

Temporal Changes to Fire Risk in Dissimilar WUI Communities

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Introduction

Despite increasing proportions of governmental budgets allocated to fire suppression resources, wildfires annually destroy great numbers of homes and critical infrastructure in the wildland-urban interface (WUI). Since 2002, the largest fires in the histories of California, Arizona, Colorado, New Mexico, Utah, Oregon, and Texas have occurred in spite of increased fire agency staffing, equipment, and training (National Interagency Fire Center 2013). To aid policy development that reduces these losses, we propose to evaluate how risk changes through time in communities expanding into fire-prone areas, but vary in demographics and socioeconomic status.

Conventional wisdom is that escalating WUI losses are caused, in part, by an expansion of residential development into fire-prone areas. However, if new construction adheres to the mitigation policies, then expansion of the WUI (with higher-resistant development) may actually buffer the older, high-risk communities from exposure to flames and embers. Thus, expanding WUI may either increase or decrease risk of residential loss dependent upon the extent of adhering to mandated mitigation strategies. To help elucidate this seeming dichotomy, we propose to utilize various GIS and remote sensing strategies to spatially analyze changes to risk of structural ignitions through time in expanding, but demographically dissimilar residential communities in California. This research compliments and expands previous

investigations by the principal investigator, which focused on how fuel treatments in the WUI simultaneously impacted wildland fire behavior and ecosystem services (including carbon sequestration and air pollution removal) at various spatial and temporal scales.

The cause of increased fire losses is related to a myriad of complex and interacting factors, the influence of each factor varies by place. Population growth into fire-prone areas has resulted in greater exposure of residential development to wildland fire. Fire managers commonly employ multiple mitigation strategies to reduce the risk of fire loss in the WUI, one example is the creation of defensible space immediately surrounding a building to reduce structural ignitions via direct flame impingement or radiant heat transfer (Cohen and Butler 1998). To that end, the California Public Resources Code Section 4291 was updated in 2006 to require 30.48 m of defensible space around structures.

Even when enforced, defensible space may not impact structural ignition from lofted embers, which is a more critical factor in residential losses than flame impingement or radiant heat (Cohen 2000). To mitigate potential residential losses, in 2008 California enacted building standards for new construction in areas in which the state has primary fire protection responsibility. California Code of Regulations Title 24, Part 2, Section 701.A now requires standards for some portions of dwellings most prone to ignition, including roofs, siding, attic ventilation, windows, decks, and others. While the new standards will likely reduce fire losses in



Figure 1—Study site locations with fire history from 2000–2012.

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future development, they will not necessarily impact the vulnerability of existing structures.

To better facilitate sustainable communities in the WUI, managers need an accurate and detailed assessment of not only the fire hazard in a given area, but also its risk to assets of value. In general, fire *hazard* is the likelihood of an area burning and how it will burn (frequency and intensity), whereas fire *risk* is the potential for damage (Sapsis 2011; Turner 2014). Many methods of WUI risk assessment involve the use of maps or spatial data (Prestemon, Pye and others 2002; Bar Massada, Radeloff and others 2009). Mapping and defining the WUI is critical for wildfire risk management because as the WUI expands, it must be monitored in order for planners to make effective policy decisions to mitigate risk (Stewart, Radeloff and others 2007). Such maps provide powerful visual images and are commonly used as tools to direct policy, which has contributed to their increasing use in the US (Radeloff and others 2005, Theobald and Romme 2007). Many studies of WUI fire risk have used Geographic Information Systems (GIS) to examine changes through time (Jain, Ravan and others 1996; Greenberg and Bradley 1997; Nourbakhsh, Sargent and others 2006), which is an effective approach because fire risk analysis commonly employs both spatial and temporal attributes (Chuvieco, Aguado and others 2010). A GIS-based model is an especially effective approach for areas in which a large part of the land is being encroached upon by development (Jaiswal, Mukherjee and others 2002).

In addition to the more traditional parameters of housing density, vegetation, and fire probability, there is a great need to develop a WUI risk assessment that more fully considers aspects of individual structure ignition (Menakis, Cohen and others 2003; Chuvieco, Aguado and others 2010; Calkin, Cohen and others 2014). For example, the inclusion of near-structure vegetation and defensible space in a remote sensing analysis would provide a better means of quantifying fire risk in WUI communities (Menakis, Cohen and others 2003; Calkin, Cohen and others 2014). Further, knowledge of a structure's location and arrangement relative to other structures or flammable materials is critical in effective risk analysis (Cohen 2000; Murnane 2006). Unfortunately, many risk analysis studies have not considered the fine-scale characteristics of vegetation immediately surrounding a home or have assumed all structures are equally flammable (Prestemon, Pye and others 2002; Menakis, Cohen and others 2003; Bar Massada, Radeloff and others 2009). Risk analysis has also traditionally emphasized the ignition and propagation potential of a wildfire, rather than potential damages (Chuvieco, Aguado and others 2010). The idea of vulnerability is an important new addition to fire risk assessment models (Calkin, Ager and others 2010; Chuvieco, Aguado and others 2012). Sound risk analysis must therefore include elements of both fire hazard and the susceptibility of assets of value (Calkin, Ager and others 2010). Because of the multitude of assets at risk during a WUI fire event, risk assessments can vary in scope and can take into account many different key factors and variables.

Methodology

The proposed research will quantify changes to risk based on characteristics of community wildfire exposure and characteristics of individual structures, including roofing materials, defensible space, and housing density. In essence, the proposed research will simultaneously (1) quantify the growth of the WUI over time in multiple, dissimilar communities, (2) analyze temporal changes to risk based on altered wildfire exposure and structural characteristics, and (3) evaluate differences in risk between multiple communities that vary in demographics and socioeconomic status.

Study Sites

Three residential communities in San Diego County, California will be assessed including Julian, Ramona, and Rancho Santa Fe (fig. 1). The area has conditions conducive to high fire hazard, including a warm climate with extended drought and regular occurrence of high-velocity Santa Ana winds, steep terrain, and flammable vegetation, which has led to several high-intensity, high-loss wildfires in the past 10 years. The three specific WUI communities represent a range of rates of development, demographics, housing density and geographic area.

Rancho Santa Fe—Rancho Santa Fe has a population of 3,100 with an average household income of over \$200,000. The community has taken numerous additional measures above county and state regulations to mitigate fire hazard and lower the chance of structural ignitions during wildfires. Rancho Santa Fe can be used in the study as an example of high construction standards and structures with low fire risk.

Ramona—The city of Ramona has a population of 20,000 with an average household income of \$60,000. The 2013 Corelogic Wildfire Hazard risk Report (Botts, Jeffery and others 2013) found that in San Diego County, Julian and Ramona had the most residential properties at risk.

Julian—Julian California is a census designated place with a population of 1500 and an average household income of \$44,000.

Project Phases

Phase 1—Remote sensing analysis to identify areas of development in each community

Phase 2—GIS analysis of housing density changes over time across the WUI

Phase 3—Remote sensing analysis of hyperspectral aerial imagery (NASA AVARIS) to detect roof type

Phase 4—Remote sensing analysis of defensible space compliance using NAIP imagery and LIDAR data

Phase 5—Validation and ground-truthing of the remote sensing results, and collection of homeowner mitigation data in San Diego

Phase 6—Evaluation of data- We are designing a flowchart to identify risk classes for each structure with input from Dr. Steve Quarles (Senior Scientist, Insurance Institute for Business and Home Safety) on the appropriate methods for assigning risk. Fire risk will be calculated as

$$\text{Fire Hazard} + \text{Mitigations} = \text{Fire Risk}$$

We will use hazard data, collected data of structural fire mitigations and defensible space compliance to classify each structure as low, medium, or high risk. Using GIS, these risk classifications will be mapped across the three communities. We will then be able to compare the three communities in present time, and using the data for previous years, discuss how these risk levels have changed over time in the three communities. We will also analyze risk of structure-to-structure fire spread, and therefore the potential effect of new ‘low-risk’ housing developments on the outskirts of WUI to provide a buffer for older ‘high-risk’ structures.

Significance of Proposed Work

Our goal is this research will acutely illustrate that proper modification of building components and near-structure vegetation does indeed reduce risk to local communities. It is anticipated, however, that there will likely be differences between communities in implementation of these mitigation activities (and subsequent risk of loss) based upon the disparate abilities of residents to pay for modifications and jurisdictional differences in willingness to enforce existing regulations. This research will develop the concept that new development buffer zones may increase community resiliency. This has the potential to inform development practices and shape community standards for building placement and neighborhood design.

This research could influence policy by illustrating the importance of lower risk development and the factors that may influence risk. Indeed, while the research is regional in nature, it is hoped that the process developed will be utilized by scientists, land managers, and policymakers on a national scale.

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