Do Repeated Wildfires Change Homebuyers' Demand for Homes in High-Risk Areas? A Hedonic Analysis of the Short- and Long-Term Effects of Repeated Wildfires on House Prices in Southern California[1]

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Abstract

Unlike most hedonic studies that analyze the effects of a one-time event, this paper analyzes the effects of forest fires that are several years apart in a small geographical area. We find that repeated forest fires cause house prices to decrease for houses located near the fires. We test and reject the hypothesis that the house price reduction from the first fire is equal to the house price reduction from the second fire. The first fire reduces house prices by about 10%, while the second fire reduces house prices by nearly 23%, a statistically significant difference.

Keywords: Economic impacts of wildfires, hedonic property models, nonmarket valuation, temporal effect of wildfires, wildfire risk.

Introduction

The occurrence of a natural disaster increases the public's perceived risk of such an event. Earthquakes, floods, wildfires and hurricanes are covered in depth by local and national media, and residents of nearby communities feel exposed to the risks of natural disasters after an event occurs. Public policy that addresses natural disasters should take into account public perception of risk. If buyers and sellers decrease the value of homes in high-risk areas, then this decrease in value will be signaled by

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decrease in house prices. By intervening and giving financial aid to victims of natural disasters, the government may provide a subsidy for living in high-risk areas.

A lack of information on natural disaster risk may also contribute to the public's inaccurate perception of the probability of loss due to natural disasters. A market failure occurs in the housing market if a homebuyer has an inaccurate view of the risk profile associated with a purchased home. Because information on natural disaster risk has public good characteristics, government intervention may be needed to provide information and prevent market failure.

Wildfires cause billions of dollars of losses in the United States each year. Our study area is Southern California, a densely populated region prone to wildfires because of decades of wildfire suppression. In 2003, the state of California suffered their worst wildfire season on record. From October 21 to November 3, 2003, there were 14 wildfires in 5 Southern California counties. Twenty-four lives were lost. Over 750,000 acres were burned, and 3,710 homes were destroyed, causing billions of dollars worth of insured losses, and costing Federal, state, and local governments millions for emergency assistance. It is important that local, state, and federal policymakers have an accurate measure of the damages caused by wildfires so that policies can correctly address issues surrounding wildfires such as prevention and disaster assistance. Although the immediate effects of wildfires have been estimated in previous studies, the long-term effects should also be considered when making policy decisions. In this study, we use the hedonic property method to analyze both the immediate and long-term effects of repeated wildfires on house prices in Los Angeles County to understand how the public responds to wildfires. In particular, do first wildfires have a different effect than second wildfires on the demand for housing and hence house prices in high-risk areas?

The hedonic property method is commonly used to model housing markets, and is often used to measure the value of environmental amenities or dis-amenities proximate to the home, including: open space (Irwin 2002), water quality (Leggett and Bockstael 2000), nuclear waste transport (Gawande and Jenkins-Smith 2001), and maintaining adequate lake water levels (Loomis and Feldman 2003)[5] In addition, several studies use hedonic property models to estimate the marginal willingness to pay for reduced risk of natural disasters. For example, Bin and Polasky (2004) used a hedonic model to estimate the effect of flooding on residential property values. They found that houses located within a floodplain have lower prices than houses located outside a floodplain. Furthermore, they found that the price differential increases after a major hurricane caused severe flooding. Bin and Polasky conclude that recent flooding causes an increase in perceived risk due to flooding. The results of Bin and

[5] See Boyle and Kiel (2001) for a comprehensive survey of hedonic studies on environmental externalities.

Polasky's study indicate that after a natural disaster, increased risk perception causes a decrease in the value of houses located in high-risk areas.

Previous studies have also found indications that homebuyers have inaccurate information on the risk of natural disasters. After failure to find significant evidence of a flood risk discount in a hedonic study, Chivers and Flores (2002) surveyed homeowners in an area that has very high risk of flooding to investigate the possibility of market failures due to lack of information. Their survey results indicate that most homebuyers were unaware of the actual flood risk of their homes until after they made an offer. In another hedonic study Beron and others (1997) found that the hedonic price of reduced earthquake risk decreased after a major earthquake in Northern California. Beron and others attributed the surprising decrease in the hedonic price of risk to inaccurate perception of earthquake risk. They contend that homebuyers over-estimated the risk of damage due to earthquakes, and after experiencing an earthquake, re-evaluated their risk profiles. So, even though the hedonic price of earthquake risk was reduced after an earthquake, Beron and others' study indicates market failure due to imperfect information. Hence, previous research on natural disasters indicates that lack of information on natural disasters can cause market failures in the housing market.

Previous research on the effect of wildfires on house prices finds a negative initial impact on house prices. A recent study by Loomis found that house prices in an unburned community 2 miles from a Colorado wildfire decreased by 15% after the fire (Loomis 2004). In addition, a study by Price Waterhouse Coopers in New Mexico found that house prices in Los Alamos decreased by 3 to 11% after the Los Alamos wildfire (Pricewaterhouse Coopers 2004). Both of these wildfire studies investigate what happens to house prices immediately following a wildfire, but neither study analyzes the long-term effect of the wildfires. Performing a broad temporal analysis is one of the objectives of our study. Both wildfire studies also assess the effect of a single wildfire on house prices. Another objective of our study is to assess the effect of repeated wildfires.

Model specification

We used the hedonic property model first proposed by Rosen (1974). The dependent variable is the log of real sale price adjusted using the housing price index for Los Angeles, Riverside, and Orange Counties (1983 base year). A log-linear specification allows the marginal effect of each independent variable to vary with the level of the independent variables. Thus, with our specification, the marginal effects of indpendent variables on the price of a house depend upon the characteristics of the house.

To address the temporal effects of wildfires on house prices, a sale date for each house is required. The recorded sale date is not the date when the actual purchase decision was made. Offers on house purchases are made one to two months in advance of the recorded sale date. Since homebuyers are locked into their offers once an offer is made, the time element of our model is represented by a decision date defined as 60 days prior to the recorded sale date. For example, if a sale date is April 30, 1998, the decision date is March 1, 1998.[6]

The independent variables of interest are wildfire indicator variables and the rate of change of house prices after each wildfire for houses located near and selling after wildfires. Controls for housing structure and neighborhood demographics are included. The general model is as follows:

$P_{it} = f(E_{it}, S_i, N_i, M_{it})$

where P_{it}: Sale amount at decision date t, with sale amount deflated using the annual housing price index for Los Angeles, Orange, and Riverside Counties (1983 Base Year).

The choice of included independent variables for our first stage hedonic property model was based on prior research, data availability, and data characteristics (i.e. correlations). Including irrelevant variables in an OLS regression results in large standard errors for the coefficient estimates, therefore, increasing the probability of type II errors (failing to reject the null hypothesis when the null is false). Furthermore, including several highly collinear explanatory variables in a regression may result in unreliable parameter estimates. Failure to include relevant variables, however, results in biased coefficient estimates (Taylor 2002). The following are the environmental variables of interest we chose to include in our empirical specification:

After One Fire: An indicator variable that equals one if a house sold after and is located within 1.75 miles of at least 1 wildfire, otherwise zero

After Two Fires: An indicator variable that equals one if a house sold after and is located within 1.75 miles of at least 2 wildfires, otherwise zero

Days Since First Fire: Number of days since the first wildfire, if the house sold after and is located within 1.75 miles of at least one wildfire

Days Since Second Fire: Number of days since the second wildfire, if the house sold after and is located within 1.75 miles of at least 2 wildfires

Our empirical specification is as follows:

$$\textbf{Log (Real Sale Amount)} = \beta_0 + \beta_1*(\textbf{After One Fire}) + \beta_2*(\textbf{After Two Fires}) + \beta_3*(\textbf{Days Since First Fire}) + \beta_4*(\textbf{Days Since Second Fire}) + \beta_5*(\textbf{Square Feet}) + \beta_6*(\textbf{\% with no High School Degree}) + \beta_7*(\textbf{Median Household Income}) + \beta_8*(\textbf{Distance to U.S. Forest Service Land}) + \beta_9*(\textbf{Unemployment Rate}) + \beta_{10}*(\textbf{Elevation}) \quad (1)$$

[6] Our timing adjustment is similar to the adjustment used in Loomis and Feldman (2003)

We want to analyze both initial and long-term effects of wildfires on house prices. The After One Fire and After Two Fires variables measure the initial effect of first and second wildfires on house prices, but the After Fire variables do not measure long-term effects of wildfires on house prices. Including the Days Since First and Second Fire variables allows house prices to change after an initial shock, and also allows the rate of change of house prices to differ after first and second wildfires. Distance to USDA Forest Service owned land is a proxy for distance to open space or forested land. The elevation of a house lot serves as a proxy for vegetation type (higher elevations have more flammable vegetation). Houses located at higher elevations and nearer to forests have a higher risk of burning from a wildfire. The distance to downtown Los Angeles is included in the model because Los Angeles is the biggest employment center in the area, and people commute to Los Angeles for work.

Several measures of housing characteristics were available. Square feet is the most commonly used approach in hedonic property models to control for housing structure, and therefore is the structural characteristic we decided to include. Neighborhood characteristics commonly included in hedonic models are school district quality and household income (Taylor 2002). A direct measure of school district quality is unavailable within our data, so a measure of the percent with no high school degree in a neighborhood is used as a proxy for the relative level of educational attainment in a particular community. Neighborhoods with high percentages of educated people generally have higher quality schools. Median household income is also included as a proxy for neighborhood desirability. The California unemployment rate is included in our model to control for market fluctuations that may shift housing demand.

Data and sampling methodology

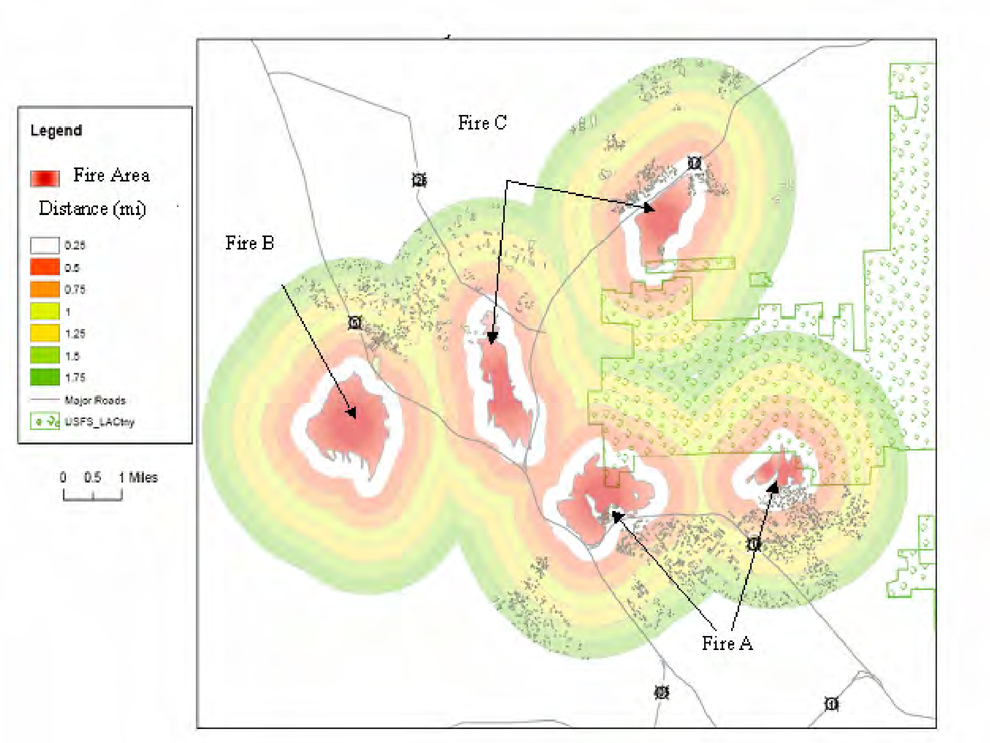
Several datasets obtained from various sources are merged to form a database that includes housing parcel sale date, sale amount, location, demographic characteristics, fire distances, and distance to employment centers. Each housing parcel is a single-family residence located within 1.75 miles of a relevant wildfire. All parcels sold at least once between 1989 and 2003.[7]

There were over 54,000 single-family residences to sample from. After outliers were removed, the sample was stratified by distance to wildfire and sale date. Each wildfire was mapped with a series of quarter mile rings from the fire center, until the last ring, which is 1.75 miles from the fire center. A target of 25 houses for each

[7] We know only the most recent sale date of a house.

distance strata and each year was used. Houses were randomly sampled when there were more than 25 houses for a given distance and sale date.[8]

Figure 1-- *Map of Fire Area*



Wildfires that occurred in the 1990's were chosen for analysis to ensure we have sufficient data after each wildfire to analyze long-term effects. Los Angeles County was selected because there were numerous wildfires within the wild-land urban interface in the county during the 1990's. The study area is composed of five fires and is approximately 5.25 miles across. See Figure 1 for a map of the fire area. The darkest areas are our fire perimeters. The gray shaded colored areas represent 0.25-mile rings mapped out from each fire perimeter. The tiny gray shapes represent housing parcels. The Sylmar and Polk fires occurred within three days and just a few miles of each other and are considered one fire (Fire A) for purposes of this analysis. The Sierra fire occurred less than 60 days after the Placerita fire, also within miles of the Placerita fire. For purposes of this analysis, the Placerita and Sierra fires are also counted as one fire (Fire C). The Towseley fire is treated as one fire (Fire B). All three wildfires are of comparable size—Fire A burned 937 acres, Fire B burned 818 acres, and Fire C burned 977 acres.

[8] No houses were lost to fire in our fire area.

Each house in the study area is located within 1.75 miles of at least one of the fires, but may have sold before the nearest fire. A house within our sample is considered to experience a wildfire if it sells after and is located within 1.75 miles of the wildfire. That is, our After First Fire variable is equal to one for the first wildfire that a particular house sold after and was located within 1.75 miles of. Alternatively, houses that sold before all fires located within 1.75 miles of the house are coded with After One Fire = 0, and are treated as a control group.

The Days Since First Fire variable equals the number of days since the first wildfire for houses with After First Fire equal to one. After Second Fire equals one for the second wildfire for houses that sell after, and are located within 1.75 miles of two wildfires. The Days Since Second Fire variable equals the number of days since the second wildfire for houses with After Second Fire equal to one. Hence, houses selling on different dates and located in different areas will have different values for the After Fire and Since Fire Variables. Some houses are located near only one of the three wildfires in our area, some houses are located near only two wildfires in our area, and some houses are located near three wildfires in our area. By allowing different wildfires to be the "first" wildfire for different houses, we reduce the likelihood that our estimates are biased by spurious correlation with other events.[9]

The parcel data were obtained from Los Angeles County through Nobel Systems.[10] The data contain the geographic location, sale date, sale price, and structural characteristics of housing parcels in Los Angeles County. Demographic variables were attached to each parcel using Geolytics software. We decided to include median household income (measured in year 2000 dollars) and percent with no high school degree in our models. Both demographic variables are proxies for overall neighborhood quality. Including demographic characteristics in the model will control for differences in house prices due to variation in neighborhood quality, allowing a more accurate measure of the effects of wildfires on house prices. GIS was used to measure a series of different distances for each parcel.[11] The geographic data include Distance to fire center for all wildfires (kilometers) and Distance to edge of nearest USDA Forest Service owned land. Sale price data is deflated using an annual Housing Price Index for Los Angeles, Orange, and Riverside Counties.[12] Annual unemployment rates for the state of California were also obtained from the Bureau of Labor Statistics website.[13] Annual mortgage rates tied to the buyer's decision date were also included in the model. Table 1 shows summary statistics for

[9] Due to the small number of houses that experience a third fire (only 34 houses), we do not analyze the effect of a third fire.
[10] We thank Shil Niyogi of Nobel Systems for his assistance with the Los Angeles County parcel data.
[11] We are very grateful to Nate Peterson, our GIS expert, for his contributions to this project.
[12] The annual Housing Price Index was obtained from the Bureau of Labor Statistics website (http://data.bls.gov/cgi-bin/srgate) and typing in the series id CUURA421SAH.
[13] The website is http://data.bls.gov/cgi-bin/srgate, with the series id LAUST06000003.

the variables included in the final empirical model.

Table 1-- *Summary statistics*

Variable name	# Of Observations	Mean	Standard Error
Real sale amount (year 1983 dollars)	2520	151,907.10	3,026.06
Log of real sale amount	2520	11.85	0.24
After one fire	2520	0.73	0.01
After two fires	2520	0.50	0.01
Days since first fire	2520	1,450.00	28.90
Days since second fire	2520	693.00	13.81
Square feet	2520	1,842.00	36.70
% with no high school degree	2520	21.76	0.43
Median household income (year 2000 thousands)	2520	65.68	1.31
Distance to USFS. land (kilometers)	2520	2.83	0.06
Elevation (meters)	2520	1,426.00	28.40
Unemployment rate	2520	6.77	0.13

Results

Our estimation results are reported in Table 2. The coefficient on the After One Fire variable is negative and statistically significant, indicating that house prices drop approximately 9.71% after one wildfire. The coefficient on the After Two Fires variable is also negative and statistically significant, indicating that house prices drop an additional 22.68% after a second wildfire. The coefficients on the Days Since First Fire and Days Since Second Fire are also statistically significant, but they have different signs.

Table 2-- *Regression Results for an OLS regression with log of deflated sale price as the dependent variable. The absolute values of t-statistics are reported in parenthesis, * indicates significance at the 5% level, ** indicates significance at the 1% level, and errors reported are robust standard errors.*

	Regression Results	Mean of Independent Variable
After one fire	-0.09706	0.73
	(5.53)**	
After two fires	-0.22681	0.50
	(11.88)**	
Days since first fire	-0.00004	1451.00
	(3.70)**	
Days since second fire	0.00024	693.00
	(15.36)**	
Square feet	0.00035	1,842.00
	(38.44)**	
Median household income	0.000963	65.68
	(2.78)**	
% no high school degree	-0.00435	21.76
	(7.75)**	
Distance to USFS land	0.00000565	2.83
	(1.60)	
Elevation (meters)	-0.00025	1426.00
	(5.72)**	
Unemployment rate	-0.02691	6.77
	(6.82)**	
Constant	11.85281	
	(128.67)**	
Observations	2520	
R-squared	0.64	

The estimated model from Equation 1 allows us to calculate marginal implicit prices for a first fire and a second fire. We have a log-linear specification, therefore the estimated implicit price is a function of the estimated coefficient on the After Fire variable and the mean house price. Therefore,

$$\text{Marginal Implicit Price} = \hat{\beta} \cdot \bar{y} \qquad (2)$$

Where, $\hat{\beta}$ is the estimated coefficient on the After Fire variable and $\hat{y}$ is the mean sale price.

Table 3 shows the marginal and cumulative effects of a wildfire for the average priced house in our sample. The mean deflated sale price over all years in our sample is $151,907. Hence, the marginal effect of the first wildfire within 1.75 miles is an initial decrease in house price of $14,744. A second wildfire within 1.75 miles will cause an additional decrease of $34,453 in house prices. The cumulative effect of two wildfires on the selling price of an average house is a $49,198 drop. Since the coefficients on the After Fire variables are both statistically different from zero, we also tested the null hypothesis that the coefficients on the After Fire variables are

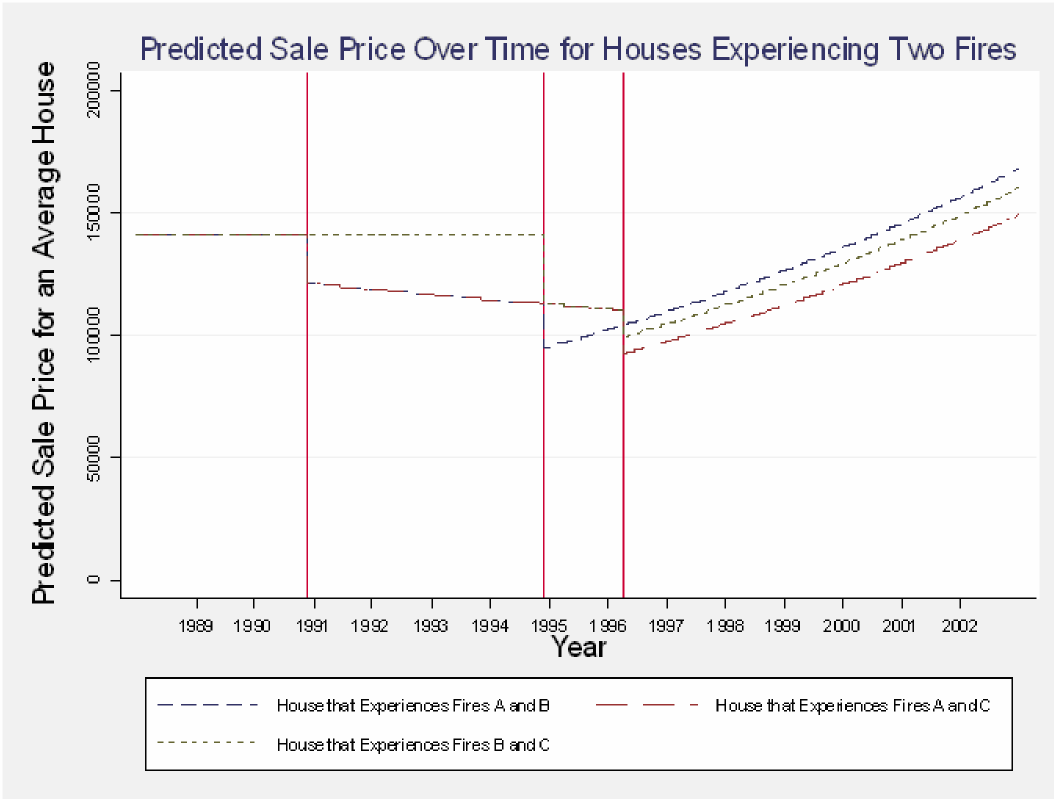


Figure 2: *Predicted sale price over time for a house that experiences two fires*

equal to each other. The test had a p-value of 0.0001, indicating that we reject the null hypothesis that the coefficients on the After Fire variables are equal to each other. We conclude that a second wildfire has a different initial effect than the first wildfire.

Table 3-- *Marginal and Cumulative Effects of First and Second Fires*

	Estimated Coefficient	Marginal Effect	Cumulative Effect
One Fire	-0.0971	-$14,744.59	-$14,744.59
Two Fires	-0.2268	-$34,453.54	-$49,198.13

In addition, the coefficients on the Days Since Fire variables are statistically different from zero in our regression. However, they have different signs. The first wildfire causes an initial drop followed by a continued decrease in house price, but the second wildfire causes an initial drop followed by a subsequent increase in house prices. The exact length of time it takes for the house price to recover after the second fire depends upon the length of time between the first and second fires. Recall that different houses can experience different combinations of fires within our area. Figure 2 illustrates the time path for an average-priced house over time in the three possible fire event combinations. It takes between 5 and 7 years for house prices to recover after a second fire. The time frame for recovery seems reasonable. Within a few years, the natural vegetation near the house will have regenerated. In addition, if several years pass without a fire, people may begin again to forget about the risk of fire.

Conclusions

A striking result from our estimation is that a second wildfire causes a larger initial decrease in house price than the first wildfire. One explanation of the observed difference in impacts is that a single wildfire may not be a sufficient stimulus to cause homeowners to move, while a second wildfire causes more risk-averse homeowners to move to areas less prone to wildfire. A homeowner may think that the first wildfire is going to be the only nearby wildfire for an extended period of time and hence remain living in a high-risk area after one wildfire. However, house prices continue to decrease after the first wildfire because of diminished surrounding landscape amenities due to wildfire damage. Then, a second wildfire occurs, causing more devastation, and another update in perceived wildfire risk. Because homeowners did not expect another wildfire for a prolonged period of time, the second wildfire causes a more devastating initial shock than the first wildfire. As a result of the second wildfire, highly risk-averse homeowners may be replaced by less risk-averse homeowners. As new homeowners move in, house prices begin to recover, explaining the subsequent recovery of house prices after a second wildfire. In other words, it takes more than one wildfire to induce a permanent reaction (in the form of moving) from current homebuyers.

Our results indicate that demand for houses located near wildfires decreases immediately following each wildfire, and that demand decreases more after repeated wildfires. This means that many homebuyers do not want to live in areas with repeated wildfires, and that perhaps homebuyers purchase homes in high risk areas without being fully aware of actual wildfire risk. Hence, policymakers could decrease losses due to wildfires by increasing wildfire risk awareness through public information campaigns. Such a campaign was initiated in Colorado where fire risk maps, including high hazard designated “red zones” were publicized in local newspapers and based on the research of Donovan, et al (2007) appears to be successful in changing house buyer awareness of wildfires.

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