An Empirical Investigation of the Effect of the Firewise Program on Wildfire Suppression Costs

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Abstract

Policy makers, landowners, and wildfire managers are seeking viable solutions to reduce wildfire risks and costs. We analyzed whether the Firewise Program, designed to reduce risks for residents, firefighters, and structures, also provides the benefit of lower firefighting costs. We quantify the effect of the Firewise Program on suppression costs using a sample of 111 western U.S. wildfires. We find no evidence of a relationship between suppression costs and Firewise participation represented by: (1) the percent of homes in Firewise Communities for the area within 6 mi. of wildfires, and (2) Firewise-related expenditures by residents. The lack of evidence that Firewise reduces suppression costs suggests that policy makers attempting to specifically address rising suppression costs should incorporate additional solutions, including increasing suppression funding and managing future development in high-risk areas.

1. Introduction

The cost of fighting wildfires is increasing while the overall federal budget is under constraints, at times straining wildland firefighting resources. A number of approaches are being tried to reduce risks and costs, including fuel reduction and voluntary landowner education to increase safety and the survivability of structures. The Firewise Program is one of many efforts to reduce wildfire risks. The purpose of this study was to determine whether this program, in addition to reducing risks, also reduces firefighting costs.

Started by the National Fire Protection Association (NFPA) in 1997, the national Firewise Communities/USA® Recognition Program aims to teach people and communities to adapt to living in areas prone to wildfire. Currently, there are more than 1,000 Firewise-designated communities throughout the U.S., many in the West. Each Firewise-designated community must complete a series of actions before receiving Firewise accreditation. First, they must get a written wildfire risk assessment from their state forestry agency or fire department. Communities are then required to form a board or committee and generate an action plan based on their risk assessment. Next, they must organize and hold a public education "Firewise Day" event. The final step requires an investment of at least $2 per person in annual Firewise actions. Once these steps are completed, communities are eligible to apply for the designation through their state Firewise liaison (NFPA 2013). Examples of Firewise actions include safe placement of structures relative to ridges and slopes, using fire-resistant landscaping in various zones around homes, improving construction and maintenance of roofs and gutters, and establishing neighborhood communication and evacuation protocols.

1.1 Past Research

Despite the interest in solutions for reducing wildfire risks and costs in the Wildland-Urban Interface (WUI), there is a shortage of research on the impacts of community-level wildfire preparedness programs, such as Firewise. Most existing studies of wildfire preparedness have been focused on approaches employed by individual homeowners for reducing the risk of home ignition (Quarles et al. 2010, Cohen 2008, National Institute of Standards and Technology (NIST) 2013, Morrison and Wooten 2013).

Several studies have documented the effect of homesite characteristics on the probability of home ignition or post-fire home survival. Examples include two recent case studies that evaluate home survival within subdivisions where recent wildfires have caused major damage (NIST 2013, Morrison and Wooten 2013). The NIST (2013) study investigated the effect of homesite characteristics, including landscaping, topographical features, and potential wildland fire exposure on home survival rates for a subdivision north of San Diego, California. The Morrison and Wooten (2013) study compared home survival rates between homes in direct contact with trees or shrubs versus other homes for the area within the southeast perimeter of the Yarnell Hill Fire in Arizona. Both studies are in agreement with previous research findings that home survival can be enhanced by wildfire preparedness actions taken by individual homeowners. However, it is not possible to infer from these studies how homeowner actions may translate into changes in fire suppression efforts, including changes to firefighter safety and to suppression costs.

One recent qualitative study documents the impacts of community-level wildfire preparedness on wildfire management outcomes. The study recorded views of senior-level wildfire managers about the potential of the Firewise Program to alter risk to structures, firefighter safety, and wildfire suppression costs (Headwaters Economics 2014). Type I and Type II Incident Commanders (ICs) were interviewed and found to have widespread agreement regarding the value of community wildfire preparedness programs, such as Firewise, in increasing the likelihood of successful structure protection and firefighter safety. There was less uniformity in perspectives on the relationship between community wildfire preparedness and suppression costs. Some of the ICs stated they did not have enough information and therefore declined to comment on the relationship. However, many ICs provided arguments as to why fires in Firewise Communities may incur decreased suppression costs since preparedness likely results in fewer resources being required to successfully engage a fire.

1.2 Study Objectives

The scientific literature contains little quantitative information about the impacts of community-level wildfire preparedness, which incorporates neighborhood communication and evacuation protocols in addition to home-site action, on wildfire management outcomes. This paper investigates empirical evidence for the effect of community wildfire preparedness on wildfire suppression costs. We examine the effect on suppression costs since there is less known about this relationship in contrast to the relationships between community wildfire preparedness, structure survival, and firefighter safety. We focus on the Firewise Program in the western U.S. because of the large number of participating communities, wide geographic coverage, and thorough documentation of the community locations and structure counts. This topic has been identified as a research need by policy makers and wildfire practitioners who want to learn more about the cost trade-offs of wildfire mitigation, including Firewise, versus suppression (Reinhardt et al. 2008).[1]

2. Methods

We investigated the evidence for the effect of the Firewise Program on wildfire suppression costs in the West, where roughly 70 percent of forests are publicly owned and managed (Gude et al. 2008). Of the 111 wildfires within our sample, 25 threatened Firewise Communities. Among these 25 fires, only five entered the community boundaries. Despite the small number, our sample is useful for investigating the effect of Firewise on suppression costs since the majority of suppression expenditures are made attempting to suppress wildfires before they enter communities. Of the 10,842 western wildfires documented by the Geospatial Multi-Agency Coordination Group from 2000 to 2011, less than ten percent of the perimeters overlap the boundaries of cities, towns, or census-designated places (U.S. Geological Survey 2013).

Isolating the effect of the Firewise Program on suppression costs required that we control for a suite of potential confounding variables, including fire size, duration, terrain, and human factors such as land ownership and road access. To decide which variables should be included we used information from prior studies that investigated factors affecting wildfire suppression costs (Gebert et al. 2007, Donovan et al. 2008, Liang et al. 2008, Gude et al. 2013).

2.1 Sample characteristics

The analysis included two types of wildfires: those that burned near Firewise Communities and those that did not. The sample of western wildfires that burned near (within 6 mi.) Firewise Communities included the entire population for which data was available excluding grassland fires, which were not included because we expected that firefighting strategies and therefore the relationship between Firewise participation and suppression cost would differ substantially between grassland and forest fires.

We gathered data for all wildfires that met the following criteria, resulting in the inclusion of 25 "Firewise fires" within Arizona, California, Colorado, Idaho, Montana, New Mexico, Oregon, Utah, and Washington (see Table 1 for wildfire characteristics).

[1] This research need was identified in a three-day forum of wildfire professionals and experts in January 2014 in Jackson, WY. The group of experts met to discuss methods for protecting communities from wildfires. See http://wildfiretoday.com/tag/wui/

1. The wildfire burned within 6 mi. of a Firewise Community.[2] Housing within this distance, and further, has been found to influence suppression costs in previous studies (Gude et al., 2013).

2. A minimum of two data sources of cumulative suppression costs agreed to within ten percent. Data sources included I-Suite Cost Reports, the U.S. Forest Service financial system, and Incident Status Summary (ICS-209) forms.

3. Data were available on the number of homes within 6 mi. of the wildfire perimeter. Within this buffer, we gathered data on total home counts and counts of homes in Firewise Communities.

In order to detect a possible effect of the Firewise Program on suppression costs, our sample also needed to include wildfires that did not burn near Firewise Communities. We selected to include as "non-Firewise fires", those that burned greater than 10 mi. from the nearest Firewise Community. Although the choice was somewhat arbitrary, it is unlikely that communities further than 10 mi. from a wildfire have a large effect on suppression efforts.

To the initial sample of 25 Firewise fires, we added 86 non-Firewise fires: 26 in the Sierra Nevada region of California, 32 in Oregon, and 28 in Montana (see Table 1 for wildfire characteristics). Due to data availability and expense, particularly for home locations, these additional 86 wildfires were added from existing datasets from three previous research efforts (Headwaters 2008, Headwaters 2012, Gude et al. 2013). In each of the three previous studies, the wildfire samples included all fires for which data were available. These wildfires met the same criteria described previously: no grassland fires were included, a minimum of two data sources of suppression costs agreed to within ten percent, and accurate data on home locations within 6 mi. of fire perimeters were available.

The final sample includes 111 wildfires (Figure 1). The wildfire characteristics within our sample fires are representative of wildfires fought in the West during the time period covered in our sample (2006-2012) (U.S. Geological Survey 2013). In every wildfire in our sample, multiple agencies were involved in providing resources for suppression. In the majority of sample fires the U.S. Forest Service was the primary agency involved. On average, the Firewise fires were roughly half as long in duration, half as large, and cost half the amount to suppress (Table 1). The characteristics of the Firewise fires were, though smaller, within the range of values captured in the non-Firewise fires for the majority of variables (Table 1).

[2] To meet this criterion, the wildfire needed to have started at least one year after the community was designated as Firewise.

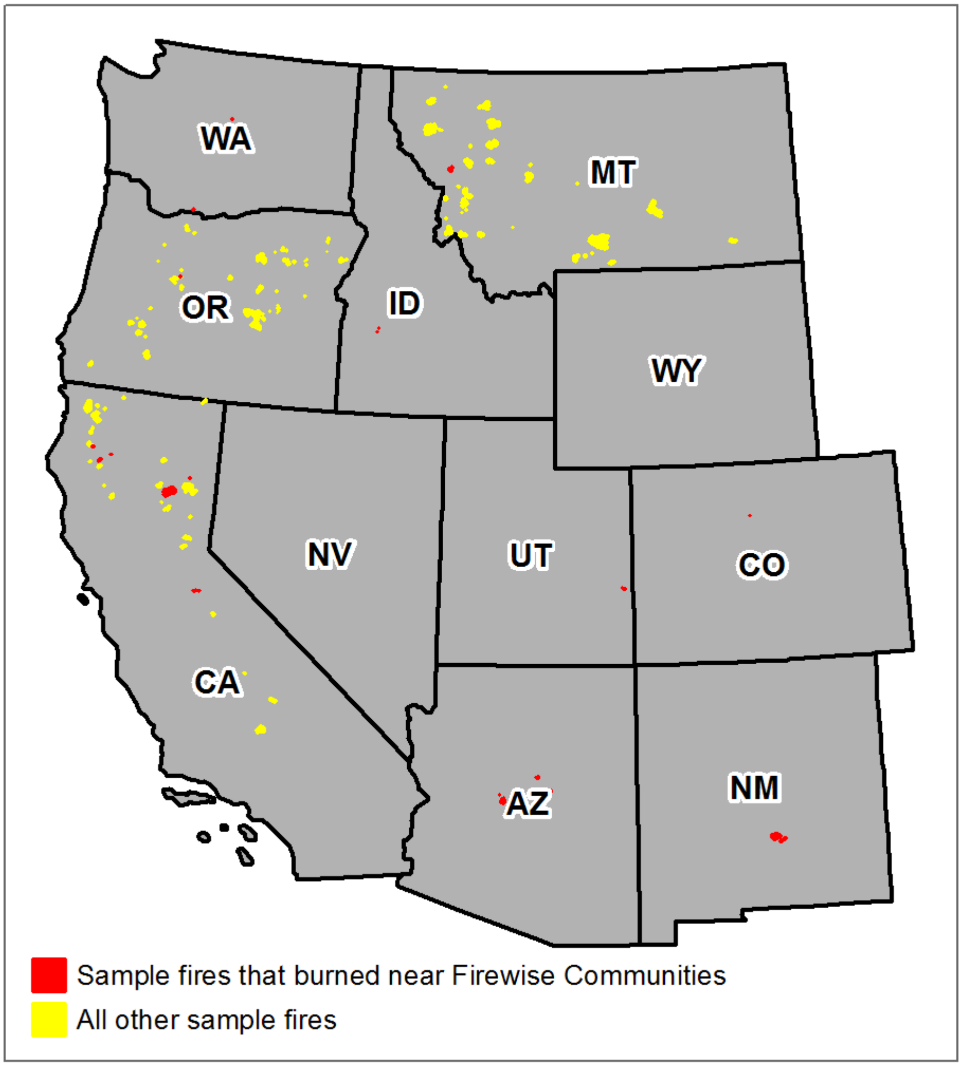

Figure 1. The sample includes 111 wildfires: 25 that burned within 6 mi. (9.7 km) of a Firewise Community and 86 that burned more than 10 miles from the nearest Firewise Community.

Table 1. Average, minimum, and maximum values of continuous variables and year are presented for 25 wildfires that burned within 6 mi. of the nearest Firewise Community and 86 that burned more than 10 mi. from the nearest Firewise Community.

Variable	Fires that burned < 6 mi. from Firewise Communities avg. (min. - max.)	Fires that burned > 10 mi. from Firewise Communities avg. (min. - max.)
Cumulative Suppression Cost	$5,929K ($194K - $53,300K)	$11,241K ($440K - $72,226K)
Fire Size	7,877 (134 - 75,431)	21,603 (156 - 208,096)
Duration (Number of Firefighting Days)	16 (4 - 46)	30 (6 - 100)
Road Count	76 (2 - 700)	76 (0 - 1315)
% Private Land within 1 mi. of wildfire	28% (0 - 91%)	16% (0 - 94%)
Homes within 6 mi. of wildfire	2851 (118 - 11,062)	547 (0 - 11,024)
% of Homes located in Firewise Communities	43% (1 - 99%)	na
Total Firewise Investment	$711K ($7K - $5,986K)	na
Year	2010 (2007 - 2012)	2007 (2006 - 2010)

2.2 Response and Explanatory Data

Data describing fire characteristics were generated using Geographic Information System (GIS) files, including perimeters available from the U.S. Geological Survey's Geospatial Multi-Agency Coordination Group website, or were compiled from tabular sources, such as I-Suite Cost Reports, ICS-209 forms, and spreadsheets provided by the NFPA (Table 2).

Cumulative suppression cost data were compiled from I-Suite Cost Reports, the U.S. Forest Service financial system, and ICS-209 forms. Wildfires for which the cumulative costs were available from only one source, or for which two or more sources did not agree to within ten percent, were eliminated from the sample. The suppression cost response variable was calculated as the average of the available cost estimates that were in agreement to within ten percent.

Calculations of fire size, road counts, percent private land within 1 mi. of wildfires, and homes within 6 mi. of wildfires, involved the use of GIS daily perimeter files. Daily road counts were calculated as the number of roads that intersected each daily fire perimeter. The percent private land variable was calculated using land ownership data from version 1.3 of the U.S. Geological Survey's Protected Areas Database of the United States (U.S. Geological Survey 2012). The homes variable was calculated by summing the number of homes within a 6 mi. radius around each daily fire perimeter. The locations of homes were determined from county tax assessor records joined to tax lot boundaries. For each of these variables, the maximum value per fire event was used in the analysis for consistency with previously published research of cumulative suppression costs. However, we did confirm that the use of average values for these predictors did not change the significance or interpretation of effects.

GIS files describing the location of Firewise Communities, the year of designation, and the Firewise expenditures made by residents to date were provided by the NFPA. We included the Firewise expenditures variable as a proxy for preparedness effort despite the likelihood that some of the investment was made after the date in which our sample wildfires burned. NFPA also coordinated efforts on the part of Firewise Community chairpersons to collect the data we requested on home counts within particular Firewise Communities. Within a 6 mi. radius of each sample wildfire, we calculated the percent of total homes (using the maximum value per fire) located in Firewise Communities.

The remaining explanatory variables, including fire duration, season, year, and categorical variables representing fire growth potential and terrain difficulty, were compiled from ICS-209 forms. Year, fire growth potential, and terrain difficulty were used as reported in ICS-209 forms and were treated as categorical variables. Season was also categorical and was calculated as "peak" if the majority of ICS-209 reports were from July or August, and otherwise was calculated as "shoulder." Duration was calculated as the number of days between the first ICS-209 entry and the subsequent ICS-209 entry after which the reported "Estimated Costs to Date" no longer increased.

Table 2. Data collected for wildfires including 25 that burned within 6 mi. of the nearest Firewise Community (within AZ, CA, CO, ID, MT, NM, OR, UT, and WA) and 86 that burned more than 10 mi. from the nearest Firewise Community (26 in CA, 32 in OR, 28 in MT).

Data	Source
Cumulative Suppression Cost	I-SUITE, USFS, and ICS-209 Forms*
Fire Size (Average)	GIS Perimeter Files
Duration (Number of Firefighting Days)	ICS-209 Forms
State	US Census
Season (Peak or Shoulder)	ICS-209 Forms
Year	ICS-209 Forms
Fire Growth Potential	ICS-209 Forms
Terrain Difficulty	ICS-209 Forms
Road Count	ESRI
Percent Private Land within 1 mi. of wildfire	US Geological Survey
Homes within 6 mi. of wildfire**	Tax Assessor Records
Percent of Homes located within Firewise Communities	National Fire Protection Assoc.
Total Firewise Investment	National Fire Protection Assoc.

* The suppression costs were crosschecked across these data sources to ensure accuracy.
** This distance was found to be influential in previous suppression cost studies (Gude et al., 2013).

2.3 Statistical Model

Statistical analyses were performed using Stata IC version 13.1. In order to stabilize variances and linearize relationships among some of the variables, we took the natural log of the variables Suppression Cost, Fire Acreage, Homes within Six Miles, and Firewise Investment. For variables containing zeroes, 0.1 was added to each value before taking the log. With Suppression Cost as the response, all other variables were entered into a linear, mixed-effects model as explanatory variables. A variable indicating a positive investment in Firewise was included as a random effect, and the two groups were allowed to have unequal variances. This approach controls for underlying differences in characteristics between the two samples and potential endogeneity from unobserved variable bias, which, if uncorrected, could affect our results if Firewise communities tend to be located in areas exposed to particularly low- or high-cost wildfires. We did not pursue model reduction, and instead present the parameter estimates for all variables since we believe that both the presence and lack of effects in the model results are noteworthy. Standard diagnostics were performed to ensure that distributional assumptions were reasonable.

3. Results

We evaluated two Firewise-related variables:

1. The percent of homes located within Firewise Communities for the area within a 6 mi. radius of each sample wildfire (values in our sample ranged from 0% to 99%).

2. The total Firewise investment, a sum of Firewise-related expenditures made by residents, for Firewise Communities within a 6 mi. radius of each sample wildfire (values in our sample ranged from $0 to $5.9 million).

Neither of the two Firewise-related variables was found to be associated with suppression cost.

3.1 Statistical model

Table 3 gives the results from our analysis using a linear, mixed-effects model. The estimates of statistically significant effects at the 0.05 level are highlighted. The six variables found to be associated with suppression cost were fire size, duration, road count, year, state, and terrain difficulty. Interpretations of the confidence intervals for log-log, log-categorical, and log-nonlog relationships are provided in the following paragraphs. The coefficient estimates of individual predictors are interpreted as the effects after controlling for the other variables in the model (Wooldridge 2000, p. 13).

Several effects are interpreted as elasticities since both the response and explanatory variables were log transformed. This is the case for fire size, duration, the count of homes within 6 mi. of the fire, and the total Firewise investment. We estimate with 95 percent confidence that the expected change in suppression costs with each 1% change in fire size is between 0.214% and 0.433%. A doubling of fire size is expected to be associated with an increase in suppression cost between 16% and 35% (calculated as $2^{0.214}\approx1.16$ and $2^{0.433}\approx1.35$). The estimated effect of fire duration on suppression cost is larger in magnitude. We estimate with 95 percent confidence that a doubling of duration is associated with an increase in suppression cost between 24% and 69% (calculated as $2^{0.308}\approx1.24$ and $2^{0.761}\approx1.69$). For both the total count of homes (Firewise or other) within 6 mi. of the fire and the total Firewise investment, confidence intervals on the coefficient estimates (95% CI -0.013 to 0.099% and -0.243 to 0.112% respectively) overlap zero. The expected change in suppression cost associated with a doubling of homes is between -1% and 7%. The expected change in suppression cost associated with a doubling of Firewise investment is between -16% and 8%.

The coefficient estimates for the remaining three continuous variables (road count, percent private land, and percent of homes in Firewise Communities) are expressed in terms of percent change. Among these three variables, only road count was found to have a significant association with suppression cost at the alpha level of 0.05. We estimate with 95 percent confidence that one additional road intersecting a fire perimeter is associated with a 0 to 0.10% increase in suppression cost. We estimate that an increase of 100 roads intersecting a fire perimeter is associated with a 0 to 11% increase in suppression cost (calculated as $e^{0*100}\approx0$ and $e^{0.001*100}\approx1.11$). We estimate that a 1% increase in the share of homes in Firewise Communities for the area within 6 mi. of a wildfire is associated with a -74% to 175% change in suppression cost (calculated as $e^{-1.032*1}\approx0.36$ and $e^{1.013*1}\approx2.75$).

Among the categorical variables, certain years, states, and levels of terrain difficulty were found to be associated with differences in suppression cost. For the set of year indicators, 2006 was used as the reference year. The coefficient estimates for years are therefore interpreted as a comparison of the particular year to 2006. We estimate with 95 percent confidence that, after accounting for the other variables, the average cost of suppression in 2011 was 0.06 to 0.40 times less than in 2006 (calculated as $e^{-2.767}\approx0.06$ and $e^{-0.907}\approx0.40$). For the set of state indicators, Arizona was used as the reference state. California, Montana, New Mexico, Oregon, and Washington were estimated to have average suppression costs greater than Arizona after accounting for the other variables. For example, we estimate with 95 percent confidence that the average cost of suppression in California was 2.71 to 10.85 times greater than in Arizona (calculated as $e^{0.999}$≈2.71 and $e^{2.385}$≈10.85). For both fire growth potential and terrain difficulty, "extreme" was used as the reference category. For fires in which the majority of days were classified as having medium terrain difficulty, we estimate the cost of suppression to be 0.39 to 0.85 times less than fires with extreme terrain difficulty. Neither season nor fire growth potential was found to be associated with change in suppression cost.

Table 3. Parameter estimates and confidence intervals resulting from a linear, mixed-effects model.

Variable	Lower 95% bound	Estimate	Upper 95% bound
Ln (Fire Size)	0.214	0.324	0.433
Ln (Duration)	0.308	0.534	0.761
Road Count	0	0	0.001
Year 2007	-0.627	-0.283	0.061
Year 2008	-0.476	-0.127	0.222
Year 2009	-0.812	-0.396	0.020
Year 2010	-0.520	0.325	1.171
Year 2011	-2.767	-1.837	-0.907
Year 2012	-0.848	-0.092	0.664
State CA	0.999	1.692	2.385
State CO	-0.468	0.979	2.425
State ID	-0.176	0.838	1.852
State MT	0.110	0.834	1.558
State NM	0.408	1.620	2.832
State OR	0.933	1.630	2.328
State UT	-1.364	0.008	1.381
State WA	0.820	1.830	2.839
Season	-0.465	-0.193	0.078
Fire Growth Potential High	-0.223	0.136	0.495
Fire Growth Potential Medium	-0.362	0.120	0.602
Fire Growth Potential Low	-0.198	0.438	1.074
Terrain Difficulty High	-0.225	0.025	0.274
Terrain Difficulty Medium	-0.950	-0.553	-0.157
Terrain Difficulty Low	-2.422	-1.089	0.243
% Private Land within 1 mi. of wildfire	-0.580	-0.008	0.565
Ln (Homes within 6 mi. of wildfire)	-0.013	0.043	0.099
% of Homes in Firewise Communities	-1.032	-0.009	1.013
Ln (Total Firewise Investment)	-0.243	-0.066	0.112

4. Discussion

4.1 Summary of results

We do not find support for an effect of the Firewise Program on wildfire suppression cost. Importantly, this is not the same as finding "no effect", since it is not possible in a statistical analysis to demonstrate no relationship (i.e., to accept a null hypothesis). We present confidence intervals as a useful means of providing a range of plausible values. For both of the Firewise-related variables in our study, the 95 percent confidence intervals are wide, indicating a high degree of uncertainty regarding their relationship to suppression costs. For example, we estimate a -74% to 175% change in suppression cost associated with a 1% increase in the share of homes in Firewise Communities for the area within 6 mi. of a wildfire. We also estimate that a doubling of Firewise investment—expenditures made by residents—is associated with a -16% to 8% change in suppression cost.

Our findings are consistent with scenarios in which comparable resources are used in attempts to suppress wildfires regardless of whether nearby communities are designated as Firewise. While some aspects of the Firewise Program (e.g., improved planning, education, and communication with first responders) could lead to decreased suppression costs, it is possible that the more expensive resources, such as aircraft, are not utilized any differently to suppress a wildfire spreading toward a Firewise-Community versus a non-Firewise Community. However, it is possible that a study of suppression expenditures made within community boundaries could yield different findings. Our sample was not restricted to wildfires that burned within communities, since such a criterion would result in too small a sample for an empirical analysis. To date, wildfires have entered Firewise Communities (post-designation) fewer than five times.

The wildfire characteristics we identify as being associated with suppression costs are similarly identified by other studies (Gebert et al. 2007, Donovan et al. 2008, Liang et al. 2008, Donovan et al. 2011, Gude et al. 2013). Consistent with these studies, we find that fire size, duration, and road count are positively related to suppression costs. We found that, after controlling for the effects of fire size, duration, terrain, infrastructure, housing, and land ownership, some states tend to have lower average suppression costs than others. For example, suppression costs in Arizona are significantly lower than in California, Montana, New Mexico, Oregon, and Washington. Suppression costs in Utah appear to be lower than three other states (California, Oregon, and Washington), and in Montana suppression costs are lower than two other states (California and Utah). These state-level effects may be the result of differences in fire regimes, state-specific approaches in responding to wildfires, or other factors not represented in our model.

Whereas Gebert et al. (2007), Liang et al. (2008), and Gude et al. (2013) find significant positive relationships between suppression cost and measures of nearby housing, the 95 percent confidence interval for the housing variable in our analysis overlaps zero. We find that a doubling of total homes (Firewise or other) within 6 mi. of a wildfire is associated with a change in suppression cost between -1% and 7%. The point estimate for this variable is similar to those reported in two previous studies that used the same measure to represent nearby housing (Gude et al. 2013, Headwaters 2011).

4.2 Limitations

Because all inferences drawn from a model assume the model is correct, it is important to keep model limitations and uncertainty in mind. Our conclusions assume that the variables used in this study adequately represent the intended wildfire characteristics and that the sample was sufficiently robust to allow for detection of effects. We describe limitations specific to the representation of variables and the sample in the following paragraphs.

Our interpretation of results assumes the variables are represented correctly. For instance, when interpreting Firewise investment as an elasticity, we estimate that the effect of a fixed number of dollars spent depends on prior investment. Our interpretation assumes correctness of the linear log-log relationship. The variable transformations we selected were supported by plots of the data and were logical choices, generally informed by previous studies of suppression costs. The interpretation also assumes the explanatory variables affect the dependent variable, and not vice versa, yet it is plausible that suppression cost is endogenous to fire duration and size. However, reverse causality is not a concern for the Firewise-related variables in our study since the sample wildfires burned after communities became Firewise-designated.

A related limitation in our study may come from a lack of potentially relevant information. Our data were not sufficiently rich to explore effects on suppression cost associated with different configurations and densities of homes, Firewise or other, within the 6 mi. buffer. Also, our variables may not have adequately captured the completeness of Firewise activities, which is known to be variable within Firewise Communities (Headwaters 2014). Lastly, we were not able to measure the level of wildfire preparedness of other communities (those not Firewise-designated) near our sample wildfires. Because some of the communities have likely worked toward wildfire preparedness by, for example, developing Community Wildfire Protection Plans, our analysis investigates the effect of the Firewise Program specifically, and is not intended to compare communities with wildfire preparedness versus no wildfire preparedness.

Sample limitations within our study may be related to both sample size and the characteristics of wildfires that burned near Firewise Communities. Due to data availability, only 25 of the 111 sample fires burned within 6 mi. of Firewise Communities. It is possible that a larger sample of wildfires would increase the statistical power and the probability of detecting an effect of Firewise on suppression cost.

To our knowledge, this research is the first empirical study to investigate the effect of the Firewise Program on wildfire suppression costs. The lack of evidence for this relationship may be related to limitations within our sample or may reflect a true lack of association. Additional research on the role of the Firewise Program in potentially altering suppression costs should be done so that more thorough conclusions can be drawn.

4.3 Management and policy implications

The cost of fighting wildfires has become a major policy issue in the United States.[3] In real dollar terms, annual wildfire protection funds for the U.S. Forest Service and Interior Department averaged $1.4 billion from FY 1991 to FY 1999. That amount more than doubled to $3.5 billion for FY 2002 to FY 2012 (Congressional Research Service 2011). The increase in cost has been accompanied by more than 200 wildfire-caused fatalities and the destruction of more than 10,000 structures during the past decade (2000 to 2010) (NWCG 2011, NIFC 2011). There is agreement that both the area burned by wildfires and the frequency of large fires will increase in coming decades (Flannigan et al. 2009, Stephens et al. 2014), likely further increasing wildfire losses and suppression costs.

The response to increases in wildfire has focused on fuels reduction and voluntary mitigation programs such as Firewise (Steelman and Burke 2007, Gude et al. 2008). These actions provide a safer environment for firefighters and homeowners, and enable more structures to be saved (Headwaters 2014). However, there is uncertainty

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[3] For example, in an effort to address the increasing risk and cost of wildfires, the President's budget proposal for FY 2015 proposes a major change in federal wildland fire funding, in which appropriations for extreme wildfire events would be handled similarly to FEMA's disaster appropriations, adjusted each year to reflect 10-year average costs. New York Times Article Feb. 22, 2014: http://www.nytimes.com/2014/02/23/us/obama-to-propose-shift-in-wildfire-funding.html?_r=1 [Verified 13 March 2014]

about the impact of these factors on suppression costs. Although the Firewise Program was not designed to lower suppression costs (NFPA 2013), it is a common belief among the public, policy makers, and land managers that wildfire preparedness, including Firewise, can lead to lower firefighting costs[4].

In this study, we do not find evidence of suppression cost reduction in association with Firewise participation. The lack of evidence suggests that policy makers attempting to specifically address rising wildfire suppression costs should incorporate additional solutions, including increasing suppression funding, directing future housing away from high-risk areas, providing support for land use planning, and shifting more of the firefighting costs to local governments, which could create a strong incentive for improved planning.

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[4] This perspective is documented in interviews of top-level Incident Commanders (Headwaters 2014), and is evident in news stories and policy proposals. See, for example, http://www.idahostatesman.com/2008/07/23/449460/fire-wise-series-part-two-firefighting.html and http://www.markudall.senate.gov/?p=press_release&id=3618.

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