Structure Ignition Assessment Can Help Reduce Fire Damages in the W-UI*

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The wildland-urban interface (W-UI) refers to residential areas surrounded by or adjacent to wildland areas. In recent years, significant W-UI residential fire losses have occurred nationwide in the United States that have focused attention on the principal W-UI problem—losses of life and property to fire.

W-UI fires with significant residential losses differ from typical residential fires in that W-UI situations usually include the following:

- Large numbers of simultaneously exposed structures,
- Rapid involvement of residential areas,
- Overwhelmed fire-protection capabilities, and
- Total loss of residence per structure ignited.

Wildland vegetation fuels initially contribute to rapid fire growth. Large areas of burning that result can simultaneously expose numerous structures to flames and, most importantly, can rain firebrands (burning embers) on homes over a wide area. Although advances in firefighting technology and management have produced the most effective firefighting capabilities in history, these advances have not prevented large losses during recent W-UI fires. Severe W-UI fires can destroy whole neighborhoods in a few hours—much faster than the response time of the best firefighting services.

To assess potential ignitions, SIAM uses an analytical approach and worst-case assumptions to establish relationships between the design of a structure and its exposure to fire.

Whether a W-UI fire occurs in Oakland, CA, as in 1991; Spokane, WA (in 1991); Grayling, MI (in 1990); or Palm Coast, FL (in 1985), it is similar to others nationwide. A recent example occurred in October 1993, when the Laguna Hills Fire in southern California destroyed—in 5 hours—nearly all the 366 homes lost during that fire. Because these fires swiftly overtake residential areas, many structures do not receive fire protection and suppression during severe W-UI fire situations. As a result, typical postfire statistics reveal that homes

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As the authors of this article explain, the chance of homes surviving a W-UI fire such as the Strong's Canyon Fire on the Wasatch-Cache National Forest is significantly "improved when homeowners implement W-UI firewise recommendations." Photo: James E. Stone, USDA Forest Service, Intermountain Region, Ogden, UT, 1990.

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either survive or are totally destroyed. Relatively few structures suffer partial damage.

The W-UI fire problem can be characterized as the exposure of a residence to flames and firebrands resulting in ignitions that produce widespread, extreme losses. If residential fire losses did not occur during wildland fires, the W-UI fire problem would not exist. Thus, the principal issue is residential structure survival.

History of the W-UI Problem

Since 1985, the public has become increasingly aware of the W-UI fire problem. During this same period, fire agencies have devoted increasing amounts of time and effort to prevention and suppression of W-UI fires. Since 1995, structure losses during wildfires occurred in such diverse locations as New York, Texas, New Mexico, and Colorado. However, the W-UI fire problem is not new.

Historically, large urban losses have accompanied wildland fires. For example, such losses occurred in Peshtigo, WI, in 1871, Wallace, ID, in 1910, Berkeley, CA, in 1923, and the State of Maine in 1947 (Martin and Sapsis 1995). Over the last four decades, frequent wildland fires in California have resulted in significant residential losses. After major losses, government agencies generated reports that identified the W-UI fire problem and provided mitigation guidance (e.g., California Department of Conservation 1972; California Department of Forestry 1980; County Supervisors Association of California 1965; Howard et al. 1973; Radtke 1983). These comprehensive reports provided recommendations, including technical specifications for W-UI urban planning, fire suppression, vegetation management, and building construction. However, recent events indicate that W-UI fires remain a problem in California and elsewhere, which suggests a lack of societal acceptance for W-UI firewise guidance.

People often use terms such as "miracle" or "luck" to describe how some homes survive amid the destruction of their neighbors' residences. These words imply helplessness, a lack of control, and a detachment from responsibility. While these phrases may accurately describe the emotional states of those who just experienced wildfires, the assumption that homeowners cannot decrease fire losses is incorrect. Chance or "luck" does play a part in home survival, but the chances for home survival can be significantly improved when homeowners implement W-UI firewise recommendations.

During workshops in 1986 and 1987 (Laughlin and Page 1987; Gale and Cortner 1987), scientists and managers began to understand that societal attitudes were a critical part of the problem. Participants recognized that homeowners in W-UI areas were not readily implementing the available W-UI firewise recommendations. During the "Wildfire Strikes Home!" conference, the research subgroup concluded that homeowner acceptance depended on their increased understanding of W-UI fire hazards and aesthetically acceptable firewise measures (Laughlin and Page 1987). The conference made the following research recommendations:

- Manage W-UI hazards in an aesthetically acceptable manner,
- Understand the relationship of building design and clearance to fire hazards,
- Learn more about ignitions from burning embers (firebrands) that have been convectively transported, and
- Develop techniques to evaluate and identify fire risk.

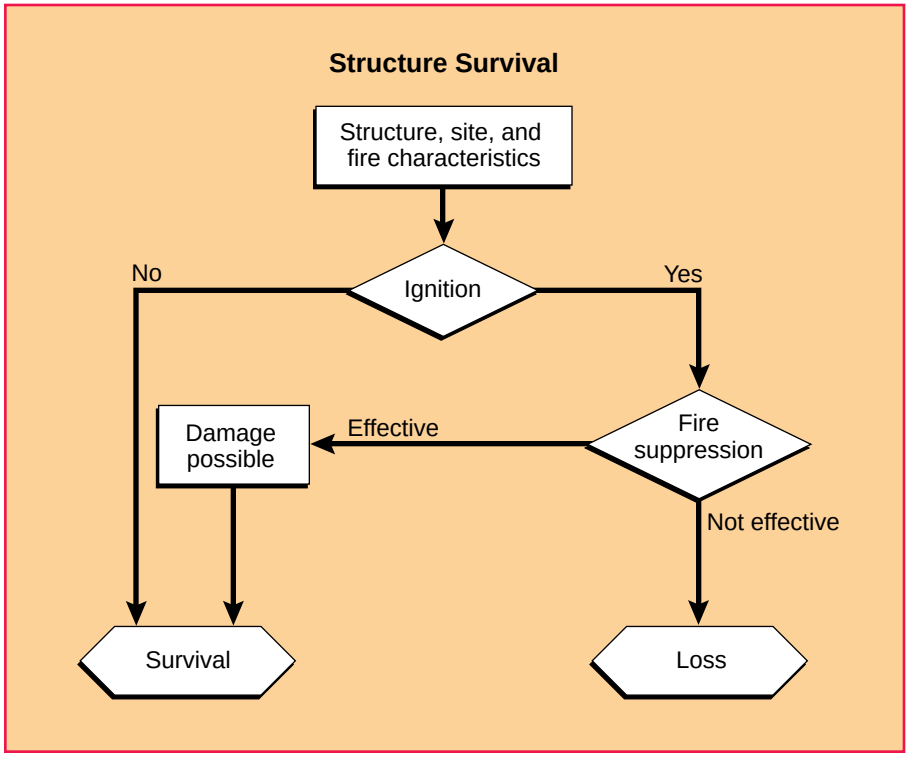
These recommendations reflected the conference participants' realization that fire-protection agencies could not cope with the W-UI fire problem without firewise home and landscape designs.

Ignition Assessment for Improving Structure Survival

What we observe after a W-UI fire is, in varying degrees, structure survival. The degree of survival results from a complex, interactive sequence of events involving the ignition and burning of vegetation and structures, accompanied by varying fire-protection efforts by homeowners and firefighters. The development of an assessment method requires an explicit description (at some resolution) of the processes involved.

Structure survival involves factors that influence fire ignition; and, if an ignition occurs, the survival of a structure involves factors that influence fire suppression. Thus, structure survival assessments require comprehensive consideration of structure ignitability and suppression effectiveness. The factors influencing suppression effectiveness (availability, capability, and access of organized suppression forces and homeowners) greatly depend on the real-time situation. The unpredictability of the real-time situation makes descriptions of suppression effectiveness unreliable (Cohen 1991). Figure 1 dia-

Figure 1—*Structure survival depends on factors that influence ignition and effective fire suppression. Regardless of the fire suppression effectiveness, survival* ***initially*** *depends on ignition resistance.*



grams the general process leading to structure survival or loss. As the figure illustrates, the structure survival process must "pass through" the occurrence or nonoccurrence of an ignition. The dichotomous nature (survival or loss) of statistics about structure loss strongly suggests that expected fire suppression effectiveness is very low. Thus, improving structure survival depends on improving ignition resistance, at least initially. Improved structure ignition resistance leads to improved suppression effectiveness by homeowners and fire agencies.

Structure Ignition Assessment Research

USDA Forest Service Fire Research recognizes the need for a greater understanding of the W-UI fire problem in general and for a risk assessment process that incorporates the previously listed W-UI research needs in particular. The Fire Behavior Unit at the Intermountain Fire Sciences Laboratory in Missoula, MT, is developing the Structure Ignition Assessment Model (SIAM) to facilitate W-UI firewise considerations. The SIAM design accounts for interactions between home design and materials and fire hazards such as vegetation and neighboring structures. Using SIAM, homeowners can achieve a firewise condition by making tradeoffs according to their specific desires, and thus, incorporate aesthetic interests.

SIAM assesses the potential for structure ignitions from wildfires burning in vegetation and other structures. SIAM is based on the premise that structure survival is the essence of the W-UI fire problem, but structure ignition is the critical element for survival. Thus, the model specifically addresses the potential for structure ignitions rather than the potential for structure survival.

SIAM is designed to improve fire safety and identify potential W-UI fire problems. In its basic form, the model has a range of applications, from providing assessments of existing single homes to assessing housing developments in the planning stages. The basic model can provide the following:

- A means for local regulators to establish firewise requirements based on potential ignition risk for a mix of factors;
- A means for integrating a resident's exterior home design and landscaping interests with firewise requirements;
- A means for integrating a developer's home and neighborhood design interests with firewise requirements; and
- A means for fire agencies to assess W-UI fire risks for presuppression and suppression planning.

To achieve these applications, SIAM uses an analytical approach to establish relationships between structure design and fire exposure that results in the assessment of potential ignitions. Because actual fire conditions of a future fire are unknown, SIAM uses worst-case assumptions. For example, how and in what sequence the vegetation and other flammable materials adjacent to a structure will burn is unpredictable. Therefore, SIAM assumes all flammables will burn at the same time. The model also assumes that no fire protection will occur, a worst-case condition suggested by the nature of W-UI fire losses. Where ignition processes are not explicitly under-

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stood, e.g., firebrand exposure and ignition, the model's developers have based descriptions on experience and an understanding of the physical processes involved.

The SIAM research has produced preliminary results that refine our understanding of how flame exposure and window breakage influence structure ignition. Experiments have shown that windows are an important W-UI fire consideration (Cohen and Wilson 1995). Single-pane, plate-glass windows can thermally fracture and fall out at fire exposures insufficient to ignite exterior wood materials. A window opening provides an entry point for firebrands, greatly increasing the chances for ignition. Double-pane, plate-glass windows also fracture and fall out, but they can be exposed to heat for longer periods before potential window collapse. Importantly, experiments showed that tempered glass has a much higher resistance to heat fracturing than plate-glass window glazing.

Additionally, experiments and model results indicate that flames are an ignition threat only at close distances to a structure (actual distances depend on the flame and structure characteristics) (Cohen 1995). This finding suggests that nearby landscape vegetation and neighboring structures are important factors in structure ignitions. However, structures commonly ignite when fires are at distances too great for flame-heated ignitions, suggesting that firebrands are an extremely important source of ignition on and adjacent to a structure. Vegetation management beyond the structure's immediate vicinity has little effect on structure ignitions. That is, vegetation management adjacent to the structure would prevent ignitions from flame exposure; but vegetation management away from the structure would not affect ignition from flame exposure and would not significantly reduce ignitions from firebrands. For example, a flame front 60 feet (18 m) high at a distance of 150 feet (46 m) requires more time to ignite wood siding from radiation than the vegetative fuel's burning time. However, 150 feet (46 m) represents a very short distance for firebrands.

Background of the Wildland-Urban (W-UI) Interface and SIAM

The term "wildland-urban interface" (W-UI), or "wildland-urban intermix," refers to residential areas in locations subject to wildland fire. Although the W-UI fire problem has received increased attention since the mid-1980's, the problem is not new.

The W-UI fire problem can be characterized as the exposure of a residence to flames and firebrands resulting in ignitions that produce widespread, extreme losses. What we observe after a W-UI fire is, in varying degrees, structure survival.

Assessments of the survival of structures require comprehensive consideration of structure ignitability and suppression effectiveness. Improving structure survival initially depends on improving ignition resistance. USDA Forest Service fire researchers are developing the Structure Ignition Assessment Model (SIAM) to assess residential ignition resistance.

Current fire inventory systems do not adequately address the W-UI problem. Future systems should include W-UI residential ignition resistance, demographics, and residential loss in addition to suppression effectiveness. These concepts and methods form a technical basis for a strategy of assisted and managed community self-sufficiency.

Fire Inventory Implications

Since their inception, wildland fire inventory systems in the United States have focused on improving wildland fire suppression effectiveness. In 1914, Coert duBois' "Systematic Fire Protection in the California Forests" established the individual fire report as the fundamental unit of information and demonstrated how using that information could improve fire programs. Since then, fire inventory systems have been used to assess and thereby improve wildland fire suppression effectiveness. The primary elements of the wildland fire inventory systems have been wildland acres burned, number and type of suppression resources assigned, and the time involved in traveling to and extinguishing the fire. With this focus on wildlands and suppression effectiveness in those wildlands, it comes as no surprise that there is no readily available public data base in the United States that adequately describes the W-UI problem or can be used to analyze and improve fire programs in the wildland-urban interface.

The minimum characteristics of a fire inventory system that would address the W-UI are feedback, risk, and responsibility. The inventory system should provide feedback on structure ignitability as well as suppression effectiveness. To address risk, defined as the chance of loss, a fire inventory system must provide information on the magnitude of loss, the likelihood of loss, and the recipient of loss. The dollar amount of insured loss is one way to assess the magnitude. The ability to link to demographic data bases will provide information on who is exposed to loss.

A good inventory system can foster homeowner responsibility by helping refute the faulty assumption that homeowners cannot decrease fire losses. At a minimum, a fire inventory system in the United States should consider collecting and archiving the following information on each structure within the perimeter of major W-UI fires:

- The tax-assessed value of the structure,
- The value of the structure's insured loss,
- The structure's ignition resistance, and
- Suppression effectiveness.

Conclusion

Past reports and recommendations as well as experimental research and modeling suggest that W-UI fire-loss mitigation should concentrate on the residence and its immediate surroundings. Any strategy for effectively reducing the W-UI fire problem must initially focus on residential fire resistance. SIAM is designed to assess ignition resistance and thereby facilitate firewise building and landscaping practices. Fire inventory systems should also include W-UI information.

These concepts and methods form a technical basis for a **strategy of assisted and managed community self-sufficiency**. Instead of all fire-protection responsibilities residing with fire agencies, homeowners take responsibility for assuring firewise conditions and the initial fire defense of their residences during wildland fires. The fire agencies become a community partner that provides information, coordinates and assists in meeting firewise requirements, and provides fire suppression assistance.

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