Firebrand Protection as the Key Design Element for Structure Survival during Catastrophic Wildland Fires

Joseph W. Mitchell[1] & Oren Patashnik[2]

EXTENDED ABSTRACT

In Southern California, fires that destroy large numbers of structures are inevitably catastrophic, wind-driven events. Characteristics of this class of fire include strong gale-force winds, low probability of professional fire intervention, and the presence of wind-driven firebrands before, during, and after the passage of the fire front. Ignition by radiant heat or direct flame exposure can be prevented by separating the structure from fuels, and this practice is being increasingly disseminated and enforced. Protection from firebrands, however, requires that the structure have no potential ignition points where small wind-driven brands can lodge and pilot structure ignition, or that this ignition be somehow prevented.

Firebrands and structure ignition

The first data collected regarding factors affecting the survival of structures in a major wildland fire was obtained by the Los Angeles Fire Department[3] following the 1961 Bel Air Fire. Brand ignition on shake roofs was listed as a leading cause of structure loss. The definitive study[4], however, was conducted by Caird Ramsay in the aftermath of the Ash Wednesday fires. The conclusion reached by this study was that the predominant ignition mechanism appeared to be embers, as determined by eyewitness accounts and forensic examination of structures. Yet another statistical study was performed by Ethan Foote[5] after the "Paint" fire that struck Santa Barbara County in California in 1990. This study demonstrated that roof type, vegetation clearance, and intervention by civilians or firefighters were determining factors in structure survival. Chen & McAneney[6] performed a satellite analysis of the 2003 Canberra fires to determine the probability of structure survival as a function of distance from the forest boundary.

The factors that allow the assumption of firebrand ignition are:

- Ignitions occurring far from the fire front
- Observed ignitions on the roof or in the attic, fences, or decks
- Ignitions that occur significantly before, or more likely after the passage of the fire front
- High probability of "self-saves" by modestly equipped civilians
- Evidence of partially ignited elements with little or no radiant heat damage

Roofing material results from the Cedar fire

Data were collected by one of the authors (Patashnik) regarding roof types for surviving and destroyed structures in an area of the Scripps Ranch neighborhood of San Diego following the Cedar fire. This study reproduces previous results for wooden shake shingle roofs, but additionally identifies a correlation

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1 M-bar Technologies and Consulting, 19412 Kimball Valley Rd., Ramona, CA 92065; Email: jwmitchell@mbartek.com
2 10388 Rue Riviere Verte, San Diego, CA 92131; 858-578-4141; Email: op AT cs.stanford.edu
3 Greenwood, Capt. Harold W.; Bel-Air – Brentwood and Santa Ynez Fires: Worst Fire in the History of Los Los Angeles; Official Report of the Los Angeles Fire Department; Los Angeles Fire Department Historical Archive; http://www.lafire.com/famous_fires/611106_BelAirFire/110761_belair_LAFDreport.htm
4 Ramsay, G.C., N.A McArthur and V.P Dowling; Preliminary results from an examination of house survival in the 16 February 1983 bushfires in Australia. Fire and Materials, 11:49; 1987
5 Foote, E.I.D.; 1994; Structure survival on the 1990 Santa Barbara "Paint" fire: A retrospective study of urban-wildland interface fire hazard mitigation factors. MS thesis, University of California at Berkeley
6 Chen, Keping and John McAneney; Quantifying bushfire penetration into urban areas in Australia; Geophys. Res. Lett. 31: L12212; 2004

between "curved tile" roofs and enhanced probability of structure ignition when compared to other types of non-flammable roofing material. The curved tile results are statistically significant, with p ranging from .01 to .04 depending on assumptions made during the analysis. This reveals yet another possible ember entry path and ignition mechanism.

Firebrand defense

There are three approaches to preventing firebrand-induced structure ignition:

1. Prevent the entry of firebrands into the structure
2. Remove all flammable materials on or in the immediate vicinity of the structure
3. Extinguish the live embers before they can pilot ignition of the structure

Current building codes, guidelines and recommendations for preventing firebrand ignition fall into the first two categories. Extinguishment of embers can be performed by civilians, firefighters, or by spray systems. There are three ways in which spray systems can protect from firebrands:

- If the density of spray is high enough, the brands will be extinguished directly.
- Water will accumulate in pools on all flat surfaces on or adjacent to the structure.
- Spray and vapor will hydrate light fuels, making them resistant to ignition.

Data supporting the effectiveness of water spray systems can be found in the Foote[7] thesis, which showed that for 38 structures where spray systems operated *during or after* the Paint fire, only one structure was destroyed.

Wind-Enabled Ember Dousing (WEEDS)

In a previous paper[8], one of the authors proposed a wind-resilient spray system specifically designed to reduce the threat of ember ignition during wind-driven wildland fires. The key features are:

- Wind resilience is achieved by outward direction of the spray
- An operational lifetime of three to four hours
- Agricultural/landscaping irrigation spray heads reduce water consumption
- A backup electrical power system.

This system was tested on October 26, 2003 as the Cedar Fire overran the property. Neighboring structures were lost on all adjacent properties, and the area suffered a 60% structure loss rate, despite the absence of flammable roofing as a contributing factor. A post-hoc analysis of the spray system determined that it generated a spray density sufficient to douse embers (>1.5 to 5 gm/m^2-sec).

Discussion

It is important to differentiate situations where firebrand ignition may *not* be the prevalent ignition mechanism, and where radiant heat and flame impingement contribute more heavily to structure ignition: structures within 10 meters of each other, those surrounded by vegetation, and those in forests where crown fires may occur.

Data collection needs to be improved. Examination of structures is currently a forensic activity, which has meant that destroyed structures have dominated statistics.

Water spray systems should also be re-evaluated. One property of water spray systems is that they are most effective when they are operated during or after the fire though this raises the issue of activation. This analysis suggests that water spray systems may join vegetation clearance and structural solutions as a valuable tool in WUI structure protection.

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7 Foote; p. 262
8 Mitchell, Joseph W.; Wind-enabled ember dousing; Fire Safety Journal; 41:444-458; 2006