Chapter 11: Wildfire Risk to Communities



Fire approaching homes in the 2020 California fire siege. Photo: CAL FIRE.

INDICATORS

- ⓘ 11.1 Structure Loss
- ⓘ 11.2 Housing by Hazard Class
- ⓘ 11.3 Housing in WUI
- ⓘ 11.4 Community-Level Wildfire Planning
- ⓘ 11.5 Incidence of Wildfire Smoke

INTRODUCTION

While wildfire is an essential ecosystem process and an inevitable outcome of living in fire-prone landscapes, safeguarding communities and infrastructure from potential damage is paramount. Recent examples—such as the 2018 Camp Fire and the 2025 Los Angeles County wildfires—illustrate the stakes to Californians of these increasingly common destructive wildfires. These high-profile events are becoming less isolated outliers and more part of a broader trend of increasing community exposure to wildfires. Communities across California are being confronted with loss of life, increasing smoke exposure, evacuation pressures, insurance affordability and availability challenges, and long-term recovery burdens. This chapter will discuss these issues from a historical perspective to better understand exposure dynamics and drivers of community vulnerability. While the chapter is retrospective, the goal is to help inform planning and mitigation and to equip communities to adapt to California's changing wildfire regime.

SUMMARY

The loss of homes and other community infrastructure from wildfire has accelerated dramatically over the past decade. Between 1990 and 2025, nearly 90,000 structures were destroyed by wildfire in California, with approximately 75% of those losses due to wildfires occurring since 2015 (ⓘ11.1). The 2018 Camp Fire alone destroyed more than 18,000 structures, losses comparable in scale to the housing stock of a medium-sized city. While the greatest losses have historically occurred in isolated events, recent wildfires increasingly challenge traditional distinctions between rural, exurban, and urban risk, demonstrating that large-scale community exposure to wildfire hazard is widespread across California. As of 2020, nearly 2.8 million housing units were located in areas with designated Fire Hazard Severity Zones (FHSZs), with 75% located in High or Very High Hazard areas (ⓘ11.2). The number of homes in the Very High category has grown by approximately 16% since 2010, reflecting both updated hazard mapping and ongoing development in fire-prone areas. About one in five homes in California are located in the wildland urban interface (WUI), where development is adjacent to, or mixed amongst, flammable vegetation (ⓘ11.3). This exposure has placed considerable

pressure on California's insurance markets and affected affordability for homeowners. Many insurers are pulling back from high-risk areas, causing numerous residents to turn to the state's FAIR (Fair Access to Insurance Requirements) Plan.

The Office of the State Fire Marshal (OSFM) continues to advance statewide regulatory actions to reduce structure-level wildfire risk. These actions include defensible space inspections, which have grown considerably over the past several years, and ongoing development and implementation of defensible space regulations. There has been an increase in scientific research supporting the efficacy of home hardening actions since the 2017 Assessment.

In addition to direct impacts to homes, health impacts from wildfire have been worsening. Wildfire smoke has become one of the most damaging and growing adverse outcomes of changing wildfire trends in California. Eighty-six percent of hazardous smoke days since 2006 have occurred since the 2017 Assessment (ⓘ11.4). The Central Valley and Central Coast have been the most heavily impacted due to smoke dispersion patterns. A growing body of research has documented the impacts of smoke on public health, highlighting the disproportionate risk faced by certain groups, such as children, seniors, and individuals with existing health conditions. Wildfire smoke is more harmful than typical urban air pollution and is linked to long-term health problems, including premature deaths, which are expected to rise dramatically in coming decades.

To meet these challenges, local planning efforts to improve wildfire resilience have expanded in line with the growing nature of the wildfire threat. As of mid-2025, there were more than 230 Community Wildfire Protection Plans (CWPPs) and over 125 local Safety Elements in County General Plans, which guide land-use decisions and risk reduction (ⓘ11.5). Participation in voluntary programs, such as Firewise USA, has also grown. However, participation is unevenly distributed across the state's geography and socio-economic conditions, reflecting a need to promote involvement and awareness in some communities. Similarly, the ability of residents to safely evacuate during wildfire events is not uniform across the state. Communities with limited road access, older populations, and high social vulnerability face higher risks during evacuations. Modeling and planning tools are improving, although significant knowledge gaps exist, including the lack of a statewide evacuation vulnerability assessment, which remains an active area of research.

The findings from this chapter illustrate the scale of the wildfire threat to communities and some potential courses of action to reduce exposure and vulnerability to damage. These include scaling up fuels management projects around vulnerable communities, expanding defensible space and home-hardening programs, improving evacuation planning, and supporting vulnerable populations during smoke events. Although not discussed in detail in this chapter, over the longer term, land-use planning decisions that consider wildfire hazard also play an important role in shaping future community exposure and vulnerability. Community protection is also influenced by landscape wildfire hazards, where risk reduction must be balanced with the ecological importance of fire in maintaining natural system structure and function (see Chapter 4, Wildfire).

The key indicators used in this chapter to describe topics related to wildfire risk to communities are presented on the following pages, followed by a detailed narrative and a list of opportunities.

Indicator 11.1: Number of Structures Destroyed by Wildfire Annually

Which Montreal Process Criterion does the indicator evaluate?

MPC6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies.

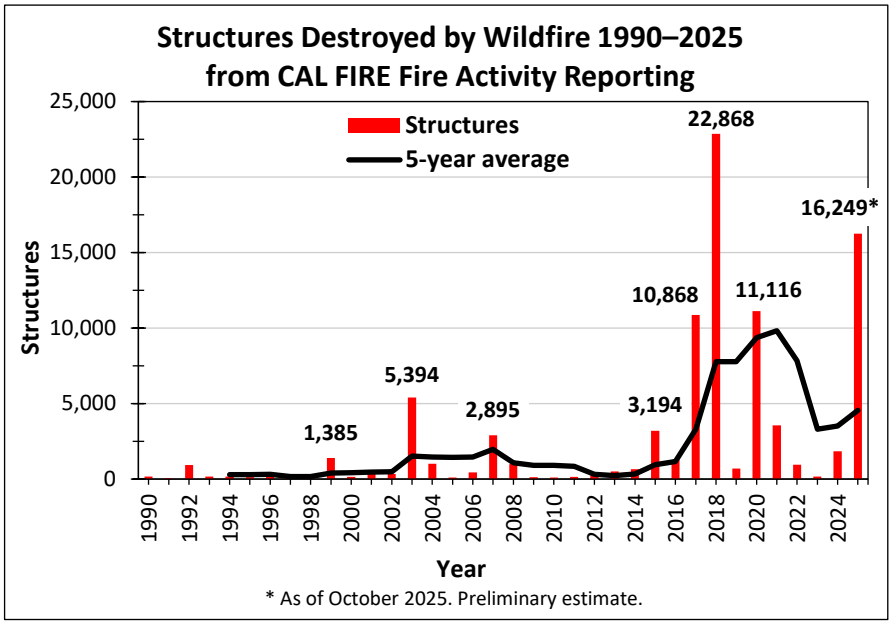
Why is this indicator important?

Structure loss over time is a reflection of factors such as development patterns, land management activities, fire suppression and pre-fire operations, and changes in climate. Tracking trends can signify when program or policy changes are needed to modify one or more of these factors.

What does the indicator show?

The number of structures destroyed by wildfire in California from 1990 to 2025. Structures include residences, commercial properties, outbuildings, and other structures declared lost. Estimates are preliminary for 2025.

Key Findings:



- CAL FIRE reported that between 1990 and October 2025, 89,758 structures were destroyed by wildfire. Fifteen of the 20 most destructive fires burned since 2015. This concentration of losses suggests a fundamental shift in wildfire impacts on the built environment.
- Prior to 2017, only one year saw more than 5,000 structures destroyed. Since then, there were four years in which losses exceeded 10,000 structures (2017, 2018, 2020, and 2025), totaling 61,101 structures destroyed. High-loss years are becoming less rare and are now a recurring feature of California wildfires.
- The magnitude of potential losses is significant. Notably, the Camp Fire in 2018 had a loss more than 10 times the average loss in the other years in this period. Single events can dominate annual losses, underscoring the importance of reducing community exposure and vulnerability.
- The loss trend is increasing. The top 20 most damaging fires on record destroyed 52,469 structures. Three-quarters of these losses occurred since 2015.

Data Sources

Damage Inspection (DINS) Data, CAL FIRE (CAL FIRE 2025a).
Wildfire Activity Statistics (Redbooks), CAL FIRE, 1990–2024 (CAL FIRE 2025e).

Indicator 11.2: Housing Units by Fire Hazard Severity Zone (FHSZ) Class

Which Montreal Process Criterion does the indicator evaluate?

MPC6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies.

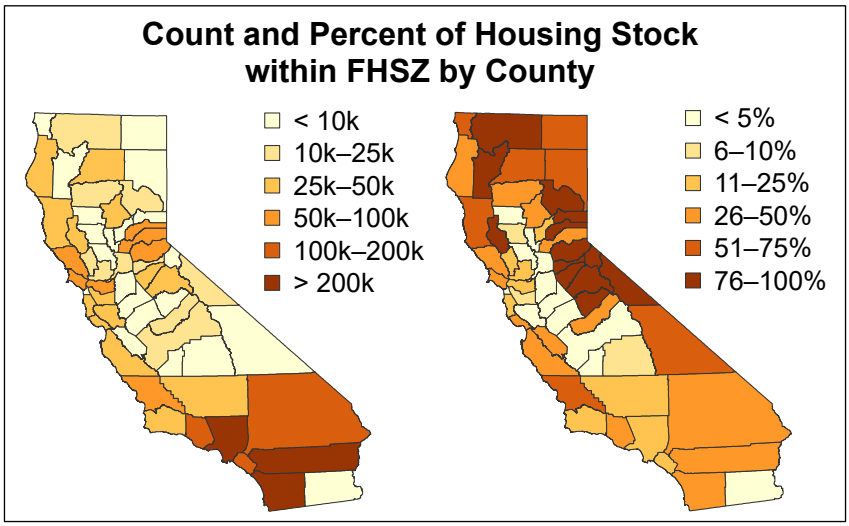
Why is this indicator important?

The number of housing units (HU) within Fire Hazard Severity Zones (FHSZ) by hazard class provides one measure of the pre-fire planning and overall fire protection problem. It also provides a measure of exposure to track and evaluate county growth patterns in terms of mitigating potential losses from wildfire and is a useful indicator of pre-fire planning challenges. Tracking this metric across California helps illustrate how human development and evolving landscape conditions are shaping wildfire risk.

What does the indicator show?

The number of housing units (in thousands) in California by county in Moderate, High, and Very High fire hazard severity zone classes for 2020, as well as the fraction of each county's housing units in FHSZ.

Key Findings:



- For 2020 there was an estimated 2,840,755 housing units (HU) in FHSZ and potentially at risk from wildfire. This represents approximately 20% of California's housing stock. Seventy-five percent of FHSZ housing units are in the High or Very High class. This percentage increased from the 2017 Assessment (69%).
- The top five counties with the most housing units in FHSZ are all located in the southern portion of the state. Los Angeles, San Diego, Riverside, San Bernardino, and Orange counties account for 51% of the state's FHSZ housing units. There are 37 counties that have at least 10,000 HU in FHSZ.
- In five counties (Alpine, Mariposa, Mono, Trinity, and Tuolumne), all housing units are located within a FHSZ. Although southern California counties contain a larger absolute number of housing units in FHSZs, counties in the Sierra Nevada and northern California have a much higher share of their total housing stock exposed to wildfire hazard.

Data Sources

Wildfire Risk to Communities: Spatial datasets of wildfire risk for populated areas in the United States (Jaffe et al. 2024).

Fire Hazard Severity Zones (CAL FIRE 2025c).

Indicator 11.3: Housing Units and Wildfire Threat within the Wildland Urban Interface (WUI)

Which Montreal Process Criterion does the indicator evaluate?

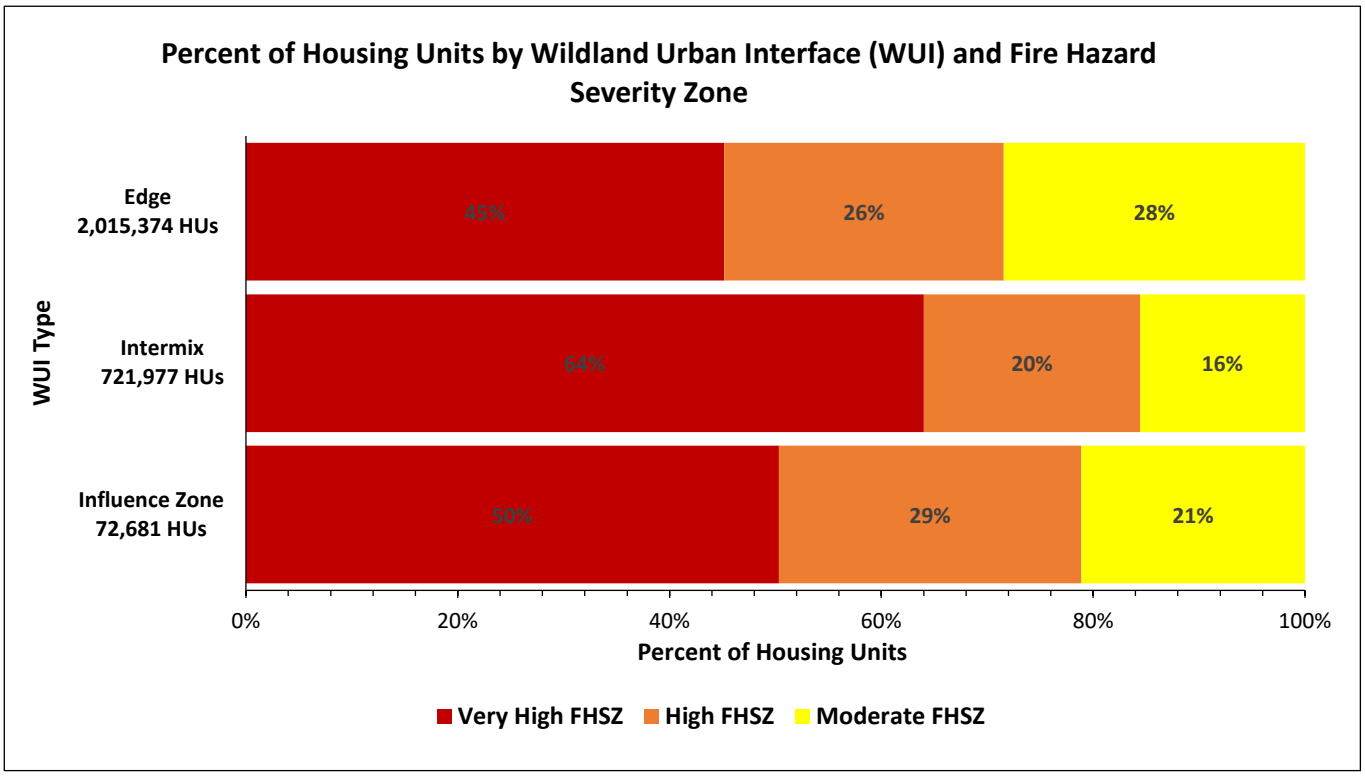
MPC6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies.

Why is this indicator important?

Risk of damage to homes from wildfire is highest when flammable vegetation is found adjacent or nearby to property. The wildland urban interface (WUI) is characterized by Edge, Intermix, and Influence zones, which pose unique problems for fire protection and pre-fire strategies, as fuel-structure interactions and suppression constraints differ across zone types. When combined with FHSZs, these WUI classes provide a way to quantify the structure protection problem and inform fire protection planning. Tracking this indicator over time will provide a measure of the effectiveness of county growth strategies.

What does the indicator show?

The sum and proportion of housing units by WUI type and FHSZ category in 2020. WUI Edge is defined as high-density development adjacent to wildland fuels. Intermix is defined as lower-density housing mingled within wildland fuels. The Influence Zone is defined as any area within 1.5 miles of either Edge or Intermix.



Key Findings:

- The WUI in California is extensive. Comprising 18,225,457 acres, the WUI is about 18% of the state.
- County development patterns create unique fire risk environments. Urban counties like Los Angeles and Orange tend to have areas of dense development next to unpopulated open space and housing units are primarily in

the Edge. Conversely, numerous counties provide a rural lifestyle that includes lower housing density dispersed within wildland fuels (Intermix and Influence Zone).

- Approximately 2,810,000 housing units are found in the WUI, with 72% (2,015,374) in the Edge, 26% (721,977) in the Intermix, and 2% (72,781) in the Influence Zone.
- As a percentage of housing units in a county, the number of housing units in WUI reflects differences in development patterns near vegetated landscapes, ranging from less than 1% (Sutter, Merced, San Joaquin, and San Francisco counties) to more than 90% (Amador, Plumas, Calaveras, Mariposa, Mono, Tuolumne, and Nevada counties). Nineteen counties have more than half of their housing units in WUI.
- Areas dominated by Edge require planning to keep fire from entering, as structure-dominated spread equates directly to losses. Areas dominated by Intermix can have a more nuanced planning approach matching ecosystem needs with community protection. In other words, different WUI settings may call for different suppression and management strategies. WUI Edge may necessitate more fire exclusion, while WUI Intermix may allow for more flexible, landscape-based approaches.
- Fire hazard—and by extension risk—exists for all WUI. In fact, Fire Hazard Severity Zones (along with housing density) are used to define WUI areas.
- For all WUI, 75% of housing units are in High or Very High FHSZs. The rest is in Moderate FHSZs. Most WUI housing units are therefore located in areas with elevated fire hazard, although Moderate FHSZ still presents a potential hazard.
- By WUI type, the percentage in High or Very High hazard is 72% for Edge, 84% for Intermix, and 79% for Influence Zone.
- Intermix fires represent a case where fire hazard and spatial complexity create very challenging operational conditions for firefighters because homes are scattered and interspersed with vegetation.

Data Sources

Fire Hazard Severity Zones (CAL FIRE 2025c).

Wildfire Risk to Communities: Spatial datasets of wildfire risk for populated areas in the United States (Jaffe et al. 2024).

Indicator 11.4: Communities with a Safety Element or Covered by a Community Wildfire Protection Plan (CWPP)

Which Montreal Process Criterion does the indicator evaluate?

MPC6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies.

Why is this indicator important?

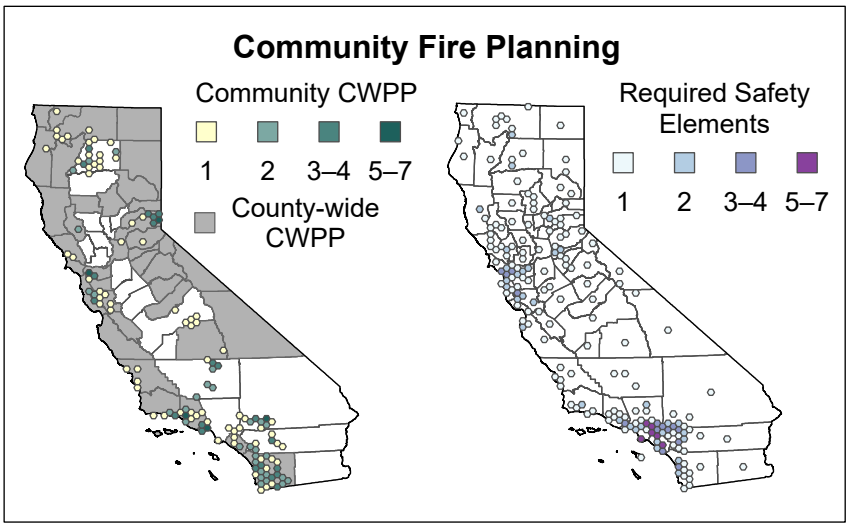
Community planning efforts, and associated pre-fire actions, have the potential to improve community safety by reducing wildfire frequency, severity, and damage. This is especially important in communities identified as having elevated risk.

What does the indicator show?

This indicator illustrates the spread of community-level community wildfire protection plans (CWPPs), county-wide CWPPs, and jurisdictions required to have wildfire Safety Elements in county and city general plans. These communities are counted within 96.5 square miles (250 square kilometer hexagons).

Key Findings:

- As of May 2025, there are 234 community-level CWPPs, 42 county CWPPs, 16 fire protection district CWPPs, and 278 jurisdictions with required wildfire Safety Elements. These community planning actions have been growing over time and indicate a broader adoption of wildfire-focused planning across the state.



- CWPPs are an especially common planning tool in the San Francisco Bay Area, around Lake Tahoe, and in highly populated southern California communities. Wildfire Safety Elements are more geographically dispersed, reflecting that they are a required component of general safety plans for all communities in the State Responsibility Area (SRA) and a number of communities in Local Responsibility Areas (LRA) with high wildfire hazard.

Data Sources

CAL FIRE Community Level Community Wildfire Protection Plans (CAL FIRE 2024a).

Fire Adapted Communities County Level Community Wildfire Protection Plans (Fire Adapted Communities Learning Network 2025).

CAL FIRE Qualifying Jurisdiction Safety Elements (CAL FIRE 2025d).

Indicator 11.5: Annual Frequency of Hazardous Smoke Days

Which Montreal Process Criterion does the indicator evaluate?

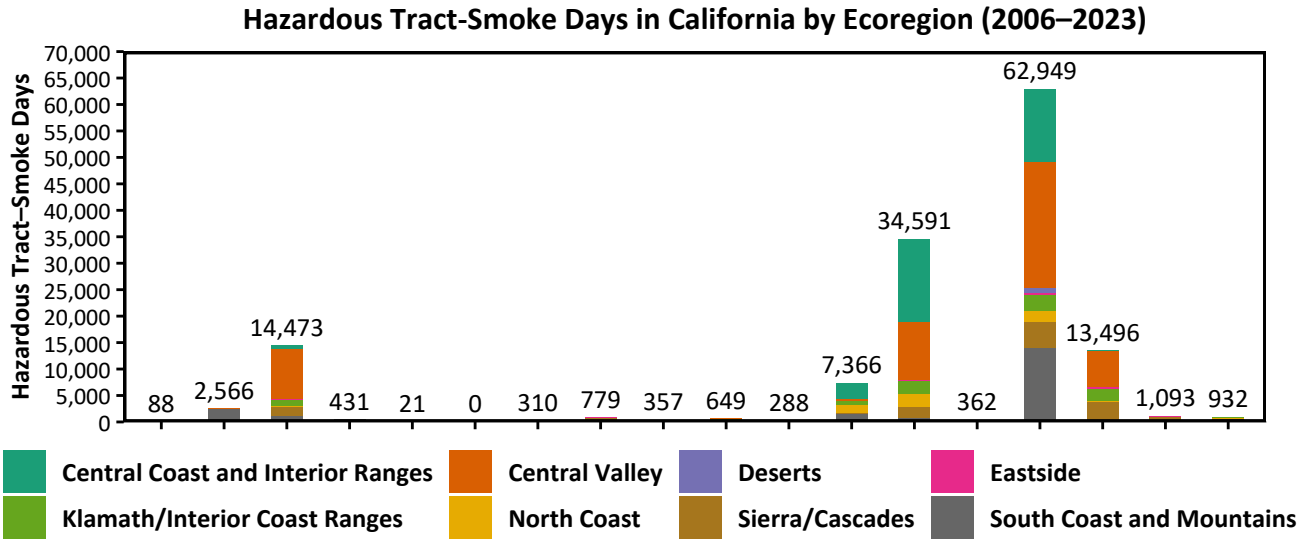
MPC6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies.

Why is this indicator important?

The fine particulate matter produced by wildfires can lead to adverse health impacts. According to the U.S. Environmental Protection Agency, PM2.5 (inhalable particulate matter 2.5 microns or smaller) levels exceeding 35 micrograms per cubic meter (mcg/m^3) of air are considered unhealthy for sensitive groups.

What does the indicator show?

The number of hazardous census tract-smoke days by California ecoregion from 2006 to 2023. A tract-smoke day is one day when a local community-sized area has unhealthy levels of wildfire smoke (PM2.5 >35 mcg/m^3) in the air.



Key Findings:

- The amount of PM2.5 from wildfire smoke is highly variable from year to year. In 2020, the most severe fire year in terms of acres burned (~4.3 million), Californians experienced over 60,000 census tract-smoke days when PM2.5 was more than 35 mcg/m^3.
- In the 2006–2023 period, four years had more than 10,000 tract-days over this threshold (2008, 2018, 2020, and 2021). In each of these years, more than 1 million acres burned in wildfires in California.
- Due to their population density and location relative to large wildfire events, the Central Coast and Central Valley ecoregions were most heavily impacted.
- Californian's exposure to smoke is not always highly correlated to the amount of wildfire. More than 1 million acres burned in 2007 and 2017, but the smoke impacts from wildfires were comparatively low due to wind patterns.

Data Sources

Daily estimates of smoke PM2.5 for the contiguous U.S. (ECHO 2025).

DISCUSSION

Structure Protection

California's communities have a long history of wildfire, yet the most damaging fires to communities, from single structure losses to community-wide events, often differ from large forest fires that primarily affect wildlands. In recent decades, these community-threatening fires have increasingly taken the form of fast-moving events that rapidly transition to urban conflagrations, producing widespread structure loss and overwhelming local response capacity (Balch et al. 2024, Calkin et al. 2023). As these events now occur at near-annual frequencies, and occur in an era of widespread smartphone use, social media, and 24-hour news coverage, public awareness of community wildfire risk has increased substantially, bringing the issue of community wildfire protection to the forefront.



Home protection during the 2024 Park Fire in Butte and Tehama counties. Photo: CAL FIRE.

Historical Structure Loss

Beginning with the Paint Fire (1990) and the Tunnel - Oakland Hills Fire (1991), where both fires spread into highly urbanized cities, CAL FIRE has engaged in data collection to audit and understand drivers and features leading to house loss. Between 1990 and May 2025, 89,346 structures were destroyed in the areas where CAL FIRE collected the data (ⓘ11.1). Data are not collected by CAL FIRE on all fires in the Local Responsibility Areas (LRA) or Federal Responsibility Areas (FRA), except when requested as part of a CAL FIRE Incident Management Team deployment on LRA or FRA lands. Prior to 2017, there was only one year, 2003, in which more than 5,000 structures were destroyed (CAL FIRE 2025e). Since then, there have been four years in which losses exceeded 10,000 structures (2017, 2018, 2020, and 2025), totaling 61,121 structures destroyed. These structure losses are the result of large, fast moving, and difficult to suppress wind-driven wildfire events that often occur in conjunction with dryer and warmer year-round conditions (Calkin et al. 2023). These events have occurred more frequently over the last decade. Fifteen of the 20 most destructive fires have burned since 2015. Losses from these 15 wildfire events account for 64% of all officially recorded structure losses since 1990 (Table 11.1). This statewide trend is mirrored nationally, where from 2014 to 2020, the five-year average of structures destroyed by wildfire rose from 2,873 to 12,255 (USFS 2022).

Table 11.1. Top 20 most destructive California wildfires and associated loss					
Fire Name (Cause)	**Date**	**County**	**Acres**	**Structures**	**Deaths**
Camp (Powerlines)	November 2018	Butte	153,336	18,804	85
Eaton (Under Investigation)	January 2025	Los Angeles	14,021	9,413	19
Palisades (Arson)	January 2025	Los Angeles	23,707	6,833	12
Tubbs (Electrical)	October 2017	Napa, Sonoma	36,807	5,636	22
Tunnel - Oakland Hills (Rekindle)	October 1991	Alameda	1,600	2,900	25
Cedar (Human Related)	October 2003	San Diego	273,246	2,820	15
North Complex (Lightning)	August 2020	Butte, Plumas, Yuba	318,935	2,352	15
Valley (Electrical)	September 2015	Lake, Napa, Sonoma	76,067	1,955	4
Witch (Powerlines)	October 2007	San Diego	197,990	1,650	2
Woolsey (Electrical)	November 2018	Ventura	96,949	1,643	3
Carr (Human Related)	July 2018	Shasta, Trinity	229,651	1,614	8
Glass (Undetermined)	September 2020	Napa, Sonoma	67,484	1,520	0
LNU Lightning Complex (Lightning/Arson)	August 2020	Napa, Solano, Sonoma, Yolo, Lake, Colusa	363,220	1,491	6
CZU Lightning Complex (Lightning)	August 2020	Santa Cruz, San Mateo	86,509	1,490	1
Nuns (Powerline)	October 2017	Sonoma	54,382	1,355	3
Dixie (Powerline)	July 2021	Butte, Plumas, Lassen, Tehama	963,309	1,311	1
Thomas (Powerline)	December 2017	Ventura, Santa Barbara	281,893	1,063	2
Caldor (Under Investigation)	September 2021	Alpine, Amador, El Dorado	221,774	1,003	1
Old (Human Related)	October 2003	San Bernardino	91,281	1,003	6
Jones (Undetermined)	October 1999	Shasta	26,200	954	1

Data Notes:
"Structures" include homes, outbuildings (barns, garages, sheds, etc.), and commercial properties destroyed. This list does not include fire jurisdiction. These are the Top 20 regardless of whether they were state, federal, or local responsibility.

Data Source: CAL FIRE (2026).

Data from the CAL FIRE Damage Inspection (DINS) program from the years 2018 through 2024 quantified the impact of wildfires on structures. The DINS program records the features of all structures within a wildfire perimeter, regardless of whether they were damaged or destroyed. Of the 82,745 structures accessible to inspection in this period, about half were either destroyed completely or sustained major damage (Table 11.2). However, excluding the especially severe year 2018 (with very large losses in the Camp Fire), the average percent destroyed or with major damage falls to 29%. The distribution of structure losses was more pronounced in 2018 than the other years, since a single incident (the Camp Fire) caused about 90% of the total losses. This catastrophic loss event dramatically increased the average loss rate over the study period. This occurred again in 2025 during the Palisades and Eaton fires in Los Angeles County, which destroyed 16,246 structures, and (as of December 2025) increased the loss ratio for the year to approximately 59%.

Table 11.2. Number of structures inspected and percent damaged or destroyed		
Years	**All Accessible Structures**	**Percent Destroyed or with Major Damage**
2018	28,403	79%
2019	2,108	28%
2020	28,626	34%
2021	12,253	27%
2022	3,009	26%
2023	229	24%
2024	8,117	21%
2018–2024	**82,745**	**47%**

Data Source: CAL FIRE (2025a).

Drivers of Structure Loss

Structure loss due to wildfires is driven by a combination of factors including building materials, design

features, and standards of compliance (such as relevant building codes); defensible space around the structure; proximity to the wildland urban interface (WUI, discussed in depth below); structure configuration; and specific characteristics of the fire itself that impinge on the structure, which is often referred to as "fire exposure." The fires driving structure loss are predominantly a result of human-related ignitions rather than natural ignitions (Higuera et al. 2023). A study of five destructive fires (all occurring since the 2017 Assessment) found that structure configuration, home hardening (i.e., upgrading homes with ignition-resistant building materials and design features to reduce the likelihood of structure loss during a wildfire), and defensible space were the main predictors of structure loss (Zamanialaei et al. 2025). The distance between structures was the main driver of loss, acting as a conduit for turning wildland fires into urban conflagrations. Features of the structure that are particularly important to reducing the likelihood of structure loss include having enclosed eaves, multi-pane windows, and vent screens (Syphard and Keeley 2019). These features protect against ember ignition, which is a leading cause of structure loss (Manzello 2020). The findings suggest that parcel-level home hardening and defensible space policies are critical to protect existing homes, but community-level planning that accounts for structure configuration is especially important for new communities, structure retrofits, and auxiliary structures.

Building codes have been adopted to improve the likelihood of structure survivability. After the Tunnel – Oakland Hills Fire in 1991, a series of legislative changes strengthened building codes, with further improvements made to the California Building Code in 2008. Several studies have shown that these requirements have been effective. For example, Baylis and Boomhower (2026) show that structures built after 2008 are 40% less likely to be destroyed due to the implementation of stronger building codes. The codes also appear to have spillover benefits, reducing the likelihood of house-to-house fire spread. Other studies, focusing on specific wildfires, have documented similar benefits of strengthened codes (Knapp et al. 2021, Troy et al. 2022). Research has also shown that adherence to defensible space vegetation clearance guidelines dramatically reduces structure-to-structure fire spread (Mockrin et al. 2023). Moreover, when defensible space is implemented in conjunction with home hardening, building survivorship probability nearly doubles (Zamanialaei et al. 2025).

Defensible space regulations are designed to reduce wildfire risk to structures (Public Resources Code (PRC) § 4291 and recent legislation from Assembly Bill [AB] 3074 (Friedman 2020)). The regulations divide the area around a structure into three zones, each requiring specific fuel reduction measures. The ember-resistant zone (0–5 feet, Zone Zero) focuses on eliminating combustible materials near the structure to prevent ember ignition. Zone 1 (5–30 feet) requires more intensive fuel reduction and landscape maintenance to reduce potential fire exposure to structures and break up connected fuels. Beyond this, the Zone 2 (30–100 feet) requires homeowners to thin vegetation, remove ladder fuels that allow fire to climb into tree canopies, and store firewood at least 30 feet from structures. These zones collectively enhance wildfire resilience by reducing fuel loads and creating defensible space for firefighting efforts.

CAL FIRE's Defensible Space Inspection Program helps owners comply with defensible space regulations. Inspectors assess properties in fire-prone areas to verify that homeowners have maintained the required 100 feet of defensible space around structures, reducing vegetation and other flammable materials that could fuel a wildfire. A Defensible Space Inspection and Compliance Report for real estate transactions in High or Very High Fire Hazard Severity Zones (FHSZs) is required by AB 38 (Wood 2019) when selling a residential property. A review of defensible space inspections shows a 40% increase in the volume of structures inspected from 2020–2024 (Figure 11.1). Staffing for inspections has increased substantially in recent years, in recognition of its importance as a tool for homeowner education and enforcement.

The risk of large wildfires within urban areas that spread directly between structures, termed urban

conflagrations, has risen in California due to housing expansion and worsening wildfire weather (Thompson et al. 2025). Recent research has shown that distances between buildings and neighborhood size and density play critical roles in urban conflagrations, with closely spaced, high density neighborhoods catalyzing house-to-house ignition (Kramer et al. 2019, Mahmoud and Chulahwat 2020). The probability of house-to-house ignitions can be dramatically reduced if adequate separation between structures is provided, with an average distance between housing of greater than 10 feet (three meters), resulting in a substantial increase in building survivorship (Suzuki and Manzello 2021). Evidence from recent wind-driven fires in Los Angeles County and Lahaina, Hawaii suggest that *downwind* fire-resistant homes may not see survivability benefits with structure spacing under 20 feet (Hedayati et al. 2024, Monroy et al. 2025). Limiting connective fuels, including both vegetation and structural fuels, is also critical for reducing structure-to-structure spread (Giammanco et al. 2023). These findings demonstrate the importance of defensible space and strategic land-use planning and zoning to building survivorship during urban conflagration events subject to extreme weather events (Aksoy et al. 2023, Taccaliti et al. 2023). However, conclusions drawn from these studies remain subject to substantial uncertainty. The observed outcomes are informative but also depend strongly on fire behavior, wind conditions, and other factors, and may not be broadly generalizable across communities or incidents. Modeling wildfire risk in the built environment is an area of active research and much remains unknown about ember transport, flammability of different materials, and the effectiveness of fire suppression under variable conditions (Thompson et al. 2025).

Wildfire Hazard and Housing Density

In this section, we calculate the number of housing units within several different wildfire hazard and risk-exposure classifications. First, we discuss the two classifications: FHSZ and WUI. We then report the number of structures within each of these classifications.

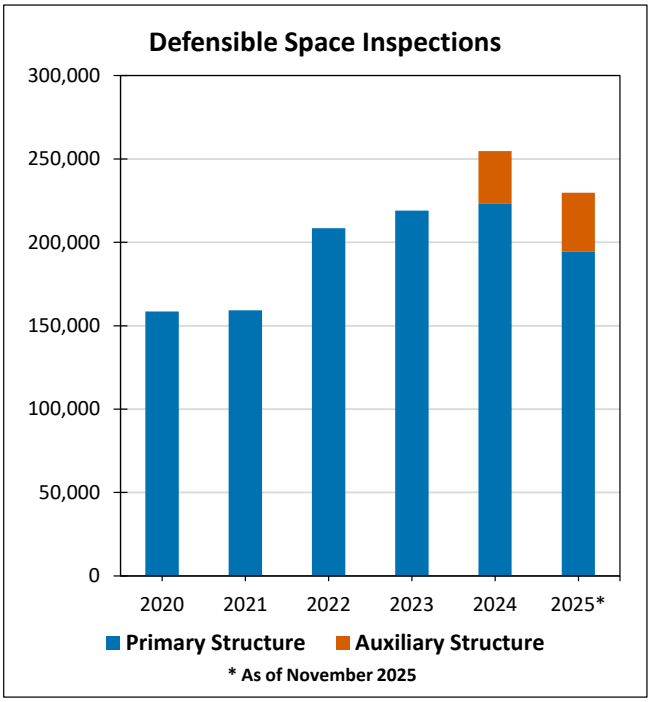


Figure 11.1. CAL FIRE defensible space inspections by fiscal year. Data Source: CAL FIRE (2025b).

Fire Hazard Severity Zones

California law requires the State Fire Marshal to classify state responsibility areas (SRA) as Moderate, High, or Very High Fire Hazard Severity Zones (PRC §§ 4201–4204, California Code of Regulations Title 14 § 1280, and California Government Code §§ 51175–89). The fire hazard zones are used for several purposes including designating areas for defensible space standards and WUI building codes (CAL FIRE 2024b). Moderate, High, and Very High fire hazard are based on the average hazard across the area included in the zone. The hazard is based on the likelihood of wildfire and its expected fire behavior, as determined by representative historical data on fuel loading, slope, fire weather, and other relevant factors. Current procedure has different regulations based on responsibility area. For the 2025 Assessment, we created a hybrid product to analyze long-term structure hazard. Figure 11.2 shows the FHSZ classification, including adopted SRA (effective April 2024), Local Responsibility Areas (LRA) recommended in February–March 2025, and Federal Responsibility Areas (FRA) obtained from the statewide source data from which the FHSZ map was derived. Both regulatory (SRA and LRA) and modeled



CAL FIRE Defensible Space Inspection during June 2021 in the Nevada-Yuba-Placer Unit. Photo: CAL FIRE.

(FRA) FHSZs currently cover 83% of California's lands (Figure 11.2).

CAL FIRE's recently updated FHSZs used an improved modeling approach that better reflects long-term wildfire hazard across both wildland and non-wildland areas. The updated methodology incorporates detailed data on vegetation, slope, historical fire occurrence, and extreme fire weather to assign the hazard designations. It also models ember dispersal to extend hazard zones into adjacent urban and agricultural areas based on proximity, wind patterns, and local vegetation. All SRA are now required to receive a hazard designation, including areas previously un-zoned. These changes enhance the accuracy and usefulness of FHSZs for planning, building codes, and wildfire risk mitigation (CAL FIRE 2025c).

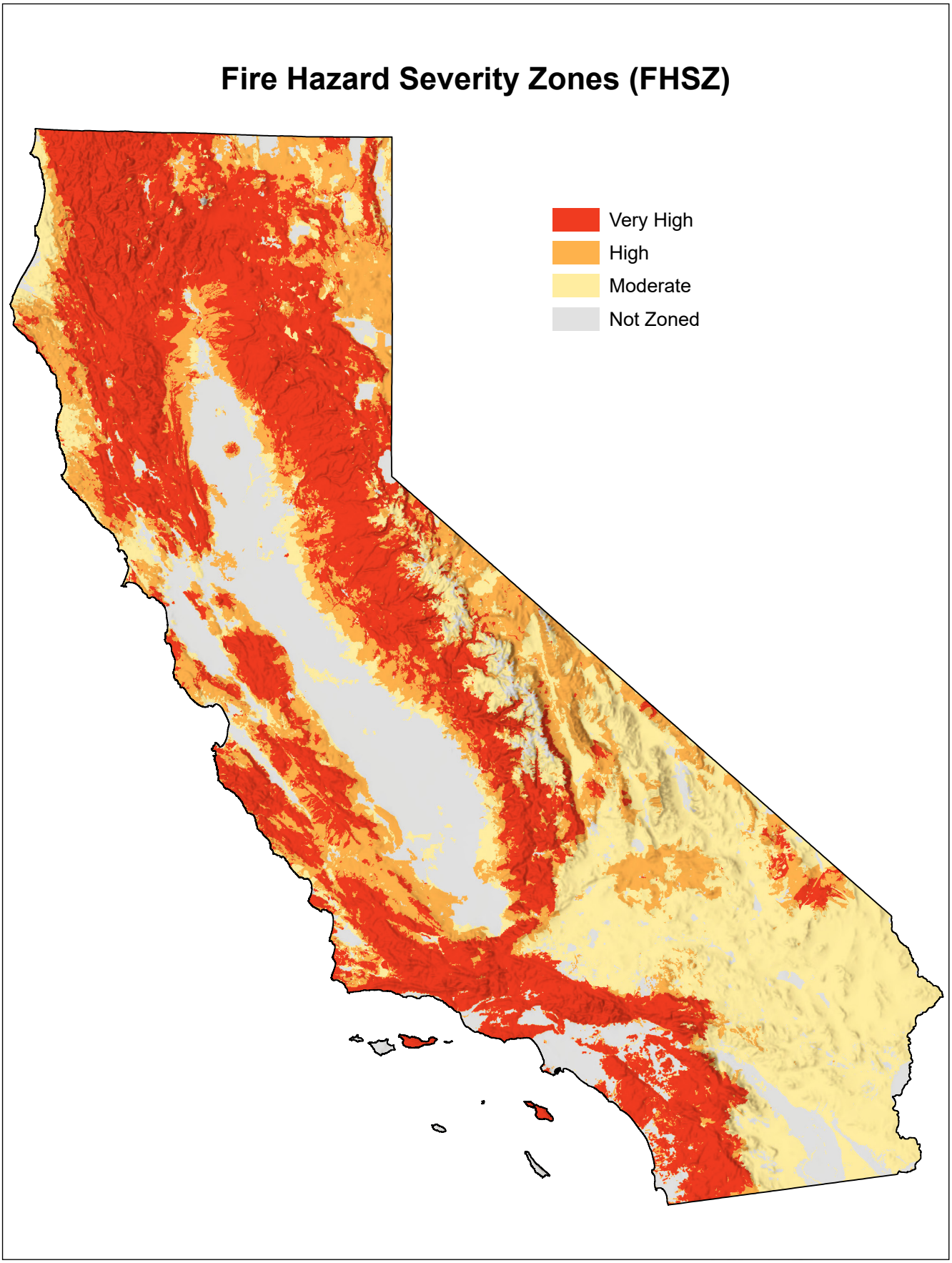


Figure 11.2. Fire Hazard Severity Zones (FHSZ). Data Source: CAL FIRE (2025c).

Wildland Urban Interface: Edge, Intermix, and Influence Zones

For this Assessment we constructed an updated map of the WUI consisting of Edge, Intermix, and Influence Zones. This new map incorporates several modeling refinements and features, as well as updated fire hazard and building density data. In general, the term WUI refers to the area where structures and other human development meet or intermingle with natural vegetation. CAL FIRE's Fire and Resource Assessment Program (FRAP) uses three separate WUI classifications:

- **Edge:** This category represents areas where dense urban development is adjacent to wildlands. There is a clear boundary between houses and wildlands fuels, and these areas provide a line of defense against wildfire coming into the built environment. Focusing mitigation efforts along this boundary, such as home hardening, strategic fuel reductions, and improved access for suppression, can help reduce fire risks.
- **Intermix:** This category represents areas where sparse development is interspersed within a landscape that still retains many wildland characteristics. In these areas, fire agencies often need to allocate additional resources to protect individual houses. Risk mitigation strategies in these areas can include suppression efforts, the use of fire-resistant building materials, and the creation of defensible spaces around structures.
- **Influence Zone:** Any area within 1.5 miles of either Edge or Intermix (i.e., possibly within range of flying brands in high wind conditions). These areas tend to have relatively few, scattered pockets of development.

Defining the Wildland Urban Interface



Homes in the WUI Edge threatened by the 2024 Franklin Fire in Los Angeles County. Photo: CAL FIRE.

The term wildland urban interface (WUI) emerged in the 1970s to describe the context where natural vegetation fuels can spread fire to homes and infrastructure (Butler 1974), and it is commonly used to describe conditions where structures connect with or are spread amongst wildland vegetation. Over time WUI has been used widely to describe the problem in general and across the full spectrum of land and infrastructure conditions where vegetation fires have potential to damage human assets likes homes and other manmade features.

As described in this Chapter, FRAP uses three WUI categories: (1) areas of concentrated development adjacent to wildlands, traditionally called "Interface", here called "Edge"; (2) areas of lower-density development mixed with wildland vegetation ("Intermix"); and (3) the surrounding "Influence Zone" where embers originate from that may ignite structures. However, this classification can result in some confusion since the term interface refers to two concepts: the overall WUI and also one specific WUI category. To reduce confusion, this Assessment adopts the term "wildland urban interface Edge" (WUI Edge) to describe areas of dense development immediately adjacent to wildland vegetation. The objective of this change is to better align terminology with function by clearly distinguishing the three separate WUI classifications.

WUI Edge presents land use of high asset density and presents challenges for modeling hazard and fire spread, where mechanisms associated with probability of structure ignition and structure fuel combustion

influence fire spread, and conditions often characterized as urban conflagration. Within the Edge, lands typically contain structures of sufficient density to promote house-to-house ignition and spread where structure separation distances are often less than 30 feet, and thus contain "High Density Interface" Type 1 and Type 2 in the National Institute of Standards and Technology (NIST) WUI density classifications system (Maranghides et al. 2025). Given both these challenges and the high asset density that dominates risk profiles for loss in the WUI Edge, research is ongoing to develop operational models for predicting spread that often occurs in these densely developed lands that commonly are associated with the most damaging WUI fires (Masoudvaziri et al. 2021, Purnomo et al. 2024).

The driving characteristics of WUI classification are housing density and vegetation cover. Housing density is derived from a 100 foot (30 m) resolution raster reprojected from the Wildfire Risk to Communities dataset (Jaffe et al. 2024), with the following classes: Class 1 (<1 HU/20 ac), Class 2 (1 HU/20 ac to 1 HU/5 ac), Class 3 (>1 HU/5 ac to 1 HU/ac), and Class 4 (>1 HU/ac). Vegetation dominance is defined as either inclusion in State Wildland Zones (flame class 1–3) or areas with >50% canopy cover, aggregated using a 3×3 cell circular focal mean to identify areas with at least 50% vegetative cover. WUI areas are constrained to areas within Moderate, High, or Very High FHSZs. WUI Edge includes contiguous clusters of housing density Class 3 or 4 cells with <50% vegetation and patch sizes of at least ~20 acres. Intermix WUI includes housing density Class 2 or 3 cells with ≥50% vegetation in patches ≥100 acres, or smaller Edge patches reclassified based on vegetation dominance. A final adjustment reverts some vegetation-dominated fragments (<100 acres) with high housing density back to Edge to avoid misclassification. The Influence Zone includes all vegetation meeting burnability thresholds within 1.5 miles of Edge or Intermix, excluding areas already classified as such. All spatial processing includes minimum patch size enforcement (~18 acres), with smaller clusters reclassified to match adjacent dominant classes to ensure spatial coherence. Figure 11.3 shows the distribution of WUI across the state.

FHSZ and WUI Housing Units and Acres Statewide

There are approximately 2.8 million housing units located in the WUI in California. These units represent 20% of the state's housing stock. Seventy-two percent of these units are in the Edge, 26% are in the Intermix, and 3% are in Influence Zones, illustrating that most of the potential risk exposure for structures is in the WUI Edge. Approximately 18.2 million acres are classified as WUI, representing approximately 18% of California's land area. The vast majority of these acres (80%) are in Influence Zones, with an additional 14% in Intermix, and 6% in Edge. This area is up slightly from the 2017 Assessment, which reported 17.7 WUI acres as of 2010. Nearly all (99%) of the housing units in FHSZ are also classified as WUI, although only 21% of FHSZ acres are classified as WUI. The large fraction of FHSZ that is non-WUI is represented by extensive areas of SRA of low housing density (less than one housing unit per 20 acres). Approximately 6.1 million Californians are living in the WUI, representing 15% of the state's population (Table 11.3).

Table 11.3. Housing units, acreage, and population by WUI class and Fire Hazard Severity Zone

	Housing Units		Area		Population	
	Units (1,000)	% of State	Acres (1,000)	% of State	People	% of State
All WUI	**2,810**	**20%**	**18,225**	**18%**	**6,116,174**	**15%**
Edge	2,015	14%	1,059	1%	4,912,331	12%
Intermix	722	5%	2,531	2%	1,037,189	3%
Influence Zone	73	1%	14,635	18%	166,654	0.4%
All FHSZ	**2,841**	**20%**	**84,950**	**84%**	**6,189,064**	**16%**
Moderate	708	5%	26,684	26%	1,640,402	4%
High	710	5%	19,743	19%	1,566,379	4%
Very High	1,423	10%	38,524	38%	2,982,283	8%

Data Source: CAL FIRE (2025c, 2025f).

The 2017 FRAP Assessment reported that in 2010 about 2.2 million housing units were in WUI Intermix

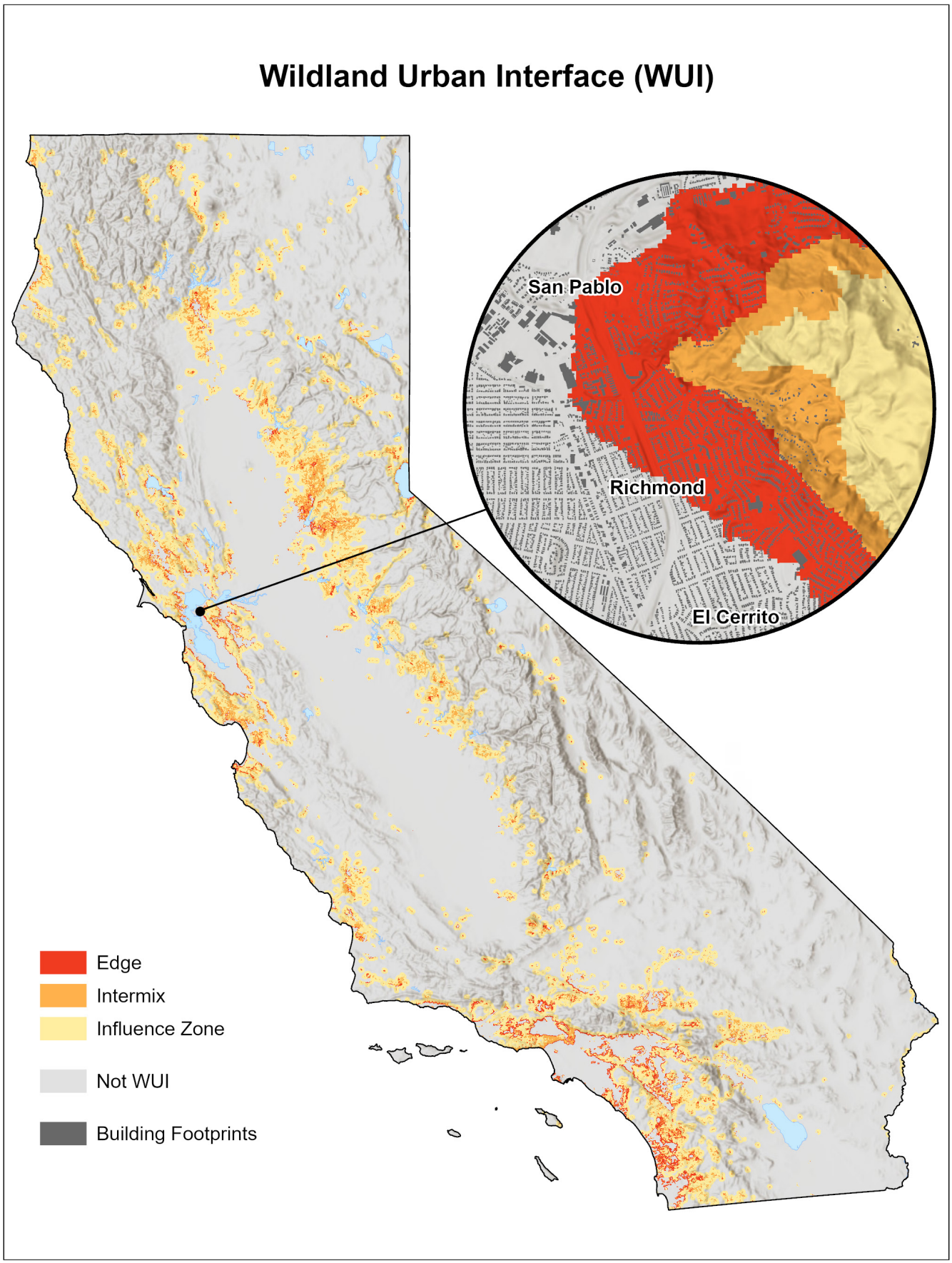


Figure 11.3. Wildland urban interface—Edge, Intermix, and Influence Zones. Data Source: CAL FIRE (2025f).

or Edge. The current estimate for 2020 is approximately 25% larger. Some of the increase can be attributed to differences in WUI modeling, including more spatially accurate building footprint-based housing density versus the previous use of census block average housing unit density. These data better capture outlying developments.

A geographic comparison of housing units in the WUI reveals that the vast majority of WUI structures are in densely populated counties in southern California (Table 11.4). The top six counties with the most WUI housing units are Los Angeles, San Diego, Riverside, San Bernadino, Orange, and Ventura, accounting for 58% of the state's WUI housing units. Across California, approximately 20% of housing units are located in the WUI, although some counties have much higher percentages. For example, El Dorado and Nevada counties have 89% and 99% of their housing units, respectively, located in the WUI.

A county may have an overall predominance of a particular WUI type, which would likely be reflected in risk mitigation strategies. For example, the number of housing units in the WUI that are in the Edge exceeds 50% in 33 counties. In 16 counties, over 50% of housing units are Intermix. Areas dominated by Edge require planning to keep fire from entering, as conditions that allow for spread in the Edge are often driven by structure ignition and associated spread resulting in high losses. Areas dominated by Intermix can have a more nuanced planning approach matching ecosystem needs with community protection. The fire hazard and spatial complexity of Intermix fires create very challenging operational conditions for firefighters.

Comparison with SILVIS WUI

FRAP's WUI methodology and results differ considerably from other published estimates of housing stock exposure to wildfire hazard. For example, the SILVIS lab (Spatial Analysis for Conservation and Sustainability) at the University of Wisconsin–Madison uses the WUI

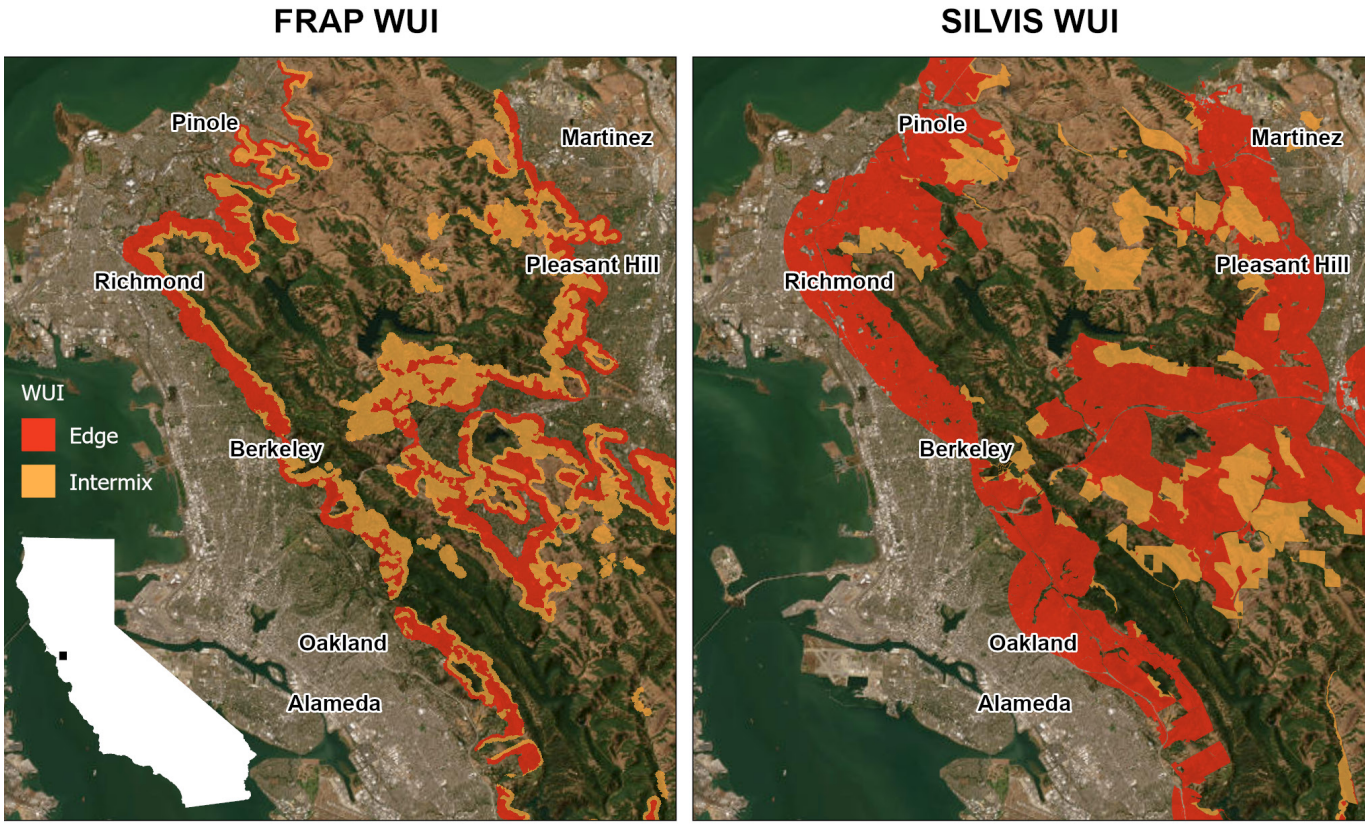


Figure 11.4. Comparison of SILVIS and FRAP WUI designation for the East Bay region of the San Francisco Bay Area. Data Sources: CAL FIRE (2025f), Silvis Lab (2026).

definition published in the U.S. Federal Register. This approach classifies WUI Edge as areas where the housing density is greater than one house per 40 acres, less than 50% vegetation cover, and within 1.5 miles of a contiguous wildland patch that is at least ~2 square miles (5 square km) in size and contains at least 75% wildland vegetation. Intermix WUI is classified as area where the housing density is greater than one house per 40 acres and more than 50% wildland vegetation cover. Using these more expansive definitions, SILVIS reports that there are 5.5 million housing units in the WUI in California, with 75% in the Edge and 25% in the Intermix. This estimate of structure exposure to wildfire hazard is nearly twice the estimate using FRAP's methodology. In terms of acreage, the SILVIS methodology estimates approximately 9 million acres in the Edge and Intermix, while the FRAP methodology estimates 3.9 million acres.

The large difference in WUI classification can be illustrated with an example of California's East Bay region of the San Francisco Bay Area (Figure 11.4). The SILVIS Edge extends much further into the urban area than the FRAP WUI, which is only designated in the Fire Hazard Severity Zones. This pattern can be seen across various urban settings and likely accounts for the much higher housing unit estimates from SILVIS. Therefore, while the SILVIS WUI captures a broader pattern of development near vegetation, the FRAP WUI is designed to more narrowly identify areas where development coincides with high wildfire hazard.

Institutional Response

Effective community planning for the existing housing stock is a critical component of California's strategy to reduce wildfire risk and enhance public safety. Local planning efforts, such as the adoption of Safety Elements in general plans, the development of Community Wildfire Protection Plans (CWPPs), and participation in voluntary programs such as Firewise USA, provide frameworks for assessing risk, guiding land use decisions, and coordinating mitigation actions. These tools, along with other state and federal programs, support communities in identifying hazards, prioritizing treatments, and improving readiness and resilience. This section describes the role of these planning mechanisms in advancing community wildfire safety across California.

Table 11.4. WUI housing units by county

County	Housing Units	% of Total County Housing Units in WUI	Edge	Intermix	Influence Zone
Los Angeles	550,569	15%	68%	32%	0%
San Diego	397,054	32%	93%	6%	1%
Riverside	222,080	26%	91%	7%	2%
San Bernardino	196,786	27%	73%	24%	3%
Orange	171,794	15%	98%	2%	0%
Ventura	111,344	38%	93%	5%	1%
El Dorado	83,377	89%	50%	47%	3%
Contra Costa	75,683	18%	86%	13%	1%
Sonoma	70,590	35%	50%	44%	5%
San Luis Obispo	64,229	52%	66%	29%	6%
Placer	59,419	35%	48%	49%	2%
Marin	54,264	49%	63%	36%	1%
Nevada	52,852	99%	30%	67%	3%
Shasta	47,571	60%	53%	41%	6%
Kern	45,167	15%	76%	19%	5%
Monterey	44,291	31%	69%	27%	4%
Alameda	42,243	7%	83%	16%	2%
San Mateo	42,153	15%	83%	16%	2%
Santa Cruz	38,259	36%	36%	61%	3%
Santa Clara	33,903	5%	70%	27%	3%
Rest of California	406,404	13%	48%	45%	8%
Total	**2,810,032**	**20%**	**72%**	**26%**	**3%**

Data Source: CAL FIRE (2025c, 2025f).

Safety Elements

Safety Elements are public documents that are required components of city and county general plans in California that address how communities prepare for and reduce risks from natural hazards, including wildfire (California Government Code § 65302[g][3]). Safety Elements are currently required in SRA and Very High FHSZ in LRA. In these areas, local governments must identify land uses and develop policies to mitigate wildfire risk. This includes planning for defensible space, emergency access, water supply for firefighting, and safe evacuation routes. The California Board of Forestry

and Fire Protection reviews the wildfire-related portions of Safety Elements in these areas to ensure consistency with state fire protection goals and regulations. CAL FIRE also provides technical support, helping jurisdictions incorporate the latest fire hazard data and best practices into their planning. Safety Elements play a central role in aligning land use decisions with wildfire risk reduction, supporting community resilience in the face of increasing fire threats.

Community Wildfire Protection Plans

CWPPs, CAL FIRE Unit Fire Plans, and the California Strategic Fire Plan work together to form a coordinated, multi-level approach to wildfire risk reduction (ⓘ11.4). At the state level, the Strategic Fire Plan provides overarching goals and guidance for reducing fire hazards and fostering resilient landscapes. CAL FIRE Unit Fire Plans translate these statewide goals into operational priorities within each of CAL FIRE's 21 operational units and six contract counties, identifying fuel treatment projects, defensible space enforcement, and fire prevention activities in SRA. Additionally, CWPPs are developed at the local or county level in collaboration with communities, fire agencies, and stakeholders. They provide fine-scale assessments of wildfire risk and identify locally prioritized mitigation strategies. When local CWPPs align with Unit Fire Plans and the statewide strategy, they strengthen funding eligibility, improve project coordination, and ensure that wildfire resilience efforts are effectively targeted across jurisdictional boundaries. Together, these plans create a tiered framework that links community-specific needs with regional and statewide fire management goals.

CWPPs are locally developed and collaboratively implemented to identify and prioritize actions to reduce wildfire risk to communities, especially those located in the WUI. CWPPs are authorized under the Healthy Forests Restoration Act of 2003 and are intended to empower communities to shape wildfire mitigation strategies tailored to their specific needs and conditions. A CWPP typically includes a definition of the community's WUI, an assessment of local wildfire risks, identification of priority fuel reduction areas, recommendations for reducing structural ignitions, and strategies for collaboration amongst local governments, fire agencies, and community stakeholders. In response to the findings of a published assessment of wildfire planning effectiveness (Zhang et al. 2025), CAL FIRE has taken steps to improve the CWPP development process. Recent updates incorporate more consistent guidance, clearer expectations for plan content, and stronger alignment with wildfire resilience frameworks such as the Fire Adapted Communities model. These improvements aim to address previously identified gaps, such as limited attention to social vulnerability, post-fire recovery, and plan monitoring, thereby enhancing the overall quality, consistency, and utility of CWPPs across California.

Indicator 11.4 shows the distribution of CWPPs and Safety Elements across the state. As of May 2025, there are 234 individual CWPPs, 127 of which are in counties with county-wide CWPPs. Of the individual CWPPs, 72% are located in High or Very High FHSZs. There are 278 jurisdictions required to have Board of Forestry and Fire Protection-approved wildfire Safety Elements. There are also 42 county CWPPs covering most regions with substantial wildfire hazard. Some counties have multiple CWPPs (e.g., San Diego) and other CWPPs cover multiple counties (e.g., Santa Cruz and San Mateo).

Firewise USA

Firewise USA is a national program that provides both a planning framework and a requirement for annual investments in reducing ignition susceptibility and mitigating risk at the local level. To become a Firewise community, a community must complete a wildfire risk assessment, develop and implement a risk-reduction strategy, engage residents through education and outreach, and document an annual investment of time or resources in wildfire mitigation. This program has grown quickly, with 990 Firewise sites in California as of August 1, 2024 (Figure 11.5). Nearly 87% of the California communities in good standing from 2005 to 2024 entered the Firewise USA program in 2017 or later. A recent analysis by Kampfschulte and Miller (2023) found that Firewise participation in California varies by region, with the Sierra Nevada and San

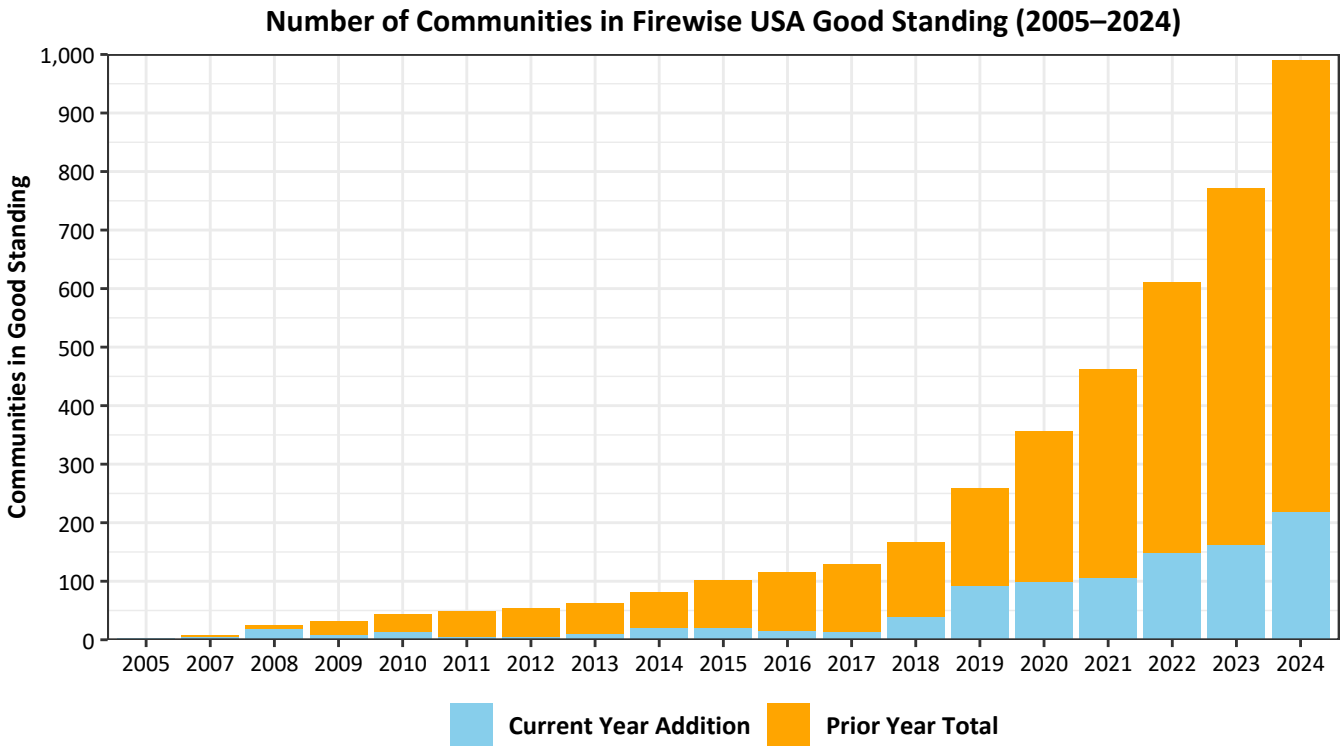


Figure 11.5. Number of communities in Firewise USA good standing as of August 2024. Data Source: NFPA (2025).

Francisco Bay Area showing the highest engagement, driven by fire history and proximity to existing Firewise sites, while northern and southern California have relatively fewer sites despite significant wildfire risks. The Bay Area tends to establish Firewise sites even in areas with mixed fire hazard levels, whereas the Sierra Nevada and sites in other regions are predominantly located in Very High fire hazard zones. Firewise communities in California are disproportionately located in whiter, older, wealthier, and more highly educated areas, while lower-income and racially diverse communities—despite facing significant wildfire risks—are underrepresented in the program (Kampfschulte and Miller 2023).

Wildfire Smoke Exposure

California communities have experienced an increase in exposure to wildfire smoke since the 2017 Assessment. Indicator 11.5, based on data from Childs et al. shows that California's exposure to wildfire smoke emissions has increased substantially over the last two decades, with a clear shift beginning in 2017. This indicator measures the number of hazardous smoke-tract days each year. A hazardous smoke tract-day is a day when a census tract (a government designated geographic area of approximately several thousand residents) experiences fine particulate matter (PM2.5) wildfire smoke exposure greater than 35 micrograms per cubic meter of air (EPA 2025). Since 2006, 86% of the hazardous smoke-tract days occurred between 2017 and 2023. While all regions of the state have been affected by smoke, the Central Valley and Central Coast ecoregions have borne the largest smoke burden.

Smoke from wildfires includes PM2.5 and other pollutants that can adversely impact public health (see Gould et al. 2024 for a review). Decades of research shows that wildfire smoke can adversely impact a number of health endpoints, including hospital admissions for respiratory and cardiovascular issues. These outcomes can be particularly acute during severe wildfire events, with recent research showing that emergency room visits increase non-linearly as smoke levels increase (Heft-Neal et al. 2023). The particulate matter in wildfire smoke is also more harmful than ambient urban PM2.5, suggesting unique toxicity related to the burning of vegetation and

structures (Aguilera et al. 2021, Mcdermott 2025). For example, Tang et al. (2025) document high concentrations of various hazardous air pollutants from structure combustion. More recent evidence from the 2025 Los Angeles County wildfires showed continued elevated levels of volatile organic compounds (VOCs) inside unburned homes within the Eaton Fire and Palisades Fire perimeters (Yao et al. 2026). This suggests a persistent public health threat long after the wildfire has ended.

Beyond immediate respiratory and cardiovascular impacts, wildfire smoke has broader health consequences, including mental health stress (Eisenman and Galway 2022), long-term chronic disease risks, and learning outcomes (Wen and Burke 2022). The smoke impacts of California wildfires extend well beyond the state. From 2007–2020, nearly half of the national exposure to wildfire smoke was due to wildfires in California (Wen et al. 2023).



Wildfire smoke from the 2020 North Complex Fire on September 9, 2020, in Oakland, California. Photo: CAL FIRE.

Wildfire smoke has disproportionate impacts on certain groups of individuals. Vulnerable populations, such as children, the elderly, and those with pre-existing conditions, are particularly at risk. Casey et al. (2024) examines long-term exposure to wildfire-generated PM2.5 in California from 2006 to 2020, focusing on disparities across racial/ethnic groups and socioeconomically disadvantaged communities. Using multiple metrics—including weeks with elevated PM2.5, peak exposure concentrations, and "smoke waves" (periods of consecutive days with high wildfire PM2.5)—the researchers found that while statewide disparities were not consistent across all groups or years, certain populations faced disproportionate exposure. In particular, non-Hispanic American Indian and Alaskan Native communities experienced higher wildfire PM2.5. Adverse health impacts extend beyond morbidity outcomes. Two recent studies have quantified the impact of wildfire smoke on mortality. Connolly et al. (2024) focused on California, estimating that between 52,480 and 55,710 premature deaths from 2008 to 2018 were attributable to wildfire-related PM2.5. The study employed wildfire-specific health responses, highlighting that prior research likely underestimated the health impacts of prolonged smoke exposure. Qiu et al. (2024) estimate 13,810 excess deaths attributable to wildfire smoke in California from 2011–2020, and predict an increase of 202–313% in the future due to climate change.

Taken together, these findings highlight the growing threat that wildfire smoke poses to public health in California. The frequency and intensity of hazardous smoke exposure has increased markedly since 2017, with significant geographic disparities and disproportionate impacts on vulnerable populations. Mounting evidence links wildfire smoke not only to acute respiratory and cardiovascular events, but also to long-term health consequences, including premature mortality. As climate change continues to drive more severe and frequent wildfires, the burden of smoke exposure is likely to grow, underscoring the urgent need for integrated strategies that reduce wildfire risk, mitigate smoke impacts, and protect the health of all Californians, especially those most at risk (see additional discussion in Chapter 3, Urban Forestry).

Evacuation Vulnerability

Assessing community vulnerability is crucial for effective evacuation planning in the face of wildfires, ensuring the safety and well-being of residents in hazardous areas. Evacuation models focus on real time decision making and emergency management (e.g. Collins et al. 2013, ODU 2013). Model types include a mix of traffic simulation, pedestrian movement, human behavior, and fire spread modeling (Ronchi et al. 2017). All the models involve the movement of many people away from fire subject to a time constraint. The models are intended to represent evacuee decision making, assist decision making, and improve public safety.

Evacuation models integrate input layers consisting of people's evacuation response, people's movement, and traffic movement in parallel with fire spread modeling (Ronchi and Gwynne 2019). People's evacuation response addresses the factors that influence human decisions to evacuate that shape when people choose to leave based on the information and instructions received (Thomas et al. 2025). The movement of people on foot to a place of safety, such as a private or shared vehicle, represents people movement modeling, which is a key input into traffic modeling, since it explicitly represents departure time of the vehicles (Duives et al. 2013). Traffic modeling typically includes generating trips, distributing them, choosing travel modes, and assigning traffic to roads (Ronchi and Gwynne 2019).

Traffic modeling is a key aspect of wildfire evacuation because it helps estimate evacuation times and identify bottlenecks. For example, a Colorado Springs study used a modified travel model to predict bottlenecks and improve traffic control (de Araujo et al. 2014). Similarly, some studies combine fire and traffic models to set evacuation triggers based on real-time fire spread and road congestion (Li et al. 2018). Dye et al. (2021) reported that the most vulnerable towns in Oregon and Washington are those with poor road networks overlapping areas with high fire hazard.

A broader review of wildfire evacuation modeling identifies key research gaps, such as the need for better integration of fire progression, real-time communication systems, and traffic flow dynamics (Beyki et al. 2023). Some studies suggest that incorporating social media data into evacuation modeling could help predict decision-making behaviors more accurately (Jones and Faas 2017, Nguyen et al. 2019). Furthermore, there is a call for more open-source tools to assist emergency planners in refining evacuation strategies (Li et al. 2015). Better data and information on people's behavior and decisions during wildfires (Jones and Faas 2017), traffic simulations (Murray-Tuite and Wolshon 2013), and vulnerable populations (NRC 2007, Paveglio et al. 2016, Zheng 2023) would improve public safety, as well as improve evacuation communication during wildfire events. Funding this type of information would improve our understanding of disaster resilience and risk management (NRC 2012).

Insurance

Increasing wildfire frequency and severity in California have placed significant pressure on the state's insurance markets. As wildfires become more frequent and intense, insurers are facing higher claims payouts, which in turn drives up premiums and reduces coverage availability in high-risk areas. Recent research has shown that this insurance instability is driven not only by wildfire hazard, but by limitations in existing models of risk that inadequately account for structure-to-structure fire spread in the built environment. This has led insurers and reinsurers to reassess the insurability of wildfire-exposed communities (Thompson et al. 2025). Homeowners in wildfire-prone regions are finding themselves unable to secure or afford standard homeowner's insurance, forcing some to rely on more expensive or limited coverage options, such as the state-backed California FAIR Plan. As of March 2025, the FAIR Plan had approximately 574,000 policies, up from 240,000 in 2021. These insurability challenges leave many homeowners vulnerable to financial loss and exacerbate the difficulty of rebuilding in affected areas.

Hazard and risk modeling plays an important role in determining how insurance markets work in the state. When models indicate higher expected losses than are manageable under approved rate structures, companies may choose not to renew existing policies, not

write new policies, or withdraw from the market altogether. Improved modeling may offer a partial solution to some of the state's insurability challenges. For example, moving towards fine-scale parcel-level risk modeling, instead of rating entire ZIP codes or counties, can possibly capture property-specific risks and reduce blanket non-renewals and incentivize mitigation. While insurance models encompass a variety of modeling strategies, scales, and components, current models do not capture parcel specific mitigations that have been shown to effectively reduce ignition potential (CAL FIRE 2023).

The California legislature enacted Senate Bill (SB) 429 (Cortese 2025), establishing the "Wildfire Safety and Risk Mitigation Program" under the California Department of Insurance (CDI). The program requires the state to develop, demonstrate, and deploy a Public Wildfire Catastrophe Model to serve as an independent benchmark in regulatory proceedings. Public investment in open, credible wildfire risk models could potentially support both fairer pricing and stronger market participation.

Improved wildfire risk models can also make insurance more predictable for both insurers and homeowners. For insurers, improved modeling can allow for more accurate pricing of risk, while for homeowners, it would send clearer signals about which mitigation efforts matter and provide greater access to coverage if risk reduction efforts are recognized.

OPPORTUNITIES

The following is a summary of opportunities discussed in the chapter to reduce costs and losses from wildfire.

Reducing Structure Loss and Exposure to Wildfire Hazard

- Incentivize home hardening through grants, rebates, or insurance discounts. Continue to enhance and support the CAL FIRE Defensible Space Inspection Program to educate and assist homeowners in correcting problems that could put them at risk from wildfire.
- Enforce and continue to update building codes in hazardous areas to reflect best practices in wildfire-resistant construction.
- Retrofit existing housing stock in high-risk areas, particularly homes built before WUI codes were adopted.
- Encourage strategic fuel breaks near communities in partnership with local fire agencies, state agencies, federal agencies, utilities, and landowners.
- Invest in more transparent, parcel-level wildfire risk models that recognize mitigation measures allowing insurers to price risk more accurately and homeowners to maintain access to affordable coverage.

Enhance Community Planning for Wildfire

- Expand and strengthen CWPPs and ensure alignment with county Safety Elements and CAL FIRE Unit Plans.
- Support local capacity for planning and implementation, particularly in resource-constrained rural or tribal communities.
- Improve interagency coordination between land use planning authorities and fire agencies when reviewing new developments.
- Ensure WUI maps and hazard designations are regularly updated to reflect the latest science.
- Research how current state and local policies may influence incentives for development in wildfire prone landscapes.

Reducing Public Health Impacts from Smoke Exposure

- Invest in clean air centers and HVAC filtration for vulnerable populations and explore opportunities for investments that reduce smoke exposure at work and home.
- Continue to improve public health messaging on smoke risks and protective actions, including targeted outreach during smoke events.

- Support land management actions, including fuels reductions and the use of prescribed fire where ecologically appropriate, that reduce the risk of large, long-duration wildfires and associated smoke exposure, while incorporating strategies to minimize short-term smoke impacts on communities.

Addressing Evacuation Vulnerability

- Improve evacuation route planning and clearly communicate evacuation zones, particularly in communities with limited ingress/egress.
- Develop a diagnostic framework to identify and categorize evacuation vulnerability across communities, accounting for differences in the road network structure, population density, development patterns, and proximity to wildfire hazard.
- Enhance early warning systems and communications networks, including multilingual and accessible alerts.
- Support planning for at-risk populations, such as residents without vehicles and medically vulnerable individuals.

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