IBHS RESEARCH

THE SCIENCE OF ZONE ZERO

July 2023

Defensible space in Zone 0, the 5-foot area immediately surrounding structures, is among the most significant advances made in wildfire science and our understanding of parcel-level mitigation actions in the past decade. As the place in which the embers, flames, and radiant heat associated with wildfire can reach the home, Zone 0 is a significant vector for home ignitions by wildfire.

Laboratory experiments and post-disaster investigations concerning Zone 0 instruct a simple and effective lesson: **removing combustible material from Zone 0 minimizes pathways for wildfires to ignite homes.**

- *Embers* that land in a combustible-free Zone 0 do not have available material to ignite.
- *Flames* that reach a combustible-free Zone 0 do not have fuels to complete the pathway to the home.
- And a *radiant heat source*, such as a burning shrub or fence, that maintains a distance of at least 5 feet from a home lessens the likelihood of home ignition.

Zone 0 is the most important of the three defensible space zones, and a fully noncombustible Zone 0 is the most effective defensible space mitigation to reduce home ignition from wildfire.

In developing defensible space requirements for Zone 0 within Section 1299 of the California Code of Regulations, Title 14, the Board of Forestry and Fire Protection (Board) has an opportunity to align these requirements to the best available science concerning the interplay of wind, wildfire, and the built environment. Although the current approach under consideration by the Board is somewhat correct, wildfire's dangerous ability to exploit vulnerabilities in Zone 0 demands more than "somewhat correct."

In this paper, we identify an approach to Zone 0 that would further reduce pathways to home ignition and explain how this approach would align the Board's draft Zone 0 regulation with the best available science.

California Board of Forestry Approach

The existing draft of the Zone 0 regulation prohibits the following combustible fuels from Zone 0:

- All dead or dying grass, plants, shrubs, trees, branches, leaves, weeds, and tree needles (§1299.3(a)(1));
- Woodchips, bark, combustible mulch, and synthetic lawn (§1299.3(a)(2));
- Combustible boards, timbers, planting pots, and containers (§1299.3(a)(6));
- Planting pots and containers mounted on the structure or located directly beneath a window (§1299.3(a)(7));
- Combustible gates and fences perpendicular to the structure (§1299.3(a)(8));
- Covered storage outbuildings (unless constructed entirely of masonry or in accordance with Chapter 7A) (§1299.3(a)(9));
- Combustible materials located on top or underneath a deck, balcony, or stairs (§1299.3(a)(10)); and
- Firewood piles (§1299.3(a)(11)).

However, the draft – either explicitly or implicitly – would allow the following combustible material in Zone 0:

- Grass and herbaceous ground cover ((§1299.3(a)(1));
- Plants with non-woody stems, subject to certain height, cultivation, and separation requirements (§1299.3(a)(3));
- Shrubs, bushes, and woody-stemmed plants, if kept in non-combustible containers and subject to height requirements ((§1299.3(a)(4));
- Live tree branches, if 10 feet above the roof and 10 feet away from chimneys and stovepipe outlets (§1299.3(a)(5)); and
- Combustible fences and gates that run parallel to the structure within Zone 0 (§1299.3(a)(8)).

While a perfect solution would be to remove grass and herbaceous ground cover (which can quickly dry out in California's frequent periods of drought) and the removal of tree limbs from the airspace of Zone 0 (to protect it, the roof and gutters from light fuels) – **the most significant concerns with the existing draft concern allowances for combustible materials within Zone 0**.

With **minor textual edits**, the Board's draft **regulation could close the most significant of these vulnerabilities**: vegetation (with and without woody stems) and fences running parallel to structures within Zone 0. These edits are suggested below:

(a) The following standards shall apply to Zone 0:

…

(4) Shrubs, bushes, and woody- and non-woody stemmed plants shall be removed from the ground. Potted vegetation of no greater than 18 inches in height may be kept on porches in small, movable, and noncombustible containers that can be easily moved and stored when necessary.

…

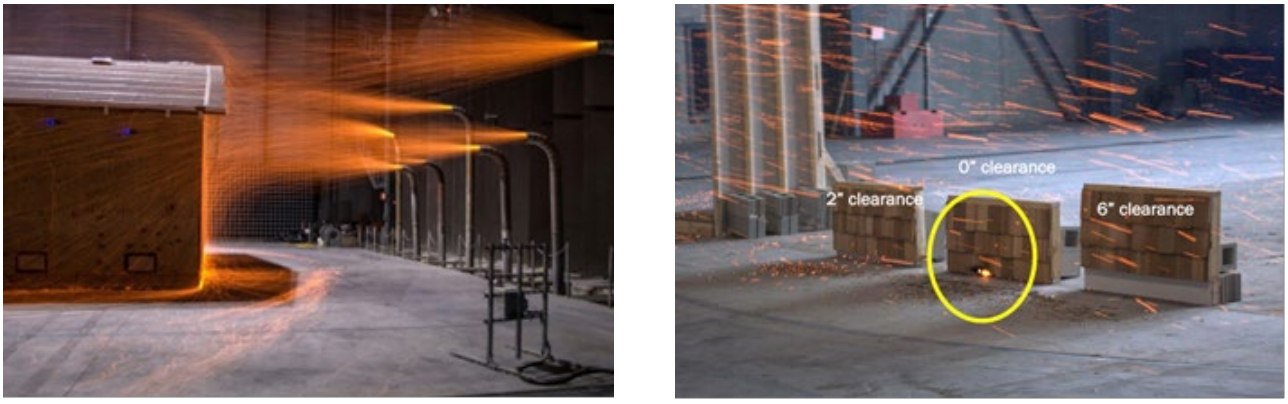
(8) The portions of combustible gates or fences within five feet (5 ft.) of the structure shall be removed or replaced with noncombustible material.

Notably, the amended approach to subsection (a)(3) (which would be deleted in its entirety), (4), and (8) would bring the Board's draft regulation into closer alignment with the Safer from Wildfire framework developed by the California Department of Insurance, the Governor's Office of Emergency Services (Cal OES), the California Department of Forestry and Fire Protection (CAL FIRE), California Public Utilities Commission, and the California Governor's Office of Planning and Research, as well as the California Wildfire Mitigation Program (California's statewide home retrofit and defensible space program), developed by Cal OES and CAL FIRE.

The Importance of Removing Combustibles from Zone 0

Wildfire research has long underscored the importance of fuel treatment and management near buildings (i.e., the creation and maintenance of "defensible space") to minimize the likelihood of flame contact and extended radiant heat exposure to reduce wildfire risk. This research has been undertaken experimentally[1] and in post-event investigations.[2] In particular, vegetation near homes is a substantial vulnerability.[3]

A specialized defensible zone in the 5 feet closest to structures is essential **because ember ignitions of combustible materials near the building create a critical threat from potential small flames**, which shift the dominant heat transfer mechanism from radiation to direct flame contact. Experiments at IBHS's Research Center demonstrate that embers accumulate at the base of buildings and within the first 5 feet during ember storm conditions with realistic wind flows (see Figure 1). Accumulation of embers in the vicinity of obstacles is also reported by others.[4] These findings suggest that combustibles in Zone 0 function as ember collectors and act as a potential ignition source. Thus, clearing this area of all combustible materials—vegetative and nonvegetative—plays an important role in reducing the likelihood of home ignition.



(a) (b)

Figure 1. *Ember accumulation at the base of the wall and causing ignition (a and b) at the IBHS Research Center.*

Analyzing over 2000 structures in San Diego County, Syphard et al. concluded that **structures were more likely to survive a fire with an effective defensible space "immediately adjacent" to them.**[5] Syphard et al. also report that reducing woody vegetation cover up to 40% immediately adjacent to structures and preventing vegetation from overhanging or touching structures were the most effective actions to reduce risk of home

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[1] *Jack D Cohen, "Relating flame radiation to home ignition using modeling and experimental crown fires," Canadian Journal of Forest Research 34, no. 8 (2004); Jack D Cohen, "Preventing disaster: home ignitability in the wildland-urban interface," Journal of Forestry 98, no. 3 (2000).*

[2] *Alexander Maranghides et al., A case study of a community affected by the Witch and Guejito Fires: Report# 2: Evaluating the effects of hazard mitigation actions on structure ignitions, National Institute of Standards and Technology, (National Institute of Standards and Technology, 2013); Xiaoyang Zhang et al., "The footprint of urban climates on vegetation phenology," Geophysical Research Letters 31, no. 12 (2004).*

[3] *Raquel SP Hakes et al., "A review of pathways for building fire spread in the wildland urban interface part II: response of components and systems and mitigation strategies in the United States," Fire Technology 53, no. 2 (2017).*

[4] *Sayaka Suzuki and Samuel L Manzello, "Experimental investigation of firebrand accumulation zones in front of obstacles," Fire Safety Journal 94 (2017).*

[5] *Alexandra D Syphard, Teresa J Brennan, and Jon E Keeley, "The role of defensible space for residential structure protection during wildfires," International Journal of Wildland Fire 23, no. 8 (2014).*

ignition. Using a statistical analysis of data from 27 independent forest fires in New South Wales, Australia, Penman et al. concluded that vegetation touching houses likely caused ignition of the house once the vegetation ignited.[6] Research that explored heat exposure on wall cladding materials concluded that ignition potential is significantly lower from sources outside of Zone 0 as compared to sources within 5 feet.[7] An analysis of aerial imagery and insurance claims data concluded that light vegetation density in Zone 0 lowers the likelihood of destruction. The probability of a total loss was about 2 times lower relative to buildings with high density vegetation in Zone 0, noting "having heavy vegetation, more than 50% coverage, (including brush, trees, and shrubs) immediately around the home can nearly double the chance of destruction."[8]

Post-wildfire investigations support both experimental and computational research in that the elimination of combustible material from Zone 0 is a necessary mitigation action to reduce the risk of home ignitions. The investigation performed after the Grass Valley Fire in 2008 concluded that **home ignitions were caused by embers igniting buildings or creating spot fires in the immediate areas around the building rather than high intensity flames.[9]**

The National Institute of Standards and Technology's post-Camp Fire report likewise concludes that overhanging trees, fences, and other combustible items within Zone 0 provided fuel pathways that led to home ignitions.[10] Additionally, this work provided examples where overhanging trees within the 0–5-foot zone could also ignite the building.

Similarly, the IBHS post-Glass Fire investigation observed vegetation that likely provided a pathway for ignition when plants—even in small amounts—touch the building as shown in Figure 2b. The house in Figure 2b was likely defended by first responders during the event.

(2a)

[6] *Heather Anu Kramer et al., "High wildfire damage in interface communities in California," International Journal of Wildland Fire 28, no. 9 (2019).*

[7] *Hedayati et al., Near-Building Noncombustible Zone; Philip Gibbons et al., "Land management practices associated with house loss in wildfires," PloS one 7, no. 1 (2012).*

[8] *Ellie Arrowsmith, Frederick Dube Fortier, and Anne D. Cope, Wildfire Fuel Management & Risk Mitigation, Zesty.ai (2021).*

[9] *Jack D Cohen and Richard D Stratton, "Home destruction examination: Grass Valley Fire, Lake Arrowhead, California," Tech. Paper R5-TP-026b. Vallejo, CA: US Department of Agriculture, Forest Service, Pacific Southwest Region (Region 5). 26 p. (2008).*

[10] *Alexander Maranghides et al., A Case Study of the Camp Fire–Fire Progression Timeline Appendix C. Community WUI Fire Hazard Evaluation Framework (National Institute of Standards and Technology, 2021).*

(2b)

Figure 2. *Example of vegetation in small amounts located in Zone 0 creating a pathway for fire spread: (a) tree branches overhanging Zone 0 burn during the Camp Fire (2018) in Butte County, California, and provide a pathway for fire to reach a home [Figure 53 in NIST Technical Note 2135 https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.2135.pdf] (used with permission) and (b) ground-level plants during the Glass Fire 2020 in Napa and Sonoma Counties, California. This house was likely defended by first responders during the event.*

The same sequence of events is applicable to non-vegetative fuels adjacent to a structure. As demonstrated in Figure 3, non-vegetative combustibles—including structural fuels, fences, and attached decks in contact with a building or located within Zone 0— provide pathways for home ignitions.[11] Even for homes with noncombustible cladding, **flames from a burning fence can threaten vulnerable components such as eaves and nearby windows.** Installing a noncombustible fence inside Zone 0 breaks the path of fire to a home. These findings have been confirmed in post-event investigations.[12]

(a) *(b)*

[11] *Karina Meerpoel-Pietri, Virginie Tihay-Felicelli, and Paul-Antoine Santoni, "Determination of the critical conditions leading to the ignition of decking slabs by flaming firebrands," Fire Safety Journal 120 (2021); Hakes et al., "A review of pathways for building fire spread in the wildland urban interface part II: response of components and systems and mitigation strategies in the United States."; Faraz Hedayati, Stephen L Quarles, and Christine Standohar-Alfano, "Evaluating Deck Fire Performance—Limitations of the Test Methods Currently Used in California's Building Codes," Fire 5, no. 4 (2022).*

[12] *Insurance Institute for Business & Home Safety, California Wildfires of 2017 and 2018 (2020), https://ibhs.org/wp-content/uploads/member_docs/camp-fire-report_ibhs-1.pdf; Kathryn Butler et al., Wind-Driven Fire Spread to a Structure from Fences and Mulch (National Institute of Standards and Technology, 2022).*

(c)

(d)

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Conclusion

Allowing combustibles in Zone 0 is akin to starting every inning of a baseball game with a runner on third. The pitching team *could* escape without allowing any runs, but the degree of difficulty increases dramatically. Just as a runner on third with no outs can score in a variety of ways, so too can the embers, flames and radiant heat of wildfire ignite a home when combustibles are present in Zone 0.

These are the stakes for the Board's Zone 0 regulation:

- Between 2014 and 2022, wildfires damaged or destroyed 56,918 structures in California.
- 70 percent of those structures are residential.
- More than 90 percent of home ignitions from California wildfires resulted in a total loss for the homeowner.

This translates to approximately 37,000 homes destroyed by California wildfire since 2014. 37,000 families with belongings and homes reduced to ash. More than 100,000 people with lives upended.

In this context, the centrality of Zone 0 to home ignition reduction is paramount and requires the most stringent fuel reduction. While additional research will undoubtedly continue to sharpen our understanding of reducing risk in Zone 0, current knowledge indicates that removing all combustibles from the 5 feet around the home is the most effective way to minimize pathways to home ignition.

In the face of the devastating impact of wildfires on California families, such risk reduction is foundational to strengthening California's resilience to wildfire. **By setting Zone 0 requirements that minimize these pathways, the Board will help protect California homes and families and contribute to the system of mitigation actions necessary to bend down the wildfire risk curve for the state.**