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Forest density preferences of homebuyers in the wildland-urban interface

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ABSTRACT

In the fire-prone Western U.S., the scale of surrounding forest density can be realized by homebuyers as an amenity for aesthetics and cooling effects, or as a disamenity in terms of wildfire risk. There has been a lack of academic attention to understanding this duality of forest density preferences for homebuyers in at-risk Wildland Urban Interfaces (WUIs). To fill this gap, we investigated the influence of forest density on WUI house sales in four high fire-risk zones in dry, mixed conifer forests of the Western U.S with a spatial hedonic pricing model. Explanatory attributes related to house structure, neighborhood, and environmental amenities were assessed, along with a set of WUI variables that included forest density ranges at two buffer levels— a 100 m radius level and a 500 m radius level. Results indicate a strong preference for lower forest density at the 100 m level, but a countering preference for higher forest density at the larger 500 m buffer. These findings suggest the need to reconsider broad approaches in public awareness campaigns and regional planning, as well as fire management policies and strategies. Preference for higher density forests implies that if left to homeowners, fuel treatments in public spaces will be underinvested.

1. Introduction

Expansion of the wildland-urban interface (WUI) has been identified as the primary cause of rapid increases in wildfire-related losses in the United States (Keeley et al., 1999; Radeloff et al., 2005), Canada (McFarlane et al., 2011; Goemans and Ballamingie, 2013), Australia (Mell et al., 2010) and the Mediterranean (Darques, 2015). This is particularly true for ecosystems that once burned frequently with low-moderate intensity before old-growth logging, overgrazing, and, perhaps most significantly, fire exclusion (Covington, 2000). Many forests, especially across the western United States, have experienced declining ecological health and increased risk of uncharacteristically large and severe wildfires (GAO, 2009a; GAO, 2015). Reducing wildland fire risk and damage within residential developments in the WUI has become one of the most pressing issues in managing U.S. public lands (Stetler et al., 2010).

Some of the most complicating factors for managing wildland fire risk are the costs of fire suppression and risk reduction, and who pays for fire management. The costs of fighting wildland fires have been escalating continuously in the United States, doubling to more than $2.9 billion annually during 2001–2007 from an average $1.2 billion annually during 1996–2000 (GAO, 2009b). Many studies have investigated the factors affecting wildland fire suppression costs (e.g. Calkin and Gebert, 2006; Gebert et al., 2007; Liang et al., 2008; Abt et al., 2009; Yoder and Gebert, 2012). The primary factors that explained the majority of variation in wildland fire suppression costs, other than fire size, were those related to the WUI, including proximity to the WUI and the proportion of private land within fire perimeters. About 897,000 properties (estimated reconstruction value at $237 billion) in the western U.S. are now located in high or very high wildfire risk areas (CoreLogic, 2015). Expansion of the WUI is likely to continue in the future, especially in the intermountain west states where the risk of large and severe fires is ever increasing (Theobald and Romme, 2007). The majority of wildfire suppression costs are born at the federal level (Gude et al., 2008). Although more than 30% of total wildfire costs can be attributed to defending private residences (Rasker, 2015), there is little incentive for state, county, or local governments who make land use decisions to curb the development within the WUI (Gude et al., 2008; Abrams et al., 2015).

Homebuyers, along with locally elected officials, may underestimate the dangers and financial consequences of fire-prone forests (Abrams et al., 2015). By assuming much of the fire suppression and management burden, the federal government may be providing a perverse incentive to locate in hazardous areas (Busby and Albers, 2010). Homebuyers' decisions to buy homes in the WUI are influenced by their preferences for

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natural amenities as well as their perceived risk of natural disasters. Forest cover provides certain amenities, including shade, privacy, noise reduction and aesthetics, while too many trees may manifest as disamenities for blocking viewsheds and increasing the chance of home ignitions during wildfires. This duality makes it hard to effectively communicate with home owners about the needs for reducing forest density in the WUI and to inform policy decisions that need to be applied in the landscape level. With forest cover representing both amenities and disamenities in high fire risk areas, there is a need to understand the influence of surrounding forest density on property values in the WUI (Venn and Calkin, 2011; Hansen et al., 2014).

In this study, we focus our attention on properties in the dry mixed-conifer WUI ecosystems of the American west where the rising trend of wildfire risk is particularly severe. The trend is expected to worsen in the future with higher frequency of fire occurrences and longer durations of wildland fire seasons with warmer and earlier springs (Westerling et al., 2006). With limited evidence of forest density preferences of WUI homebuyers, a primary research question remains: How does forest density influence sales value in high fire risk WUI regions, and to what scale? To investigate this question, we applied a spatial hedonic pricing model to a set of high fire risk WUI house sales in four Western regions.

1.1. Literature review: WUI forest density and hedonic pricing

By observing home sale prices in the market, we can discern the preferences of homebuyers for different attributes of homes in aggregate form. The idea of measuring the value of certain implicit characteristics of property, i.e. hedonic pricing, dates back many years. The first application of the hedonic method in residential properties was by Ridker and Henning (1967), where they investigated the association between air quality and property values. Since then, there have been many hedonic studies in urban housing markets that show evidence of negative impacts of poor air quality on housing prices (e.g. see the meta-analysis of more than 160 separate estimates from 37 studies by Smith and Huang, 1993).

However, the influence of tree density on housing prices has been found to be both positive and negative, making results hard to generalize. Although there are many benefits of increasing canopy covers in communities, especially in urban areas, there are also costs, such as increased fire risk, energy costs and water usage (Nowak et al., 2010). Thus, homebuyer preferences for tree density depend on the degree of urbanization in the area (Cho et al., 2008) and the relative scarcity of trees in the neighborhood (Netusil et al., 2010). Natural amenity values of forests can vary spatially and temporally depending on forest-patch size and density (Cho et al., 2009) and can vary based on prevailing ecological, social, and economic conditions (Nowak et al., 2010). Additionally, variations in tree density at the household level can create positive and negative externalities for adjacent land owners and can influence neighbors' efforts at creating defensible space (Shafran, 2008).

Given mixed findings of direction and scale for forest density preferences, we view forest density as a blessing and a curse depending on location-specific and behavioral contexts reflecting home buyers' knowledge, attitude, and preferences. Economists treat environmental amenities, or avoidance of environmental disamenities, as spillover effects that are typically external (externality) to the measurement of total economic trade-offs (Mendelsohn and Olmstead, 2009; Mishan, 1974). Hedonic price models are well suited for determining the amenity or disamenity influence of a perceived attraction or hazard on a particular market segment of home buyers. However, hedonic models assume buyers and sellers have full and accurate information about housing characteristics and that housing markets are mobile enough to reflect current preference or risk (Mendelsohn and Olmstead, 2009).

The assumption of complete information may be particularly problematic for homeowner's perception of wildfire risk and the financial consequences of experiencing a wildfire. Abrams et al. (2015) found a large discrepancy between community fire risks perceived by local homeowners and assessed by fire officials. Mozumder et al. (2009) found positive willingness to pay among WUI residents for updated wildfire risk maps, indicating that residents do not have complete information. Donovan et al. (2007) found no preference for the level of surrounding vegetation density (e.g., high or low) for WUI homeowners outside of Colorado Springs, Colorado, despite finding a decrease in prices after the fire department initiated wildfire risk ratings for individual houses. Champ et al. (2009) surveyed WUI homeowners in the same location and found little consideration (only 27% of WUI homeowners) for wildfire risk when purchasing their house. They also found higher preference for homes closer to "dangerous topography" in terms of wildfire risk (Champ et al., 2009). Similarly, high natural amenity locations are typically correlated with high hazard risk (Loomis, 2004). This suggests that in some areas, the attraction of the wilder natural features that are typically associated with greater wildfire risk outweigh the disamenity, or hazard, represented by wildfire risk.

None of the published hedonic studies were able to separate changes in wildfire risk perception and natural amenities (Venn and Calkin, 2011), as it likely requires the use of survey-based stated preferences methods as opposed to revealed preference methods. There is little information on the role of wildfire risk on homebuyer preferences in fire-prone areas (Champ et al., 2009). Even for homebuyers with some awareness, the full level of risk is poorly defined as many wildfire risk variables are difficult to quantify at the WUI parcel-specific level. Furthermore, homebuyer's risk perceptions in high natural hazard areas have largely been shown to be inaccurate for many natural disasters, including fire, flooding, and earthquakes (Mueller et al., 2009). So in this case, complete information is unknown and homebuyers have incomplete and varied level of risk assumptions. This is complicated by the fact that the federal government assumes much of the fire suppression and management burden, providing a government subsidy to WUI homeowners (Gude et al., 2008; Busby and Albers, 2010). Federal aid and assistance for victims of natural disasters is common practice, but the reactionary nature of federal payments and resources used to help residents in high risk natural areas (e.g., WUI, floodplain, or coast) provides an incentive to locate in hazardous areas (Kim and Hjerpe, 2011). This incentive creates a market failure leading to excessive risk taking by individuals with insurance and federal assistance, generating free-rider effects whose tabs are collectively paid by society (Loomis, 2004; Talberth et al., 2006; Cavallo and Noy, 2009; Busby and Albers, 2010).

The hedonic fire risk literature has largely been focused on empirical *ex post* investigations of wildfires (Huggett, 2004; Loomis, 2004; Mueller and Loomis, 2008; Mueller et al., 2009; Stetler et al., 2010). They have generally found negative associations between housing prices and proximity to a wildfire. A couple exceptions to the *ex post* investigations in the hedonic fire risk literature include investigations of the effects of a wildfire risk rating (Donovan et al., 2007; Champ et al., 2009) and forest density variation for one community (Kim and Wells, 2005). Hedonic studies of other natural disasters, such as hurricanes and floods, showed the effects of recent experience with a disaster on perceived risk and property values (Bin and Polasky, 2004; Morgan, 2007). Although experiences with a disaster tend to increase perceived risk and negatively affect property values, those impacts may be short lived (Atreya et al., 2013). Much less is known about *ex ante* behavior of WUI homebuyers before experiencing a close fire. Preferences for forest density, prior to major fires, as well as the mechanisms through which forest density is processed in home owners' preferences, are in need of further investigation and hold important policy implications for correcting market failures.

2. Methods

We first specified a comprehensive WUI hedonic price model a priori of existing data, and then generated a sampling methodology that would best fit our model specification. Once our hedonic model was