Reducing the Wildland Fire Threat to Homes: Where and How Much?[1]

Jack D. Cohen[2]

Abstract

Understanding how ignitions occur is critical for effectively mitigating home fire losses during wildland fires. The threat of life and property losses during wildland fires is a significant issue for Federal, State, and local agencies that have responsibilities involving homes within and adjacent to wildlands. Agencies have shifted attention to communities adjacent to wildlands through pre-suppression and suppression activities. Research for the Structure Ignition Assessment Model (SIAM) that includes modeling, experiments, and case studies indicates that effective residential fire loss mitigation must focus on the home and its immediate surroundings. This has significant implications far agency policy and specific activities such as hazard mapping and fuel management.

The threat of life and property losses during wildland fires is a significant issue for Federal, State, and local fire and planning agencies who must consider residential development within and adjacent to wildlands. The 1995 USDA Forest Service *Strategic Assessment of Fire Management* (USDA Forest Service 1995) lists five principal fire management issues. One of those issues is the "loss of lives, property, and resources associated with fire in the wildland/urban interface" (p. 3). The report further identifies "the management of fire and fuels in the wildland/urban interface" as a topic for further assessment. Because this is more than a Forest Service issue, the National Wildland/Urban Interface Fire Protection Program, a multi-agency endeavor, has been established for over a decade and is sponsored by the Department of Interior land management agencies, the USDA Forest Service, the National Association of State Foresters, and the National Fire Protection Association. This program also has an advisory committee associated with the multi-agency National Wildfire Coordinating Group. These examples indicate that the wildland fire threat to homes significantly influences fire management policies and suggests that this issue has significant economic impacts through management activities, direct property losses, and associated tort claims.

The wildland fire threat to homes is commonly termed the wildland-urban interface (W-UI) fire problem. This and similar terms (e.g., wildland-urban intermix) refer to an area or location where a wildland fire can potentially ignite Homes. A senior physicist at the Stanford Research Institute, C.P. Butler (1974), coined the term "urban-wildland interface" and described this fire problem:

> In its simplest terms, the fire interface is any point where the fuel feeding a wildfire changes from natural (wildland) fuel to man-made (urban) fuel. …For this to happen, wildland fire must be close enough for its flying brands or flames to contact the flammable parts of the structure (p. 3).

In his definition, Butler provides important references to the characteristics of this problem. He identifies homes ("urban") as potential fuel and indicates that the distance between the wildland fire and the home ("close enough") is an important factor for structure ignition. How close the fire is to a home relates to how much heat the structure will receive.

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[2] Research Physical Scientist, Fire Sciences Laboratory, Rocky Mountain Research Station, PD. Box 8089, Missoula, MT 59807. e-mail: Jcohen/rmrs_missoula@fs.fed.us

These two factors, the homes and fire proximity, represent the fuel and heat "sides" of the fire triangle, respectively. The fire triangle—fuel, heat, and oxygen— represents the critical factors for combustion. Fires burn and ignitions occur only if a sufficient supply of each factor is present. By characterizing the home as fuel and the heat from flames and firebrands, we can describe a home's ignitability. An understanding of home ignitability provides a basis for reducing potential W-UI fire losses in a more effective and efficient manner than current approaches.

Ignition and Fire Spread are a Local Process

Fire spreads as a continually propagating process, not as a moving mass. Unlike a flash flood or an avalanche where a mass engulfs objects in its path, fire spreads because the locations along the path meet the requirements for combustion. For example, C.P. Butler (1974) provides an account from 1848 by Henry Lewis about pioneers being caught on the Great Plains during a fire:

> When the emigrants are surprised by a prairie fire, they mow down the grass on a patch of land large enough for the wagon, horse, etc., to stand on. They then pile up the grass and light it. The same wind, which is sweeping the original fire toward them, now drives the second fire away from them. Thus, although they are surrounded by a sea of flames, they are relatively safe. Where the grass is cut, the fire has no fuel and goes no further. In this way, experienced people may escape a terrible fate (p. 1-2).

It is important to note that the complete success of this technique also relies on their wagons and other goods not igniting and burning from firebrands. This account describes a situation that has similarities with the W-UI fire problem.

A wildland fire does not spread to homes unless the homes meet the fuel and heat requirements sufficient for ignition and continued combustion. In the prairie fire situation, sufficient fuel was removed (by their escape fire) adjacent to the wagons to prevent burning (and injury) and the wagons were ignition resistant enough to not ignite and burn from firebrands. Similarly, the flammables adjacent to a home can be managed with the home's materials and design chosen to minimize potential firebrand ignitions. This can occur regardless of how intensely or fast spreading other fires are burning. Reducing W-UI fire losses must involve a reduction in the flammability of the home (fuel) in relation to its potential severe-case exposure from flames and firebrands (heat). The essential question remains as to how much reduction in flammables (e.g., how much vegetative fuel clearance) must be done relative to the home fuel characteristics to significantly reduce the potential home losses associated with wildland fires.

Insights for Reducing Ignitions from Flames

Recent research provides insights for determining the vegetation clearance required for reducing home ignitions. Structure ignition modeling, fire experiments, and W-UI fire case studies provide a consistent indication of the fuel and heat required for home ignitions.

The Structure Ignition Assessment Model (SIAM) (Cohen 1995) assesses the potential ignitability of a structure related to the W-UI fire context. SIAM calculates the amount of heat transferred to a structure from a flame source on the basis of the flame characteristics and the flame distance from a structure. Then, given this thermal exposure, SIAM calculates the amount of time required for the occurrence of wood ignition and flaming (Tran and others 1992). On the basis of severe-case assumptions of flame radiation and exposure time, SIAM calculations indicate that large wildland flame fronts (e.g., forest crown fires) will not ignite wood surfaces (e.g., the typical variety of exterior wood walls) at distances greater than 40 meters (Cohen and Butler [In press]). For example, the incident radiant heat flux, the amount of radiant heat a wall would receive from flames, depends on its distance from the fire. That is, the rate of radiant energy per unit wall area decreases as the distance increases (*fig. 1,)*. In addition, the time required for a wood wall to ignite depends on its distance from a flame front of the given height and width (*fig. 1)*. But the flame's burning time compared to the required ignition time is important. If at some distance the fire front produces a heat flux sufficient to ignite a wood wall, but the flaming duration is less than that required for ignition, then ignition will not occur. At a distance of 40 meters, the radiant heat flux is less than 20 kilowatts per square meter, which corresponds to a minimum ignition time of greater than 10 minutes (*fig. 1*). Crown fire experiments in forests and shrublands indicate that the burning duration of these large flames is on the order of 1 minute at a specific location.[3] This is because these wildland fires depend on the rapid consumption of the fine dead and live vegetation (e.g., forest crown fires).

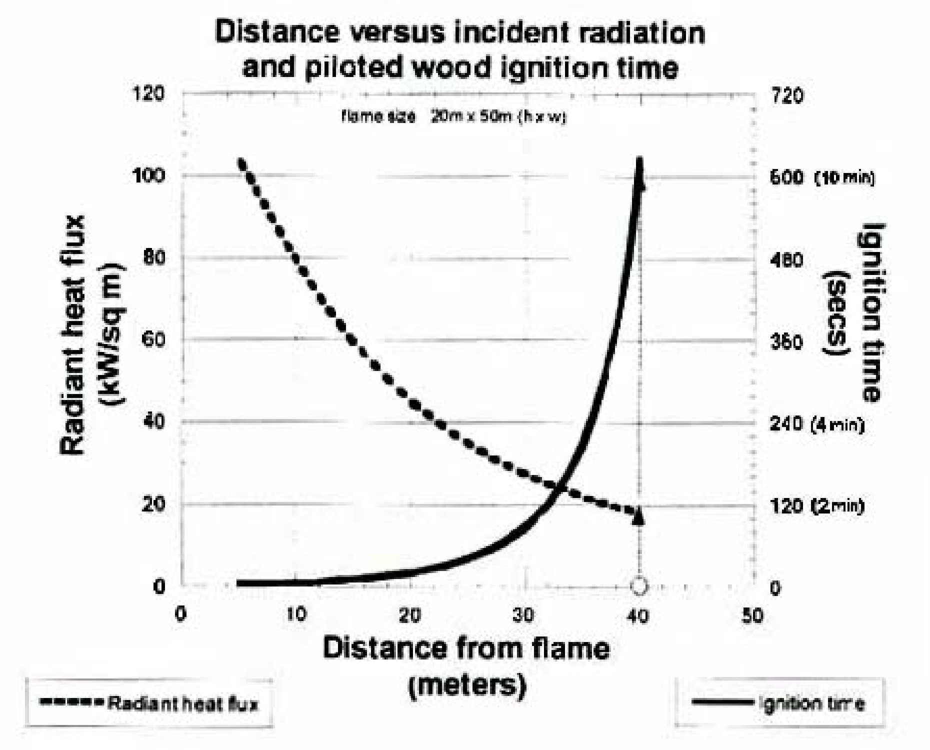

Figure 1
SIAM calculates the incident radiant heat flux (energy/unit-area/time reaching a surface) and the minimum time for piloted ignition (ignition with a small ignition flame or spark) as a function of distance for the given flame size. The flame is assumed to be a uniform, parallel plane, black body emitter.

Experimental fire studies associated with the International Crown Fire Modeling Experiment (Alexander and others 1998) generally concur with the SIAM calculations. Data were obtained from instrumented wall sections that were placed 10 meters from the forest edge of the crown fire burn plots. Comparisons between SIAM calculations and the observed heat flux data indicate that SIAM overestimates the amount of heat received.[4] For example, the SIAM calculated potential radiant heat flux for an experimental crown fire was 69 kW/ sq meter as compared to the measured maximum of 46 kW/sq meter. This is expected since SIAM assumes a uniform and constant heat source and flames are not uniform and constant. Thus, the SIAM calculations for an actual flame front represent a severe-case estimate of the heat received and the potential for ignition. The SIAM distances represent an upper estimate of the separation required to prevent flame ignitions (*fig. 1)*.

Past fire case studies also generally concur with SIAM estimates and the crown fire observations. Analyses of southern California home losses done by the Stanford Research Institute for the 1961 Belair-Brentwood Fire (Howard and others 1973) and by the University of California, Berkeley, for the 1990 Painted Cave Fire (Foote and Gilless 1996) are consistent with SIAM estimates and the experimental crown fire data. Given nonflammable roofs, Stanford Research

[3] Unpublished data on file, Rocky Mountain Research Station, Fire Sciences Laboratory) Missoula, Montana.

[4] Unpublished data on file, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, Montana.

Institute (Howard and others 1973) found a 95 percent survival with a clearance of 10 to 18 meters, and Foote and Gilless (1996) at Berkeley found 86 percent home survival with a clearance of 10 meters or more.

The results of the diverse analytical methods are congruent and consistently indicate that ignitions from flames occur over relatively short distances—tens of meters not hundreds of meters. The severe-case estimate of SIAM indicates distances of 40 meters or less. Experimental wood walls did not ignite at 10 meters when exposed to experimental crown fires. And, case studies found that vegetation clearance of at least 10 meters was associated with a high occurrence of home survival.

As previously mentioned, firebrands are also a principal W-UI ignition factor. Highly ignitable homes can ignite during wildland fires without fire spreading near the structure. This occurs when firebrands are lofted downwind from fires. The firebrands subsequently collect on and ignite flammable home materials and adjacent flammables. Firebrands that result in ignitions can originate from wildland fires that are at a distance of 1 kilometer or more. For example, during the 1980 Panorama Fire (San Bernardino, California), the initial firebrand ignitions to homes occurred when the wildland fire was burning in low shrubs about 1 kilometer from the neighborhood. During severe W-UI fires, firebrand ignitions are particularly evident for homes with flammable roofs. Often these houses ignite and burn without the surrounding vegetation also burning. This suggests that homes can be more flammable than the surrounding vegetation. For example, during the 1991 fires in Spokane, Washington,[5] houses with flammable roofs ignited without the adjacent vegetation already burning. Although firebrands may be lofted over considerable distances to ignite homes, a home's materials and design and its adjacent flammables largely determine the firebrand ignition potential.

Research Conclusions

SIAM modeling, crown fire experiments, and W-UI fire case studies show that effective fuel modification for reducing potential W-UI fire losses need only occur within a few tens of meters from a home, not hundreds of meters or more from a home. This research indicates that home losses can be effectively reduced by focusing mitigation efforts on the structure and its immediate surroundings. Those characteristics of a structure's materials and design and the surrounding flammables that determine the potential for a home to ignite during wildland fires (or any fires outside the home) can be referred to as home ignitability.

The evidence suggests that wildland fuel reduction for reducing home losses may be inefficient and ineffective: inefficient because wildland fuel reduction for several 100 meters or more around homes is greater than necessary for reducing ignitions from flames; ineffective because it does not sufficiently reduce firebrand ignitions. To be effective, given no modification of home ignition characteristics, wildland vegetation management would have to significantly reduce firebrand production and potentially extend for several kilometers away from homes.

Management Implications

These research conclusions redefine the W-UI home fire loss problem as a home ignitability issue largely independent of wildland fuel management issues. Consequently, this description has significant implications for the necessary actions and economic considerations for fire agencies.

One aspect of the Forest Service approach to reducing the W-UI fire problem is to determine where the problem is and focus fuel management activities in those areas. *The Strategic Assessment of Fire Management* (USDA Forest Service 1995) states:

[5]Unpublished video data on file, Rock)' Mountain Research Station, Fire Sciences Laboratory, Missoula, Montana.

> The Forest Service should manage National Forest lands to mitigate hazards and enhance the ability to control fires in the wildland/urban interface. The risk of wildland fire to communities can be lessened by reducing hazards on Forest Service lands adjacent to built-up areas.... Broad-scale assessment processes for the next generation of forest plans should identify high-risk areas related to the wildland/urban interface... The highest risk areas within the United States should be identified and mitigation efforts directed to these locations (p. 20).

It describes a costly, intensive, and extensive W-UI hazard mapping and mitigation effort specifically for reducing home fire losses. As described, this approach is not necessary.

The congruence of research findings from different analytical methods suggests that home ignitability is the principal cause of home losses during wildland fires. Any W-UI home fire loss assessment method that does not account for home ignitability will be critically non-specific to the problem. Thus, to be reliable, land classification and mapping related to potential home loss must assess home ignitability. Home ignitability also dictates that effective mitigating actions focus on the home and its immediate surroundings rather than on extensive wildland fuel management. Because homeowners typically assert their authority for the home and its immediate surroundings, the responsibility for effectively reducing home ignitability can only reside with the property owner rather than wildland agencies.

Mapping Home Loss Potential

The evidence indicates that home ignitions depend on the home materials and design and only those flammables within a few tens of meters of the home (home ignitability). The wildland fuel characteristics beyond the home site have little if any significance to W-UI home fire losses. Thus, the wildland fire threat to homes is better defined by home ignitability, an ignition and combustion consideration, than by the location and behavior of potential wildland fires.

Home ignitability has implications for identifying W-UI fire problem areas and suggests that the geographical implication of the term "wildland-urban interface" as a general area or zone misrepresents the physical nature of the wildland fire threat to homes. The wildland fire threat to homes is not where it happens related to wildlands (a location) but how it happens related to home ignitability (the combustion process). Therefore, to reliably map W-UI home fire loss potential, home ignitability must be the principal mapping characteristic.

Wildland Fuel Hazard Reduction

Extensive wildland vegetation management does not effectively change home ignitability. This should not imply that wildland vegetation management is without a purpose and should not occur for other reasons. However, it does imply the imperative to separate the problem of the wildland fire threat to homes from the problem of ecosystem sustainability due to changes in wildland fuels. For example, a W-UI area could be a high priority for extensive vegetation management because of aesthetics, watershed, erosion, or other values, but not for reducing home ignitability. Vegetation management strategies would likely be different without including the W-UI home fire loss issue. It also suggests that given a low level of home ignitability (reduced wildland fire threat to homes), fire use opportunities for sustaining ecosystems may increase in and around WUI locations.

W-UI Home Loss Responsibility

Home ignitability implies that homeowners have the ultimate responsibility for W-UI home fire loss potential. Because the ignition and flammability characteristics of a structure and its immediate surroundings determine the home fire loss potential, the home should not be considered a victim of wildland fire, but rather a potential participant in the continuation of the wildland fire. Home ignitability, i.e., the potential for W-UI home fire loss, is the homeowner's choice and responsibility.

However, public and management perceptions may impede homeowners from taking principal responsibility. For example, the Federal Wildland Fire Management, Policy, and Program Review (1995) observes, "There is a widespread misconception by elected officials, agency managers, and the public that wildland/urban interface protection is solely a fire service concern" (p. 23). In the *Journal of Forestry,* Beebe and Omi (1993) concur, stating that, "Public reaction to wildfire suggests that many Americans want competent professionals to manage fire flawlessly, reducing the risks to life, property, and public lands to nil" (p. 24). These statements agree with Bradshaw's (1988) description of the societal roles in the W-UI problem. He observes that homeowners expect that fire protection will be provided by others. Contrary to these expectations for fire protection, the fire services have neither the resources for effectively protecting highly ignitable homes during severe W-UI fires, nor the authority to reduce home ignitability.

An Alternative

Specific to the W-UI fire loss problem, home ignitability ultimately implies the necessity for a change in the relationship between homeowners and the fire services. Instead of all pre-suppression and fire protection responsibilities reading with fire agencies, homeowners should take the principal responsibility for assuring adequately low home ignitability. The fire services become a community partner providing homeowners with technical assistance as well as fire response in a strategy of assisted and managed community self-sufficiency (Cohen and Saveland 1997). For success, this perspective must be shared and implemented equally by homeowners and the fire services.

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