

# Estimating the Impact of Proximity of Houses on Wildfire Suppression Costs in Oregon and Washington<sup>1</sup>

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## Abstract

The relationship between development in the wildland urban interface (WUI) and suppression costs has received increasing attention from policy makers in recent years; however, few empirical studies have addressed the issue. Data from 58 wildfires that burned in Oregon and Washington during the 2002 fire season and 2000 census data are used to examine the relationship between proximity of houses and suppression costs. Results fail to show a relationship between either total housing or housing density and suppression cost. Several possible explanations of this negative result are offered.

## Introduction

The rising cost of wildfire suppression on public land in the United States has been attributed to two main factors. First, increases in fuel loads and changes in stand structure have resulted in more intense wildfires that are more difficult and costly to suppress (Arno and Brown 1991). Second, development in the wildland urban interface (WUI) has increased the values at risk from wildfire, prompting increased suppression spending to protect these structures (USDA 2003). Although there is broad agreement that increases in both fuel loads and development in the WUI have contributed to rising suppression costs (USDA Forest Service 1995; USDA 2003), little empirical work has been done to quantify the effect of either. In this paper we examine the importance of the second of these two factors—development in the WUI—by empirically estimating the effect of proximity to housing on wildfire suppression costs. Our hypothesis is that if there are more houses in proximity to wildfire, then that wildfire will be more expensive to suppress, because fire managers will use more resources to protect the threatened houses.

Few studies in the fire economics literature have looked empirically at the factors that drive wildfire suppression costs, however, some studies have examined the cost of different components of a wildfire organization. González-Cabán (1983) developed a model to estimate suppression costs based on the number and type of resources used to fight a fire. González Cabán and others (1984) used a cost-aggregation approach to estimate the cost of hand crews, engines, helitack crews,

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smokejumpers, and bulldozers. The authors found considerable variation in resource cost estimates both between fires and between different regions of the country.

Although there has been little empirical work on the factors that affect wildfire suppression costs, several authors have studied the determinants of prescribed fire costs. Early work by Rich (1984) studied prescribed burning costs in 1982 on the Powell District of the Clearwater National Forest in Idaho. He investigated both managerial factors and physical site characteristics including aspect, slope, elevation, slash, fuels, and other topographical features. Rich concluded that managerial factors influence costs more than physical factors. A follow-up study (Rich 1989) looking at similar information from the Powell district from 1982-1985 supported his conclusion that management variables have greater influence on prescribed burning costs than physical variables. Jackson and others (Jackson, Flowers et al. 1982) examined total project costs and per acre costs for prescribed burns used to improve wildlife habitat. They found both physical and managerial factors to be significant, and that economies of scale existed with increasing fire size.

Cleaves and Brodie (1990) analyzed the economics of prescribed burning, focusing on benefits, costs, and risks of prescribed fire. They determined that fuels, topography, weather, management objective, and unit size and shape were important influences on the cost of prescribed burning projects. Additionally, they emphasized the impact that risk can have on burning costs, including the risk of escape, risk of smoke interference in surrounding areas, and managers' perception of risk. In conclusion, they point to the need for reliable cost records for future economic analyses of prescribed fire.

Cleaves and others (2000) analyzed trends and influences on prescribed burning costs in the National Forest system during the period 1985-1994. Using survey methodology they asked managers to rank the importance of several factors on the cost of prescribed burning: unit size and shape, compliance with environmental laws and regulations, labor costs and availability, insurance availability, liability, residential development, crew safety, weather, multiple objectives satisfaction, and safeguards to minimize escaped fires. Nationally, managers ranked unit size and the cost and availability of labor as the most important factors influencing costs. Safeguards to minimize escaped fires ranked third, and compliance with environmental laws and regulations was fourth. In the Pacific Northwest, unit size, costs and availability of labor, and compliance with environmental laws and regulations ranked highly. However, unit shape and the need to satisfy multiple objectives were also among the most important factors in this region. The availability of liability insurance and agency policies about risk-taking received low ranks in all regions.

Rideout and Omi (1995) used a National Park Service database to estimate prescribed fire cost models. Their data included information on project size, fuel model, project type, administrative or legislative mandate, fire complexity rating, and ranking scores for natural resource values, historic importance, and wildlife habitat. Using a constant elasticity model of declining cost with increases in scale, they found that the costs of fuels treatments varied with respect to two management goals: maintaining or restoring ecosystems and hazard fuel reduction. Higher precision was found in cost estimates for traditional hazard reduction treatments compared to ecosystem management treatments.

In summary, little empirical has been done to identify the determinants of suppression cost. More studies have investigated the factors that affect prescribed fire costs, finding that treatment size, fuel model, management objectives, and the cost and availability of labor can affect treatment cost.

## Methods

To relate the costs of suppressing a wildfire to the proximity of that fire to housing requires spatial information on the area burned by wildfire and housing density. Spatial data on the area burned by wildfires were obtained from Region 6 (Oregon and Washington) of USDA Forest Service. Fire managers created a GIS layer of the area burned by 58 of the largest wildfires in Oregon and Washington during the 2002 fire season. These fires varied in size from 25 acres to 499,570 acres. This GIS layer was superimposed on a GIS layer of housing density in the US—derived from 2000 census data—allowing the calculation of housing density and total number of houses within the perimeter of each wildfire. However, the number of houses within the final perimeter of a wildfire does not fully capture the effect of housing density on suppression costs. Although a wildfire may only destroy a small number of homes, it may threaten many more, affecting the suppression strategy used by fire managers and, therefore, suppression costs. To capture the influence of houses not destroyed but threatened by wildfire, we calculated the number of houses in successively larger (2, 5, 10, and 20 miles) buffers around the perimeter of each wildfire. Conceptually these variables can be thought of as spatial lag variables.

Although housing is the focus of this paper, several other factors may affect suppression costs. Therefore, the following variables were also included in the analysis: 100 hour fuel moisture; fire size; a binary variable indicating if the incident commander on the fire classified the terrain as extremely difficult; and the number of uncontained acres burning in Oregon and Washington on the day a fire started. This last variable was intended to capture the relative scarcity of suppression resources; we hypothesize that if many other large fires were burning in the region at the time a fire started, then some suppression resources may not be available, which may affect costs. Data on suppression costs were obtained from the 209 forms that fire managers are required to complete on each day of a major wildfire.

## Results

The above dependent variables were regressed on total suppression costs (table 1).

**Table 1**--Regression results—fire size and extreme terrain on total suppression costs

Variable	Coefficient	Std. Error	t-stat	Prob.
Intercept	-129,522	1,441,778	-0.0898	0.929
Fire size	291	14.8	19.6	0.000
Extreme terrain	7,277,264	2,487,116	2.93	0.0059
Adjusted R-squared	0.926			

Unsurprisingly, the most significant determinant of total suppression costs is fire size. The only other significant variable is the binary variable denoting whether or not fire managers considered the terrain a fire was burning in extreme. The positive

coefficient on the extreme terrain variable indicates that fires burning under these conditions are more costly to suppress.

In contrast to fire size and the extreme terrain variable, none of the total housing or housing density variables was significant. In addition, standard transformations (natural log, quadratic, etc.) did not improve the explanatory power of any of the total housing or housing density variables. The 100 hour fuel moisture and resource scarcity variables were also insignificant.

To determine if housing variables better explain per acre as opposed to total costs, the above model was re-estimated with per acre costs as the dependent variable. As with the total cost model, none of the housing variables, or transformed variables, were significant. In addition, all other variables, including fire size and the extreme terrain variable, were insignificant.

## Discussion

The purpose of this paper is to determine if proximity to housing affects wildfire suppression costs. Data were drawn from the 2002 fire season in Oregon and Washington and from the 2000 census. Results show that neither total housing nor housing density explained any of the observed variation in suppression costs. The only variables that were shown to influence total suppression costs are fire size and the binary variable denoting extreme terrain. Analysis of per acre costs found no significant variables. Care should be taken when interpreting the influence of fire size on suppression cost. Fire size is not an exogenous variable, but rather suppression cost and fire size are simultaneously determined.

The inability of the analysis to show a significant relationship between housing and suppression costs may have a number of explanations. The relatively small sample of 58 fires may have been a factor; a larger data set might yield more significant results.

Another factor that may be important is the correlation between housing density and road density. Areas with more housing have better road access, which may allow firefighters to reach a fire more quickly with cheaper ground based resources rather than relying on more expensive aerial resources. Therefore, although housing may affect suppression costs, this effect may be confounded by easier access.

It is possible that housing does affect suppression costs; it may be that the reason why this effect was not identified is that the sample did not contain any examples where this was not the case. In a region like the Pacific Northwest, during severe fire conditions (hot, dry, weather, and low fuel moisture) all fires may threaten housing. That is, the region is sufficiently densely populated that wherever an ignition occurs, houses will be threatened, and fire managers will suppress wildfires accordingly.

The absence of any significant variables in the per-acre cost model may have a number of causes. As with the total cost model, sample size may have contributed to the lack of significance, or we may have simply not selected the correct variables. It is also possible that the per-acre cost of a wildfire is largely determined by factors unique to that fire, and that variables common to all fires are relatively unimportant. If this is the case, there are significant policy implications. Care should be taken in designing policies to control suppression costs. If indeed per acre costs are largely

determined by factors unique to a given fire, then a generic approach to cost containment would be inappropriate and probably ineffective. Future work could valuably focus on identifying the importance of these unique factors.

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