that will be completed with these aggregate measures of mitigation, I will also model each mitigation action individually. OLS will produce predictions that lie outside of the appropriate range of 0 to 1. Additionally, linear estimation cannot account for variation in the marginal effects. To deal with these issues, I will model each mitigation action using a probit model, which constrains the range to [0,1] and allows for changing marginal effects. If there is evidence of endogeneity, I will use an instrumental variable probit model.

5. Results

5.1 Number of Mitigation Actions Completed

When mitigation behaviors are modeled as a count variable (*count6*), the results indicate that increased homeowner concern has a positive and statistically significant effect on the number of mitigation behaviors performed. Moreover, estimates from the instrumental variable model suggest that the magnitude of the effect of increased concern is more than double the estimates from models that ignore the potential endogeneity. For example, the coefficient estimate on *Burn Concern* from the standard OLS in Column 1 of Table 5 indicates that a one unit increase in *Burn Concern* on the Likert scale, a homeowner will, on average and holding other variables constant, perform .368 more mitigation behaviors. However, when *Burn Concern* is instrumented with *bp*, the effect of concern is significantly larger. The coefficient estimate on *Burn Concern* in Column 4 of Table 5 indicates that the same one unit increase in *Burn Concern* causes homeowners to complete an additional 1.029 mitigation actions. The marginal effect of increasing level of concern from 1 to 2 on the Likert scale is the same as increasing the level of concern from 2 to 3, or from 4 to 5.

If the Durbin and Wu-Hausman tests suggest that concern can be treated as exogenous, then the OLS model will provide more efficient estimates. These tests cannot be performed after Poisson regressions, but the results of the tests after 2SLS regression can prove informative. For this model, these tests [Durbin (p=.0233) and Wu-Hausman (p=.0376)] both reject the null hypothesis of exogeneity, suggesting that concern is indeed endogenous for the aggregate measure *count6*, and that the instrumental variable approach is appropriate for this model. Furthermore, when two instruments are used, overidentification tests can be performed to test for instrument validity. The 2SLS regression of *count6* (p=.59) and the Poisson estimation of *count6* (p=.66) fail to reject the null hypothesis that at least one instrument is invalid, indicating that both instruments are valid. First stage diagnostics of *count6* indicate that using two instruments is weak (F=8.949), but that *bp* alone is a strong instrument (F=12.93). This test is not possible on Poisson estimates. These tests demonstrate that *bp* is a strong instrument to model the effect of wildfire concern on mitigation behaviors[2]. If homeowner concern about wildfire is endogenous, then objective probability of wildfire can be used as an instrument to model the true effect of concern on mitigation.

[2] Because burn probability proved to be the strongest instrument across models, *bp* is used as the preferred instrument referenced in this results section. Results of models using the other instruments can be found in the Appendix.

Table 5: Estimation results of count of mitigation actions completed (*count6* and *count6na*)

	(1) OLS	(2) Poisson	(3) Poisson N/A=no	(4) IV	(5) IV Poisson	(6) IV Poisson N/A=no
Burn Concern (1-5)	0.368***	0.113***	0.096***	1.029***	0.270**	0.233**
	(0.072)	(0.023)	(0.019)	(0.333)	(0.108)	(0.097)
Enough Money (1-5)	0.145**	0.039*	0.034*	0.261***	0.062**	0.048**
	(0.070)	(0.022)	(0.018)	(0.094)	(0.025)	(0.020)
Efficacy of Action (1-5)	0.388***	0.129***	0.120***	0.254**	0.097**	0.094***
	(0.101)	(0.033)	(0.027)	(0.121)	(0.041)	(0.035)
Satisfaction with area efforts to reduce wildfire (1-5)	-0.114	-0.030	-0.009	0.018	-0.003	0.013
	(0.100)	(0.031)	(0.027)	(0.124)	(0.033)	(0.030)
Expectations of Neighbors = "Yes"	0.626***	0.159**	0.139**	0.025	0.036	0.035
	(0.211)	(0.065)	(0.054)	(0.382)	(0.102)	(0.086)
Expectations of Neighbors = "I don't know"	-0.190	-0.052	-0.072	-0.535**	-0.128	-0.137**
	(0.200)	(0.064)	(0.052)	(0.269)	(0.079)	(0.066)
Willingness to contact local FD (1-5)	0.300***	0.091***	0.080***	0.127	0.057	0.052
	(0.105)	(0.030)	(0.025)	(0.149)	(0.042)	(0.033)
Gender	0.033	0.009	0.081*	0.068	0.024	0.091*
	(0.184)	(0.057)	(0.048)	(0.198)	(0.055)	(0.047)
Age	0.005	0.001	0.000	-0.003	-0.000	-0.001
	(0.006)	(0.002)	(0.002)	(0.008)	(0.002)	(0.002)
Observations	468	468	746	468	468	746
Log Likelihood	-915.986	-937.935	-1457.502			
Chi-squared		115.410	130.049	115.347		
R-squared	0.221			0.071		
F-Stat				12.927		
DWH F-Stat				4.347		

The more appropriate Poisson estimation produces results that are similar to those of the OLS estimates. The results of a naïve Poisson regression find a positive and statistically significant effect of *Burn Concern* ($p<.001$) on number of mitigation actions completed. The coefficient suggests that a one unit increase in *Burn Concern* corresponds to an increase in the difference in the logs of expected counts of .113. This suggests that a person who has a concern level of C+1 has an expected count of mitigation actions that is 12 percent higher than a person who reported a concern level of C. For a person who completed 4 actions, a one unit increase in concern would increase the expected number of actions completed to 4.48, a substantial increase. When an instrumental variable approach is used, a one unit increase in *Burn Concern* is expected to increase the expected count by 30 percent ($p=.013$), meaning that a one unit increase in concern would increase the expected count of someone who had completed 4 actions to 5.2 actions. In this model, having enough money and perceived efficacy of actions were also significant at the one percent level.

5.2 Treating N/A as no

When the "N/A" responses are treated as "no", the results are similar. The Poisson results without an instrument estimate a coefficient of .096 on *Burn Concern* (Column 3), which suggests that a one unit increase in *Burn Concern* increases the expected count of completed actions by 10.1 percent (p<.001). For a homeowner who has completed 4 actions, the expected count of competed actions would increase to 4.4 actions. The effect of *Burn Concern* is smaller when *count6na* is the dependent variable compared to *count6*. This is expected because the measure treats all "N/A" responses as if a homeowner did not do an action regardless of whether the homeowner had the opportunity to complete the action.

When *bp* is the instrument, the Durbin (p=.072) and Wu-Hausman (p=.055) tests cannot reject the null hypothesis of exogeneity at the five percent level, but they do reject at the ten percent level. This suggests the presence of an endogeneity problem, and that an instrumental variable approach may provide less biased estimates.

When *bp* is used as an instrument, estimates suggest that a one unit increase in *Burn Concern* increases the average expected count of completed actions by 26.3 percent. The expected count of completed actions for someone who had completed 4 actions would increase to 5.05 actions with a one unit increase in concern. This model also suggests that answering "I don't know" to whether people in their area believed homeowners should be taking action against wildfire on their property resulted in an expected value of counts that was only 87% of the expected count of those who answered "no". Having enough money (p=.016), perceived efficacy of actions (.007), and being male (p=.054) also yielded positive impacts on the number of mitigation actions completed.

5.3 Proportion of Mitigation Actions Completed

As previously stated, using the *count6* indicator sacrifices a lot of the sample. Using *count6na* allows those observations to be used, but it assumes that all of the actions with "N/A" responses were not completed by the homeowner. Constructing a proportion (*prop6*) of applicable actions completed for each homeowner allows me to use more of the sample, while still taking respondents at their word that an action was truly not applicable to their property. For example, mitigation number 3 asks respondents if they cleared flammable debris from under their decks. If a home does not have a deck, this action is truly not applicable, and treating it as "no" is not representative of the mitigation behavior of that respondent. When *prop6* is the dependent variable, tests for endogeneity suggest that concern may be exogenous (p=.14). In this case, while *bp* is a strong instrument (F=17.6), an instrumental variable approach may not be necessary.

Table 6: Estimation of proportion of applicable mitigation actions undertaken (*prop6*)

	(1) OLS	(2) IV *(bp)*
Burn Concern (1-5)	0.052*** (0.010)	0.121** (0.050)
Enough Money (1-5)	0.019* (0.010)	0.026** (0.011)
Efficacy of Action (1-5)	0.071*** (0.014)	0.054*** (0.018)
Satisfaction with area efforts to reduce wildfire (1-5)	-0.016 (0.014)	-0.003 (0.016)
Expectations of Neighbors = "Yes"	0.068** (0.029)	0.012 (0.049)
Expectations of Neighbors = "I don't know"	-0.041 (0.026)	-0.075** (0.036)
Willingness to contact local FD (1-5)	0.042*** (0.014)	0.026 (0.019)
Gender	0.039 (0.025)	0.041* (0.025)
Age	0.001 (0.001)	0.001 (0.001)
Observations	782	782
Log Likelihood	-169.366	
Chi-squared		129.491
R-squared	0.165	0.107
F-Stat		17.642
DWH F-Stat		2.144

Coefficients are reported with standard errors in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels.

A regression on the variable *prop6* estimates a coefficient of .0517 for *Burn Concern* ($p<.001$). For a one unit increase in *Burn Concern*, the proportion of actions completed by a homeowner is expected to increase by 5.2 percentage points, on average, holding other variables constant. This means that for the average possible number of actions (5), a one unit increase in concern increases number of mitigation actions by 0.26 actions. Linear predictions of the proportion of actions completed for this sample all lie between zero and one, with the lowest predicted proportion being .134, and the highest being .934. It is promising that these predictions do not fall outside of the possible range of a proportion. The instrumental variable approach with *bp* estimates that a one unit increase in concern is associated with a 12.8 percentage point increase in the proportion of actions completed, on average, holding other variables constant. If 5 mitigation actions were possible for a homeowner, a one unit increase in concern would result in the completion of .64 additional actions, on average. Again, linear predictions of the proportion fall within the appropriate (0,1) range. The lowest predicted proportion was .076; the highest prediction was .979. Results of estimation with other instruments, as well as overidentification tests, can be found in the appendix.

5.4 Probit Estimation of Each Mitigation Action

For the IV probit models, the Wald test of exogeneity can determine whether an instrumental variable approach is necessary. Only one mitigation action (#2 - moving flammable material) presented strong evidence of endogeneity (p=.054). Actions 5 (covering vents; p=.15) and 6 (removing flammable vegetation; p=.11) demonstrated weaker evidence of endogeneity.

These tests of endogeneity indicate the possibility that *Burn Concern* is endogenous for some actions and not others. One possible explanation for this is that some actions have a more significant issue with reverse causality. The measure of perceived efficacy of action used as a control was not specific to each individual action, and only to mitigation as a whole. Therefore, homeowners could perceive some actions to be more effective than others, and the mediating effect on concern would be larger for those. Additionally, unobserved personality characteristics that affect perceived risk could affect likelihood to perform different types of mitigating actions disproportionately.

Actions that indicate strong evidence of exogeneity of concern are estimated using a traditional probit model. Actions with some evidence of endogeneity are modeled using burn probability as an instrument.

Table 7 presents the results of the probit estimation for the six actions in Zone 1. Column 1 shows that *Burn Concern* has a positive and statistically significant effect on installing non-combustible material. On average, those who were concerned (*Burn Concern* = 4) were 10.2 percentage points more likely to install noncombustible material than those who were unconcerned (*Burn Concern* = 2). Age had a small, negative effect on installing non-combustible material. Having enough money, willingness to talk to the fire department, and efficacy of action had a positive effect on this mitigation behavior. Particularly, rating perceived efficacy of action as a 4, relative to a 2, was associated with a 17.57 percentage point increase in likelihood of installing non-combustible material.

Burn concern also had a positive effect on likelihood of clearing flammable debris from under decks (Column 3). On average, homeowners who were concerned, relative to unconcerned, were 12.62 percentage points more likely to clear debris from under their decks. Having enough money and perceived efficacy of action affected this action positively and were significant at the five percent level.

Only perceived efficacy of action, willingness to contact the fire department for an assessment, and age had a statistically significant effect on whether a homeowner cleaned out their gutters (Column 4). Older homeowners were more likely to clean out gutters, as were homeowners who felt mitigation actions could successfully reduce wildfire risk. Burn concern did not significantly impact homeowners' likelihood to clean out gutters.

Column 5 shows that higher levels of burn concern did increase a homeowners' propensity to cover their vents with wire mesh or screens. On average, concerned homeowners (*Burn Concern*=4) were 9.27 percentage points more likely to cover vents than those who were unconcerned about wildfire in the area (*Burn Concern*=2). Respondents who answered that they weren't sure what people in their area believed about whether homeowners should be mitigating were 11.02 percentage points less likely to cover their vents than respondents who answered "no" to the same question. Column 6 shows that respondents who answered "yes" to that question were significantly more likely to remove flammable vegetation from the area around their house. In fact, on average, those who said "yes" were 18.04 percentage points more likely to remove vegetation than those who answered "no". Burn concern, having enough money, perceived efficacy of action, and willingness to contact the fire department also had a significant effect on likelihood to remove flammable vegetation. Moving from unconcerned (*Burn Concern*=2) to concerned (*Burn Concern*=4) was associated with 12.3 percentage point increase in likelihood of removing hazardous trees and shrubs on average.

Table 8 presents the results of the probit estimations using *bp* as an instrumental variable[3]. Column 2 shows the preferred model for moving flammable material, which demonstrated strong evidence of endogeneity. Concerned homeowners (*Burn Concern*=4), on average, were 14.27 percentage points more likely to move flammable material such as firewood, patio furniture, or propane cylinders than unconcerned homeowners (*Burn Concern*=2).

Columns 5 and 6 show the instrumental variable results for covering vents and removing vegetation, actions which presented some evidence of endogeneity of concern. Surprisingly, the instrumental variable approach estimates smaller marginal effects of increasing *Burn Concern* from 2 to 4. The effect decreases from 9.27 to 8.23 percentage points for covering vents, and from 12.3 to 11.2 for removing flammable vegetation. Column 6 shows that having enough money was an important determinant of the likelihood of removing flammable vegetation. At the means, respondents who felt they had enough funds to mitigate (*Enough Money*=4) had a likelihood of performing vegetative mitigation in Zone 1 that was 6.43 percentage points greater than respondents who felt they did not have adequate funds to mitigate (*Enough Money*=2).

[3] Burn probability proved to be the strongest instrument, so it was used as the preferred instrument. Results of models using the other instruments can be found in the Appendix.

Table 7: Probit estimation of mitigation actions - without IV

	(1) Installed non-combustible material	(2) Moved flammable material	(3) Cleared out under decks	(4) Cleaned out gutters	(5) Covered vents with wire mesh	(6) Removed flammable vegetation
Burn Concern (1-5)	0.135***	0.210***	0.191***	0.078	0.124***	0.172***
	(0.042)	(0.044)	(0.047)	(0.049)	(0.046)	(0.044)
Enough Money (1-5)	0.081*	0.025	0.097*	0.051	0.026	0.096**
	(0.042)	(0.045)	(0.051)	(0.053)	(0.045)	(0.046)
Efficacy of Action (1-5)	0.229***	0.228***	0.134**	0.177***	0.108*	0.231***
	(0.059)	(0.064)	(0.067)	(0.068)	(0.063)	(0.065)
Satisfaction with area efforts to reduce wildfire (1-5)	-0.006	-0.039	-0.112	-0.016	-0.024	-0.074
	(0.060)	(0.064)	(0.069)	(0.076)	(0.066)	(0.066)
Expectations of Neighbors = “Yes”	0.094	0.323**	0.225	0.181	0.087	0.533***
	(0.131)	(0.138)	(0.148)	(0.162)	(0.137)	(0.140)
Expectations of Neighbors = “I don’t know”	-0.156	-0.128	0.120	0.072	-0.294**	-0.077
	(0.114)	(0.121)	(0.132)	(0.136)	(0.125)	(0.119)
Willingness to contact local FD (1-5)	0.151***	0.130**	0.134**	0.102	0.115*	0.194***
	(0.057)	(0.060)	(0.067)	(0.067)	(0.062)	(0.061)
Gender	0.212*	0.030	0.009	-0.012	0.032	0.140
	(0.108)	(0.116)	(0.125)	(0.130)	(0.118)	(0.114)
Age	-0.009**	0.003	0.006	0.014***	0.007*	0.001
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Number obs.	748	696	650	615	637	700
Log Likelihood	-480.797	-424.361	-344.956	-309.434	-412.498	-418.997
Chi-squared	64.362	78.462	55.607	35.451	34.366	97.055

Coefficients are reported with standard errors in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels.

Table 8: Instrumental Variable Probit Estimation of Mitigation Actions (IV = burn probability)

	(1) Installed non-combustible material	(2) Moved flammable material	(3) Cleared out under decks	(4) Cleaned out gutters	(5) Covered vents with wire mesh	(6) Removed flammable vegetation
Burn Concern (1-5)	0.335	0.637***	0.403	0.349	0.472**	0.535***
	(0.231)	(0.171)	(0.277)	(0.274)	(0.208)	(0.194)
Enough Money (1-5)	0.101**	0.075	0.126**	0.078	0.068	0.134***
	(0.046)	(0.046)	(0.062)	(0.059)	(0.050)	(0.048)
Efficacy of Action (1-5)	0.178**	0.093	0.080	0.108	0.021	0.131
	(0.086)	(0.091)	(0.097)	(0.105)	(0.084)	(0.092)
Satisfaction with area efforts to reduce wildfire (1-5)	0.027	0.053	-0.054	0.033	0.051	0.006
	(0.070)	(0.074)	(0.103)	(0.087)	(0.077)	(0.077)
Expectations of Neighbors = "Yes"	-0.075	-0.093	0.038	-0.054	-0.223	0.184
	(0.237)	(0.236)	(0.293)	(0.292)	(0.230)	(0.259)
Expectations of Neighbors = "I don't know"	-0.262	-0.337**	-0.000	-0.073	-0.443***	-0.250*
	(0.163)	(0.141)	(0.210)	(0.199)	(0.139)	(0.143)
Willingness to contact local FD (1-5)	0.099	0.020	0.081	0.031	0.015	0.074
	(0.086)	(0.079)	(0.103)	(0.101)	(0.094)	(0.098)
Gender	0.213**	0.067	0.018	0.030	0.042	0.154
	(0.106)	(0.112)	(0.123)	(0.131)	(0.114)	(0.111)
Age	-0.011**	-0.002	0.004	0.010*	0.002	-0.004
	(0.004)	(0.004)	(0.005)	(0.006)	(0.005)	(0.004)
Number obs.	748	696	650	615	637	700
Log Likelihood	-1619.894	-1477.386	-1328.584	-1245.592	-1381.170	-1476.465
Chi-Squared	66.273	129.091	51.330	41.206	45.947	138.393
Wald Exogeneity Chi-sq.	0.698	3.712	0.522	0.840	2.114	2.534
Wald p-value	0.404	0.054	0.470	0.359	0.146	0.111

6. Discussion

The results of my analysis consistently suggest that *Burn Concern* has a positive effect on wildfire risk mitigation behaviors. Homeowners who were more concerned about the threat of wildfire tended to complete more mitigation actions than those who were not as concerned. The estimated magnitude of the effect of a one unit increase in *Burn Concern* is both statistically and practically significant. If a homeowner increases their reported level of concern from "Neither concerned or unconcerned" to "Concerned", the effect is estimated to be up to 1 additional mitigation action completed. This is not a small increase, particularly depending on the action. My findings are consistent with others that have found that positive risk perceptions positively influence mitigation (Fischer et al. 2014, Martin et al. 2009, Brenkert-Smith et al. 2012, McCaffrey 2002, McFarlane et al. 2011), but go further to demonstrate that the positive relationship is causal rather than purely correlational.

Other researchers have used an instrumental variable in an attempt to causally identify the relationship between wildfire risk perception and mitigation, however the instrument used may not be as effective. Champ and colleagues (2013) used whether or not a homeowner knew that their house was in an at-risk zone for wildfire when they moved in as an instrument for concern. This binary indicator did have a strong relationship with reported levels of perceived risk, however, the measure was self-reported, and homeowners may be inclined to exaggerate their knowledge about the wildfire risk on their property. If homeowners who were unaware of the risk reported that they were aware, and were also less likely to mitigate, that could explain why the results did not find a statistically significant effect of perceived risk on mitigation. Additionally, the instrument may not be exogenous to mitigation. Homeowners that knew about the wildfire risk when they moved into their home may have been more prepared for the wildfire mitigation responsibilities on their property and therefore be more likely to mitigate. Thus, variation in mitigation could not be directly attributed to variation in perceived risk.

Burn probability estimates do not require a homeowner to be aware of the risk, and therefore variation in mitigation can be attributed to differences in perceived risk. The instrument proved to be a strong predictor of perceived risk. This approach provides the unique advantage of demonstrating the changes in mitigation that result from the changes in perceived risk due to variation in objective probability of wildfire. As such, the change in concern is driven by changes in objective risk, which strips out the effect of expected severity and consequences. While some studies have considered the endogeneity and reverse causality of this question (Champ et al. 2013, Fischer et al. 2014), I am not aware of any that have used objective burn probability as an instrumental variable to approach the problem.

In every case, the magnitude of the effect of *Burn Concern* on aggregate measures of mitigation behaviors is larger when an instrumental variable approach is utilized. This supports the hypothesized presence of reverse causality and endogeneity. Naïve estimates of the effect of concern on risk mitigation behaviors may be downwardly biased due to the mediating effect of mitigation behaviors on levels of concern. This provides a possible explanation for studies that did not consider the simultaneity of perceived risk and mitigation that were unable to find a statistically significant effect of perceived risk.

When there is evidence that perceived risk is endogenous to mitigation behaviors, objective wildfire risk can be used to obtain estimates without the downward bias. However, my results indicate that an instrumental variable approach may not always be necessary, particularly when considering individual actions as opposed to aggregate measures of mitigation. This finding implies that some mitigation behaviors may have a stronger mediating effect on concern.

While the results are statistically and practically significant, inference to other populations outside of Montana may not be appropriate, particularly due to the high mean age (64.6) of the sample, which may not be representative of populations in the WUI. It is also important to recognize that the focus of this study was mitigation actions taken in the immediate area around the home (Zone 1), and these results should not be extrapolated to mitigation on the entire property.

7. Conclusion

Wildfire has always been a hazard in vegetated regions, but population influx to the WUI has increased the risk to homeowners and their property. The financial impacts of wildfire can be broad, burdening local, state, and federal government budgets. Encouraging homeowners living in the WUI to undertake more actions to protect their properties from wildfire is of extreme importance to efforts to reduce the negative impacts of wildfire. Better understanding of the drivers of mitigation is necessary to inform the implementation of successful wildfire prevention programs, as mitigation efforts by private landowners can help reduce fire severity and lower costs of fire suppression.

My results show that, on average, homeowners in this region respond to increased wildfire risk by increasing their mitigation activities. Moreover, although the self-reports of homeowners' level of concern about wildfire conflate the effects of the likelihood of fire and the consequences of fire, the effects on mitigation measured in this study are driven by changes in the likelihood of wildfire. That is not to say that homeowners are unresponsive to changes in the consequences of wildfire, they may very well be. But these results provide strong evidence that efforts to correct homeowners' misperceptions of the likelihood of wildfire alone will cause these homeowners to undertake more mitigation activities.

It may seem surprising that informing homeowners of these relatively low probabilities would cause an increase in mitigation activities (the maximum probability of wildfire for a parcel in the sample is less than three percent). However, the behavioral economics literature has provided substantial evidence that, consistent with prospect theory, individuals tend to transform objective probabilities and when they do they are more responsive to changes in probabilities closer to zero and one (Tversky and Kahneman, 1992; Gonzalez & Wu, 1999; Barberis, 2013). Thus, informing a homeowner who believes the probability of a fire is 0.50 percent that it is actually 2 percent will result in a homeowner behaving as if the increase in probability of a fire is greater than 1.5 percent.

I also find that efforts to increase perceived efficacy of action and reduce the financial costs associated with mitigation may also induce more action among homeowners in the WUI. Taken as a whole, these findings support the continuation of fire education programs that increase homeowner awareness of wildfire susceptibility while simultaneously providing information about the effectiveness of mitigation measures.

References

Abatzoglou, John T. and A. P. Williams. 2016. "Impact of Anthropogenic Climate Change on Wildfire Across Western US Forests." *Proceedings of the National Academy of Sciences of the United States* 113 (42): 11770. doi:10.1073/pnas.1607171113.

Alba, Joseph W. and J. W. Hutchinson. 2000. "Knowledge Calibration: What Consumers Know and what they Think they Know." *Journal of Consumer Research* 27 (2): 123-156. doi:10.1086/314317.

Arvai, Joseph, Robin Gregory, Dan Ohlson, Bruce Blackwell, and Robert Gray. 2006. "Letdowns, Wake-Up Calls, and Constructed Preferences: People's Responses to Fuel and Wildfire Risks." *Journal of Forestry* 104 (4): 173-181.

Barberis, Nicholas C. 2013. "Thirty Years of Prospect Theory in Economics: A Review and Assessment." *Journal of Economic Perspectives* 27(1): 173–196.

Brenkert-Smith, Hannah, Patricia A. Champ, and Nicholas Flores. 2006. "Insights into Wildfire Mitigation Decisions among Wildland-Urban Interface Residents." *Society & Natural Resources* 19 (8): 759-768. doi:10.1080/08941920600801207.

Brenkert-Smith, Hannah, Patricia A. Champ, and Nicholas Flores. 2012. "Trying Not to Get Burned: Understanding Homeowners Wildfire Risk Mitigation Behaviors." *Environmental Management* 50 (6): 1139-1151. doi:10.1007/s00267-012-9949-8.

Brettman, Allan. "Charges filed against 15-year-old boy in Eagle Creek fire." *The Oregonian* (Portland, OR), Oct. 20, 2017.

Champ, Patricia A. and Hannah Brenkert-Smith. 2016. "Is Seeing Believing? Perceptions of Wildfire Risk Over Time." *Risk Analysis* 36 (4): 816-830. doi:10.1111/risa.12465.

Champ, Patricia A., Geoffrey H. Donovan, and Christopher M. Barth. 2013. "Living in a Tinderbox: Wildfire Risk Perceptions and Mitigating Behaviours." *International Journal of Wildland Fire* 22 (6): 832-840. doi:10.1071/WF12093.

Champ, Patricia A., Geoffrey H. Donovan, and Christopher M. Barth. 2009. "Homebuyers and Wildfire Risk: A Colorado Springs Case Study." *Society & Natural Resources* 23 (1): 58-70. doi:10.1080/08941920802179766.

Cohen, Jack. 2000. "Preventing Disaster: Home Ignitability in the Wildland-Urban Interface." *Journal of Forestry* 98 (3): 15.

Collins, Timothy W. 2008. "What Influences Hazard Mitigation? Household Decision Making about Wildfire Risks in Arizona's White Mountains." *The Professional Geographer* 60 (4): 508-526. doi:10.1080/00330120802211737.

Committee on Stabilization Targets for Atmospheric Greenhouse Gas Concentrations and Research Council National. 2011. *Climate Stabilization Targets: Emissions, Concentrations, and Impacts Over Decades to Millennia* National Academies Press.

Corace, Greg, Shelby Weiss, and Lindsey Shartell. 2015. “Fire-Dependent Ecosystems and Wildlife.” *The Wildlife Professional.* Winter (2015): 52-55.

Crowley, C.S.L., Arun S. Malik, Gregory S. Amacher, and Robert G. Haight. 2009. "Adjacency Externalities and Forest Fire Prevention." *Land Economics* 85 (1): 162-185. doi:10.3368/le.85.1.162.

Daniels, Jeff. “Strength in numbers could help California in massive rebuilding effort after wildfire disaster.” *CNBC* (Englewood Cliffs, NJ), Nov. 1, 2017.

Department of Natural Resources. 2008. “Firewise Landscaping: A guide to protecting your home from wildfire.” http://dnr.wi.gov/topic/forestmanagement/documents/pub/FR-417.pdf

Dettmer, Sarah. “Montana firefighters granted federal aid.” *Great Falls Tribune* (Great Falls, MT), Jul. 27, 2017.

Dickinson, Katherine, Hannah Brenkert-Smith, Patricia A. Champ, and Nicholas Flores. 2015. "Catching Fire? Social Interactions, Beliefs, and Wildfire Risk Mitigation Behaviors." *Society & Natural Resources*: 1-18. doi:10.1080/08941920.2015.1037034.

Dillon, Gregory K.; Menakis, James; Fay, Frank. 2015. Wildland fire potential: A tool for assessing wildfire risk and fuels management needs. In: Keane, Robert E.; Jolly, Matt; Parsons, Russell; Riley, Karin. Proceedings of the large wildland fires conference; May 19-23, 2014; Missoula, MT. Proc. RMRS-P-73. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 60-76.

Erickson, David. “Local businesses hit hard by wildfires; state steps in with help.” *Missoulian* (Missoula, MT), Sept. 26, 2017.

Evans, A., S. Auerbach, L. Wood Miller, R. Wood, K. Nystrom, J. Loevner, A. Aragon, M. Piccarello, and E. Krasilovsky. 2015. Evaluating the Effectiveness of Wildfire Mitigation Activities in the Wildland-Urban Interface. Forest Stewards Guild, Madison, WI.

Federal Emergency Management Agency. “Wildfire Mitigation Project Types Overview – Lesson 21.” https://emilms.fema.gov/IS0277A/groups/1254.html

Finney, Mark A. 2006. “An Overview of FlamMap Fire Modeling Capabilities.” In: Andrews, Patricia L.; Butler, Bret W., comps. 2006. Fuels Management-How to Measure Success: Conference Proceedings. 28-30 March 2006; Portland, OR. Proceedings RMRS-P-41. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 213-220

Finney, Mark, Charles McHugh, Isaac Grenfell, Karin Riley, and Karen Short. 2011. "A Simulation of Probabilistic Wildfire Risk Components for the Continental United States." *Stochastic Environmental Research and Risk Assessment* 25 (7): 973-1000. doi:10.1007/s00477-011-0462-z.

Fischer, A., Jeffrey Kline, Alan Ager, Susan Charnley, and Keith Olsen. 2014. "Objective and Perceived Wildfire Risk and its Influence on Private Forest Landowners' Fuel Reduction Activities in Oregon's (USA) Ponderosa Pine Ecoregion." *International Journal of Wildland Fire* 23 (1): 143-153. doi:10.1071/WF12164.

Fried, Jeremy, Margaret Torn, and Evan Mills. 2004. "The Impact of Climate Change on Wildfire Severity: A Regional Forecast for Northern California." *Climatic Change* 64 (1): 169-191. doi:CLIM.0000024667.89579.ed.

Gonzalez, Richard, and George Wu. 1999. “On the Shape of the Probability Weighting Function.” Cognitive Psychology 38(1): 129–66.

Hall, Troy E. and Megan Slothower. 2009. "Cognitive Factors Affecting Homeowners' Reactions to Defensible Space in the Oregon Coast Range." *Society & Natural Resources* 22 (2): 95-110. doi:10.1080/08941920802392187.

Husari, Sue, H. T. Nichols, Neil G. Sugihara, and Scott L. Stephens. 2006. *Fire and Fuel Management* University of California Press. doi:10.1525/california/9780520246058.003.0019.

Kaval, P. 2009. "Perceived and Actual Wildfire Danger: An Economic and Spatial Analysis Study in Colorado (USA)." *Journal of Environmental Management* 90 (5): 1862-1867.

Kidston, Martin. “Fires near Seeley Lake taking a bite out of businesses.” *Missoula Current* (Missoula, MT), Aug. 2, 2017.

Legislative Fiscal Division. 2017. “Montana Fire Season 2017.” http://leg.mt.gov/content/Publications/fiscal/2017-COTW/Fire-Costs-Oct-25.pdf

Martin, Wade E., Ingrid M. Martin, and Brian Kent. 2009. "The Role of Risk Perceptions in the Risk Mitigation Process: The Case of Wildfire in High Risk Communities." *Journal of Environmental Management* 91 (2): 489-498.

Martin, Wade E., Carol Raish, and Brian M. Kent. 2008. *Wildfire Risk : Human Perceptions and Management Implications*. Washington, DC: Washington, DC : Resources for the Future.

McCaffrey, Sarah. "Understanding Public Perspectives of Wildfire Risk." In *Wildfire Risk : Human Perceptions and Management Implications* by Wade E. Martin, Carol Raish, and Brian M. Kent. 2008. Washington, DC: Washington, DC : Resources for the Future.

McCaffrey, Sarah. 2002. *For Want of Defensible Space a Forest is Lost: Homeowners and the Wildfire Hazard and Mitigation in the Residential Wildland Intermix at Incline Village, Nevada*, edited by Lynn Huntsinger ProQuest Dissertations Publishing.

McCaffrey, Sarah, Melanie Stidham, Eric Toman, and Bruce Shindler. 2011. "Outreach Programs, Peer Pressure, and Common Sense: What Motivates Homeowners to Mitigate Wildfire Risk?" *Environmental Management* 48 (3): 475-488.

McFarlane, Bonita L., Tara K. McGee, and Hilary Faulkner. 2011. "Complexity of Homeowner Wildfire Risk Mitigation: An Integration of Hazard Theories." *International Journal of Wildland Fire* 20 (8): 921-931. doi:10.1071/WF10096.

McGee, Tara K., Bonita L. McFarlane, and Jeji Varghese. 2009. "An Examination of the Influence of Hazard Experience on Wildfire Risk Perceptions and Adoption of Mitigation Measures." *Society & Natural Resources* 22 (4): 308-323. doi:10.1080/08941920801910765.

Meldrum, James R., Patricia A. Champ, Hannah Brenkert-Smith, Travis Warziniack, Christopher M. Barth, and Lilia C. Falk. 2015. "Understanding Gaps between the Risk Perceptions of Wildland-Urban Interface (WUI) Residents and Wildfire Professionals." *Risk Analysis* 35 (9): 1746-1761.

National Fire Protection Association. 2018. "The ember threat and the home ignition zone" https://www.nfpa.org/Public-Education/By-topic/Wildfire/Firewise-USA/The-ember-threat-and-the-home-ignition-zone

National Institute of Standards and Technology. 2017. "National Institute of Standards and Technology Special Publication 1215" 72 pages. http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1215.pdf

National Interagency Fire Center. 2017. “Wildland Fire Fatalities by Year.” https://www.nifc.gov/safety/safety_documents/Fatalities-by-Year.pdf

National Wildfire Coordinating Group. “Wildland Fire: A Natural Process.” https://www.nifc.gov/prevEdu/comm_guide/appendix/7SAMPLEFACT_FireFactSheet.pdf

Noonan, Francis and Robert Fitzgerald, “On the Role of Subjective Probabilities in Fire Risk Management Studies,” *Fire Safety Science—Proceedings of the 3rd International Symposium on Fire Safety Science,* Edinburgh, Scotland, pp. 495–504 (1991).

Northern Rockies Coordination Center. 2017. “Year-to-Date Fires and Acres by State and Agency.” https://gacc.nifc.gov/nrcc/predictive/intelligence/ytd_historical/ytd-daily-state.htm

Papakosta, Panagiota and Daniel Straub. (2013). A Bayesian network approach to assessing wildfire consequences. Safety, Reliability, Risk and life-Cycle Performance of Structures and Infrastructures.

Short, Karen C., Mark A. Finney, Joe H. Scott, Julie W. Gilbertson-Day, Isaac C. Grenfell. 2016. Spatial dataset of probabilistic wildfire risk components for the conterminous United States. Fort Collins, CO: Forest Service Research Data Archive. https://www.fs.usda.gov/rds/archive/Product/RDS-2016-0034/

Slovic, Paul. 1999. "Trust, Emotion, Sex, Politics, and Science: Surveying the Risk-Assessment Battlefield." *Risk Analysis* 19 (4): 689-701.

Thomas, Douglas, et al. 2017. “The Costs and Losses of Wildfires: A Literature Survey.” *National Institute of Standards and Technology Special Publication* (1215).

Tversky, Amos and Daniel Kahneman. 1974. "Judgment Under Uncertainty: Heuristics and Biases." *Science (New York, N.Y.)*185 (4157): 1124.

Tversky, Amos and Daniel Kahneman. 1992. “Advances in Prospect Theory: Cumulative Representation of Uncertainty.” Journal of Risk and Uncertainty 5(4): 297–323

United States Census Bureau (2016). *New Census Data Show Differences Between Urban and Rural Populations.* https://www.census.gov/newsroom/press-releases/2016/cb16-210.html

United States Department of Agriculture (2017). *Forest Service Wildland Fire Suppression Costs Exceed $2 Billion*. https://www.usda.gov/media/press-releases/2017/09/14/forest-service-wildland-fire-suppression-costs-exceed-2-billion

United States Department of Agriculture – Economic Research Service. 2016. “State Fact Sheet – Montana.” https://data.ers.usda.gov/reports.aspx?StateFIPS=30&StateName=Montana&ID=17854

United States Forest Service. 2015. “Fuel Treatments: Thinning & Prescribed Burns.” USFS Pacific Northwest Research Station. https://www.fs.fed.us/pnw/research/fire/fuel-treatments.shtml

Voltz, Matt. “US Government Reverses Denial of Montana Firefighting Aid.” *Associated Press*, Jul. 27, 2017.

Von Meyer, Nancy, and Brent Jones. “Building National Parcel Data in the United States: One State at a Time.” *Fair & Equitable*, July 2013, pp. 3–10. *International Association of Assessing Officers*, www.iaao.org/media/Topics/FE_July13_National_Database.pdf.

Westerling, A. L., H. G. Hidalgo, D. R. Cayan, and T. W. Swetnam. 2006. "Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity." *Science (New York, N.Y.)* 313 (5789): 940.

Winter, Greg and Jeremy S. Fried. 2000. "Homeowner Perspectives on Fire Hazard, Responsibility, and Management Strategies at the Wildland-Urban Interface." *Society & Natural Resources* 13 (1): 33-49. doi:10.1080/089419200279225.

Wright, William F. and Urton Anderson. 1989. “Effects of Situation Familiarity and Financial Incentives on use of the Anchoring and Adjustment Heuristic for Probability Assessment.” *Organizational Behavior and Human Decision Processes* 44 (1).

Appendix

Table A.1: Estimates of Models with Proportion of Completed Actions (*prop6*)

	(1) OLS	(2) IV = bp	(3) IV = bigfire	(4) 2 IVs
Burn Concern (1-5)	0.052***	0.121**	0.138*	0.122**
	(0.010)	(0.050)	(0.076)	(0.051)
Enough Money (1-5)	0.019*	0.026**	0.028**	0.026**
	(0.010)	(0.011)	(0.012)	(0.011)
Efficacy of Action (1-5)	0.071***	0.054***	0.050**	0.054***
	(0.014)	(0.018)	(0.022)	(0.018)
Satisfaction with area efforts to reduce wildfire (1-5)	-0.016 (0.014)	-0.003 (0.016)	-0.000 (0.019)	-0.003 (0.016)
Expectations of Neighbors = "Yes"	0.068** (0.029)	0.012 (0.049)	-0.002 (0.067)	0.011 (0.049)
Expectations of Neighbors = "I don't know"	-0.041 (0.026)	-0.075** (0.036)	-0.083* (0.045)	-0.075** (0.036)
Willingness to contact local FD (1-5)	0.042*** (0.014)	0.026 (0.019)	0.022 (0.023)	0.026 (0.019)
Gender	0.039	0.041*	0.042	0.041*
	(0.025)	(0.025)	(0.025)	(0.025)
Age	0.001	0.001	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	782	782	782	782
Log Likelihood	-169.366			
Chi-squared		129.491	122.353	129.254
R-squared	0.165	0.107	0.076	0.105
F-stat		17.642	10.121	9.356
DWH F-stat		2.144	1.563	2.192

Standard errors in parentheses. Coefficients are reported with standard errors in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels.

Overidentification tests indicate that both instruments are valid for *prop6* (p=.74). First stage diagnostics indicate that *bp* is the strongest instrument (F=17.6), and that two instruments are weak (F=9.356).

Table A.2: Relationship Between Burn Concern and Installing Non-combustible Material-Mitigation 1

	(1) Probit	(2) IV Probit (bp)	(3) IV Probit (bigfire)	(4) IV Probit (2 ivs)
Burn Concern (1-5)	0.135*** (0.042)	0.335 (0.231)	0.185 (0.326)	0.326 (0.237)
Enough Money (1-5)	0.081* (0.042)	0.101** (0.046)	0.087 (0.053)	0.100** (0.046)
Efficacy of Action (1-5)	0.229*** (0.059)	0.178** (0.086)	0.218** (0.096)	0.181** (0.087)
Satisfaction with area efforts to reduce wildfire (1-5)	-0.006 (0.060)	0.027 (0.070)	0.002 (0.079)	0.025 (0.071)
Expectations of Neighbors = "Yes"	0.094 (0.131)	-0.075 (0.237)	0.053 (0.302)	-0.067 (0.242)
Expectations of Neighbors = "I don't know"	-0.156 (0.114)	-0.262 (0.163)	-0.183 (0.206)	-0.257 (0.165)
Willingness to contact local FD (1-5)	0.151*** (0.057)	0.099 (0.086)	0.139 (0.099)	0.102 (0.087)
Gender	0.212* (0.108)	0.213** (0.106)	0.213** (0.108)	0.213** (0.106)
Age	-0.009** (0.004)	-0.011** (0.004)	-0.009* (0.005)	-0.011** (0.004)
First Stage Results				
Enough Money (1-5)		-0.109*** (0.038)	-0.100*** (0.038)	-0.109*** (0.038)
Efficacy of Action (1-5)		0.211*** (0.052)	0.210*** (0.052)	0.211*** (0.052)
Satisfaction with area efforts to reduce wildfire (1-5)		-0.153*** (0.056)	-0.140** (0.056)	-0.151*** (0.056)
Expectations of Neighbors = "Yes"		0.757*** (0.103)	0.780*** (0.104)	0.756*** (0.103)
Expectations of Neighbors = "I don't know"		0.508*** (0.099)	0.527*** (0.100)	0.508*** (0.100)

Willingness to contact local FD (1-5)		0.221***	0.231***	0.221***
		(0.052)	(0.052)	(0.052)
Gender		-0.017	-0.026	-0.018
		(0.097)	(0.098)	(0.097)
Age		0.011***	0.011***	0.011***
		(0.003)	(0.003)	(0.003)
Overall Burn Probability		0.902***		
		(0.214)		
Probability of a Large Fire (Intensity Levels 3-6)			1.253***	0.978**
			(0.386)	(0.400)
Probability of a Small Fire (Intensity Levels 1-2)				0.859***
				(0.291)
Observations	748	748	748	748
Log Likelihood	-480.797	-1619.894	-1625.355	-1619.864
Chi-squared	64.362	66.273	57.329	65.508
Wald Test Exogeneity Chi-sq.		0.698	0.024	0.610
Wald p-value		0.404	0.878	0.435

Coefficients are reported with standard errors in brackets. ***,**,and * indicate significance at the 1%, 5%, and 10% levels.

Table A.3: Relationship Between Burn Concern and Moving Flammable Materials - Mitigation 2

	(1) Probit	(2) IV Probit (bp)	(3) IV Probit (bigfire)	(4) IV Probit (2 ivs)
Burn Concern (1-5)	0.210***	0.637***	0.653***	0.634***
	(0.044)	(0.171)	(0.186)	(0.165)
Enough Money (1-5)	0.025	0.075	0.075	0.074
	(0.045)	(0.046)	(0.046)	(0.046)
Efficacy of Action (1-5)	0.228***	0.093	0.087	0.095
	(0.064)	(0.091)	(0.099)	(0.089)
Satisfaction with area efforts to reduce wildfire (1-5)	-0.039	0.053	0.055	0.052
	(0.064)	(0.074)	(0.078)	(0.074)
Expectations of Neighbors = “Yes”	0.323**	-0.093	-0.114	-0.090
	(0.138)	(0.236)	(0.251)	(0.229)
Expectations of Neighbors = “I don’t know”	-0.128	-0.337**	-0.345**	-0.336**
	(0.121)	(0.141)	(0.142)	(0.139)

Willingness to contact local FD (1-5)	0.130**	0.020	0.013	0.021
	(0.060)	(0.079)	(0.086)	(0.078)
Gender	0.030	0.067	0.067	0.067
	(0.116)	(0.112)	(0.111)	(0.112)
Age	0.003	-0.002	-0.003	-0.002
	(0.004)	(0.004)	(0.005)	(0.004)
First Stage Results				
Enough Money (1-5)		-0.115***	-0.105***	-0.113***
		(0.040)	(0.040)	(0.040)
Efficacy of Action (1-5)		0.211***	0.210***	0.209***
		(0.054)	(0.055)	(0.055)
Satisfaction with area efforts to reduce wildfire (1-5)		-0.184***	-0.170***	-0.180***
		(0.055)	(0.056)	(0.055)
Expectations of Neighbors = "Yes"		0.751***	0.770***	0.749***
		(0.105)	(0.105)	(0.105)
Expectations of Neighbors = "I don't know"		0.473***	0.488***	0.474***
		(0.103)	(0.103)	(0.103)
Willingness to contact local FD (1-5)		0.192***	0.202***	0.192***
		(0.054)	(0.055)	(0.054)
Gender		-0.079	-0.091	-0.081
		(0.100)	(0.100)	(0.100)
Age		0.011***	0.011***	0.011***
		(0.003)	(0.003)	(0.003)
Overall Burn Probability		0.931***		
		(0.223)		
Probability of a Large Fire (Intensity Levels 3-6)			1.341***	1.124***
			(0.396)	(0.381)
Probability of a Small Fire (Intensity Levels 1-2)				0.819***
				(0.288)
Observations	696	696	696	696
Log Likelihood	-424.361	-1477.386	-1482.661	-1477.164
Chi-squared	78.462	129.091	135.341	128.556
Wald Test Exogeneity Chi-sq.		3.712	3.102	3.964
Wald p-value		0.054	0.078	0.046

Coefficients are reported with standard errors in brackets. ***,**,and * indicate significance at the 1%, 5%, and 10% levels.

Table A.4: Relationship Between Burn Concern and Clearing Debris from Under Decks - Mitigation 3

	(1) Probit	(2) IV Probit (bp)	(3) IV Probit (bigfire)	(4) IV Probit (2 ivs)
Burn Concern (1-5)	0.191*** (0.047)	0.403 (0.277)	0.636*** (0.245)	0.413 (0.295)
Enough Money (1-5)	0.097* (0.051)	0.126** (0.062)	0.150*** (0.052)	0.127** (0.064)
Efficacy of Action (1-5)	0.134** (0.067)	0.080 (0.097)	0.006 (0.106)	0.077 (0.102)
Satisfaction with area efforts to reduce wildfire (1-5)	-0.112 (0.069)	-0.054 (0.103)	0.020 (0.107)	-0.051 (0.108)
Expectations of Neighbors = “Yes”	0.225 (0.148)	0.038 (0.293)	-0.202 (0.307)	0.028 (0.308)
Expectations of Neighbors = “I don’t know”	0.120 (0.132)	-0.000 (0.210)	-0.154 (0.210)	-0.006 (0.220)
Willingness to contact local FD (1-5)	0.134** (0.067)	0.081 (0.103)	0.004 (0.111)	0.078 (0.108)
Gender	0.009 (0.125)	0.018 (0.123)	0.022 (0.116)	0.018 (0.123)
Age	0.006 (0.004)	0.004 (0.005)	0.001 (0.006)	0.004 (0.005)
First Stage Results				
Enough Money (1-5)		-0.149*** (0.041)	-0.138*** (0.041)	-0.148*** (0.041)
Efficacy of Action (1-5)		0.222*** (0.055)	0.221*** (0.056)	0.221*** (0.055)
Satisfaction with area efforts to reduce wildfire (1-5)		-0.241*** (0.057)	-0.225*** (0.058)	-0.240*** (0.058)
Expectations of Neighbors = “Yes”		0.760*** (0.112)	0.786*** (0.112)	0.759*** (0.112)
Expectations of Neighbors = “I don’t know”		0.503*** (0.105)	0.521*** (0.106)	0.503*** (0.105)

Willingness to contact local FD (1-5)		0.219***	0.231***	0.219***
		(0.056)	(0.056)	(0.056)
Gender		-0.021	-0.027	-0.021
		(0.103)	(0.104)	(0.103)
Age		0.010***	0.010***	0.010***
		(0.004)	(0.004)	(0.004)
Overall Burn Probability		0.894***		
		(0.221)		
Probability of a Large Fire (Intensity Levels 3-6)			1.146***	0.949**
			(0.414)	(0.416)
Probability of a Small Fire (Intensity Levels 1-2)				0.861***
				(0.330)
Observations	650	650	650	650
Log Likelihood	-344.956	-1328.584	-1333.524	-1328.569
Chi-squared	55.607	51.330	90.970	51.984
Wald Test Exogeneity Chi-sq.		0.522	1.806	0.498
Wald p-value		0.470	0.179	0.480

Coefficients are reported with standard errors in brackets. ***,**,and * indicate significance at the 1%, 5%, and 10% levels.

Table A.5: Relationship Between Burn Concern and Cleaning Out Gutters - Mitigation 4

	(1) Probit	(2) IV Probit (bp)	(3) IV Probit (bigfire)	(4) IV Probit (2 ivs)
Burn Concern (1-5)	0.078	0.349	0.668***	0.509**
	(0.049)	(0.274)	(0.143)	(0.237)
Enough Money (1-5)	0.051	0.078	0.103**	0.092*
	(0.053)	(0.059)	(0.048)	(0.054)
Efficacy of Action (1-5)	0.177***	0.108	-0.008	0.056
	(0.068)	(0.105)	(0.087)	(0.105)
Satisfaction with area efforts to reduce wildfire (1-5)	-0.016	0.033	0.088	0.061
	(0.076)	(0.087)	(0.070)	(0.082)
Expectations of Neighbors = “Yes”	0.181	-0.054	-0.369*	-0.204
	(0.162)	(0.292)	(0.218)	(0.279)
Expectations of Neighbors = “I don’t know”	0.072	-0.073	-0.264*	-0.166
	(0.136)	(0.199)	(0.147)	(0.187)

Willingness to contact local FD (1-5)	0.102	0.031	-0.076	-0.018
	(0.067)	(0.101)	(0.078)	(0.099)
Gender	-0.012	0.030	0.077	0.054
	(0.130)	(0.131)	(0.116)	(0.125)
Age	0.014***	0.010*	0.003	0.007
	(0.004)	(0.006)	(0.005)	(0.006)
First Stage Results				
Enough Money (1-5)		-0.111***	-0.104**	-0.108**
		(0.043)	(0.043)	(0.043)
Efficacy of Action (1-5)		0.219***	0.219***	0.218***
		(0.055)	(0.056)	(0.056)
Satisfaction with area efforts to reduce wildfire (1-5)		-0.169***	-0.146**	-0.156**
		(0.060)	(0.061)	(0.061)
Expectations of Neighbors = "Yes"		0.775***	0.798***	0.777***
		(0.116)	(0.116)	(0.116)
Expectations of Neighbors = "I don't know"		0.496***	0.511***	0.501***
		(0.110)	(0.111)	(0.110)
Willingness to contact local FD (1-5)		0.235***	0.241***	0.236***
		(0.056)	(0.056)	(0.056)
Gender		-0.130	-0.135	-0.130
		(0.106)	(0.107)	(0.106)
Age		0.010***	0.011***	0.011***
		(0.004)	(0.004)	(0.004)
Overall Burn Probability		0.945***		
		(0.248)		
Probability of a Large Fire (Intensity Levels 3-6)			1.610***	1.511***
			(0.410)	(0.386)
Probability of a Small Fire (Intensity Levels 1-2)				0.586*
				(0.354)
Observations	615	615	615	615
Log Likelihood	-309.434	-1245.592	-1246.321	-1244.289
Chi-squared	35.451	41.206	116.089	58.613
Wald Test Exogeneity Chi-sq.		0.840	6.514	2.161

Wald p-value		0.359	0.011	0.142

Coefficients are reported with standard errors in brackets. ***,**,and * indicate significance at the 1%, 5%, and 10% levels.

Table A.6: Relationship Between Burn Concern and Covering Vents with Wire Mesh - Mitigation 5

	(1) Probit	(2) IV Probit (bp)	(3) IV Probit (bigfire)	(4) IV Probit (2 ivs)
Burn Concern (1-5)	0.124***	0.472**	0.199	0.431*
	(0.046)	(0.208)	(0.299)	(0.228)
Enough Money (1-5)	0.026	0.068	0.035	0.063
	(0.045)	(0.050)	(0.058)	(0.051)
Efficacy of Action (1-5)	0.108*	0.021	0.091	0.032
	(0.063)	(0.084)	(0.093)	(0.088)
Satisfaction with area efforts to	-0.024	0.051	-0.009	0.042
reduce wildfire (1-5)	(0.066)	(0.077)	(0.089)	(0.079)
Expectations of Neighbors = "Yes"	0.087	-0.223	0.022	-0.185
	(0.137)	(0.230)	(0.289)	(0.248)
Expectations of Neighbors = "I don't	-0.294**	-0.443***	-0.330*	-0.427***
know"	(0.125)	(0.139)	(0.181)	(0.144)
Willingness to contact local FD (1-5)	0.115*	0.015	0.095	0.028
	(0.062)	(0.094)	(0.102)	(0.097)
Gender	0.032	0.042	0.034	0.041
	(0.118)	(0.114)	(0.118)	(0.115)
Age	0.007*	0.002	0.006	0.002
	(0.004)	(0.005)	(0.006)	(0.005)
First Stage Results				
Enough Money (1-5)		-0.123***	-0.116***	-0.122***
		(0.040)	(0.041)	(0.040)
Efficacy of Action (1-5)		0.207***	0.206***	0.205***
		(0.055)	(0.055)	(0.055)
Satisfaction with area efforts to		-0.195***	-0.182***	-0.191***
reduce wildfire (1-5)		(0.058)	(0.058)	(0.058)
Expectations of Neighbors = "Yes"		0.784***	0.805***	0.782***
		(0.112)	(0.113)	(0.112)

Expectations of Neighbors = "I don't know"		0.460*** (0.108)	0.478*** (0.109)	0.462*** (0.109)
Willingness to contact local FD (1-5)		0.239*** (0.056)	0.247*** (0.057)	0.239*** (0.056)
Gender		-0.038 (0.105)	-0.039 (0.106)	-0.038 (0.105)
Age		0.012*** (0.004)	0.012*** (0.004)	0.012*** (0.004)
Overall Burn Probability		0.918*** (0.229)		
Probability of a Large Fire (Intensity Levels 3-6)			1.508*** (0.378)	1.154*** (0.433)
Probability of a Small Fire (Intensity Levels 1-2)				0.812*** (0.283)
Observations	637	637	637	637
Log Likelihood	-412.498	-1381.170	-1385.463	-1380.965
Chi-squared	34.366	45.947	29.521	42.483
Wald Test Exogeneity Chi-sq.		2.114	0.063	1.464
Wald p-value		0.146	0.802	0.226

Coefficients are reported with standard errors in brackets. ***,**,and * indicate significance at the 1%, 5%, and 10% levels.

Table A.7: Relationship Between Burn Concern and Removing Flammable Vegetation - Mitigation 6

	(1) Probit	(2) IV Probit (bp)	(3) IV Probit (bigfire)	(4) IV Probit (2 ivs)
Burn Concern (1-5)	0.172*** (0.044)	0.535*** (0.194)	0.491* (0.254)	0.528*** (0.192)
Enough Money (1-5)	0.096** (0.046)	0.134*** (0.048)	0.129** (0.050)	0.134*** (0.048)
Efficacy of Action (1-5)	0.231*** (0.065)	0.131 (0.092)	0.147 (0.105)	0.133 (0.091)
Satisfaction with area efforts to reduce wildfire (1-5)	-0.074 (0.066)	0.006 (0.077)	-0.006 (0.084)	0.004 (0.076)
Expectations of Neighbors = "Yes"	0.533*** (0.140)	0.184 (0.259)	0.231 (0.310)	0.192 (0.257)

Expectations of Neighbors = “I don’t know”	-0.077 (0.119)	-0.250* (0.143)	-0.229 (0.164)	-0.247* (0.143)
Willingness to contact local FD (1-5)	0.194*** (0.061)	0.074 (0.098)	0.091 (0.116)	0.077 (0.097)
Gender	0.140 (0.114)	0.154 (0.111)	0.152 (0.112)	0.154 (0.111)
Age	0.001 (0.004)	-0.004 (0.004)	-0.003 (0.005)	-0.003 (0.004)
First Stage Results				
Enough Money (1-5)		-0.127*** (0.039)	-0.116*** (0.039)	-0.125*** (0.039)
Efficacy of Action (1-5)		0.196*** (0.052)	0.197*** (0.053)	0.196*** (0.052)
Satisfaction with area efforts to reduce wildfire (1-5)		-0.179*** (0.054)	-0.166*** (0.055)	-0.177*** (0.055)
Expectations of Neighbors = “Yes”		0.720*** (0.106)	0.746*** (0.106)	0.718*** (0.106)
Expectations of Neighbors = “I don’t know”		0.441*** (0.101)	0.460*** (0.102)	0.441*** (0.101)
Willingness to contact local FD (1-5)		0.263*** (0.053)	0.272*** (0.053)	0.264*** (0.053)
Gender		-0.059 (0.096)	-0.070 (0.097)	-0.060 (0.096)
Age		0.011*** (0.003)	0.011*** (0.003)	0.011*** (0.003)
Overall Burn Probability		0.970*** (0.224)		
Probability of a Large Fire (Intensity Levels 3-6)			1.391*** (0.395)	1.097*** (0.382)
Probability of a Small Fire (Intensity Levels 1-2)				0.901*** (0.298)
Observations	700	700	700	700
Log Likelihood	-418.997	-1476.465	-1482.803	-1476.380

Chi-squared	97.055	138.393	124.751	136.509
Wald Test Exogeneity Chi-sq.		2.534	1.205	2.502
Wald p-value		0.111	0.272	0.114

Coefficients are reported with standard errors in brackets. ***,**,and * indicate significance at the 1%, 5%, and 10% levels.