THE WILDLAND-URBAN INTERFACE FIRE PROBLEM

by Jack Cohen

The fire destruction of hundreds of homes associated with wildfires has occurred in the United States for more than a century. From 1870 to 1920, massive wildfires occurred principally in the Lake States but also elsewhere. Wildfires such as Peshtigo (Wisconsin, 1871), Michigan (1881), Hinckley (Minnesota, 1894), Adirondack (New York, 1903), the Big Blowup (Idaho-Montana, 1910), and Cloquet (Minnesota, 1918) extended across millions of acres, destroying towns and causing several thousand civilian fatalities (Pyne 1982). This period produced significantly greater destruction of property and lives than has occurred in the past 50 years.

More recently, the home destruction problem related to wildfires became nationally recognized in 1985 and has become known as the wildland-urban interface (WUI) fire problem. The initial fire management response to the WUI fire problem, principally organized by the U.S. Forest Service and the National Fire Protection Association, resulted in the 1986 Wildfire Strikes Home conference (Laughlin and Page 1986). The current national Firewise program developed out of that initiative (*www.firewise.org*). Since 2000, federal and state wildland fire management policy has recognized the WUI fire problem as a principal issue in a number of documents including the National Fire Plan (2000), Federal Wildland Fire Management Policy (2001), 10-Year Comprehensive Strategy (2001), and the Healthy Forests Restoration Act (2003).

Wildfire exclusion started as a prime directive in the early years of the U.S. Forest Service and became a broad national perspective. Chief Forester Henry Graves stated in 1913 that “the necessity of preventing losses from forest fires requires no discussion. It is the fundamental obligation of the Forest Service and takes precedence over all other duties and activities” (Pyne 1982). Although several prominent foresters and researchers, like Coert DuBois of the Forest Service and H.H. Chapman of Yale University, promoted the benefits of wildland burning in the 1920s and 1930s, the questioning of fire control policies was considered a threat to nationally organized forestry programs (Pyne 1982). For the next four decades the federal public land management policy largely addressed wildfires as unwanted—to be prevented, and if not prevented, to be suppressed at the smallest area possible (the fire exclusion paradigm).

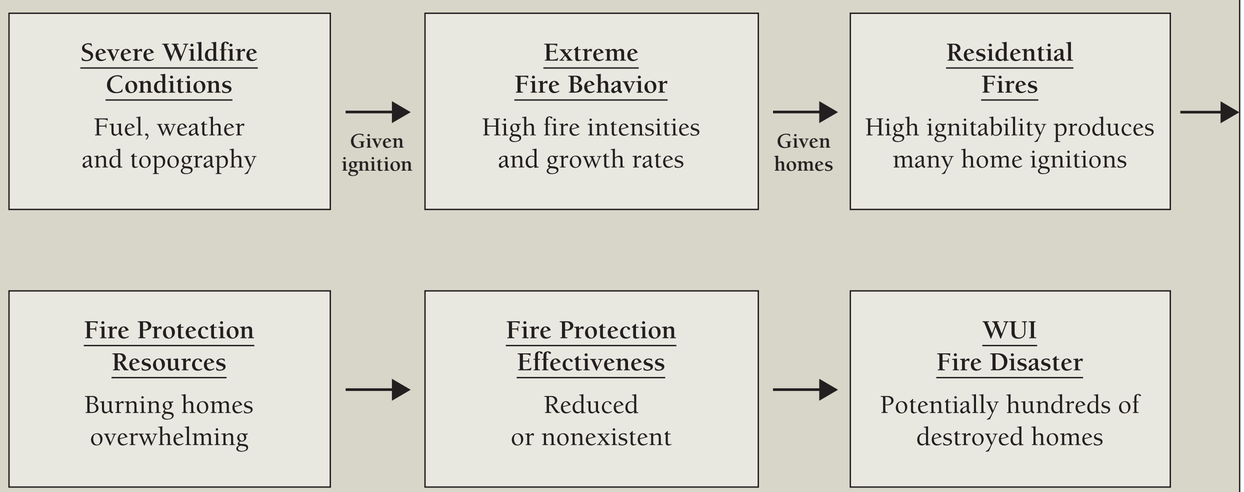
Federal policy began to recognize wildland fire as a historical, ecological factor in the late 1960s and early 1970s (Pyne 1982). Current policy recognizes that wildland fire can be an important ecological process and provides latitude for planned burning (prescribed fire) and designating unplanned fires as desirable. In practice, however, the nationwide total number of wildland fires suppressed as wildfires overwhelmingly dominates the fire occurrence statistics. For example, on federal lands the ten-year (1998–2007) average number of total wildland fires per year designated for suppression is approximately 80,000 occurrences, compared with 327 designated as desirable (National Interagency Fire Center).

Although some agencies have more management latitude in principle, the proportion of fires suppressed suggests that an exclusion

TABLE 1. WILDLAND-URBAN INTERFACE DISASTERS DURING EXTREME WILDFIRES (1990–2007)

Year	Incident	Location	Homes destroyed (approx.)
1990	Painted Cave	Santa Barbara, CA	479
1991	Spokane “Firestorm”	Spokane, WA	108
	Tunnel/Oakland	Oakland, CA	2900
1993	Laguna Hills Old Topanga	Laguna and Malibu, CA	634
1996	Millers Reach	Big Lake, AK	344
1998	Florida Fires	Flagler and Volusia Counties, FL	300
2000	Cerro Grande	Los Alamos, NM	235
2002	Hayman	Lake George, CO	132
	Rodeo-Chediski	Heber-Overgaard, AZ	426
2003	Aspen	Summerhaven, AZ	340
	Old, Cedar, etc.	Southern CA	3640
2006	Texas-Oklahoma Fires	Texas and Oklahoma	723
2007	Angora	Lake Tahoe, CA	245
	Witch, Slide, Grass Valley, etc.	Southern CA	2180

FIGURE 1. WILDLAND-URBAN INTERFACE FIRE SEQUENCE.



WUI fire disasters depend on the exposure of ignitable homes to the flames and firebrands of uncontrollable, extreme wildfires. Many burning and highly ignitable homes overwhelm firefighters, resulting in many homes without protection. If homes exposed to wildfire are ignition-resistant, then an extreme wildfire can occur without a WUI fire disaster.

approach largely continues. The term "fire exclusion paradigm" refers to this organizational culture and operational practice of preventing and suppressing nearly all wildland fires.

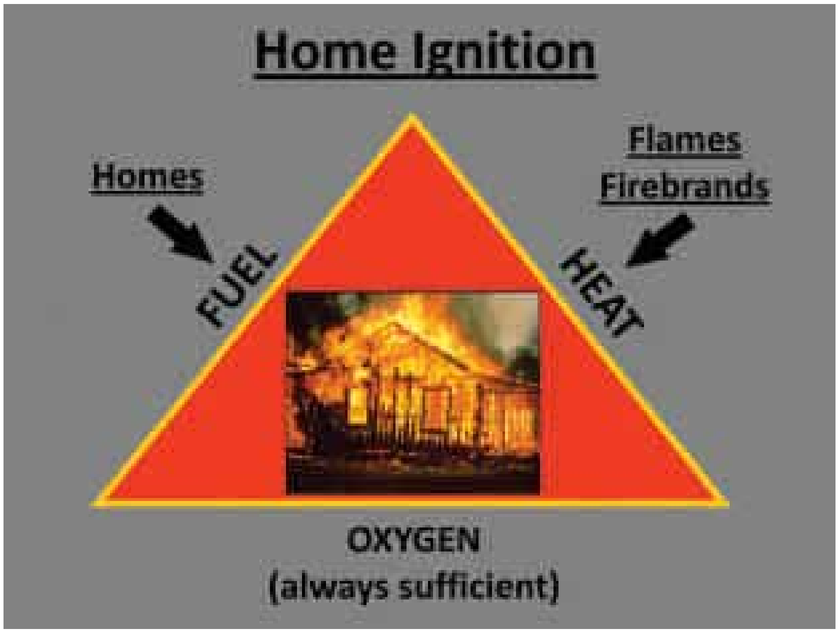
As a consequence of these practices, fire suppression has significantly contributed to the reduction of fire occurrence in most areas of the United States. The National Fire Plan report states, "As a result of the all-out effort to suppress fires, the annual acreage consumed by wildfires in the lower 48 states dropped from 40 to 50 million acres (16 to 20 million hectares) a year in the early 1930s to about 5 million acres (2 million hectares) in the 1970s" (USDA and USDI 2000). In some ecosystems, such as the ponderosa pine (*Pinus ponderosa*) forests in the western U.S., the reduction of fire occurrence has resulted in significant changes to the species composition and increases in the amount of live and dead vegetation (Arno and Brown 1991; Finney and Cohen 2003). Furthermore, it has been shown that in many areas aggressive fire suppression over many years has contributed to reduced fire occurrence that has led to increased fuels and changed fuel composition and arrangements. In turn, that has contributed to the extensive areas of high intensity wildfires experienced in recent years (USDA and USDI 2000).

DEFINING DISASTER

One might assume there is an unbreakable link between increasing wildfire extent and intensity and increasing WUI residential fire destruction. However, we cannot assume extreme wildfires directly cause WUI fire disasters; these disasters depend on homes igniting during wildfires. Certainly extreme wildfires initiate ignitions within residential areas, but if homes do not ignite and burn during wildfires, then the WUI fire problem largely does not exist.

Widespread WUI home destruction during wildfires does not occur when normal wildfire control and structure protection capabilities limit the fire spread. Wildland fire suppression operations successfully control 97–99% of all wildfires with the initial response (Stephens and Ruth 2005), and firefighters typically limit a fire to a single structure or prevent the fire from spreading beyond that structure. However, big flames and extensive showers of burning embers (firebrands) resulting from high intensity fires over broad areas (referred to as "extreme wildfire conditions") is not a typical situation. When residential development is exposed to extreme wildfire conditions numerous houses can ignite and burn simultaneously, overwhelming firefighters and reducing fire protection effectiveness. WUI fire disasters principally occur during these extreme wildfire conditions that account for the one to three percent of wildfires that escape control (Menakis et al. 2003). Table 1 lists WUI fire disasters between 1990 and 2007. Every one of these disasters occurred because extreme wildfire conditions overwhelmed firefighters attempting wildfire control and firefighters attempting to protect structures.

FIGURE 2. THE FIRE TRIANGLE



Home ignitions depend on a sufficiency of FUEL, the flammable parts of a home, and HEAT, the flames and firebrands of all objects burning around a home. OXYGEN will always be sufficient for home ignitions.

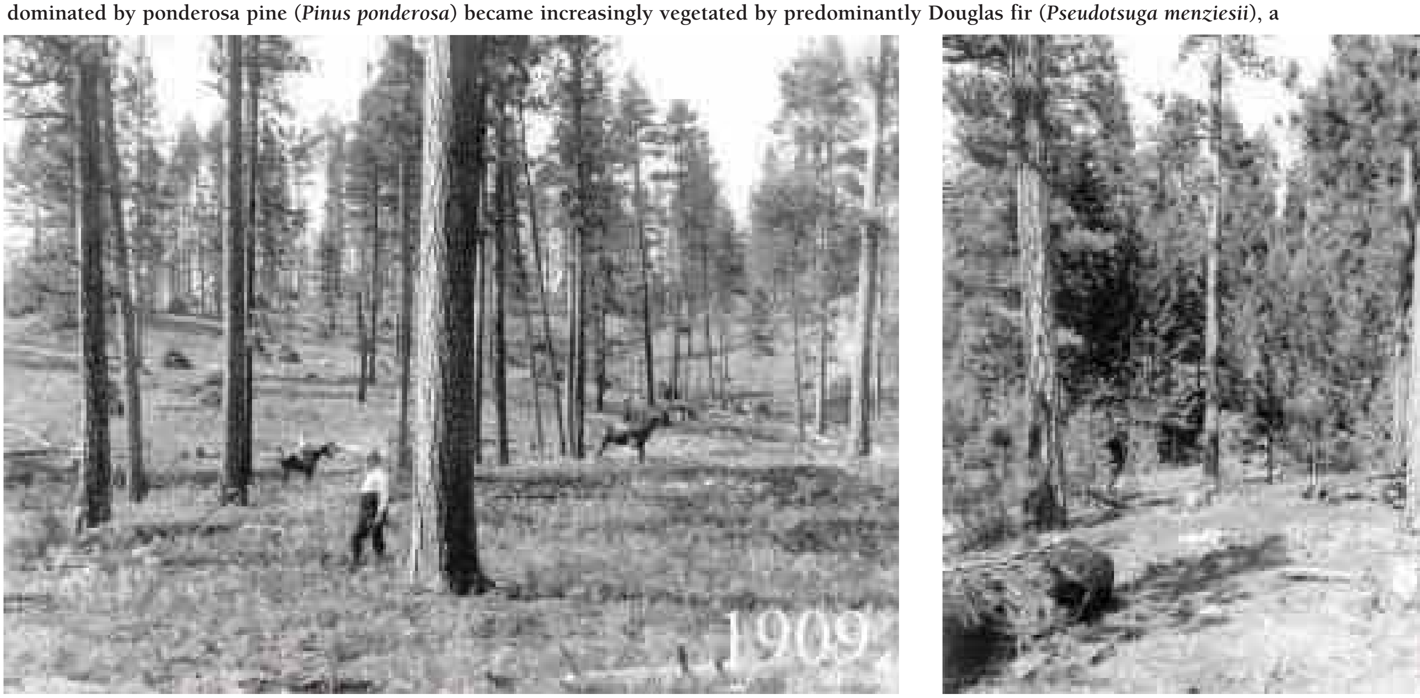
The WUI fire disaster context can be generally described as a set of contingencies (Figure 1). The disaster sequence starts when a wildfire or multiple wildfires burn during extreme fire conditions. The combination of extreme vegetation, weather, and topographic conditions given a fire start produces fast-spreading, intensely burning fires that overwhelm wildfire suppression efforts. If extreme wildfire spreads close enough to residential development with its flames and firebrands, hundreds of ignitable homes can be simultaneously exposed.

Although protection may be effective for some homes, an extreme wildfire's high intensities and rapid spread combine to produce broad residential fire exposures that potentially ignite many houses and jeopardize firefighters' safety. This prevents fire protection for many structures. With homeowners likely evacuated and firefighters unable to protect every house, small, easy-to-extinguish ignitions can result in total home destruction.

If homes are sufficiently resistant to ignition and do not ignite when exposed to extreme wildfire, the homes survive with little to no firefighter protection; we have an extreme wildfire but not a WUI fire disaster. Thus, the occurrence of WUI fire disasters principally depends on home ignition potential.

Homes ignite and burn by meeting and sustaining the requirements for combustion. Fire is a process that requires a sufficiency of fuel, heat, and oxygen to continue. The fire process is graphically represented by the "fire triangle" (Figure 2). For the WUI fire context, the house is the "fuel" and all burning objects surrounding the house (vegetation and other structures) are the "heat." In this context oxygen will always be sufficient. During extreme WUI fires the requirements for combustion can be met, resulting in home (fuel) ignitions in two principal ways: 1) direct flame heating—radiation and

This historical photo series from western Montana (Smith and Arno 1999) shows how an initially open forest (with management activity) dominated by ponderosa pine (*Pinus ponderosa*) became increasingly vegetated by predominantly Douglas fir (*Pseudotsuga menziesii*), a



convection (flame contact), and 2) firebrands collecting on flammable house surfaces (burning ember spot ignitions) (Cohen and Wilson 1995; Cohen 2000a).

Research indicates that WUI fire destruction occurs principally due to conditions local to destroyed homes. Computational modeling and laboratory and field experiments that describe the heat transfer required for ignition have shown that the large flames of burning shrubs and tree canopies (crown fires) must be within 100 feet to ignite a home's wood exterior (Cohen and Wilson 1995; Cohen 2000a; Cohen 2004). Actual case examinations find that extreme wildfire behavior does not occur within most residential areas (Cohen 2000b; Cohen and Stratton 2003; Cohen and Stratton 2008). Unconsumed vegetation surrounding most destroyed homes and generally throughout burned residential areas indicates home ignitions occur from lower intensity surface fires spreading to contact a home and from firebrands contacting the flammable surfaces of a house.

Computations, experiments, and disaster examinations show that a home's ignition potential during extreme wildfire is principally determined by the characteristics of a home's exterior materials, design, and associated flammable debris related to surrounding burning objects within 100 feet (30 meters) and firebrands (lofted burning embers). I call this area—a home and its immediate surroundings—*the home ignition zone* (HIZ). Thus, given an extreme wildfire, the HIZ principally determines the potential for home ignition and this reveals opportunities for preventing WUI fire disasters.

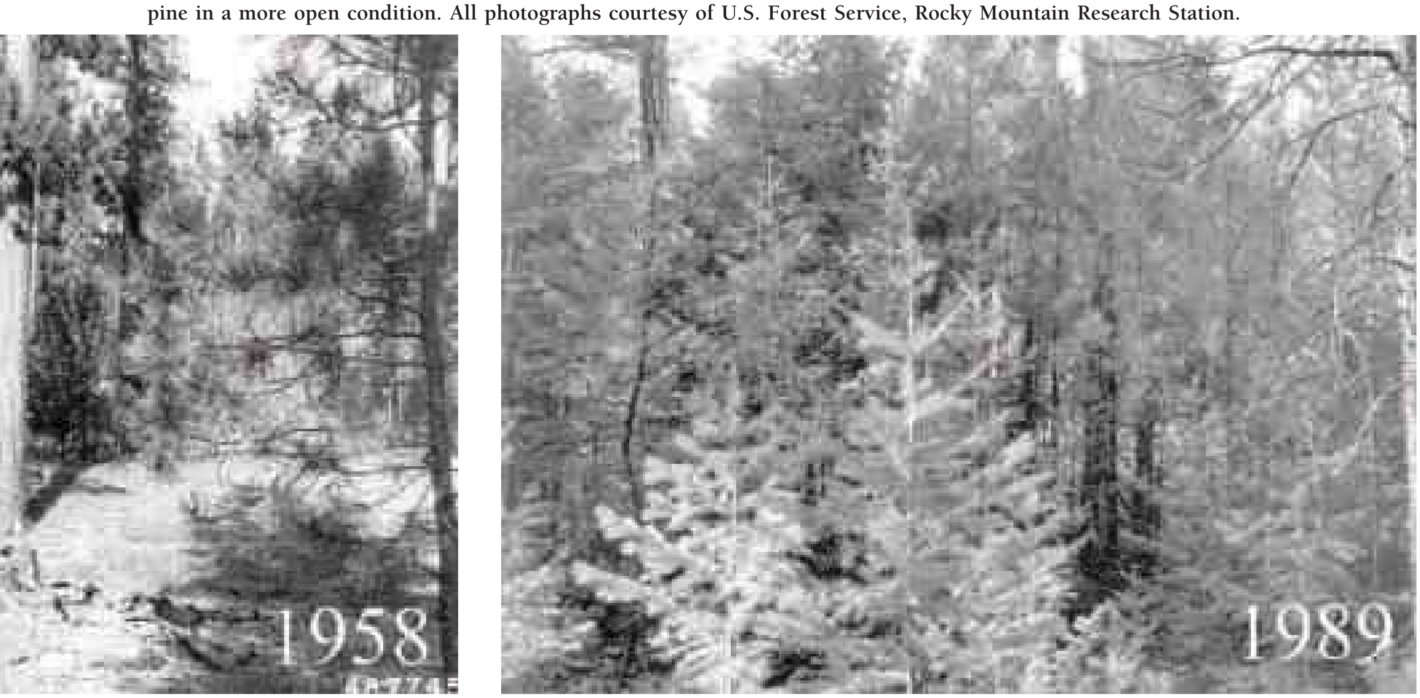
PREVENTING DISASTER

The above research suggests an alternative for preventing disastrous home destruction without the necessity of controlling wildfires under extreme conditions. Addressing conditions within the HIZ can significantly reduce the home ignition potential. Thus, given ignition-resistant homes, extreme wildfires can spread to residential areas without incurring WUI fire disasters. To date, however, WUI ignition resistance has not been the primary approach used by most federal, state, and local fire agencies to prevent disastrous WUI fire destruction. Although the HIZ approach for preventing WUI fire disasters has been adopted by the national Firewise program (*www.firewise.org*), fire suppression with a focus on the wildfire and fuel treatment outside the home ignition zone still remains the principal approach.

For example, the U.S. Departments of Agriculture and Interior produced a report in response to the home destruction (principally at Los Alamos, NM) and wildfires of 2000 that became known as the National Fire Plan (USDA and USDI 2000). This report designated fire suppression at the federal, state, and local levels as the first priority. Several years later a multiagency plan was developed called the 10-Year Comprehensive Strategy (Western Governors Association 2006). This plan is currently in effect and promotes multi-agency collaboration for reducing wildfire risks, including the risk of WUI fire disasters. The first goal of the strategy directs the improvement of wildfire prevention and suppression. In general, the 10-Year Comprehensive Strategy promotes a fire suppression approach for preventing WUI fire disasters without consideration for home ignition potential and the HIZ as a key component (Western Governors Association 2006).

Vegetation fuel reduction treatments, as reported in the Healthy Forests Report of May 2007, also

change in forest type and density. Historically, such a site had frequent fire occurrence every decade or so that maintained ponderosa pine in a more open condition. All photographs courtesy of U.S. Forest Service, Rocky Mountain Research Station.



ABOVE: **Unconsumed vegetation adjacent to four destroyed homes in this view indicates ignitions from lower intensity surfaces fires and/or firebrands directly igniting homes.** • TOP RIGHT: **This condition typically prevails across entire residential areas of WUI fire destruction. The areas of consumed canopy vegetation in this scene are related to homes burning.** • BOTTOM RIGHT: **High intensity fire spread in the tree canopy (crown fire) stopped at this residential street and did not continue as crown fire. However, all of the structures for several more blocks burned.**

point to the widespread use of a wildfire modification and control approach that does not address a home's ignition potential, but rather focuses on areas outside the HIZ (USDA and USDI 2008). Fuel treatments in the vicinity are expected to protect homes by creating conditions that enable successful fire suppression. Wildfire operations appear to be consistent with the above policy as indicated by the significant U.S. Forest Service expenditure of suppression resources for WUI protection. A November 2006 Office of Inspector General report (USDA 2006) on large wildfire suppression costs documents this practice:

> FS managers and staff stated that WUI protection was the major driver of FS suppression costs, with some staff estimating that between 50 to 95 percent of large wildfire suppression expenditures were directly related to protecting private property and homes in the WUI….When FS protection responsibilities are directly adjacent to WUI development, FS line officers feel compelled to aggressively suppress wildfires because the fires threaten privately-owned structures, even if the fires pose no threat to FS resources.

These findings are consistent with Forest Service Manual directives regarding WUI fire protection. Section 5137 of the manual defines Forest Service structure protection measures in terms of wildfire control (USFS 2004). "The Forest Service's primary responsibility and objective for structure fire protection is to suppress wildfire before it reaches structures." The evidence from policy documents, fire management operations, and manual directives indicates that wildfire suppression and activities in support of suppression constitute the principal approach for preventing disastrous residential fire destruction. Yet the evidence of disastrous WUI fire occurrence suggests that reasonable levels of fire suppression cannot prevent these disasters.

The inevitability of wildfires—including the extreme wildfires that account for the one to three percent of the fires that escape control—is axiomatic. But WUI fire disasters occur during this one to three percent of uncontrollable wildfires. This might suggest the inevitability of WUI fire disasters; however, research shows it is the HIZ that principally determines the potential for WUI fire disasters. The continued focus on fire suppression largely to the

exclusion of alternatives that address home ignition potential suggests a persistent inappropriate framing of the WUI fire problem in terms of the fire exclusion paradigm.

Preventing WUI fire disasters requires that the problem be framed in terms of home ignition potential and not fire exclusion. Because this principally involves the HIZ, and the HIZ primarily falls within private ownership, the responsibility for preventing home ignitions largely falls within the authority of the property owner. If we are to prevent extensive home destruction within the WUI, property owners must become engaged, matching their authority over the HIZ with the responsibility to create ignition resistant homes. Fire agencies can reinforce the necessity of property owner engagement as well as facilitate property owners in reducing the ignition vulnerability of their homes.

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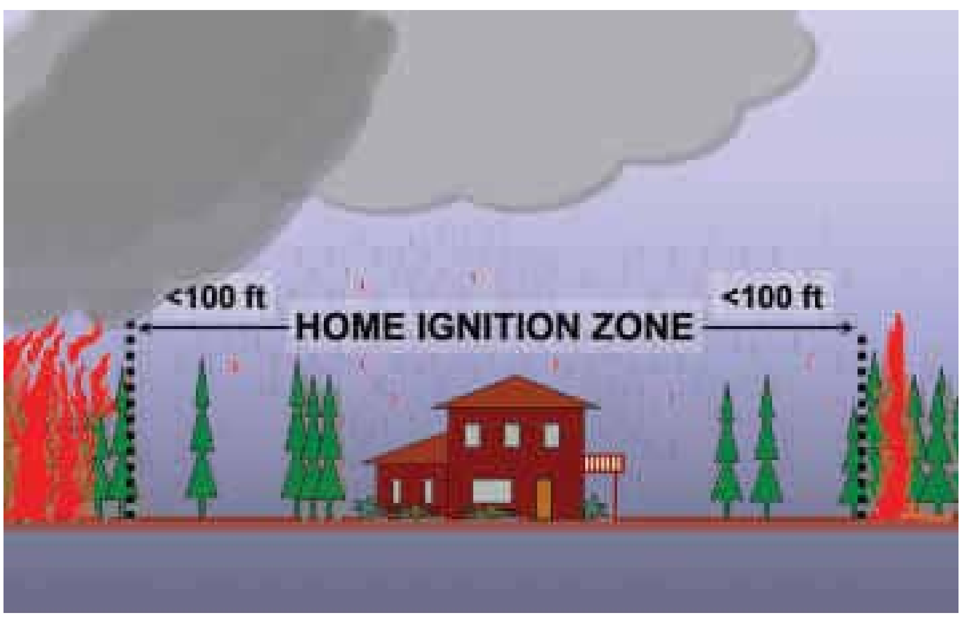

The home ignition zone (HIZ) is the area that principally determines a home's ignition potential during extreme wildfires when active fire protection is unlikely. It is the fire behavior within the HIZ, about 100 feet or less in relation to a home's ignition vulnerability, that principally determines ignition potential. Firebrands, regardless of travel distance, are a significant ignition factor, but only based on the HIZ characteristics. The firebrand ignition threat depends on spot ignitions within the HIZ that can burn to contact a house or collect on a home's flammable surfaces, all HIZ conditions.

Jack Cohen, Fire Sciences Laboratory, 5575 W. US Highway 10, Missoula, MT 59808, jcohen@fs.fed.us