IBHS PRIMER SERIES ON WILDFIRE

PART TWO

THE BUILT ENVIRONMENT

IBHS PRIMER SERIES

July 2020

Wildland fire is a natural phenomenon and necessary for the health of some ecosystems. When a wildland fire gets out of control and becomes a wildfire, it can threaten homes and businesses. Acknowledging that it will continue to be a threat (despite our best efforts) is an important first step in developing resilience in the face of this hazard. The best path toward adapting to wildfire is to find ways to limit the impact of wildfires on the built environment by limiting or preventing the ignition of structures.

The ignition of a building can be caused by one of the following processes:

EXPOSURE TO WIND-BLOWN EMBERS (ALSO KNOWN AS FIREBRANDS)

Embers land on combustible materials and ignite. These can be materials that are adjacent to a building, such as landscaping material, organic material that has accumulated on a roof or in a gutter, or the building materials themselves (such as a wood shake roof or siding).

Indirect ignition. Debris in the gutters was ignited by embers.

DIRECT FLAME CONTACT

This occurs when flames are in direct contact with the structure, igniting combustible building materials. Direct flame contact is the most aggressive type of fire spread, which can be caused by ember deposition on a vulnerable material.

Direct ignition. Embers have accumulated and ignited combustible wood shake siding.

RADIANT HEAT EXPOSURE

Radiant heat is the thermal energy that you feel when standing next to a fire. As this energy is transferred to nearby materials, their temperature rises, and a vulnerable material will ignite once a critical temperature is reached. In this scenario, the heat source can be a burning woodpile, outbuilding, shrub, or the approach of the fire front itself.

Radiant heat. Here an infrared burner is used to simulate the radiant heat from flame.

Radiant heat. The radiant heat caused the glass to break and the window frame to ignite.

WHY DEFENSIBLE SPACE?

Good defensible space around a structure (Figure 1) can reduce the vulnerability against all three types of ignition. In situations like closely spaced suburban neighborhoods, the area needed for defensible space is not available and even well-maintained defensible space can be overwhelmed. Maintaining defensible space provides the opportunity for first responders to defend your house in an effective way.

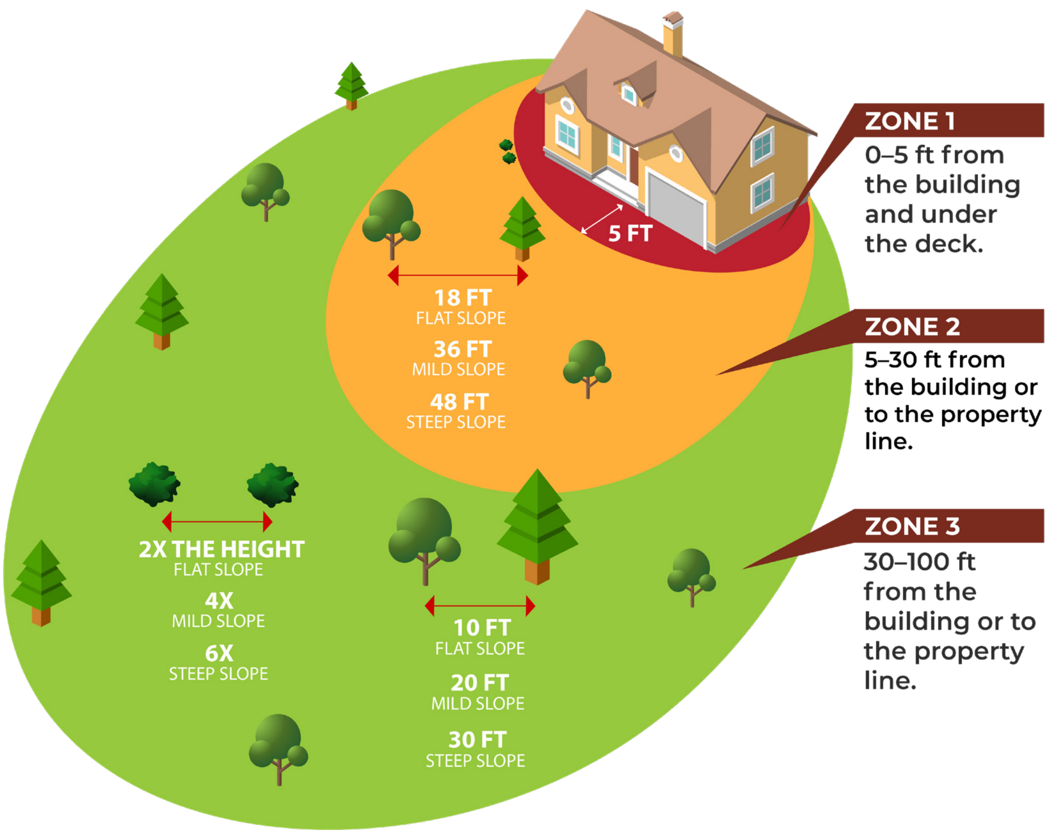

Figure 1: Diagram showing the characteristics of well-maintained defensible space.

Of the three ignition processes, research over the last decade has shown exposure to wind-blown embers is the most important to defend against.[1] Wind-blown embers generated by burning wildland vegetation or burning structures can land on or near a home or business, or even enter through the various vents and openings that most structures have and ignite vulnerable materials.

[1] *Quarles, S.L. (2017), Vulnerability of Vents to Wind-Blown Embers*

Examples of a direct ember ignition include embers entering through a vent or open/broken window with subsequent ignition of combustible materials or furnishings inside the building. Direct ignition by embers can also occur when embers accumulate on combustible materials such as a wood shake roof, on combustible decking, or immediately adjacent to combustible materials such as siding.

Examples of indirect exposure include ember accumulation and ignition of vegetation or other combustible materials (e.g., a woodpile or shed) located near your home or business, with subsequent ignition of a building component by a radiant heat and/or direct flame contact.

FIRE IN THE BUILT ENVIRONMENT

When a wildland fire enters the built environment, building-to-building fire spread becomes a key factor in overall fire spread. This is because all three ignition mechanisms are often active at the same time. Also, many communities are often designed with small lot sizes and densely packed homes to maximize use of available land. These factors are the primary challenges to the resiliency of the built environment when dealing with wildfire as a hazard. IBHS researchers examined post-event data collected by CAL FIRE after wildfires from 2014–2017 to investigate what might be the critical factors in the built environment that could provide clues as to why a structure did or did not burn. This dataset included several notable fires in 2017 from across the state, including the Tubbs, Atlas, and Thomas fires. Each data entry contains 48 attributes including street address, assessor name, date of assessment, CAL FIRE unit, and building statutes.

The following table shows the attributes used by IBHS for our analysis.

Attributes	CHARACTERISTICS
Topography	Flat ground, slope, saddle, ridge top, chimney
Vegetative Clearance	Unknown; 0–30; 30–60; 60–100; >100
Roof Construction	Unknown; Combustible; Fire Resistant
Exterior Siding	Unknown; Combustible; Fire Resistant
Window Panes	Unknown; Single; Multi Pane
Decks or Porches	Unknown; Not Applicable; Masonry; Composite; Wood
Eaves	Unknown; Not Applicable; Enclosed; Un-Enclosed
Vent Screens	Yes (Screened); No (Unscreened)
Year Built	Before or after 2008?

The damage to each structure was rated with one of these five damage categories:

1. Not affected
2. Affected
3. Minor
4. Major
5. Destroyed

Figure 2 shows the percentage of structures inspected at each damage level by structure type. More than 60% of the structures evaluated were destroyed and for single-family homes it could approach 90%.

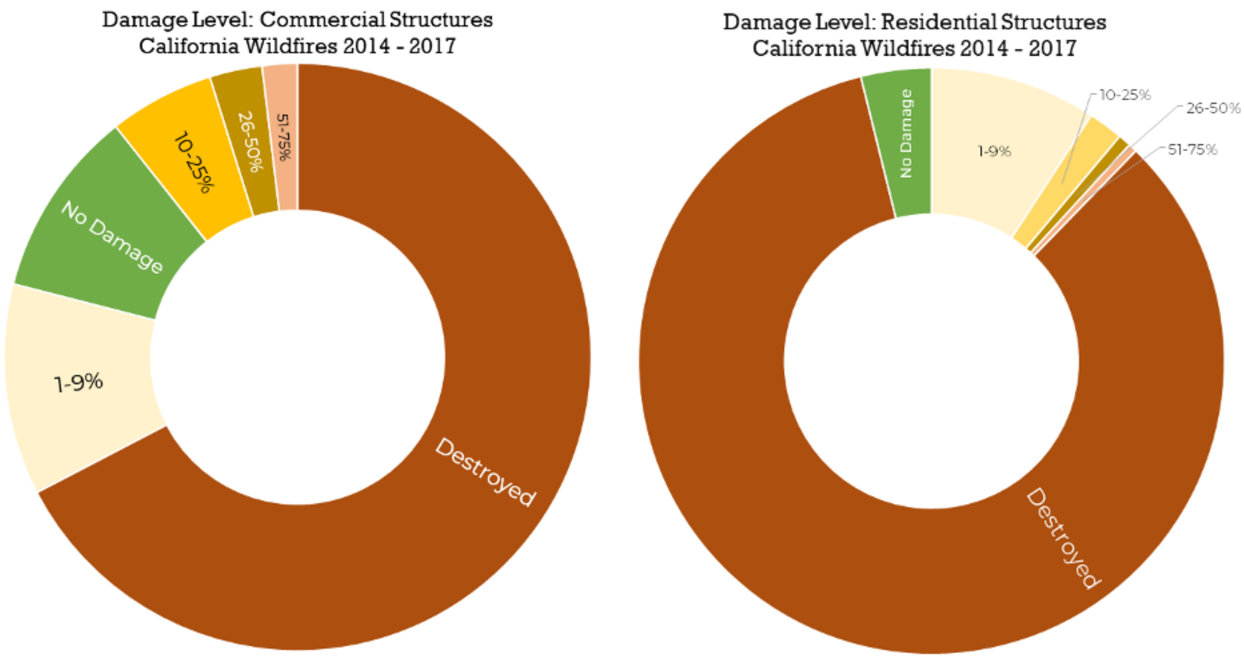

Figure 2. Breakdown of damage categories for (left) residential and (right) commercial structures from California wildfires from 2014-2017.[2]

The dataset was further analyzed using a machine learning technique to determine if a repeatable correlation between unique attributes, including building features, vegetation clearance, local topography, and damage level could be identified. The ability to classify damage level for any individual attribute was small in an absolute sense. The analysis from the 2014–2017 fires does indicate that a building's vulnerability to ignition from a wildfire is not strictly reliant on the performance of a single component. It is a function of the entire building envelope and local surroundings.

[2] *The CAL FIRE DINS dataset was quality and controlled and the "Outbuildings" category of structure was not used in this analysis.*

IBHS compared the relative importance of the top five attributes (vegetative clearance, roof material, combustible or noncombustible siding, vent screens, and topography) in classifying damage levels for the Tubbs, Atlas, and Thomas fires. The results in Figure 3 show that topography and vegetative clearance are leading relative predictors for potential damage level. These two factors determine thermal exposure (radiant heat, direct flame contact, embers) to the structure, and are not building components. It is important to note that for the three fires that were examined in more detail, the order of significance varies from fire to fire. The behavior and intensity of the fire also dictates which combination of attributes matter most.

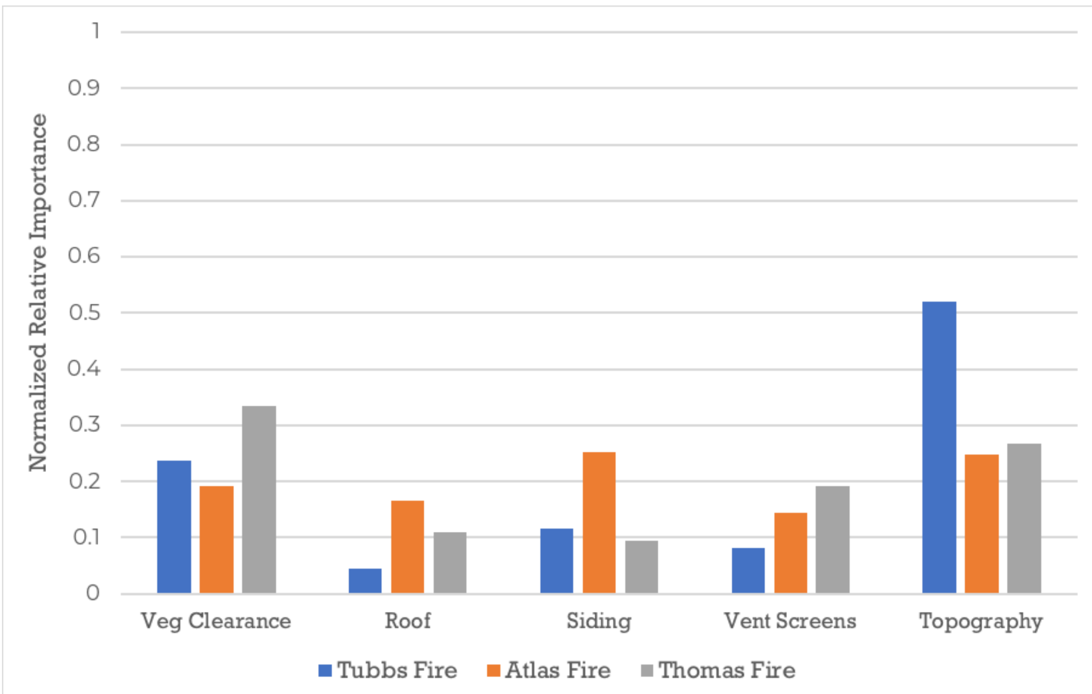

Figure 3: Relative importance of select attributes from CAL FIRE post-event dataset for predicting structure damage level.

Another factor in the survivability of a residential or commercial structure is the proximity to other structures that might ignite. The presence of high winds increases the probability of rapid spread from building to building after fire has spread to a suburban or urban environment. In several neighborhoods, evidence of building-to-building fire spread was observed based on structure separation distances. Fire spread from building to building in communities is a known challenge to addressing resiliency to wildland-urban fire perils. To be efficient with available land, communities can be densely packed with minimal separation between adjacent homes. Examples include Coffey Park and manufactured-home communities in Paradise, California (see Figures 4 and 5 on page 9).

Wildfires are usually accompanied by high winds that increase the potential of direct flame contact between neighboring structures, similar to fire spread through continuous vegetative fuels. Building-to-building spacing is a contributing factor of cascading damage from one burning building to another that needs significantly more attention because there is limited research-based guidance available.

IBHS analyzed measurements taken by the UL Firefighter Safety Research Institute (FSRI) in Dayton, OH, during a series of experiments on full-sized homes in 2019. The testing included free-burn tests under low wind speeds of approximately 2–5 mph, which is significantly lower than a typical wildfire scenario. Results indicated that having less than 10 ft between structures posed a significant risk for building-to-building ignition. Separation distances greater than 50 ft posed little risk. To provide practical guidance on these issues, further research is needed to understand at what spacing intervals less than 50 ft would reduce the risk, and by how much, under typical wildfire wind conditions.

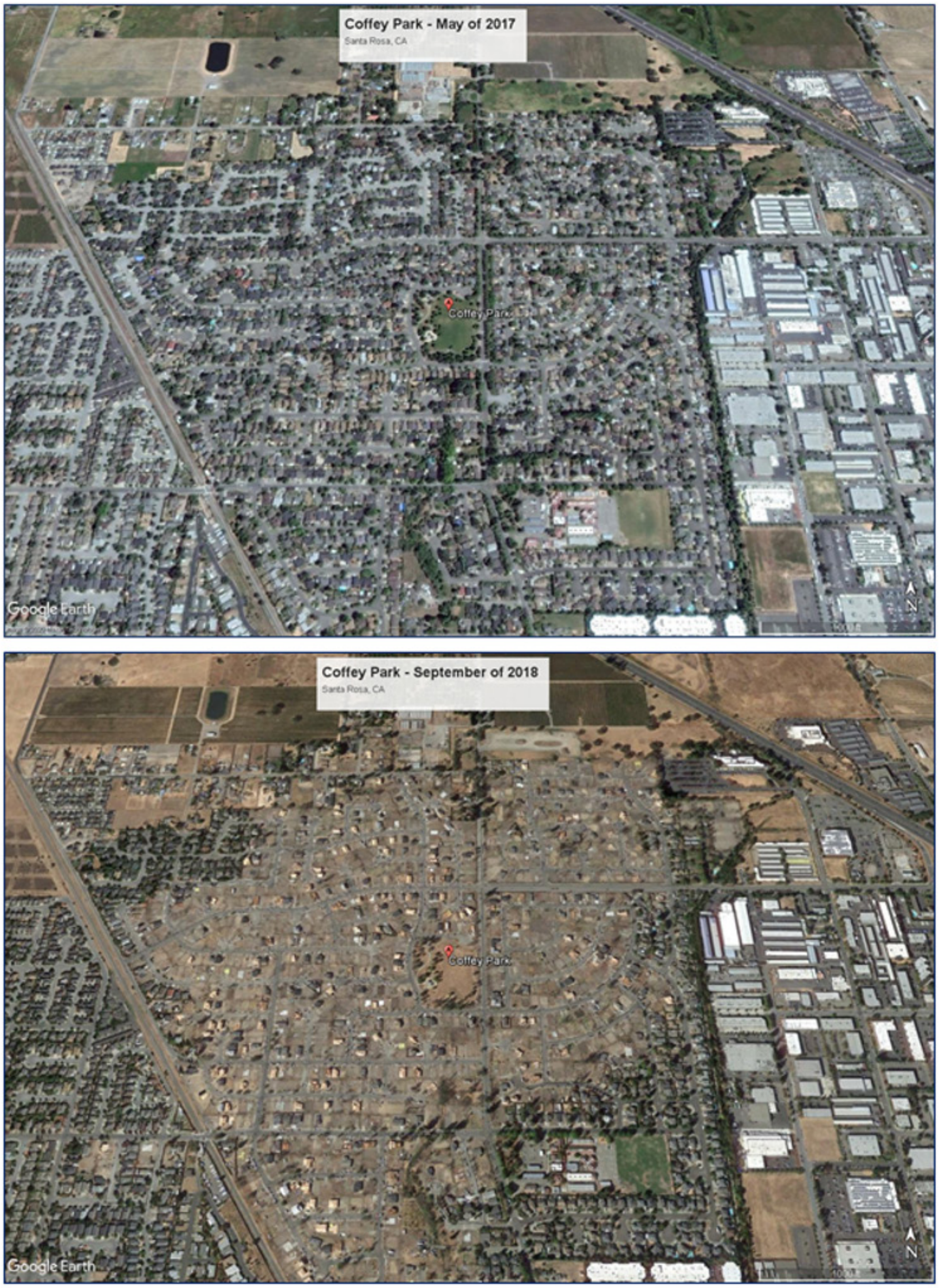

Figure 4: Aerial imagery of the Coffey Park neighborhood in Santa Rosa, California, before the Tubbs fire in May 2017 (top), and after the fire (bottom). The average spacing between adjacent walls of homes was approximately 10 ft. Imagery courtesy of Google Earth.

Figure 5: Aerial imagery of a manufactured-home community in Paradise, California, (top) in May 2018 prior to the Camp Fire, and after the fire (bottom). The average distance between structures was approximately 18 ft. Aerial imagery courtesy of Google Earth.

Following most wildfires, there are often only a few cases with partial building damage. While interior smoke damage has emerged as a loss driver, it is unclear if it is or will become a larger piece of the loss picture. There is a connection between wildland fire behavior, influenced by fuel, weather, and topography, and the severity or intensity of the exposure. As a result, the factors that affect the severity and spread of fires in the wildland regions are also the same factors that affect the severity of the hazard to the built environment. Because it is common for multiple mechanisms to impact a building simultaneously, the focus must be on the ignition-resistance of buildings instead of just resistance to the fire itself.

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