

**Defensible Space in the Eaton Fire: How Landscaping and
Maintenance Affected Home Survivability**

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Introduction

Fires in California have become increasingly damaging and frequent across the wildland-urban interface (WUI) raising urgent questions about how best to safeguard these communities from future fire risk. To do this, extensive research has focused on hardscaping homes to protect from embers and radiant heat. However, less focus has been placed on landscaping and green spaces surrounding houses. This project aims to better understand the role that landscaping played in increasing or decreasing risk to structures in the Eaton Fire—a devastating fire which impacted Altadena, California in January 2025—to inform future policies and recommendations for fire-resilient/fire-resistant landscaping that balance ecological benefits and fire-risk posed by urban vegetation. To do this, I designed and conducted a resident survey asking about maintenance and landscaping practices before the fire as well as expert interviews with fire ecologists, landscape architects, non-profit leaders, and a fire marshal.

This research is situated in an actively changing policy and information landscape. Immediately after the Eaton Fire, the Office of the State Fire Marshal (under the California Department of Forestry and Fire Protection (CalFire)) provided recommendations to be enacted over the next three years (2026-2029) asking residents to extensively limit vegetation¹. These recommendations, which should be published after public comment processes finished on Dec. 8th², initially had little scientific backing and ignored the crucial environmental benefits of vegetation such as shade, habitat for urban fauna, and aesthetics. This policy will be extremely influential. Estimations indicate these policies will cause the loss of up to 18% of tree canopy cover in neighborhoods across LA³. These qualities were crucial to Altadena residents, who in my interviews over the summer, boasted of the mature tree cover that existed before the fire. Now, as homeowners work through the slow process of rebuilding and relandscaping their properties, the risk of future fire and how to avoid the loss felt from the Eaton Fire is a top priority. To help inform the rebuilding and relandscaping process, there are limited scholarship and resources. Additionally, fire behavior is impacted by highly local circumstances such as topography, climate, urban design and more. Thus, this case study research helps fill this information gap with community and expert input and provide targeted and location specific recommendations.

I start by providing a brief background about the Eaton Fire, the focus of my case study, and fire ecology in Southern California. I then review prior research on plant-fire interactions, defensible space and Zone 0, landscape connectivity and fuel location, embers, home-hardening, and community-level planning. Next, I provide an overview of my research design and explain

¹California Board of Forestry and Fire Protection. “Zone Zero Regulatory Advisory Committee Meeting.”

² The release of official Zone 0 policies has been delayed past the original 12/31/25 deadline. This paper is updated as of 1/5/26 to reflect most recent policy updates.

³ California Board of Forestry and Fire Protection. “Zone Zero Regulatory Advisory Committee Meeting.”

relevant and significant findings. Finally, putting my findings into context with prior research, I provide targeted recommendations.

Background:

The Eaton Fire: overview, response, and impact

The Eaton Fire was a highly destructive wildfire that burned in Los Angeles County in January 2025. The fire ignited on January 7 in Eaton Canyon (a popular outdoor recreation area north of Pasadena and northeast of Altadena in Los Angeles County) and spread rapidly for the first 48 hours, during which thousands of structures were burned⁴. The fire spread quickly due to a severe Santa Ana windstorm blowing gusts up to 90 mph⁵. This corresponded to an exceptionally dry and hot year in which significant rainfall did not occur until early winter throughout Southern California⁶. This created dry fuels for wildfire across wildlands and foothills adjacent to communities like Altadena. On January 31, the Eaton Fire was entirely contained—but by then, it had destroyed more than 9,000 structures and killed 19 people, making it the fifth deadliest and second most destructive wildfire in California history. Approximately 200 of these structures were in neighboring Pasadena, the majority were in Altadena⁷.



⁴ Street, *After-Action Review of Alert Notification Systems and Evacuation Policies for the Eaton and Palisades Fires*.

⁵ Street, *After-Action Review of Alert Notification Systems and Evacuation Policies for the Eaton and Palisades Fires*.

⁶ KCRA 3 Weather. (2024, September 10). *NOAA: Summer 2024 was California's hottest on record*. kcra.com.

⁷ Altadena Now. (2025, February 19). *Federal Official Says Eaton Fire Cleanup Will Be Completed by January 8, 2026*. Altadena Now.

Figure 1. Map of Eaton Fire extent displaying reach of fire past Wildlands and Wildland-Urban Interface (WUI) into central and west Altadena. (CalFire Incidents, Eaton Fire).

Altadena lies at the wildland-urban interface (WUI), where housing meets undeveloped vegetation, creating some of the highest fire risks for residents in Southern California. This risk is well documented and publicly available through the CalFire zoning maps which outline high fire-risk zones (fig. 2, 3). These inform insurance policies and brush clearance ordinances throughout California. Coincidentally, updated maps released in March of 2025 included an expanded fire-risk zone throughout California, adding nearly 4 million residents to the Fire-hazard zone⁸. This expansion included part of Altadena. Despite the expanded range of expected wildfire risk in CalFire’s 2025 maps, the Eaton Fire extended far beyond any previous expectations as strong winds pushed the wildfire into the urban core of Altadena. Due to the extent of this fire and its spread largely through structures rather than vegetation, it has been referred to as an urban fire rather than a wildfire⁹.

In responding to this rapidly spreading urban fire, there was uneven and insufficient firefighting response across Altadena. High winds prevented helicopter water drops and flame retardants, a crucial aspect of slowing the spread of wildland fires. Additionally, water supply was constrained by damaged infrastructure and disrupted power supply in damaged areas. In west Altadena, where all 19 deaths caused by the Eaton Fire occurred, evacuation alerts for residents were delayed by several hours¹⁰. This lack of warning and response contributed to the devastation that occurred during the Eaton Fire.

⁸ CalMatters, “New Fire Maps Put Nearly 4 Million Californians in Hazardous Zones. What Does That Mean for the People Who Live There?”

⁹ California Board of Forestry and Fire Protection. “Zone Zero Regulatory Advisory Committee Meeting.”

¹⁰ Street, After-Action Review of Alert Notification Systems and Evacuation Policies for the Eaton and Palisades Fires.

Cal Fire Zoning Map, 2007-2011

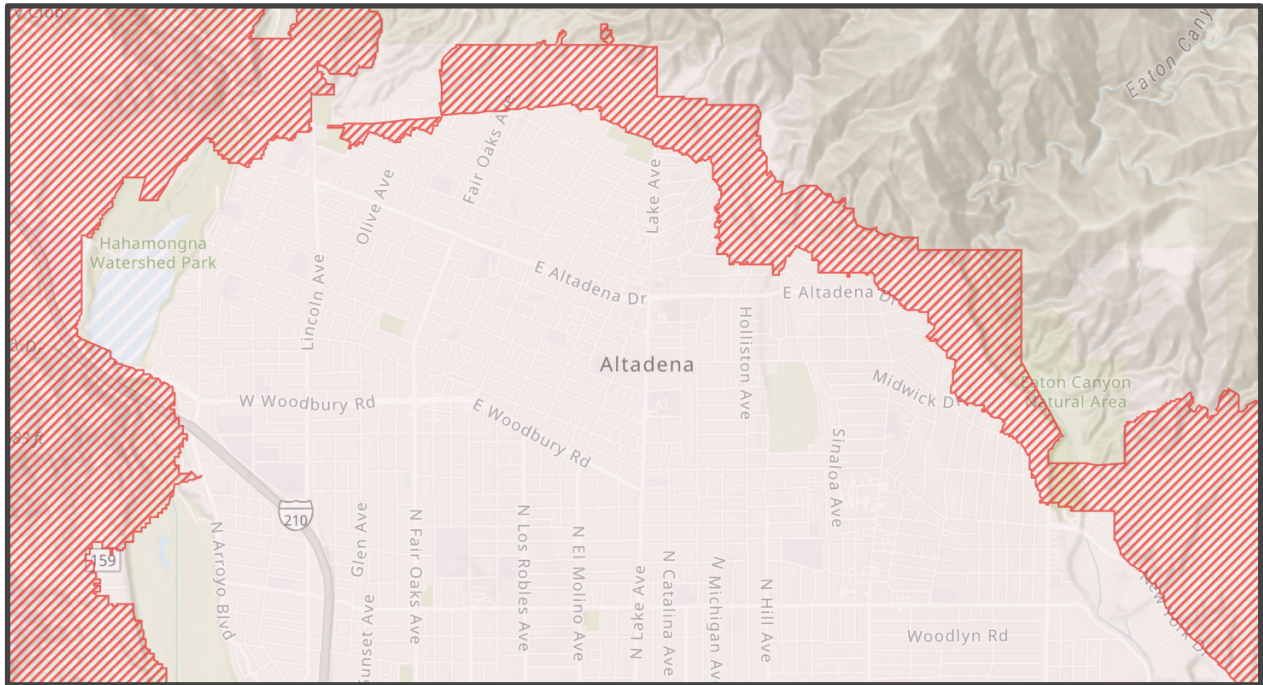


Figure 2. Image of CalFire Fire Hazard Severity Zone (FHSZ) maps 2007-2011. (CalFire, Fire Hazard Severity Zones).

Cal Fire Zoning Map, 2025

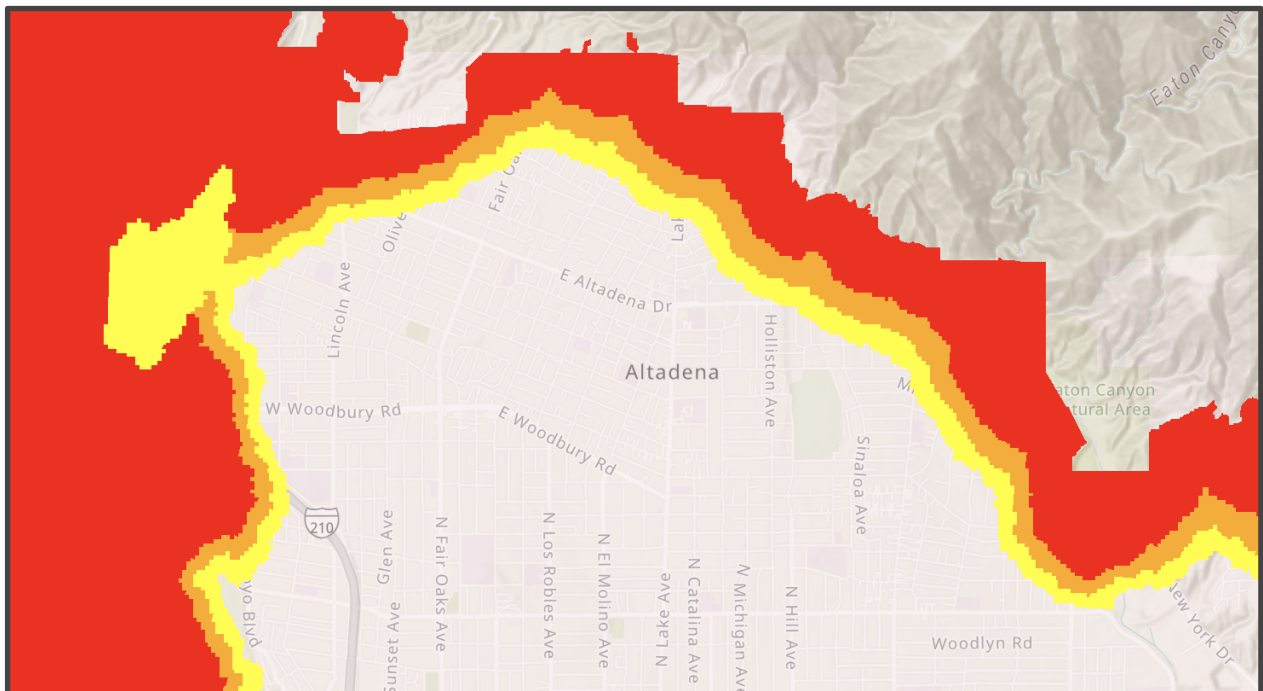


Figure 3. Image of CalFire Fire Hazard Severity Zone (FHSZ) new 2025 recommendation released in March of 2025, immediately following the Eaton and Palisades Fires. Hazard zones were expanded and classified by risk into three tiers, very high (red), high (orange), and moderate (yellow). (CalFire, Fire Hazard Severity Zones).

Fire Ecology in Southern California

While the location and impact of the Eaton fire was unprecedented, wildfires are a fundamental part of ecology in Southern California. To most effectively understand the defensible space in the Eaton Fire it is crucial to contextualize the natural relationship between Southern California and wildfire.

Classified as having a Mediterranean climate¹¹ (wet winters and long dry summers), Southern California is home to vegetation that has adapted to and fuels periodic fire. These cycles are referred to as a fire regime. The fire regime of Southern California supports intense wildfires, often referred to as ‘stand-replacing’ wildfires, indicating that all vegetation present is entirely burned, therefore replacing the ‘stand.’ Over thousands of years, the Chaparral, a major plant community in Southern California, has adapted to the presence of these fire cycles.¹² This plant community is composed of plants that rely on the promotion of seed germination by heat or chemical stimulation from smoke or charred wood, nutrients redistributed into soil from burned material, and cleared landscapes provided by fires.¹³ However, fires in Chaparral ecosystems have historically occurred infrequently, every 30-130 years.¹⁴ This cycle was first influenced by Indigenous burning patterns, which altered landscapes to promote local biodiversity and the abundant regrowth that follows fires.¹⁵ While this process impacted local landscapes, research shows that human-created fire did not significantly alter natural fire patterns until as recently as the past 40 years.^{16;17} This is significant because historic fire regimes have been disrupted by recent human activity,¹⁸ dramatically increasing fire frequency from campfires, discarded cigarette butts, power lines, fireworks, arson, and more. These human caused ignitions account for nearly 85% of wildland fires in the United States¹⁹.

Increased fire frequency presents a challenge to native vegetation, which requires extended time to regrow and reestablish after a fire.²⁰ This high fire frequency leads to decreased native species abundance, called community-type conversion, as invasive grasses and other

¹¹ Keeley, Jon. Postfire Ecology and What Urban Communities Can Learn About Adapting to Fire. Theodore Payne Foundation Fire Lecture Series, 2017, Sun Valley, CA.

¹² “Fire Ecology - Santa Monica Mountains National Recreation Area (U.S. National Park Service).”

¹³ Keeley et al., “Demographic Patterns of Postfire Regeneration in Mediterranean-Climatic Shrublands of California.”

¹⁴ Keeley, Jon. Postfire Ecology and What Urban Communities Can Learn About Adapting to Fire. Theodore Payne Foundation Fire Lecture Series, 2017, Sun Valley, CA. <https://www.youtube.com/watch?v=vbgghBEXp5o>

¹⁵ Kimmerer and Lake, “The Role of Indigenous Burning in Land Management.”

¹⁶ Keeley and Fotheringham, “Historic Fire Regime in Southern California Shrublands.”

¹⁷ “Expert Perspective: Wildland Fuels Management Would Not Have Saved Us from the January 2025 LA Fires | Sustainable LA Grand Challenge.”

¹⁸ Keeley and Fotheringham, “Historic Fire Regime in Southern California Shrublands.”

¹⁹ National Parks Service, “Wildfire Causes and Evaluations (U.S. National Park Service).”

²⁰ Livingston and Varner, “Fuel Moisture Differences in a Mixed Native and Non-Native Grassland.”

weedy species grow faster and outcompete native vegetation, effectively replacing them.²¹ Type conversion is already being seen in many of the hills around Los Angeles as the grass-fire cycle continues to alter the region's native ecosystems. These grasses exhibit much lower live fuel moisture than native shrubs (a comparison of the moisture content within living vegetation), further increasing fire risk.^{22,23}

Altadena's position bordering the steep vegetated slopes of the San Gabriel Mountains, puts the community at extreme fire risk and connects the neighborhood to global fire dialogue focused on these WUI areas. Urban sprawl in Los Angeles and nationally continues to push development into these fire-prone borderlands.^{24,25} Thus, it is crucial to consider the practices on residential properties to mitigate the spread of fire.

Fires often occur in the fall as vegetative growth from moist winters dries over the hot summer months and is then exposed to the Santa Ana winds, which can occur during autumn and winter.²⁶ These strong, southwesterly winds become faster and drier as they funnel down the San Gabriel Mountains²⁷ and pose a significant fire risk to WUI communities. Common misconceptions argue that fuel modification practices like controlled burning are necessary to decrease fire risk.²⁸ While true in forested environments in Northern California, fuel management is not effective in Southern California due to the wind-driven fires that occur there²⁹ and the issue of type conversion.

Another factor shaping the fire ecology of Southern California is climate change. Specifically, climate change has altered and intensified drought patterns in Southern California leading to vegetation that is drier, increasing the risk of burning, and an increased frequency in the dry season co-occurring with the Santa Ana winds.³⁰ These conditions were exemplified by the Eaton Fire as drought conditions overlapped with an extreme Santa Ana wind event.

Wildfire has long shaped Southern California's ecosystems; however, human-driven changes including increased ignition frequency, type conversion, and development in the WUI have disrupted historic fire regimes and increased the presence of fire. Altadena's location at the edge of the San Gabriel Mountains exposes the community to wind-driven, climate-amplified

²¹ Bell et al., *Invasive Plants and Wildfires in Southern California* Southern California.

²² Bell et al., *Invasive Plants and Wildfires in Southern California* Southern California.

²³ Livingston and Varner, "Fuel Moisture Differences in a Mixed Native and Non-Native Grassland."

²⁴ Shafran and Lepore, *Urban Sprawl and the Dangers of Public Provision of Wildfire Suppression*.

²⁵ Halsey, Richard W. *Fire, Chaparral, and survival in Southern California*. San Diego, Calif: Sunbelt Publications, 2008.

²⁶ Livingston and Varner, "Fuel Moisture Differences in a Mixed Native and Non-Native Grassland."

²⁷ "Fire Ecology - Santa Monica Mountains National Recreation Area (U.S. National Park Service)."

²⁸ Keeley and Fotheringham, "Historic Fire Regime in Southern California Shrublands."

²⁹ Abatzoglou and Williams, "Impact of Anthropogenic Climate Change on Wildfire across Western US Forests."

³⁰ Abatzoglou and Williams, "Impact of Anthropogenic Climate Change on Wildfire across Western US Forests."

fire behavior such as the conditions seen in the Eaton Fire. This is crucial to understand as fire modeling indicates that future fires are inevitable, even in the areas that have recently experienced fires.³¹

Conclusion

As WUI communities throughout Southern California consider the risk of future fire, Altadena provides an alarming example of the potential devastation. Despite mapping efforts to predict fire risk, the spread of the Eaton Fire into the urban core of Altadena surpassed all prior expectations. Interventions by fire-fighters were not sufficient to slow the rapid spread and delayed evacuation orders put lives at risk. Centuries of vegetated fire adaptation show us that the conditions that created the Eaton fire will occur again. Therefore, we must look to our communities to see how we can decrease our vulnerability to future fire.

³¹ Alexandre et al., “The Relative Impacts of Vegetation, Topography and Spatial Arrangement on Building Loss to Wildfires in Case Studies of California and Colorado.”

Prior Research

The Eaton Fire calls for intensified scrutiny to analyze how landscaping practices influenced structural outcomes in a dense Wildlife-Urban Interface (WUI) community. Understanding the flammability of urban vegetation and its role in structure damage during the Eaton Fire reveals crucial lessons for communities at risk of future fires. This review of prior research places my analysis of the Eaton Fire into a context of existing research on fire ecology, plant flammability traits, defensible space, and the WUI as a high fire-risk location.

Plant-fire Interactions

Before focusing on vegetation at the property-level or community level, it is important to understand how plants interact with fire at the individual level as this influences wildfire risk in WUI settings like Altadena. This section focuses on plant traits and conditions best suited to limiting fire risk rather than specific species. For more information on specific species see resources referenced in the recommendations section.

At the individual plant level, there are a variety of traits which influence plant–fire interactions. These traits include plant moisture content, volatile compounds in leaves and bark, arrangement and density of plant growth, and many more. Globally, several plant communities are adapted to unique fire regimes and within each community are varying strategies to survive fires. For example, Coast Live Oak, a dominant species in Southern California tree canopies (including that of Altadena), has thick bark and robust waxy leaves that hold in moisture and limit the likelihood of ignition. Another example—also common throughout Southern California—is Eucalyptus, which has oily leaves and loose-papery bark that easily ignite.

Halsey³² developed some key criteria for developing a fire-safe plant list focused on the ease of maintenance. He explains that the plant should:

- Have easily distinguished dead vs. living material
- Require only minimal bending over or ladder work to maintain
- Have an open, accessible growth habit to allow easy pruning without damaging the plant
- Have a slow to moderate growth pattern to minimize the frequency of maintenance
- Have a robust root system to help prevent erosion
- Be long lived

³² Halsey, Richard W. *Fire, Chaparral, and survival in Southern California*.

More specifically, recent work has emphasized the importance of species-specific traits in fire behavior. Tumino et al.,³³ studying Eucalyptus Forest systems, finds that volatile compounds, leaf morphology (shape/form), and moisture content strongly predicted fire potential. These findings resonate with the work of Fauss et al.,³⁴ which shows significant relationships between plant traits (particularly hydration and branch, leaf morphology) and flammability. Building on Fauss' note on hydration, literature consistently highlights plant moisture as one of the most important variables in determining plant-fire interaction. Live plants with high moisture are less flammable, while dry or drought-stressed vegetation ignites more readily.

When translating these traits to our urban environments, Fauss et al.³⁵ recommends “[selecting] landscaping plants that will remain at a higher hydration during drought, and then, to maintain plants in a healthy and hydrated condition, removing dry, combustible material within defensible space.” Ondei et al.³⁶ and Gibbons et al.³⁷ confirms this emphasis on hydration, as they identify vegetation watering status and "vegetation greenness" respectively as important variables in determining fire hazard. These studies show that plant-level physiology and maintenance practices directly impact landscape-level fire risk.

Defensible Space and “Zone 0”

Beyond these individual traits, the way plants are arranged at the landscape level determines how fire travels and thus directly affects structural vulnerability in fire-prone areas. The importance of this defensible space around structures is highlighted throughout the literature and emphasized by dominant landscaping recommendations and policies; however, it is also highly contested. While many papers find that the space directly next to a house is the most significant vegetation-related factor influencing fire risk, others point to the connectivity and location of fuels, and others find maintenance to be the most important. The following sections unpack each line of thinking.

The specific location of fuels relative to structures is a theme that has emerged in the literature on fire risk and has defined the soon-to-be implemented CalFire landscaping policies. This policy, as mentioned earlier, intends to limit fuels (anything flammable, including vegetation, wooden or plastic materials, mulches, dried needles or leaf litter) adjacent to structures. While not officially released, these policies will impact millions of Californians and

³³ Tumino et al., “Plant Traits Linked to Field-Scale Flammability Metrics in Prescribed Burns in Eucalyptus Forest.”

³⁴ Fauss et al., “Landscaping Defensible Space.”

³⁵ Fauss et al., “Landscaping Defensible Space.”

³⁶ Ondei et al., “An Expert System to Quantify Wildfire Hazards in Gardens and Create Effective Defensible Space.”

³⁷ Gibbons et al., “Options for Reducing House-Losses during Wildfires without Clearing Trees and Shrubs.”

dominate public perception on defensible space. These will likely become additional requirements for homeowners hoping to get home insurance.

As Figure 4 shows, CalFire’s recommendation describes 3 zones, which encircle all structures. Zone 0 requires that 0–5 feet from all structures are ember-resistant (free of flammable vegetation to prevent ember ignitions). Zone 1, spanning 5–30 feet from structures, requires reduced continuity of fuels (including vegetation and hardscaping) through plant spacing and pruning. And Zone 2, from 30–100 feet, requires thinning and removing dead vegetation to slow fire spread (CalFire, 2025). This is a significant policy because most homes do not comply with it. As Ondeï et al.³⁸ found in WUI communities in Tasmania who face frequency risk of fire, “a majority of gardens had a high or very high hazard score in the zone closest to the house” (or Zone 0), where shrubs near windows and flammable groundcovers in contact with woody plants created dangerous connectivity between fuels, particularly the vertical transfer of through “ladder fuels” (see figure 5).

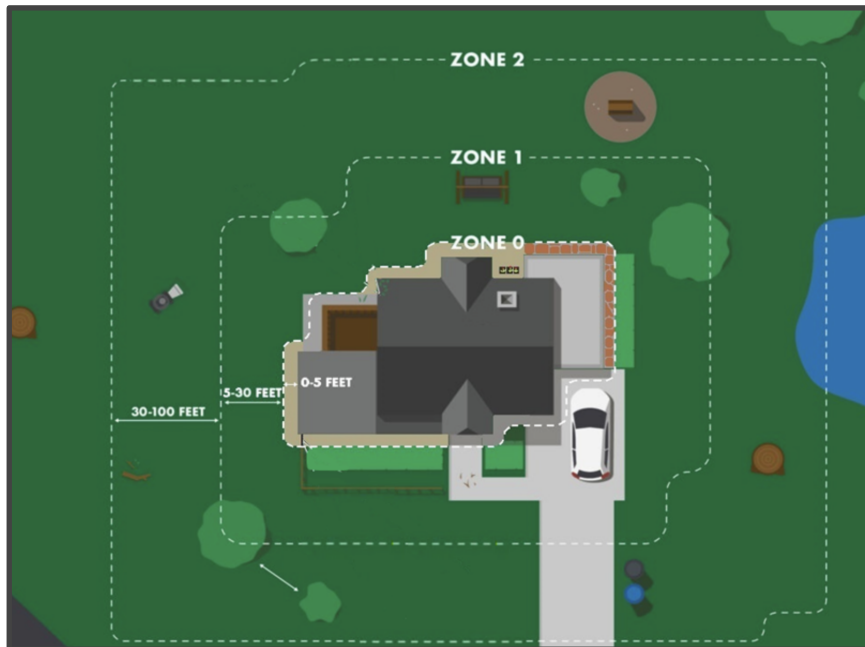


Figure 4. Graphic of Zone 0, 1, and 2, surrounding a structure. Zone 0 shows an ember resistant 0-5 feet barrier around the Structure. Zone 1 shows a “lean, clean, and green” 5-30 feet barrier around the structure. Finally, zone 2 shows a buffer from moving fire between 30-100 feet around the structure. (California Department of Forestry and Fire Protection (CalFire), Defensible Space Zones 0, 1, and 2.

Despite these recommendations applying to communities throughout California there is limited scholarly evidence in support of Zone 0 particularly for the wind-driven fires seen in Southern California. For example, Escobedo et al.³⁹ highlights that conditions in Zone 0 outweigh other potential risk factors further away. But this was based on research conducted

³⁸ Ondeï et al., “An Expert System to Quantify Wildfire Hazards in Gardens and Create Effective Defensible Space.”

³⁹ Escobedo et al., “Exploring Urban Vegetation Type and Defensible Space’s Role in Building Loss during Wildfire-Driven Events in California.”

after the Paradise fire in Northern California Fir forests which have entirely different fire regimes. Similarly, Zamanialaei et al.⁴⁰ found similar results when analyzing five fires that occurred between 2017 and 2020, yet four of these were in northern California.

The risk posed in “Zone 0” is complicated as Escobedo et al.⁴¹ notes that “properly selected, irrigated, located, and maintained urban vegetation is not always complicit in building loss during fire events.” This raises the question: Can vegetation near homes provide ecological benefits without significantly impacting risk if managed appropriately?

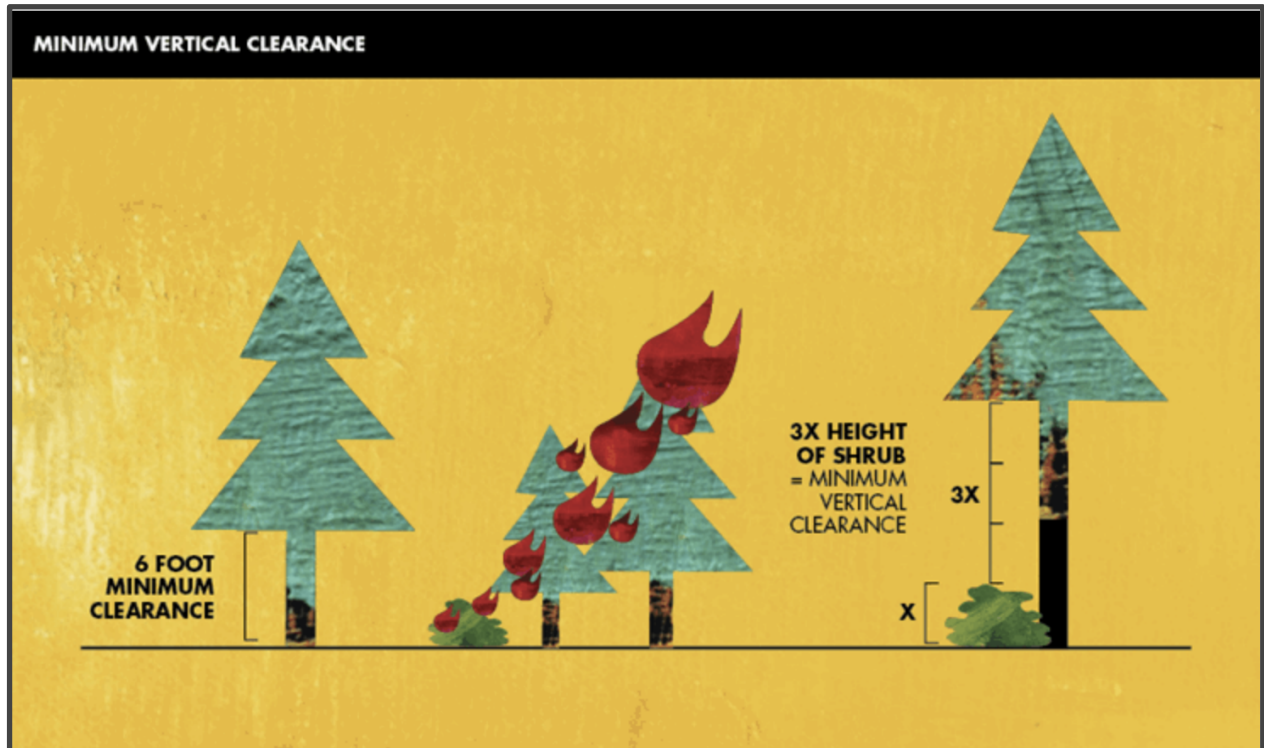


Figure 5. Image showing recommended vertical clearance to prevent connectivity of fuels. The center trees which are on fire show the impact of ladder fuels on fire spread. (CalFire, Defensible Space, Vertical Spacing).

The role of vegetation management in mitigating fire risk to structures is crucial. Both Fauss et al.⁴² and Ondeï et al.⁴³ highlights the importance of pruning vegetation. Ondeï et al.⁴⁴ analyzed 32 gardens in a WUI community in Tasmania and developed a system to quantify each garden’s wildfire hazard by assessing plant placement, biomass, and maintenance, as well as other fuels and overall vegetated surface cover. Their work demonstrated that defensible space is

⁴⁰ Zamanialaei et al., “Fire Risk to Structures in California’s Wildland-Urban Interface.”

⁴¹ Escobedo et al., “Exploring Urban Vegetation Type and Defensible Space’s Role in Building Loss during Wildfire-Driven Events in California.”

⁴² Fauss et al., “Landscaping Defensible Space.”

⁴³ Ondeï et al., “An Expert System to Quantify Wildfire Hazards in Gardens and Create Effective Defensible Space.”

⁴⁴ Ondeï et al., “An Expert System to Quantify Wildfire Hazards in Gardens and Create Effective Defensible Space.”

not only a function of species selection but of irrigation, arrangement, and pruning practices. Similarly, Fauss et al.⁴⁵ conducts controlled plant flammability testing to inform recommendations for landscaping in high fire-risk communities. Their findings indicate that even “fire-resistant” species can become hazardous if poorly maintained or planted close to structures. These papers reinforce that the effectiveness of defensible space—especially within Zone 0—depends on plant type, careful placement, irrigation, and long-term maintenance.

Importantly, vegetation removal is not always necessary to minimize structure loss. Gibbons et al.⁴⁶ demonstrated that homes can be protected through targeted fuel modification and spatial planning without the wholesale clearing of trees and shrubs. Their findings reinforce that maintenance, separation from structures, and selection of lower-flammability species often matter more than vegetation quantity alone.

Landscape Connectivity and Fuel Location

While Zone 0 focuses on the immediate area surrounding structures (0-5 feet), the area further away from structures is also an important aspect of defensible space. Particularly between 5-100 feet away from structures (Zones 1 and 2), connectivity, height, and arrangement of fuels can determine how fire travels across individual properties and neighborhoods.

Ondei et al.⁴⁷ observes that “connected vegetation facilitates fire spread,” especially when shrubs or groundcovers connect vertical fuel ladders that could carry flames into the structure itself. Alexandre et al.⁴⁸ supports this claim, finding that the amount and connectivity of vegetation play a larger role in risk to structures rather than type of vegetation.⁴⁹ These arguments point to fire risk as determined more by arrangement, rather than the individual plant traits discussed earlier. Gibbons et al.⁵⁰ explain that discrete patches of vegetation pose less risk to structures because “[a]s fuels become less continuous, the heat transfer between burning fuel and adjacent fuel becomes less efficient and the intensity and spread of a fire will decline.”

The risk posed by fuel arrangement is also impacted by wind-spread fires (like the Santa Ana-driven Eaton Fire). Gibbons et al.⁵¹ find that “trees and shrubs represented greatest risk when they occurred in the upwind direction from which the wildfire arrived, except where this

⁴⁵ Fauss et al., “Landscaping Defensible Space.”

⁴⁶ Gibbons et al., “Options for Reducing House-Losses during Wildfires without Clearing Trees and Shrubs.”

⁴⁷ Ondei et al., “An Expert System to Quantify Wildfire Hazards in Gardens and Create Effective Defensible Space.”

⁴⁸ Alexandre et al., “The Relative Impacts of Vegetation, Topography and Spatial Arrangement on Building Loss to Wildfires in Case Studies of California and Colorado.”

⁴⁹ Alexandre et al., “The Relative Impacts of Vegetation, Topography and Spatial Arrangement on Building Loss to Wildfires in Case Studies of California and Colorado.”

⁵⁰ Gibbons et al., “Options for Reducing House-Losses during Wildfires without Clearing Trees and Shrubs.”

⁵¹ Gibbons et al., “Options for Reducing House-Losses during Wildfires without Clearing Trees and Shrubs.”

vegetation was very close to houses.” Alexandre et al.⁵², comparing case studies across California and Colorado, similarly concluded that wind exposure amplifies the effects of vegetation and its arrangement on structure vulnerability. This research shows that defensible space is shaped both by what plants are present, and how vegetation is arranged, connected, and positioned relative to wind.

Embers

In considering the role of wind in the WUI wildfires, it is crucial to understand the transfer of embers. Embers play a significant role in the movement of fire through WUI communities. In fact, substantial historical, case-study, and modeling research shows that wind-blown embers or firebrands are the predominant mechanism of ignitions and fire spread in WUI conflagrations. A case study analyzing the 2007 Witch Creek Fire in San Diego County concluded that “wind-blown embers, which can travel one mile or more, were the biggest threat to homes... There were few, if any, reports of homes burned because of direct contact with flames.”⁵³ Historical analysis reinforces this finding. Koo et al. found that seven major wind-driven urban fires indicated spot ignitions (ignitions past the fire line which are created by traveling embers or firebrands) as the dominant mechanism for fire spread⁵⁴. This counters claims that label radiant heat as the cause for fire spread in conflagration events. As Koo et al. acknowledges that while some dense urban environments can support radiative (heat or direct fire contact) roof-to-roof ignition; “firebrands have been observed as the main cause of the roof-to-roof fire spread in many fires with high wind conditions.”⁵⁵ Altadena, in the path of fierce Santa Ana winds, is a perfect example of this.

Several months after the Eaton Fire, the official report published by the county of Los Angeles indicated this kind of spotting behavior: “[t]he winds created flames up to 200 feet long horizontally and sent embers flying up to two miles away, where they started spot fires.”⁵⁶ The fire’s rapid escalation was so driven by embers that crews described facing a fire that appeared to spread “everywhere all at once rather than a single line of fire moving in one direction.”⁵⁷ With such intense wind patterns this prevalence of spot fires is not surprising, as countless papers

⁵² Alexandre et al., “The Relative Impacts of Vegetation, Topography and Spatial Arrangement on Building Loss to Wildfires in Case Studies of California and Colorado.”

⁵³ Institute for Business and Home Safety. “MEGA FIRES: The Case for Mitigation”

⁵⁴ Koo et al., “Firebrands and Spotting Ignition in Large-Scale Fires.”

⁵⁵ Koo et al., “Firebrands and Spotting Ignition in Large-Scale Fires.”

⁵⁶ Street, *After-Action Review of Alert Notification Systems and Evacuation Policies for the Eaton and Palisades Fires*.

⁵⁷ Street, *After-Action Review of Alert Notification Systems and Evacuation Policies for the Eaton and Palisades Fires*.

argue that increased fire intensity and flame length correlates to further spread of embers and increase in size of traveling embers.^{58,59}

Recent simulations modeling fire and atmospheric patterns⁶⁰ show that firelines interacting with discontinuities in fuels (including fuel breaks like vegetation free Zone 0) can generate increased ember production. As Pimont et al. (2009)⁶¹ note, when a fire reaches a fuel break, decreased drag increases entrainment flows which then “loft more [embers].”⁶² Entrainment flows are fluid dynamics phenomena in which a fast-moving flow of fluids or, in this case, air pulls stagnant or slower moving particles along the way. In the case of a fire this would pull embers from other fuels and loft them into faster moving gusts. A situation which occurs more frequently when drag is decreased and flows are uninterrupted. Essentially, the disturbed flow of wind by trees or other vegetation decreases the lofting of embers and the speed of wind. This finding is essential to understanding the costs of creating cleared defensible spaces, as it indicates that the removal of vegetation may lead to increased ember generation and transport. Which in the case of extreme wind-driven fires are found to be the leading cause of fire spread. Together, these modeling insights and real-world case studies illustrate that ember generation, transport, and deposition are central drivers of structure loss and large-scale fire propagation in both WUI and urban settings. Additionally, the removal of vegetation to create targeted fuel breaks may aid the generation and spread of further embers.

Home Hardening

Determining fire-risk in the Wildland-Urban Interface (WUI) is complex. While this section has focused on the role of vegetation in determining risk, aspects of the built environment, including home-hardening, density, and structure configuration, outweigh vegetation in predicting fire loss. In some ways, this is made clear by the immense impact of embers on wind-driven fires. Open vents, awnings, exposed crawl space, and many other structural aspects can allow embers to enter homes and begin spot fires. Beyond just home hardening, Alexandre et al.⁶³ found that topography and the spatial arrangement of buildings, particularly high-density and close proximity, were stronger predictors of building loss than vegetation type or amount. In addition, the focus of Moritz et al.⁶⁴ on different urban design patterns and their impact on flammability within the WUI reveals that dense developments make communal or fuel breaks easier to maintain and allow firefighters to work more effectively. However, this benefit likely does not outweigh the increased risk of home-to-home fire spread in

⁵⁸ Koo et al., “Firebrands and Spotting Ignition in Large-Scale Fires.”

⁵⁹ Koo et al., “Modelling Firebrand Transport in Wildfires Using HIGRAD/FIRETEC.”

⁶⁰ Koo et al., “Modelling Firebrand Transport in Wildfires Using HIGRAD/FIRETEC.”

⁶¹ Pimont, François, Jean-Luc Dupuy, Yves Caraglio, and Dominique Morvan. "Effect of vegetation heterogeneity on radiative transfer in forest fires." *International journal of wildland fire* 18, no. 5 (2009): 536-553.

⁶² Koo et al., “Modelling Firebrand Transport in Wildfires Using HIGRAD/FIRETEC.”

⁶³ Alexandre et al., “Factors Related to Building Loss Due to Wildfires in the Conterminous United States.”

⁶⁴ Moritz et al., “Elevating Survivability as the Goal of Community Wildfire Risk Reduction.”

a high-density development.⁶⁵ Halsey⁶⁶ describes alternatives in WUI communities in Australia where neighborhoods are built in "clusters surrounded by circular roadways that act as a protective buffer against wildfire." While the distance between structures is often the most important factor in determining house-to-house spread, it is also the least modifiable factor. As Alexandre highlights, these factors "cannot be changed after buildings are in place."

Halsey⁶⁷ also explores another method used in Australian WUI communities; explaining that "homes are designed to provide "shelter in place." whereby able-bodied homeowners are not evacuated. Instead, they remain home to help defend the structures." This system of fire response, "prepare: go early or stay and defend," puts more responsibility on homeowners but requires planning, education, and training⁶⁸. This was implemented with marginal success in Rancho Santa Fe, California by the local fire district to mitigate the confusion and inefficiencies of evacuations; however, little emphasis was placed on homeowners actively defending their structures from incoming fire⁶⁹.

Returning to Zamanialaei et al.⁷⁰ allows us to see that community-wide application of structure hardening and removal of fuels adjacent in the Zone 0 can substantially reduce the overall number of destroyed homes⁷¹. But there are more than property level changes or fundamentally altering urban planning that can be done to decrease risk for community-wide impact as explored below.

Community Planning: Fuel Breaks and Firefighting

High fire-risk areas and communities have developed effective community responses to address vulnerability. Some WUI communities have created Fire Safe Councils, which collectively manage WUI areas to decrease risk. In other cases, highly managed fuel breaks have been used to stratify wildlands from urban areas.

This kind of community planning is highlighted by Moritz et al.,⁷² who developed a "Regional Wildfire Mitigation Program" (RWMP), which reframes wildfire risk management to include vegetation, landscape buffers, the built environment, and community engagement. Implemented in Santa Barbara County Fire Safety Council, this model demonstrates how mitigation depends on integrating defensible space practices within a broader, regional framework that includes education, preparedness, and collaboration.⁷³ This council offers free

⁶⁵ Moritz et al., "Elevating Survivability as the Goal of Community Wildfire Risk Reduction."

⁶⁶ Halsey, Richard W. *Fire, Chaparral, and survival in Southern California*.

⁶⁷ Halsey, Richard W. *Fire, Chaparral, and survival in Southern California*.

⁶⁸ Mutch et al., "Protecting Lives and Property in the Wildland-Urban Interface."

⁶⁹ Mutch et al., "Protecting Lives and Property in the Wildland-Urban Interface."

⁷⁰ Zamanialaei et al., "Fire Risk to Structures in California's Wildland-Urban Interface."

⁷¹ Zamanialaei et al., "Fire Risk to Structures in California's Wildland-Urban Interface."

⁷² Moritz et al., "Beyond a Focus on Fuel Reduction in the WUI."

⁷³ Moritz et al., "Beyond a Focus on Fuel Reduction in the WUI."

defensible space assistance, home evaluations, community chipping events to clear vegetation, and more. Ultimately this council has established the maintenance and education for a community wide fuel break which aims to help protect those living in the WUI.

While the impact of Santa Barbara’s council cannot yet be quantified, a similar assessment of a fuel break in the Los Padres National Forest provides an interesting layer of analysis. Syphard et al.⁷⁴ found that fuel break treatments stopped fires 46% of the time—almost always because of active fire suppression rather than the fuel break alone. This analysis shows that the combined effort of active firefighting and the presence of a fuel break stopped nearly half of fires. Syphard et al. concludes that vegetation structure and accessibility determine whether suppression crews can reach a break in time to stop a fire.⁷⁵ This can teach communities like Santa Barbara who are actively working to defend their community with a fuel break that factors like firefighter access, fire size, and maintenance of a fuel break matters. These findings underscore that fuel treatments and defensible space are necessary but insufficient; they must be coupled with strategic placement, long-term maintenance, and fire-fighter capacity to respond effectively. Successful fire mitigation in the WUI requires moving beyond parcel-level fuel treatments toward regionally coordinated and informed landscape strategies.

A Summary of Prior Research

Prior research largely shows that wildfire risk in the WUI emerges from the ecological processes, vegetation management, and the built environment. Southern California’s fire regime intensified by climate change, increased ignitions, and type conversion creates landscapes primed for fast-moving, wind-driven fires like the 2025 Eaton Fire. At the plant level, species-specific traits such as moisture content, volatile oils, and growth form significantly influence ignition potential. These traits become meaningful predictors of structure loss when combined with maintenance, arrangement, and proximity to homes. While defensible space policies emphasize Zone 0, research shows vegetation connectivity, spacing, and wind alignment across properties and neighborhoods may be equally or more important, particularly during wind driven events.

The literature also highlights that in wind-driven conflagrations, embers rather than direct flame contact or radiant heat are the predominant cause of structure ignition. This challenged traditional ideas of fuel clearance. Spot fires created by flying embers during the Eaton Fire ignited structures up to two miles from the flame. This highlights vulnerabilities in home construction and neighborhood-level layout as important to address.

⁷⁴ Syphard et al., “Factors Affecting Fuel Break Effectiveness in the Control of Large Fires on the Los Padres National Forest, California.”

⁷⁵ Syphard et al., “Factors Affecting Fuel Break Effectiveness in the Control of Large Fires on the Los Padres National Forest, California.”

WUI fire resilience requires coordination beyond the property level. Community-scale interventions like fire safe councils and fuel breaks. Ultimately, reducing fire risk in places like Altadena depends on addressing vegetation characteristics, ember exposure pathways, structural vulnerabilities, and community-wide collaboration. This overview of relevant literature provides the foundation for analyzing how these factors manifested during the 2025 Eaton Fire and how landscaping practices influenced structure survival and loss. This case study aims to fill crucial information gaps in the impacts of residential vegetation in determining structure outcome for wind-driven fires and to provide localized analysis of the Eaton Fire. This is particularly important as fire behavior is highly idiosyncratic and impacted by a multitude of regional factors; therefore, specified research is required to provide individual communities information to reduce the risk of future fire.

Research Design

This research employs a mixed-methods approach, combining qualitative and quantitative data and analysis to investigate landscaping practices and fire impacts on residential properties in Altadena, California in the context of the 2025 Eaton Fire. More specifically, I designed and distributed a survey to residents whose properties were in or near the affected area of the fire. This data was supplemented and contextualized by 7 semi-structured interviews with fire/landscaping experts (including landscape architects, fire ecologist, a local fire marshal, and local non-profit leaders). The interviews and surveys provide a holistic picture of how landscaping influenced structure fire-risk during the Eaton Fire by combining detailed property-level analysis with broader community patterns. This information helps to inform future best landscaping and maintenance practices for residents and highlight the accuracies and inaccuracies in regional fire landscaping policies as discussed further in the results and recommendations section.

Resident Survey

I designed a 15- to 20-minute survey for Altadena residents using the Qualtrics online software. The survey asked questions about property location, impacts on the property from the fire, maintenance and watering practices throughout the year (pre-fire), if defensible space was maintained, and resources used to maintain defensible space. Most questions were multiple-choice, of which many allowed respondents to select multiple answers, with some short-answer (open-ended) questions at the end. I distributed the survey online and in-person through existing community connections, cold-contacting, and flyer distribution. More specifically, the survey was included on four organizational mailing lists (two of which were through pre-existing personal connections), three online posts, flyers were posted in thirty-five Altadena businesses/churches/community centers/libraries, countless direct messages with local organizations and businesses, and at one in-person tabling event. One of the four mailing lists was a network of residents who participated in a summer research project, which preceded this project. These residents were asked to circulate the survey among neighbors and any online forum, chat, Facebook group, or neighborhood group which they may be a part of. Survey respondents were eligible for one of two \$100 raffle prizes for completing the survey. The survey was open from October 20th to November 25th. In the end, I had 32 survey participants. Of these responses 67% indicated that the structures on their property completely burned in the fire. From the remaining responses of residents whose homes did not completely burn in the fire most indicated that a neighboring property burned (see fig. 6). This indicates that the data collected thoroughly represents the affected area of the Eaton Fire.

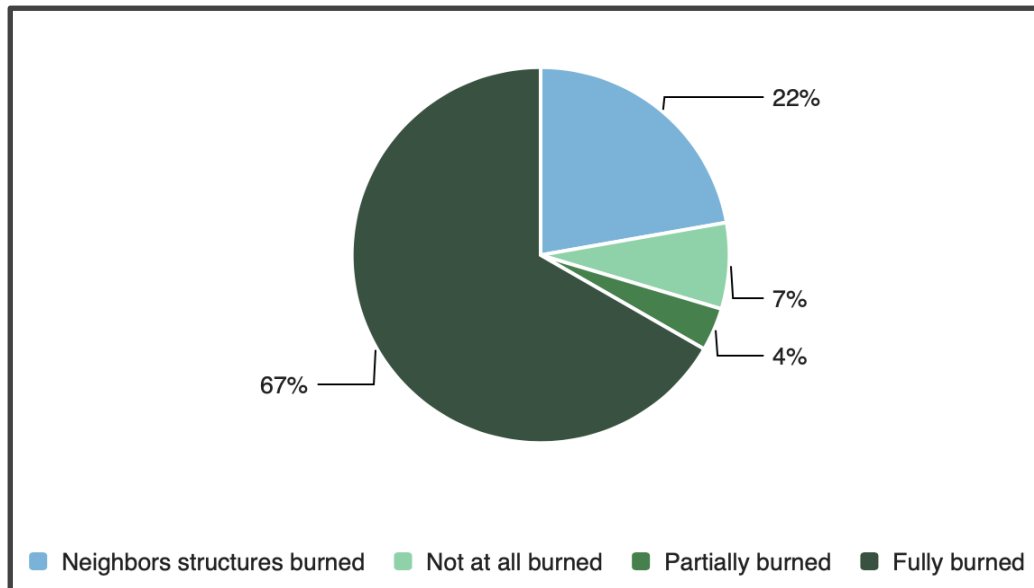


Figure 6. Pie graph showing structure outcome for survey participants. 67% fully burned, 22% not burned but neighbors' structures burned, 7% not burned, and 4% partially burned

Semi-Structured Interviews with Experts

I conducted seven interviews with fire/landscaping experts. All interviews were semi-structured and lasted between 45 minutes and one hour. I asked each interviewee general questions related to fire, defensible space, and the Eaton Fire as well as specialized questions based on their given expertise/field. The experts included one landscape designer and educator, two landscape architects, two local environmental non-profit directors, a fire ecologist, a Fire Chief, and a retired fire fighter who now operates an environmental non-profit.

Analytic Methods

To analyze survey data, I used Qualtrics report building features for all descriptive statistics and visualizations. I then exported this data into a SSRS file which I transitioned to a Stata file. From there I ran a secondary analysis separating responses that indicated structures were fully or partially burned from structures that were not burned. For each statistic I ran a chi squared test through Stata to quantify the statistical significance. Throughout this paper I will use the 0.1 significance level to classify statistically significant results. There are reported results in this paper that go beyond this 0.1 significance level; however, the p-value is included for each respective report.

To analyze my interview data, using [Atlas.ti](https://atlas.ti.com/), I coded transcripts to identify recurring topics. I developed descriptive and in vivo codes based on the main topics covered in interviews. Ultimately, I separated 141 quotations into 27 codes from which eight code groups emerged including defensible space, ecosystem services, fire education for residents, fire response and home hardening, future planning, insurance, plant flammability and arrangement, and situational

factors specific to the Eaton Fire. I edited Apple Intelligence transcripts from recordings done on the Apple Voice Memo app for all seven interviews to ensure that quotations were accurate.

Limitations:

This research was limited by a relatively small sample size. Due to the significance and emotional weight of this event as well as the oversaturation of research in the Altadena area following the Eaton Fire, collecting survey responses was difficult. Additionally, there may be overrepresentation, and thus sampling bias, as residents and experts who are more passionate about landscaping and plants may have been more inclined to fill out my survey or be interviewed. Similarly, only one current fire department representative was interviewed. This conversation brought up unique points that indicate that my interview process may not have reached full saturation, whereas all other interviews repeated themes by the end of the research period. Therefore, the timeline of this research was a limitation as more interviews and survey responses may benefit the validity or significance of various findings.

Findings

This section presents findings based on my analysis of qualitative and quantitative data from 31 resident surveys and seven expert interviews. The following section will explore themes and results from both forms of data collection. Throughout this section survey and interview responses will be combined to address the effect of landscaping and maintenance choices on home survivability in the Eaton Fire and to better understand the balance between mitigating fire risk to structures and ecosystem benefits provided by vegetation.

Landscaping for Fire

Participants indicated that online resources, personal knowledge, and professional landscapers are the greatest source of information (selected 27, 16, and 12 times, respectively) for landscaping and maintenance decisions. While online resources accounted for nearly 40% of all responses, only 4 of those 27 participants selected specific fire-related resources, indicating that fire was not a concern for most residents when making landscaping decisions. One participant specifically named the Theodore Payne Foundation as a specific resource; however, most respondents did not specify further than online resources.

Immediately before the fire, red flag warnings and forecasts of high winds led many Altadena residents to prepare with specific pre-fire interventions. These are discussed in detail in the maintenance subsection below; however, nearly half (48%) did not consider fire-risk when landscaping. These results illuminate the reality of defensible space in Altadena before the Eaton Fire: many residents did not consider fire risk when landscaping.

These results are not surprising. As one survey respondent wrote: “I was not in a [high-fire severity zone] HFSZ... what happened was a complete shock.” Most of the Altadena area affected by the Eaton Fire lived beyond CalFire’s fire-severity zones, which aim to help insurers, homeowners, and policymakers understand which homes may be affected by fire.

As established in the prior research, defensible space is the limitation of fuels adjacent to a home to decrease vulnerability to potential fires. Altadena residents were not deliberately creating defensible space, nonetheless, it is possible they practiced aspects of defensible space. The next section explains what interviewees highlighted as the most important aspects of defensible space and what participants reported to have adjacent to their homes before the fire.

Defensible Space

Expert interviewees consistently framed defensible space as a strategic buffer around homes that interrupts fire pathways and protects both people and structures. According to one landscape architect, defensible space “provid[es] a space that allows for the best protection for the safety and welfare of the people, as well as their structure.” To better understand the role that the defensible space plays in protecting structures from fire risk, expert interviewees emphasized

that a key tenet of defensible space is the removal or modification of fuel to prevent fire from reaching structures. As explored in prior research, fire can ignite a structure through direct flame contact, radiant heat, and flying embers. The Fire Ecologist reiterated this: When unmaintained or ‘wild’ vegetation connects to landscaping or fences there is “a direct burnable path to the structure.” In the case of embers, defensible space provides “protection against the wind transfer of embers.” The Fire Marshal explains that effective defensible space must “reduce the volume of embers in that modified zone...” including the reception and subsequent creation of embers by anything flammable within a defensible space.

In the case of the Eaton Fire, most participants had bare ground/gravel/stone, mulch or wood chips, and bushes or shrubs in Zone 0 (directly next to their homes) (fig. 7). Many also had potted plants and trees touching or overhanging the roof (fig. 7). Participants were allowed to select multiple choices to reflect the high variety of landscaping styles. In zone 1 (5-30 feet away from structures), there is a wide spread of responses with most residents having lawn or low groundcover, trees spaced apart, medium sized bushes, and plastic or wood furniture. Decorative shrubs/flowers, wood fencing, and gravel/stone/pathways were also popular (fig. 8).

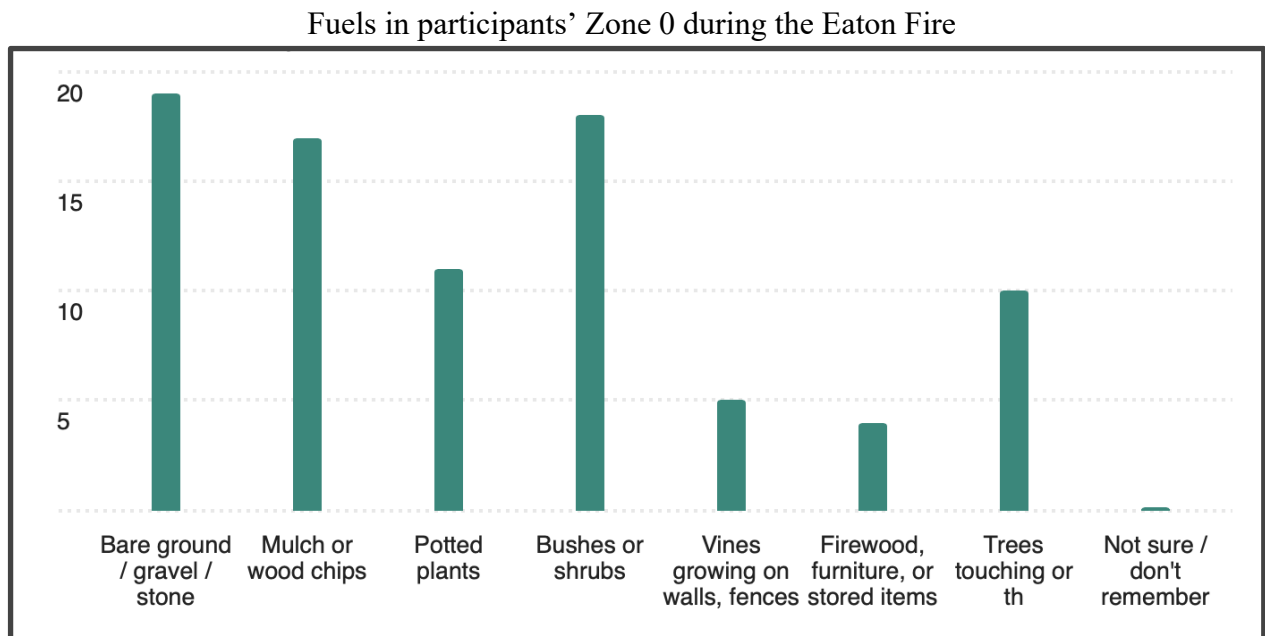


Figure 7. Bar graph showing types of fuels present in Zone 0 (0-5 ft from structures) during the Eaton Fire.

Fuels in participants' Zone 1 during the Eaton Fire

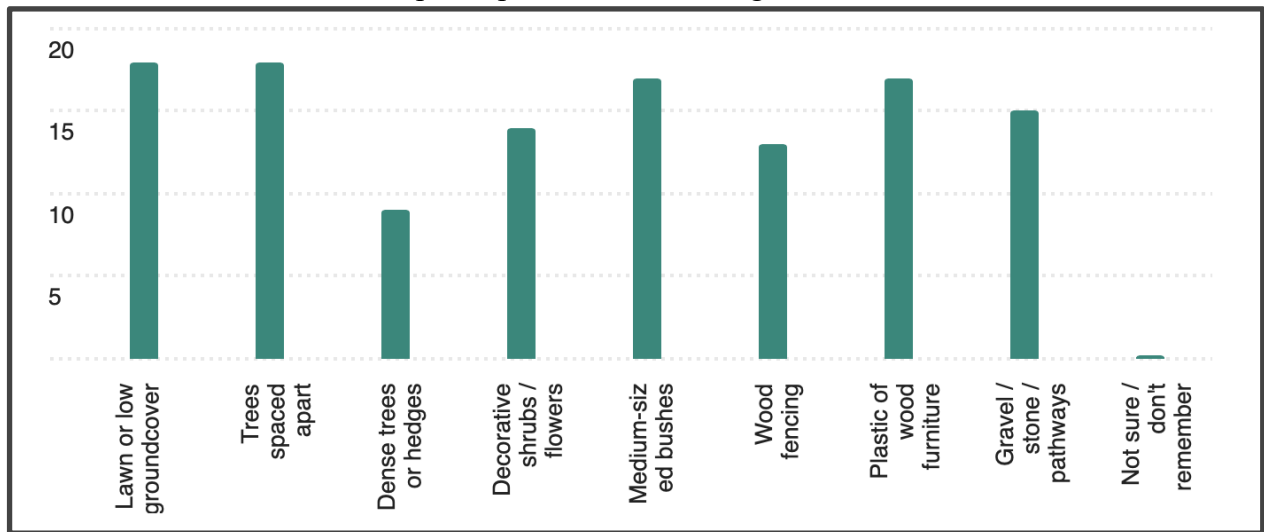


Figure 8. Bar graph showing types of fuels present in Zone 1 (5-30 ft from structures) during the Eaton Fire.

The results for both Zone 0 and 1 display that aspects of defensible space likely existed widely on Altadena properties. This is highlighted by ‘bare ground/gravel/stone’ and ‘lawn or low ground cover’ being the most common choices in Zone 0 and zone 1 respectively. Therefore, while fire was not a factor for most residents when planning landscapes, many of these properties had some level of defensible space adjacent to their homes.

Looking specifically at houses which did not burn, results show that a cleared defensible space did not make a clear difference in structure survival. For example, 87.5% of not burned structures had mulch in their Zone 0 when compared to less than 50% of homes that burned ($p=0.04$). Similarly, 50% of not burned structures had vines growing on their walls when compared to 4% of homes that burned ($p=0.002$). Looking at houses which did burn 83.3% had bare ground/gravel directly next to their home when compared to only 50% of the homes that burned ($p=0.059$). Overall, the findings indicate that some commonly promoted “safe” Zone 0 landscaping such as bare ground or fully cleared areas were not associated with better outcomes. Instead, certain vegetative features including mulch and vines growing on walls were correlated with higher rates of structure survival.

In Zone 1, similar conclusions can be made. In 50% of not burned structures dense trees and shrubs were growing; however, this was true for only 25% of burned structures ($p=0.186$). Additionally, 87.5% of not burned homes had lawn or ground cover near their structures compared to 58.3% of burned structures ($p=0.133$). These results once again suggest that structure survival was correlated with increased vegetation in Zone 1.

While a cleared defensible space did not seem to increase the safety of structures its role can be twofold. According to interviewees, one of the roles of the cleared Zone 0 is to allow for fire-fighting efforts. As the Fire Marshal explained: “vegetation... plays a part in determining

whether or not firefighters can safely maneuver as part of that protection... the firefighters' probability of success [is] based on how [defensible space] is treated.” This was echoed by a landscape architect who highlighted the role of defensible space in allowing firefighting intervention. The Fire Marshal explained further that directly before a fire “firefighting activities that often occur in the protection of a group of structures or a structure.... they're trying to achieve [a zone zero] within a couple of hours.” They continued: “If the fire behavior is altered by that treatment, meaning a little bit less intensity... then the home stands a better chance. Also, probably a reduction of ember cast against the home.” This shows that while vegetation may provide a buffer against embers, it may also restrict the ability for firefighters to intervene.

This property-level intervention from fire-fighters is ideal—but is it realistic? The retired fire-fighter argued that this kind of intervention is only possible in “fantasy fires” which could be “put out in their [fire-fighters] sleep” rather than the conditions in intense wind-driven fires. The intensity and scope of the Eaton Fire prevented any impactful fire-fighting intervention until after most structures had been destroyed. This has been a point of frustration for many Altadena residents, as one participant explained: “It’s disappointing that we have to garden a certain way to be fire-wise when this could have been prevented or even maintained if the fire department had shown up and did their job.” This sentiment reflects a long history of fire departments being blamed for devastating fires; however, active fire intervention is only a piece of a much larger puzzle in protecting WUI communities.

Maintenance and Irrigation

Despite fuel type, interviewees built on findings in prior research by highlighting maintenance as a crucial aspect to proper defensible space. One interviewee explained that plants are “resistant, depending on how well they're maintained.” They warned that dead material can accumulate under ornamental vegetation and “become a very receptive fuel” for fire. Another interviewee elaborated on this: “...having dead material in tree canopies is really bad for defensible space.” This then required ongoing care from residents and homeowners: “preparation matters.... And it's ongoing.” Homeowners therefore must be proactive in long-term maintenance as there is a “10 to 20 year [fire] cycle, [and] keeping that level of awareness up to focus on the maintenance part of it” is crucial to the long-term safety of communities.

Residents in Altadena practiced regular (at least once a month) maintenance within Zone 0. In Zone 1, nearly half of respondents practiced weekly maintenance and the other half only a few times per year. These results show varied maintenance schedules throughout Altadena residents. As interviewees highlighted the need for constant and ongoing maintenance in defensible space, residents may not be able to keep up uniformly. As a resident highlighted, this differential maintenance matters: “So many of our neighbors had completely unmaintained yards that were poorly watered. That kind of lack of maintenance catches neighborhoods on fire.”

The difficulty to properly upkeep a defensible space around their homes also came up in interviews; as an environmental non-profit director explained, there is a “huge discrepancy in [the] amount of care [residents] give to the landscape.” This is partially a personal and aesthetic issue as both Landscape professionals brought up accounts of clients prioritizing specific plants because of family stories or personal taste. which examples. However, it is also an education and resources issue as one interviewee explained, not everyone “ha[s] an irrigation system and ha[s] gardeners [to] weed, deadhead, and remove things so that there [isn’t] fuel.” While some residents may be able to devote time to yard maintenance or to pay to have someone help this is not the case for everyone.

Targeted maintenance before red-flag days or Santa Ana events may help alleviate pressure on residents. This is often possible, as the Santa Ana wind event that led to the Eaton Fire was predicted weeks before the fire occurred. While nearly half of participants did not consider fire in their landscaping as explored earlier, several irrigated, removed dead vegetation, and cleared space between vegetation. Furthermore, several long-answer responses which detailed extensive and repeated water treatments on the days before or during the fire. This displays that this practice is already being partially implemented in Altadena.

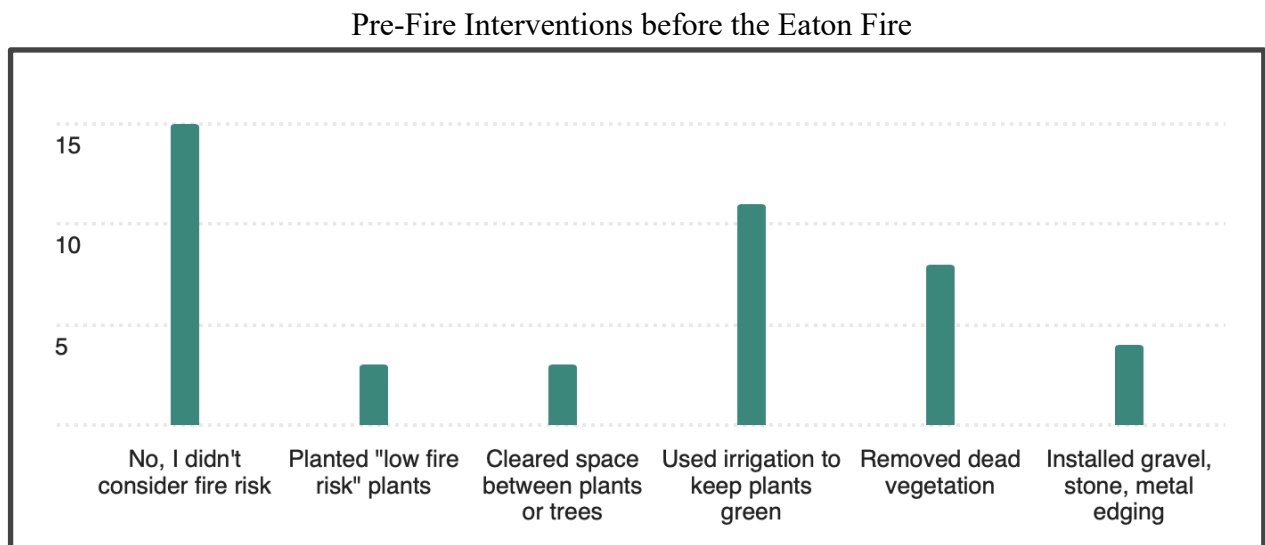


Figure 9. Bar graph showing specific pre-fire interventions directly before the Eaton Fire.

Another aspect of maintaining an effective defensible space is keeping plants hydrated. Not only was this emphasized in the prior research, but interviewees expanded on this, describing high-moisture plants as a tool to prevent direct fire transfer or the spread of embers to structures. These comments challenge CalFire Zone 0 recommendations, which label all vegetation as fuels that should be removed or isolated from structures. Instead, interviews highlighted vegetation as a barrier from fire risk if vegetation is well hydrated and maintained.

One Landscape Architect explains: “there have been plantings that are very moist and green, that have also served as defensible spaces for homes and prevented them from burning.”

The Fire Ecologist affirmed this, noting that “well-hydrated, well-maintained trees... could potentially even act as ember shielding.” On a smaller scale, Fauss gave the example of “well-maintained succulents” which “are probably about as inert as... non-living material” because of their high moisture content. Through hydration, this vegetation becomes an ember sink, where embers extinguish or lose energy before reaching a structure or another potential fuel. This may help explain why mulch and vegetation in Zone 0 and 1 was more common in structures that did not burn as explored earlier.

A few interviewees, who were there during the fire saw this themselves, commented on trees as a barrier against fire. As one resident recalled, “what I saw during the fire was that the trees were a really important protection, they didn't let the embers through,” instead they were “anchors in the wind” slowing the rapid transport of embers. Another interviewee affirmed this observation based on working to harden homes for clients as a landscape designer, saying that “trees, hedges, and native [vegetation] are very resilient... they can cut down on lateral movement of embers and slow fire down.” They also recalled that “homes were saved because of the trees around them, particularly oaks and deodars.” Although deodar cedars are considered highly flammable⁷⁶ the location and maintenance of these trees appear to have protected houses around them. In fact, several of these trees remain alive long after the fire, having acted as a barrier from flying embers. This was echoed by another landscape Architect who referenced Santa Rosa Ave. (commonly known as Christmas Tree Lane) which was largely unaffected by the Eaton Fire due to large deodar Cedars which slowed the spread of embers. Several survey respondents also mentioned similar findings, whether in their own yards or around the community. For example, one respondent wrote that: “the density of the plants in the 0-5ft zone may have protected our home.” These accounts highlight the beneficial role of hydrated vegetation in protecting urban communities like Altadena from fire. Throughout these communities, hydration of vegetation and placement in relation to structures differs greatly, as some residents have green manicured lawns and others have unwatered drought-tolerant landscapes.

Survey questions focusing on frequency of irrigation on properties provides a lens into how hydrated vegetation may have been throughout Altadena leading up to, and immediately before the Eaton Fire. Most respondents irrigated their properties frequently (daily, multiple times per week, weekly, or biweekly). However, when looking specifically at structures which did not burn 62.5% irrigated often (weekly or every other week) when compared to only 25% of structures that burned ($p=0.053$)⁷⁷. This indicates that regular watering throughout the year was seen more frequently in homes that did not burn. Immediately before the Eaton fire, most respondents indicated that their property had been watered within a few days or a week. This majority was higher though in structures which did not burn, as 87.5% watered within days of

⁷⁶ Los Angeles County Fire Department, Plant selection guidelines by Zone

⁷⁷ This result is complicated by a higher proportion of burned structures which watered very often (daily or multiple times per week); however, this result was not statistically significant, so it is not reported.

the fire when compared to 66% in houses that burned ($p=0.197$). Furthermore, 0% of homes which did not burn indicated no watering within a few months of the fire whereas 22% of burned homes indicated the same ($p=0.197$). This demonstrates that vegetation was more hydrated on properties that did not burn when compared to properties that did during the Eaton Fire. This is an important point which supports the several accounts of plants slowing the spread of embers earlier.

Ultimately, results show that houses with mulch, and vines in zone 0 and shrubs and trees in zone 1 burned less frequently. Despite this, fire experts confirm the findings throughout literature; landscaping directly adjacent to a structure should be “lean, clean, and green” to ensure the safety of structures. This means proper spacing, removal of dead vegetation, and sufficient hydration. This upkeep is costly, but survey data indicates that residents regularly upkeep the areas adjacent to their homes. Furthermore, irrigation—a crucial aspect of vegetation maintenance in mitigating fire risk—is used throughout Altadena, especially directly before the fire. This likely significantly impacted plant hydration and allowed vegetation to slow or even stop the spread of fire as many personal accounts from the Eaton Fire indicate. Finally, water schedules were found to be more frequent, throughout the year and immediately before the Eaton Fire, in homes that did not burn when compared to homes that did burn.

Home Hardening

Although the focus of this research is on defensible space, interviewees emphasized that home hardening—making buildings less receptive to ignition—is central to limiting fire risk. One Altadena resident noted the vulnerability of the historic housing throughout Altadena; “our structures were at [risk]... most of us had wood structures. And it was... 1940 when our house was built... all the structures around us had pitch roofs with vents.” Another interviewee emphasized how important this may have been in the Eaton Fire: “the largest combustible area [of your house] is the roof.” Therefore, homes with older roofs that had not been updated or treated for fire would have been vulnerable.

To address the vulnerability of structures, the Fire Ecologist noted that “structural hardening is so important. There are lots of things that you can do there like patching up holes in the structure. We have a lot of really cool technology for that now that's surprisingly low tech.” These technologies, like vent seals and fire treated siding and roofing, are simple fixes that can be done in WUI communities like Altadena. While some treatments are extremely costly, these property-level fixes are crucial because, as a local non-profit director said, residents “can harden their house, they can't move their neighbor further away.” As established in prior research, density of structures is a crucial factor in determining fire risk; however, this is extremely difficult to change as building codes and lot boundaries often pre-determine housing density. Therefore, changes like hardening can mitigate risk with relative ease.

Based on prior research and these expert comments, to accurately determine the role of vegetation in determining risk to homes, it was crucial to understand what home hardening had been done in Altadena before the Eaton Fire. Results show that structural hardening changes are generally more popular in Altadena as compared to the vegetation changes discussed at the beginning of the defensible space section. For example, fire resistant roofing, dual-paned windows, fire resistant walls, and cleaned gutters were all popular responses. When separating the data by homes that burned and those that didn't, no results were statistically significant except for fire resistant fencing which showed that 30% of homes which burned had this home hardening feature whereas 0% of homes that did not burn had this feature ($p=0.084$). This finding is surprising but may be insignificant as fences were explained in multiple interviews as a means for the direct transfer of flames rather than embers which were the predominant driver in the Eaton Fire.

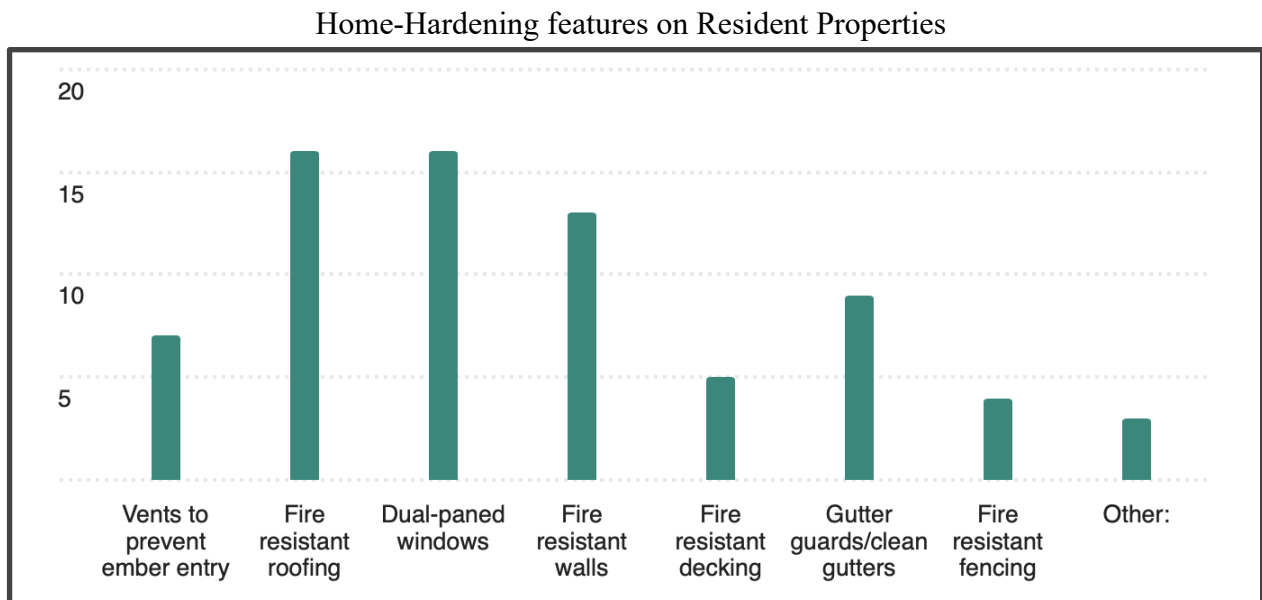


Figure 10. Bar graph showing home-hardening features on Resident Properties in Altadena.

Resident Reflections on Rebuilding and Replanting

Participants indicate that residents will generally be planting according to firesafe recommendations moving forward. These results indicated significant skepticism about defensible space guidelines, explaining that vegetation adjacent to homes seemed to have no negative impact on home outcome or that it even protected homes from ignition. Others highlighted concerns about the ecological and aesthetic impacts of removing vegetation. Some focused more on hardscaping changes to their structures they would focus on when rebuilding rather than replanting. And a few simply acknowledged that they needed more information.

When results were separated by homes that burned and those that didn't, attitudes understandably reflected these different outcomes. For example, 73% of participants whose

structures burned will plant fire safe landscapes moving forward. Only 20% of non-burned residents will do the same. 60% of participants with non-burned structures indicated that they would make no change moving forward (of which one-third indicated that they believed they were already doing enough).

Conditions Unique to the Eaton Fire

Interviewees described the Eaton Fire as an urban conflagration, exceeding both local firefighting capacity and traditional modes of wildfire planning and response. A local non-profit director explained: “we do not have the equipment or the personnel to respond to a conflagration that was of the intensity of Altadena [‘s Eaton Fire].” This is because, unlike a typical wildland fire, the Eaton Fire transitioned into an urban event where the human environment rather than vegetation became the primary fuel. As the Fire Marshal elaborates this “urban conflagration... [was] clearly something a little bit different in terms of how it transition[ed] from [a] traditional [wildfire] to a conflagration primarily driven by a built environment.” Moving through the dense urban setting of Altadena, the energy exponentially increased. As the Fire Ecologist described, “The amount of energy in a fire that is moving... structure to structure... is just incredible... above and beyond anything that you would see in [a] wildfire.” This is because of the concentration of fuels in and around homes and, as another local non-profit director explained, “gas lines that stayed on” fueling a destructive firestorm. Ultimately, as the retired fire fighter explained: “There's not enough firefighters [or] engines in the world to defend homes in an Eaton Fire situation... Their main job is to get people out of the way and save lives. They don't have the capability of defending anything.”

Moreover, as I explain above, the Eaton Fire was fueled by extreme Santa Ana wind conditions. The Fire Marshal identified “the wind driven dynamic” and resulting “Embercast” as the two central factors that made the fire so destructive. As embers were lifted from burning homes, “structures, fences, sheds, [and] things in the yard” caught fire, producing more embers and igniting homes even “several blocks away”. This is describing the spot fires explained in the prior research which started from embers that traveled as far as two miles in the Eaton Fire.

Intense wind and energy became dangerous when meeting the development patterns of Altadena. A local non-profit director critiqued planning decisions that intensified vulnerability to fire: “planning is part of the problem, and so is development in the wildland interface, [these are] areas that historically burn and we densify everything without looking at the natural processes.” They added, “Why do we allow homes to be... [against a] lot line... when we know that to prevent a fire, you need to be 20 feet away from another building [otherwise] it becomes the ignition point.” Another local non-profit director shared a similar perspective, linking risk to decades of unregulated growth: “it took decades for Altadena to grow as wild as it did... because we're unincorporated, there weren't neighborhood standards to force people to... take out the

bushy dense stuff in the front...” These comments describe a dense urban community with aging housing stock in fire-prone terrain, increasing vulnerability for all residents.

Altadena’s location and topography also contributed to fire risk. As the Fire Marshal explained, “the position of the slope that you’re on and the position of the topography plays the key part in determining whether or not you can do effective [fire fighting] treatment” in the steep canyons and foothill neighborhoods, containment was difficult (see fig. 1).

Understanding the unique aspects that made the Eaton Fire so destructive, including extreme wind and energy in the urban context and infrastructure and planning vulnerability, it is reasonable to question the extent to which property-level defensible space may prevent such damage in another similar event. This points to another theme in interviews: the power of community-level planning and governance to mitigate fire risk.

Green Barriers and Community Planning

Beyond property-level defensible space, in which vegetation serves as a barrier between incoming embers and a structure, interviewees also envisioned neighborhood-scale green barriers as a strategy to buffer entire communities from fire. One interviewee explained how “community collaboration can go a long way” with something as simple as planning vegetation along a property boundary with a neighbor. They quickly pushed this example further, advocating for “green swards”⁷⁸ to protect their whole neighborhood. This theme was continued as a landscape architect asked, “how do we plant as a community to have vegetative barriers [that are] successful in breaking up these huge spreads of embers...” A fire ecologist described how Santa Barbara has coincidentally developed to have these “green fuel breaks...” between residential areas and the Santa Ynez mountains as “belts of avocado and citrus orchards buffer fire.” They further proposed that “a native green buffer... [like] coastal live oaks...” may be even more effective at preventing the spread of fire without the intense water requirements of agricultural orchards: “once [coastal live oaks] are established, they don’t need any water input... [and] don’t burn unless it’s a very high severity fire.”

One of the landscape architects also emphasized that community planning requires “green, thoughtful planning, [using] vegetative barriers, shared plants, shared trees, [so it] becomes a shared responsibility.” Similarly, another landscape architect highlighted urban vegetation, particularly tree canopy, as a “community asset” which must be invested in. This community approach to vegetation framed by these interviewees is reminiscent of the work done in Santa Barbara by the Fire Safe Council (FSC), a group of community members collectively managing fire risk at the community level. This is an example that the Fire Ecologist pointed to—leading coordinated maintenance efforts led by the Fire Safe Council— “a whole community organized effort where they weed whack [grasses in the fuel break]” which is composed of

⁷⁸ An expanse of grass or short vegetation.

sparse established native shrubs “[so] the fire loses energy when it hits a fuel break.” By working together to create green barriers the work of the FSC provides protection to all residents in Santa Barbara. This decreases, but does not eliminate, the need for property level maintenance and hardening.

Vegetation-based strategies were paired with an equally strong emphasis on structural resilience. The fire ecologist stated: “If I personally had a home... I would be doing everything I can to invest in structural hardening. And then maintaining a very robust, well-maintained defensible space.” A landscape architect echoed this, arguing that “building materials are essential... we just continue to build the way we want [in] the cheapest way,” and that “if we give you a grant... first place you should put it? ... home-hardening, because it doesn’t matter how many trees or plants you move. If your house isn’t hardened, it’s going to burn down.” This sentiment reflects much of the prior research which emphasizes the key role of home hardening in limiting the vulnerability of structures. They also stressed the need for coordinated effort “when you silo [home hardening and defensible space], you weaken both.” Another interviewee summarized this collective responsibility: “we need to harden everything. We all must agree to harden our structures.” While fire resistant siding, roofing, fencing, vents and other defensible space changes have increased in popularity in conversations surrounding fire safety, creative solutions that protect homes are still needed.

Local Governance and Collective Action

Interviewees also identified systemic barriers and policy reforms necessary for coordinated resilience. A local non-profit director argued that “planning needs to be readdressed and looked at in terms of how people plan with natural processes and not with the idea that we can subjugate natural processes.” Multiple interviewees also called on Cal Fire to better address the unique nature of Chaparral wildfires, as the current board only includes foresters who create policies that reflect a very different fire regime in Northern California forests. As one landscape architect explained that “[Cal Fire] should have had a diverse amount of fire experts. Somebody from the Santa Barbara area... Somebody from Southern California, maybe somebody from San Diego, Somebody from Berkeley and then somebody from Humboldt County.” Improved resources and policies that reflect the unique ecosystems and communities of California is crucial to mitigate the risk of future fire.

In the absence of such governance interviewees highlighted emerging local structures of governance. The fire ecologist cited fire safe councils which “organized effort[s]... [to] apply for grant funding” to fund things like a chipper day or bringing in goats to manage vegetation. They further explained that “the best source of that information is typically your local fire safe council” as it is specific to a specific regions topography, climate, and development. The Fire Marshal pointed to a growing model of multilevel coordination and emphasized that such a model should be increased “where the government at different levels... and communities [are]

working together.” They also emphasized the role of these groups in identifying policy and planning gaps, finding grant opportunities, and addressing the need for “better methods of communication with homeowners and property owners.”

Conclusion

Across the findings, several clear patterns emerge from both survey responses and expert interviews. In the *Landscaping for Fire* section, results show that most residents did not consider fire when making landscaping decisions, relying primarily on general online resources rather than fire-specific guidance. The *Defensible Space* section demonstrates that while many Altadena properties had features commonly associated with defensible space, vegetation such as mulch, vines, shrubs, and trees was more common around homes that survived, and cleared areas did not consistently correspond with better outcomes. Despite this, defensible space was emphasized in interviews as a crucial aspect of decreased structure vulnerability.

In the *Maintenance and Irrigation* section, interviewees emphasized the central role of ongoing upkeep and plant hydration, and survey data show that more frequent watering (both year-round and immediately before the fire) was reported among homes that did not burn. The *Home Hardening* findings indicate that residents adopted structural hardening measures more widely than vegetation-related changes, though few features showed significant differences between homes that burned and those that did not.

The *Conditions Unique to the Eaton Fire* section identifies the event as an urban conflagration driven by extreme wind, ember cast, dense development patterns, aging housing, and challenging topography. Finally, the *Green Barriers and Community Planning* and *Local Governance and Collective Action* sections highlight interviewees’ emphasis on neighborhood-scale vegetation strategies, coordinated maintenance, structural resilience, and the need for collective structures—such as fire safe councils and improved planning processes—to support community-wide fire mitigation.

Recommendations

The findings above reveal that addressing wildfire risk in Altadena requires a shift from fragmented, property-level interventions toward coordinated, community-wide resilience. The Eaton Fire exposed how wind, density, and aging infrastructure can overwhelm traditional defensible space strategies. This demonstrates the need for integrated approaches that link home hardening, vegetation management, and local governance. Interviewees described a vision of neighborhoods where residents collectively maintain green barriers, harden structures, and plan with natural processes rather than against them. Future fire planning in Altadena and other WUI communities must emphasize shared responsibility, long-term maintenance, and coordination between homeowners, community organizations, and local agencies. This collective management of the built and ecological landscape can help communities mitigate the growing risks of urban wildfires.

The lessons from the Eaton Fire and extensive WUI wildfire research point toward several locations of potential intervention to increase fire resilience in Altadena and across WUI communities. As the finalized Defensible Space policies from CalFire have yet to be released these recommendations do not specifically address the policy or its language. The following recommendations show pathways forward.

1. CalFire defensible space policies must deprioritize state-wide regulation

As explored in prior research and in my interviews, the complexities of California Fire Ecology are not appropriately represented by the decision-making processes in CalFire. While one interviewee pointed towards increasing the participants to include experts in each unique regional fire context I urge CalFire to take a step further in acknowledging the diverse need by giving communities flexibility for local fire policies and management plans. Furthermore, all policies must reflect the actively changing research available regarding the role of defensible space in structure vulnerability. They should do this by:

- Adding a qualifier or clause to the soon-to-be released defensible space policies which allows Local Responsibility Areas (LRAs) to overpower State Responsibility Areas (SRAs) with proper scientific based evidence. Communities with organized Fire Safe Councils or other local organizations should be entitled to an appeals process.
- Establishing the soon-to-be released defensible space policies as temporary and amendable. The Eaton and Palisades fires have inspired increased scrutiny in this research; therefore, allowing necessary further data to support scientifically based policies is crucial to effectively protecting communities like Altadena.

2. Altadena should establish a Fire Safe Council

As explored extensively in prior research and in my interview data, local governance and community specific solutions are crucial to effective wildfire risk management. Altadena would benefit greatly from the creation of a local Fire Safe Council, modeled after successful examples in Santa Barbara County and throughout California. This council should:

- Be born from existing organizations that have managed the recovery effort in Altadena. There are several strong community organizations, such as Altadena Beautiful, Recovery Altadena, and the Altadena collective, which already coordinate community-wide support and information spread. As the community begins rebuilding, it is crucial that already-existing organizations serving Altadena residents lead the effort.
- This council should provide free or low-cost home-hardening assessments for residents like that of other Fire Safe councils and continue to advertise, trial, and share creative home-hardening solutions.
- Work to develop neighborhood scale fuel-breaks and fire-fighting access routes.
- Offer public education on defensible space, plant selection, and ember entry points.
- Connect residents with LA County Fire, CalFire, and regional emergency planning efforts.
- Develop community-led mitigation beyond lot-specific changes (i.e. home hardening and defensible space). Inspired by Australian fire management practices, Altadena would benefit from a “prepare: go early or stay and defend” method of fire response. In this case, able-bodied neighborhood ambassadors who receive the proper training and supplies would stay and defend homes from incoming embers. This would require significant initial investment, potential regulation changes, and community investment to protect ambassadors and their neighborhoods. Responsibilities for ambassadors could include turning off all neighborhood gas lines, turning on all sprinkler systems, and snuffing out incoming embers. The construction of fire-safe bunkers in which ambassadors could hide in the case of intense winds or overwhelming heat would allow further safety if homes are not designed for “shelter in place.”

3. Ember Exposure must be centered in Risk Mitigation Planning

The Eaton Fire demonstrated that embers, rather than direct flame contact, are the dominant mechanism of fire spread in wind-driven WUI fires. Embers traveled up to two miles ahead of the fire front, igniting structures, as one interviewee said, “everywhere all at once.” Effective mitigation must therefore treat ember exposure as the primary driver of risk. This looks like:

- Emphasizing home-hardening, above vegetation management, as the most direct pathway to protecting structure.
- Ensuring public education materials explicitly communicate that fuel reduction alone cannot protect homes from embers in high-wind fires.
- Providing a rebate program to pay homeowners in fire-risk communities to install ember-resistant vents, enclosed eaves, non-combustible decking, screened openings, and other home-hardening changes. This could follow the model of the Los Angeles Department of Water and Power which provides funds for turf removal if it is replaced with drought tolerant landscaping. For home-hardening residents should be able to apply for funds for specific home alterations. This would allow all residents to quickly access the necessary hardening tools and ultimately save communities millions of dollars in the case of future fires.

4. Improve Defensible Space Through Proper Plant Selection, Hydration, and Maintenance

While embers drive ignition, surrounding vegetation still influences whether a structure survives. Research consistently shows that plant hydration, species traits, spacing, and maintenance shape how vegetation responds when embers land. Based on these findings, residents should:

- Prioritize plants that retain higher moisture during drought and avoid species with volatile oils, peeling bark, or inherently flammable growth forms.
 - Follow resources like the Fire-Resistant Plant List⁷⁹ from the San Diego Fire Safe Council or the Plant Selection Guidelines document⁸⁰ from the Los Angeles County Fire Department for specific species selection.
- Reduce connectivity—both horizontal and vertical—to prevent flame ladders and continuous fuel beds.
- Irrigate strategically to keep vegetation hydrated through peak fire season.
- Remove dead material, prune regularly, and avoid dense groundcovers that accumulate litter.

⁷⁹ Santa Barbara County Fire Safe Council, *Comprehensive Fire-Resistant Plant List*.

⁸⁰ Los Angeles County Fire Department, *Plant selection guidelines by Zone*.

5. Integrate Fire Risk into Future Urban Development and Planning

The Eaton Fire highlights the structural vulnerability in WUI development patterns. Looking forward, fire risk must become a central consideration in how future communities are planned and built throughout fire-prone regions. This includes:

- Ensuring adequate spacing between structures to reduce home-to-home ignition in new developments.
- Requiring ember-resistant construction in all WUI houses.
- Incorporating evacuation, firefighter access, and defensible community buffers into planning.
- Avoiding further development in high-severity fire-prone landscapes.
- Implementing community-level planning and governance for fire mitigation through structures like Fire Safe Councils.

These recommendations align with defensible space practices, home-hardening, and long-term planning. The Eaton Fire shows that ember-driven wildfire behavior requires a layered approach. By establishing an Altadena Fire Safe Council, prioritizing ember-centric mitigation, maintaining defensible space through thoughtful landscaping, and designing future communities with fire in mind, Altadena and WUI communities around the world can proactively reduce risk and build a more fire-adapted future.

Conclusion

The Eaton Fire revealed how wildfire risk in the Wildland–Urban Interface is shaped by ecology, landscaping practices, urban design, and wind-driven ember behavior. Situating the events of the Eaton Fire within broader literature on Southern California fire regimes, plant flammability traits, defensible space, ember transport, and community planning, this paper demonstrates that determining structure survival is complicated.

Across surveys and interviews, the findings show that most Altadena homes did not consciously design or maintain cleared defensible space prior to the Eaton Fire. Although defensible space is meant to limit fuels and interrupt fire pathways, the data reveals that homes that survived were more likely to have mulch and vines in Zone 0, and to have shrubs and trees in Zone 1. These novel findings are supported by interviews and in-person accounts which ultimately point to the protective role that well-hydrated, well-maintained vegetation played during the wind-driven Eaton Fire. Trees acted as “anchors in the wind,” slowing embers and reducing their energy before reaching structures. This aligns with another finding in which houses that did not burn watered their vegetation more frequently both throughout the year and immediately before the fire, resulting in moisture-rich plants that functioned as ember catchers rather than fuels.

While vegetation characteristics influenced outcomes at the property scale, interviewees emphasized how the density of homes, planning decisions, and aging infrastructure contributed to the destruction that occurred. These findings underscore that community-level governance, be it coordinated maintenance expectations, shared vegetative buffers, neighborhood-scale green barriers, or collective planning, is essential for building fire-resilient communities.

Ultimately, Vulnerability to fire comes from the effects of vegetation condition and arrangement, home-hardening measures, neighborhood layout, and regional fire ecology. Understanding vulnerability shows the need for community-wide approaches to wildfire mitigation that go beyond home hardening and defensible space. If we address and learn from the lessons of the Eaton Fire it is possible to imagine a future where thoughtful landscaping, hydrated and well-maintained defensible space, ember-resistant construction, and community governance work together to build more resilient WUI communities. As climate change continues to intensify wind-driven fire behavior in Southern California, these insights will be essential for protecting both ecosystems and the people living within them.

References

- Abatzoglou, John T., and A. Park Williams. "Impact of Anthropogenic Climate Change on Wildfire across Western US Forests." *Proceedings of the National Academy of Sciences* 113, no. 42 (2016): 11770–75. <https://doi.org/10.1073/pnas.1607171113>.
- Alexandre, Patricia M., Susan I. Stewart, Nicholas S. Keuler, et al. "Factors Related to Building Loss Due to Wildfires in the Conterminous United States." *Ecological Applications* 26, no. 7 (2016): 2323–38. <https://doi.org/10.1002/eap.1376>.
- Alexandre, Patricia M., Susan I. Stewart, Miranda H. Mockrin, et al. "The Relative Impacts of Vegetation, Topography and Spatial Arrangement on Building Loss to Wildfires in Case Studies of California and Colorado." *Landscape Ecology* 31, no. 2 (2016): 415–30. <https://doi.org/10.1007/s10980-015-0257-6>.
- Aspinwall, Nick. "'It's Insane to Build the Same Thing and Expect Different Results': Can LA Fire-Proof Itself?" BBC News, June 28, 2025. <https://www.bbc.com/future/article/20250626-can-la-fire-proof-itself>.
- Bell, Carl E, Joseph M DiTomaso, and Matthew L Brooks. *Invasive Plants Invasive Plants and Wildfires in and Wildfires in Southern California Southern California*. n.d.
- Christopher, Ben. "New Fire Maps Put Nearly 4 Million Californians in Hazardous Zones. What Does That Mean for the People Who Live There?" CalMatters, March 24, 2025. <https://calmatters.org/housing/2025/03/calfire-maps-hazard-california/>.
- California Board of Forestry and Fire Protection. "Defensible Space Zones - 0, 1, and 2." BOF. Accessed December 9, 2025. <https://bof.fire.ca.gov/projects-and-programs/defensible-space-zones-0-1-and-2>.
- California Board of Forestry and Fire Protection. "Zone Zero Regulatory Advisory Committee Meeting." *2025 Zone 0 Committee Public Workshops*. Lecture, December 8, 2025.
- CAL FIRE. "Defensible Space." Accessed December 9, 2025. <https://www.fire.ca.gov/dspace>.
- Escobedo, Francisco J., Kamini Yadav, Onofrio Cappelluti, and Nels Johnson. "Exploring Urban Vegetation Type and Defensible Space's Role in Building Loss during Wildfire-Driven Events in California." *Landscape and Urban Planning* 262 (October 2025): 105421. <https://doi.org/10.1016/j.landurbplan.2025.105421>.
- "Expert Perspective: Wildland Fuels Management Would Not Have Saved Us from the January 2025 LA Fires | Sustainable LA Grand Challenge." Accessed September 4, 2025. <https://sustainablela.ucla.edu/fuels-management-jan-2025>.
- Fauss, Kristina, Joe V. Celebrezze, Robert Lloyd Fitch, Indra Boving, Rachel Dye, and Max A. Moritz. "Landscaping Defensible Space: Plant Flammability Testing Informs Recommendations to Reduce Community Fire Hazard." *Landscape and Urban Planning* 264 (December 2025): 105483. <https://doi.org/10.1016/j.landurbplan.2025.105483>.

- “Fire Ecology - Santa Monica Mountains National Recreation Area (U.S. National Park Service).” Accessed October 5, 2025. <https://www.nps.gov/samo/learn/management/fireecology.htm>.
- Gavrilov, Konstantin, Gilbert Accary, Dominique Morvan, Dmitry Lyubimov, Sofiane Meradji, and Oleg Bessonov. “IJWF2009.” October 28, 2013.
- Gibbons, Philip, A. Malcolm Gill, Nicholas Shore, Max A. Moritz, Stephen Dovers, and Geoffrey J. Cary. “Options for Reducing House-Losses during Wildfires without Clearing Trees and Shrubs.” *Landscape and Urban Planning* 174 (June 2018): 10–17. <https://doi.org/10.1016/j.landurbplan.2018.02.010>.
- Halsey, Richard W. *Fire, Chaparral, and survival in Southern California*. San Diego, Calif: Sunbelt Publications, 2008.
- Institute for Business and Home Safety. “MEGA FIRES: The Case for Mitigation, The Witch Creek Wildfire, October 21 – 31, 2007,” 2008.
- Keeley, Jon E., and C. J. Fotheringham. “Historic Fire Regime in Southern California Shrublands.” *Conservation Biology* 15, no. 6 (2001): 1536–48.
- Keeley, Jon E., C. J. Fotheringham, and Melanie Baer-Keeley. “Demographic Patterns of Postfire Regeneration in Mediterranean-Climate Shrublands of California.” *Ecological Monographs* 76, no. 2 (2006): 235–55. [https://doi.org/10.1890/0012-9615\(2006\)076%255B0235:DPOPRI%255D2.0.CO;2](https://doi.org/10.1890/0012-9615(2006)076%255B0235:DPOPRI%255D2.0.CO;2).
- Kimmerer, R.W., and F.K. Lake. “The Role of Indigenous Burning in Land Management.” *Journal of Forestry* 99, no. 11 (2001): 36–41. <https://doi.org/10.1093/jof/99.11.36>.
- Koo, Eunmo, Rodman R. Linn, Patrick J. Pagni, and Carleton B. Edminster. “Modelling Firebrand Transport in Wildfires Using HIGRAD/FIRETEC.” *International Journal of Wildland Fire* 21, no. 4 (2012): 396–417. <https://doi.org/10.1071/WF09146>.
- Koo, Eunmo, Patrick J. Pagni, David R. Weise, and John P. Woycheese. “Firebrands and Spotting Ignition in Large-Scale Fires.” *International Journal of Wildland Fire* 19, no. 7 (2010): 818–43. <https://doi.org/10.1071/WF07119>.
- Livingston, Amy C., and J. Morgan Varner. “Fuel Moisture Differences in a Mixed Native and Non-Native Grassland: Implications for Fire Regimes.” *Fire Ecology* 12, no. 1 (2016): 73–87. <https://doi.org/10.4996/fireecology.1201073>.
- Los Angeles County Fire Department, Plant selection guidelines by Zone Accessed December 11, 2025. <https://fire.lacounty.gov/wp-content/uploads/2020/05/Plant-Selection-Guidelines.pdf>.
- Moritz, Max A., Susan L. Cutter, and Alan March. “Elevating Survivability as the Goal of Community Wildfire Risk Reduction.” *Cell Reports Sustainability* 2, no. 7 (2025): 100436. <https://doi.org/10.1016/j.crsus.2025.100436>.
- Moritz, Max A., Rob Hazard, Kelly Johnston, et al. “Beyond a Focus on Fuel Reduction in the WUI: The Need for Regional Wildfire Mitigation to Address Multiple Risks.” *Frontiers in Forests and Global Change* 5 (May 2022): 848254. <https://doi.org/10.3389/ffgc.2022.848254>.

- Mutch, Robert W., Michael J. Rogers, Scott L. Stephens, and A. Malcolm Gill. "Protecting Lives and Property in the Wildland–Urban Interface: Communities in Montana and Southern California Adopt Australian Paradigm." *Fire Technology* 47, no. 2 (2011): 357–77. <https://doi.org/10.1007/s10694-010-0171-z>.
- National Parks Service. "Wildfire Causes and Evaluations (U.S. National Park Service)." Accessed December 10, 2025. <https://www.nps.gov/articles/wildfire-causes-and-evaluation.htm>.
- Ondei, Stefania, Grant J. Williamson, Scott Foyster, and David M.J.S. Bowman. "An Expert System to Quantify Wildfire Hazards in Gardens and Create Effective Defensible Space." *International Journal of Disaster Risk Reduction* 121 (April 2025): 105424. <https://doi.org/10.1016/j.ijdr.2025.105424>.
- Santa Barbara County Fire Safe Council, "Comprehensive Fire-Resistant Plant List." SBFSC, December 5, 2024. <https://sbfiresafecouncil.org/resource-library/comprehensive-fire-resistant-plant-list/>.
- Shafran, Aric P, and Jason J Lepore. *Urban Sprawl and the Dangers of Public Provision of Wildfire Suppression*. n.d.
- Street, N Fairfax. *After-Action Review of Alert Notification Systems and Evacuation Policies for the Eaton and Palisades Fires*. n.d.
- Syphard, Alexandra D., Jon E. Keeley, and Teresa J. Brennan. "Factors Affecting Fuel Break Effectiveness in the Control of Large Fires on the Los Padres National Forest, California." *International Journal of Wildland Fire* 20, no. 6 (2011): 764. <https://doi.org/10.1071/WF10065>.
- Tumino, Bianca J., Thomas J. Duff, Jason Q. D. Goodger, and Jane G. Cawson. "Plant Traits Linked to Field-Scale Flammability Metrics in Prescribed Burns in Eucalyptus Forest." *PLOS ONE* 14, no. 8 (2019): e0221403. <https://doi.org/10.1371/journal.pone.0221403>.
- "Wildfire Causes and Evaluations (U.S. National Park Service)." National Parks Service. Accessed December 10, 2025. <https://www.nps.gov/articles/wildfire-causes-and-evaluation.htm>.
- Zamanialaei, Maryam, Daniel San Martin, Maria Theodori, et al. "Fire Risk to Structures in California's Wildland-Urban Interface." *Nature Communications* 16, no. 1 (2025): 8041. <https://doi.org/10.1038/s41467-025-63386-2>.