FIRE RESILIENT DEVELOPMENT:
HOW SCIENCE-INFORMED COMMUNITY PLANNING CAN CONTRIBUTE TO HOUSING AFFORDABILITY IN CALIFORNIA

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Executive Summary

For decades, California has faced a deepening housing crisis. While housing availability and affordability have long been statewide priorities, climate change-accelerated wildfire losses are rapidly contributing to a decline in the supply of existing housing units and instability in the insurance market, constraining new development and increasing the cost of housing statewide.

While there are often good reasons to limit new development in the wildland-urban interface (WUI), such as the preservation of recreational opportunities or cultural, historic, or natural resources, we argue that wildfire risk is rarely a reason not to build in a particular area. Thoughtfully designed master-planned communities engineered to match local wildfire behavior and parcels adhering to modern ignition-resistant building and landscaping standards can be both highly resilient to wildfire exposure and help reduce regional wildfire risk. In this position paper, we discuss the role of science-driven planning and development in wildfire adaptation at the parcel, neighborhood, and regional scales and outline a path to limiting wildfire-caused losses while increasing housing availability and affordability. Moreover, we argue that thoughtfully designed resilient communities can lead to improvements in the availability the availability of accurately priced insurance products throughout the western United States.

Introduction

By all metrics, wildfire activity and losses in California and other Western states are rapidly increasing. Fires are becoming bigger, more frequent, and more intense. Perhaps most importantly for community planning, wildfires are becoming faster[1]. Fast-moving, wind-driven fires resulting from ignitions near communities are those most likely to result in large-scale urban loss. Indeed, despite accounting for only 2.7% of fires on record, fast-moving wildfires were responsible for more than 88% of the homes destroyed in the western US between 2001 and 2020[2]. These climate-change-driven trends are representative of fire activity across the western United States, where both burned area and structure losses are rapidly increasing.

The increasing frequency of city-scale disaster fires has direct consequences on the housing economics in California and other Western states. Wildfire-caused structure losses directly reduce the number of housing units in already housing-limited communities[3] and exacerbate long-standing housing shortages as displaced residents compete for scarce units[4]. Moreover, wildfire losses are increasingly causing admitted insurance markets[5] to reduce or eliminate coverage in high-risk areas. The resulting impacts to property sales, home values[6], and long-term mortgage markets[7] are creating are creating unstable insurance markets that struggle to accurately price home insurance[8,9]. Together, these factors make home ownership and access to rental units more difficult and increasingly expensive in many parts of the state.

Developers are often hesitant to construct new developments in areas with high wildfire risk. A potential lack of insurability raises concerns that newly constructed units will not sell or will be prohibitively expensive[4]. Further, frequent calls to limit development in fire prone areas reflect the widely held belief that new new development in the WUI will increase the regional risk of wildfire losses[10,11] through structure-to-structure fire spread[12]. In California, recent legislative efforts[13,14] have been proposed to limit new development at the vegetative edge, citing ember deposition and cascading ignitions from the new structures that could expose existing communities to increased wildfire activity. These concerns further increase the difficulty of creating a sufficient supply of affordable, accessible housing in many of California's populated areas.

Risk Mitigation in a Fire-Prone Environment

California's ecosystems are fire-adapted and fire-dependent. Fire is not only inevitable in these landscapes, but required for healthy ecosystem regeneration and function[18]. There is strong evidence of frequent, low-severity wildfires across the state prior to European settlement[15]. These fires reduced fuel loads, provided opportunities for seedling regeneration, and created natural disturbances that promoted healthy forest growth. Fire acted as nature's primary regulatory measure to keep the landscape in balance. Because contemporary fire suppression policies have limited the size of fires in much of the state, fuel loads have increased substantially over the past century, resulting in a greater availability of vegetative fuel. Climate change-driven changes in atmospheric moisture balance in the last several decades are further contributing to extreme fire behavior across the state with future increases all but certain[16]. Despite the use of aggressive suppression tactics with modern firefighting equipment and advanced alerting systems, further increases in fire frequency and severity are projected as the state's landscapes equilibrate to contemporary conditions. More simply, over the next several decades, a century of accumulated fuel is poised to burn under warmer, drier conditions more conducive to rapid fire growth than at any other point in human history.

Many of California's communities are located in or adjacent to wildland fuels. Nearly 45% of the homes built in California between 1990 and 2020 were built in the WUI and more than 80% of the state's wildfire losses have been in this area[9,17]. Because of California's long-standing housing shortages, there are integrated social, economic, and political factors operating at both the state and local levels that often push new housing into undeveloped areas likely to be exposed to future wildfires[14,15,16].

When new homes are placed in or adjacent to areas of combustible vegetation, there is strong experimental, theoretical, and observational evidence supporting the position that housing development projects that create fire-adapted neighborhoods can withstand wildfire exposure. This is achieved in part with structures constructed to meet modern WUI building codes and neighborhoods that integrate community-scale wildfire protection measures such as the strategic placement of low- and non-combustible landscape features like parks, water features, vineyards, and orchards[19]. Communities with a combination of new structures built to the California Building Code Chapter 7A standard[20] or the International WUI Code, those that create and maintain defensible space around the community and individual buildings, and those with strategically located landscaping elements, survive at much higher rates than communities with older buildings that lack on parcel and community-scale wildfire mitigations [21,22,23].

Risk mitigation measures are most effective when applied in a systematic, layered approach. Distributed, uncoordinated risk reduction activities undertaken by individual homeowners leave gaps that result in contiguous vegetative and structural fuel corridors, limiting mitigation effectiveness and increasing the residual risk of structure-to-structure ignition cascades. Although defensible space and home hardening are effective in preventing structure ignition from vegetative fuels and embers, they are not designed to protect against the heat fluxes produced by adjacent burning buildings. In dense neighborhoods, structure loss due to urban conflagration can still occur even when defensible space and home hardening measures are implemented on some parcels, because wildfire mitigation and construction features are not designed to withstand the increased heat fluxes associated with adjacent structure fires. Therefore, it is important that communities undertake comprehensive and complementary risk mitigation strategies that minimize the likelihood of initial structure ignition and subsequent urban conflagration initiation. The most effective way to increase resilience and reduce residual fuel corridors is to develop and implement a strategic plan that addresses the neighborhood's unique risk factors and ensures high compliance across all parcels with wildfire exposure.

Figure 1: Rancho Santa Fe, California which incorporated fire-adapted features and withstood wildfire exposure[19].

The Master Planned Development as a Blank Slate for Effective Mitigation

In existing developments, the comprehensive and strategic implementation of systematic wildfire adaptation measures can be exceptionally challenging due to fragmented land ownership, limited financial resources and resident motivation in support of change, and inadequate communication and coordination among stakeholders. Furthermore, existing communities often have limited capabilities to install new design features or relocate existing ones; it's not easy to reposition a park in a 100-year-old community.

In contrast, new, thoughtfully planned developments provide a blank slate where wildfire risk mitigations can be implemented from the ground up. Using readily available fire behavior modeling and weather history, science-guided planning (SGP) can be used to develop a comprehensive assessment of risk, evaluate potential mitigation strategies, and identify and locate key mitigation features and low-combustibility community amenities in a manner that is both desirable for resident use but also disrupts the vegetation-to-structure transition points that propagate fire into the community. SGP can also help design interior and perimeter vegetation planting locations, types, and arrangement that reduce fire behavior across the site, decreasing the risk of high-severity fire encroaching into the development and minimizing the consequences of ember-caused spot fires adjacent to homes. The mitigation measures identified by of the SGP process are tailored to the development's unique risk factors and address the specific fuel types, fuel corridors, and regional fire weather threatening the development.

New developments can also leverage legal and regulatory processes to ensure ongoing funding and mandates for enduring wildfire mitigation. For example, newly established homeowners associations (HOAs) and the associated legally binding agreements, such as Covenants, Conditions, and Restrictions (CC&Rs), can be used to provide a durable mechanism for ensuring widespread compliance with defensible space within the community and to address the gaps in coordination faced by existing communities. Such process-based approaches to mitigations can help educate the community residents while preventing the accumulation of new vulnerabilities over time, such as combustible backyard furniture, play structures, and parked vehicles near homes that were not accounted for in the original plan.

Most communities, both master-planned and traditional, incorporate recreational and commercial amenities. Traditionally, little consideration has been given to the location of these landscape features in relation to fire resilience. However, if sited properly, these low-combustibility or non-burnable features can serve a dual purpose by (1) creating a buffer between wildland vegetation and the adjacent homes and (2) providing residents with an enjoyable and functional amenity. For example, common features such as dog parks, sports fields, orchards, parking lots, commercial districts, and maintenance yards can be strategically located along the edge of the development, at the points of transition where the fire is most likely to enter the development. These design choices reduce the likelihood that ground fire will come into contact with tightly spaced homes where there is the likelihood of subsequent structure-to-structure fire spread. In conjunction with other mitigations, such as a system of roads or trails that reduces fuel continuity on the periphery of the community and a network of traditional fuel modifications that reduces fuel volume and spotting potential upwind, strategically planned amenities can act as buffers that absorb heat energy that would otherwise be transfered to homes.

To meet the density requirements needed to create affordable, non-luxury communities, new developments often must site buildings with structure separation distances below those known to support structure-to-structure fire spread[20,21]. However, with a systematic approach to fire-resilient design, master-planned communities can create compartmentalized high-density blocks separated by low-combustibility vegetation and amenities. This approach to interior compartmentalization limits fire spread to discrete blocks, reduces the overall potential for conflagration and structure loss in the community, and increases the effectiveness of firefighting resources by limiting the size of conflagration blocks.

Science-Guided Planning for Fire Resilient Design

Recent advances in fire behavior modeling present opportunities to integrate fire science and data-informed mitigation strategies into the planning process. While there are still, and likely always will be, gaps in the scientific understanding of the timing and mechanisms of fire spread within the built environment, new models of fire behavior in the built environment have been shown to be highly predictive in identifying the combinations of building and landscape features responsible for large-scale structural losses[26].

In the following example, we utilize the XyloPlan Urban Fire Spread Model to characterize the differences in regional fire activity and associated structural loss outcomes under three different development scenarios involving the construction of a new planned neighborhood. This model incorporates fire spread via convective and radiant heating, embercast, and surface fire spread from both structures and vegetation. This model performed well when retrospectively modeling past fire outcomes, including the 2025 Eaton fire. Perhaps most importantly, it is flexible and highly configurable, enabling iterative development of highly resilient community wildfire mitigation and compartmentalization plans. In the figures below, we illustrate a hypothetical development in the Inland Empire, in southern California. This modeling exercise is designed to highlight the role SGP can play in the community design process, rather than any particular community. A strong, dry west wind fire weather scenario is used to illustrate the potential for fire spread from an open space into the community.

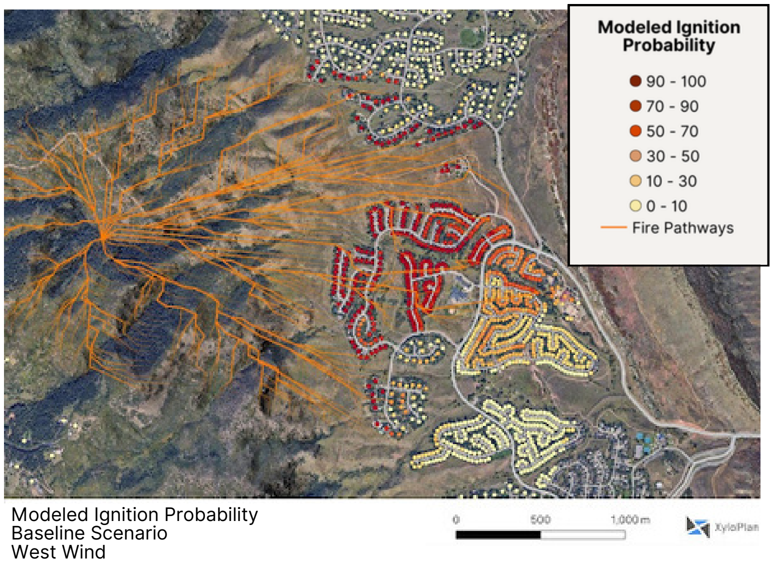
Location
Riverside County, CA

Wind Speed
25 MPH

Wind Direction
West Wind

Duration
3 Hours

Figure 2: Baseline Development Scenario with No Design Features



This development follows a traditional design where homes have tight structure separation distances, structures have direct connectivity to wildland vegetation, and lack compartmentalization that can limit fire spread within the built environment.

90 Minutes	120 Minutes	150 Minutes	180 Minutes
23 Structures	99 Structures	258 Structures	448 Structures

Figure 2 illustrates the modeled structure ignition risk to a hypothetical legacy community with traditional exurban design principles. While this community is hypothetical, it is representative of traditional neighborhoods that built without wildfire consideration and lacking passive wildfire risk mitigation measures. These communities rely exclusively on the availability of responding firefighters to prevent large-scale structure loss. This community is characterized by high-density homes that have little to no separation from either the surrounding wildland fuels or from adjacent structures. This design has limited inherent resistance to wildfire, facilitating a rapid transition from vegetation to the built environment with high subsequent potential for structure-to-structure spread.

In this hypothetical west wind scenario, the community experiences 448 (± 96.3[22]) ignited structures within the first three hours of the simulated wildfire. After fire transitions from vegetation to the built environment and becomes established in the tightly spaced homes, subsequent fire spread is driven by structure-to-structure fire dynamics[23]. Embers originating from the burning structures play a critical role in sustaining the conflagration by facilitating new ignitions ahead of the main fire front in as-yet-unignited blocks. These embers can bridge gaps in contiguous combustible material and ignite structures that initiate cascading ignitions due to extreme radiant heat impacting neighboring structures on the block. Ember caused ignitions take additional time to ignite structure and result in slower initial spread than unconstrained direct structure-to-structure fire spread.

Box 1 : Modeling Fire Spread in the Built Environment

Given a graph $G = (V, E)$, where V is the set of fuel sources in the modeling domain and E is the set of edges representing potential fire pathways between these sources, fire spread in the domain can be modeled by iteratively selecting the highest-probability pathways at each timestep. Fuel sources, V, encompass both structures and vegetation, facilitating an interplay between vegetation, low-density development, and high-density urban environments. Fire pathways, E, between sources include radiant and convective heat between fuel sources, direct flame impingement, and embercast. At each timestep, the probability of ignition via a given pathway is a function of the conditions at the source fuel source, the length and characteristics of the pathway, and the conditions at the target fuel source. Structures can be hardened against one or more of these fire pathways, limiting their capacity for fire spread.

Mathematically, fire may spread from node i to node j via three mechanisms:

- Radiant or convective heat transfer R,
- Direct flame impingement F,
- Embercast E

Each pathway $(i, j) \in E$ has an associated ignition probability at time t:

$$p_{ij}(t) = p_{ij}^{(R)}(t) + p_{ij}^{(F)}(t) + p_{ij}^{(E)}(t)$$

where each term corresponds to one of the transmission mechanisms. These probabilities depend on:

- Source conditions (e.g., fire intensity, duration, ember production),
- Pathway characteristics (e.g., distance, wind speed and direction, slope),
- Target susceptibility (e.g., fuel type, hardening state)

For structural fuel sources, define a hardening vector that describes the structure's resistance to ignition for each fire pathway.

$$\mathbf{H}_j = [h_j^{(R)}, h_j^{(F)}, h_j^{(E)}] \in [0,1]^3$$

Each component of $\mathbf{H}_j$ describes the level of resistance to the corresponding fire spread mechanism (1 = fully resistant, 0 = no resistance), such that the structure's ignition from that mechanism can be computed:

$$p_{ij}^{(m)}(t) = B_{ij}^{(m)}(t) \cdot (1 - h_j^{(m)})$$

where $B_{ij}^{(m)}(t)$ is the baseline ignition potential via mechanism m, determined by the fire behavior at node i and the environmental conditions along the path to node j at time t.

At each timestep, we calculate the probability that a fuel source j ignites based on the characteristics of adjacent fuel sources. The probability that source j ignites at time t + 1 is computed as

$$\pi_j(t+1) = \prod_{i \in \mathcal{N}_j} (s_i(t) \cdot p_{ij}(t))$$

Where:

- $\mathcal{N}_j$ is the set of nodes with a fire pathway to j
- $s_i(t) \in \{0,1\}$ indicates whether node is burning at time t,
- $p_{ij}(t) \in [0,1]$ is the probability that fire spreads from i to j.

The ignition outcome for node j is then sampled from a Bernoulli distribution to reflect the probabilistic nature of the ignition event:

$$s_j(t+1) \sim \text{Bernoulli}(\pi_j(t+1))$$

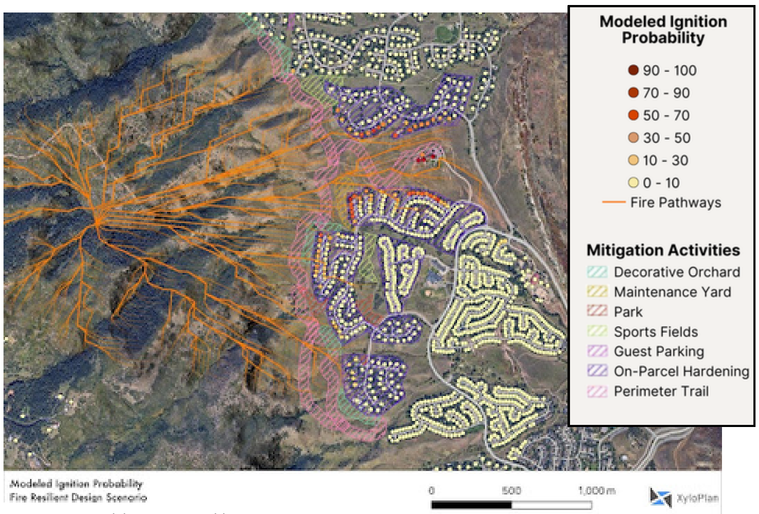
Because the hardening state $\mathbf{H}_j$ impacts the spread probability of $\pi_j(t+1)$, this formulation allows for targeted risk reduction by adjusting specific components of $\mathbf{H}_j$. For example, ember-resistant vents reduce $h_j^{(E)}$, while defensible space reduces $h_j^{(F)}$, $h_j^{(R)}$, and $h_j^{(E)}$.

Structure Ignition Risk is Reduced through Mitigation

When comprehensive and systematic mitigations are implemented at the neighborhood scale, the risk of large-scale urban fire in this community is projected to be much lower. Figure 3 illustrates the modeled risk for a community with a similar built environment footprint that incorporates a series of layered passive fire mitigation measures, including home hardening and defensible space, strategically placed fire-resistant amenities, and a perimeter trail system that decouples the community from ground fires. This community is substantially less susceptible to wildfire-initiated urban fire losses: not accounting for firefighting response, this second community is projected to experience 141 ± 30.4 structure ignitions within the first three hours, or approximately 30% of those in the traditional community.

Because of the widespread structural hardening and a robust non-combustible zone on each parcel modeled in this scenario, each structure is significantly less likely to ignite when exposed to embers launched from upwind burning structures and vegetation. Moreover, low and noncombustible amenities, such as orchards, sports fields, and parks, buffer the homes from direct exposure to surface fire spread and compartmentalize the built environment, limiting the extent of structure-to-structure fire spread potential. Finally, the perimeter trail system decreases the continuity of the fuels as the fire approaches the community, slowing its approach.

Figure 3: Design Scenario with Systematic Mitigation Design Features



This development integrates the house-out mitigation approach with strategically located low-combustibility amenities and a perimeter trail system.

Modeled Ignition Probability
Fire Resilient Design Scenario
West Wind

90 Minutes	120 Minutes	150 Minutes	180 Minutes
<1 Structure	22 Structures	81 Structures	141 Structures

Table 1 : Estimated structure ignitions at each timestep after the modeled ignition.				
	90 Minutes	**120 Minutes**	**150 Minutes**	**180 Minutes**
Baseline Design	23 ±3.1	99 ±22	258 ±63.1	448 ±96.3
Fire Resilient Design	0.3 ±0.5	22 ±3.8	81 ±8.4	141 ±30.4
Change	-98.7% ± 13.5%	-77.8% ± 31.4%	-68.6% ± 39.8%	-68.5% ± 38.1%

Table 1 highlights the differences in cumulative structure ignitions projected under each of the two design scenarios. In the baseline community, the number of ignited structures increases exponentially as the fire reaches the built environment, reflecting the nearly immediate transition of the fire from vegetation into the built environment and subsequent rapid urban fire spread among closely spaced structures and interior landscape elements. While the risk is not eliminated in the fire-adapted design scenario, fire spread is slowed, providing more time for the aggregation of an effective firefighting response and community evacuation.

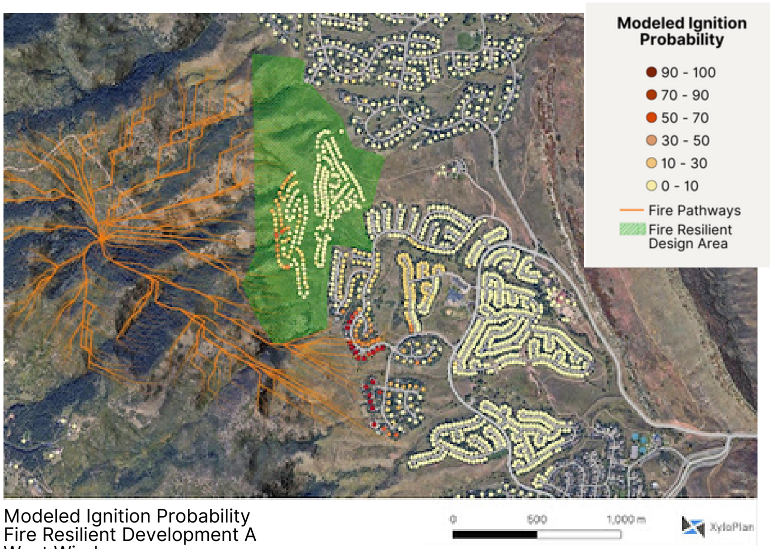
While firefighting actions are not explicitly modeled due to the many on-site decisions made during the response, our collective firefighting experience suggests that an average of less than one ignited structure after 90 minutes would enable sufficient firefighting resources to arrive on scene in most locations. These resources would be very likely to successfully contain the fire by interrupting downwind ignitions and prevent subsequent cascading losses as shown in the unmitigated model.

New Development Can Reduce the Risk to Adjacent Communities

As shown in Table 1 and borne out in fire-adapted communities around the West, the complete implementation of on-parcel and community mitigations, complemented by community-level design choices, is highly effective at reducing the consequences of a wildfire exposure. However, partial implementation, where only some mitigation components are put in place, leaves gaps that severely limit the overall effectiveness of the risk mitigation strategies. Fire is opportunistic and exploits residual vulnerabilities in parcel and community-level design, leaving significant conflagration risks when the risk mitigation is incomplete. In an urban/suburban context, these residual vulnerabilities represent an opportunity for the initiation of urban fire, where structures are the primary fuel and wildfire specific mitigations are inadequate[24]. As a result, partial wildfire risk reduction measures are often fully inadequate. Unfortunately, achieving this level of mitigation is often beyond the realities of community resource constraints and/or the willingness to undertake changes, meaning that, for practical purposes, widespread and systematic mitigations are very difficult to achieve in legacy neighborhoods.

Modeling suggests that new, fire-adapted developments can serve as durable non-burnable barriers or firebreaks, disrupting fire pathways and de-coupling existing communities from vegetative fuels resulting in a reduction in the regional risk of wildfire loss. Although new development in fire-prone areas places new homes adjacent to combustible wildland fuels, these communities, even when built with high-density, tightly spaced structures, can have substantially lower ignition risks than their existing, lower-density counterparts when designed using an SGB approach. With the complete suite of mitigations described above, each structure in the community, particularly those along the wildland's edge, has substantially less relative risk of ignition than existing structures in existing communities. Further, the community design, inclusive of perimeter fuel modification approaches, can be tailored to reduce the absolute risk of reduction at a given time to acceptable levels. Although low-density, single-family design is often promoted as the most effective way to prevent large-scale wildfire impacts in new developments[25], the thoughtful use of clustering, compartmentalization, and non-combustible spaces can allow higher structure densities while limiting the potential for significant structure-to-structure fire activity in the built environment. Furthermore, clustering structures into dense defensible compartments decreases the length of the perimeter, reducing the extent of perimeter fuel mitigation areas required to achieve adequate coverage and also increasing the effectiveness of the firefighting response. During the early stages of a wind-driven fire, dense communities allow firefighters to operate more effectively due to the smaller operational surface area.

Figure 4: Modeled Ignition Probability of Hypothetical Developments



Modeled Ignition Probability
Fire Resilient Development A
West Wind

Modeled ignition probability of two hypothetical new developments on the edge of the existing community designed using DSAP. Note the low ignition probability in the existing portion of the community compared to the baseline scenario, shown in Figure 2.

90 Minutes	120 Minutes	150 Minutes	180 Minutes
<1 Structures	2 Structures	14 Structures	52 Structures

Figure 4 illustrates the modeled ignition potential for two potential new development plans located upwind of the hypothetical, traditionally designed scenario presented above. These two hypothetical master-planned communities each contain 243 structures, compartmentalized into two blocks. Each is designed with targeted vegetation management around the community, as well as the full suite of home hardening and defensible space mitigations on each parcel. The differences in the two developments is their spatial layout relative to the prevailing wind and the existing community. In these scenarios, no wildfire mitigations are modeled in the existing community.

Table 2: Ignition probabilities for structures in the three hypothetical communities.

	Traditional Development	Development A
Risk of Homes in Development Area	31.2%	4.2%
Regional Risk in Existing Downwind Community	31.2%	2.9%

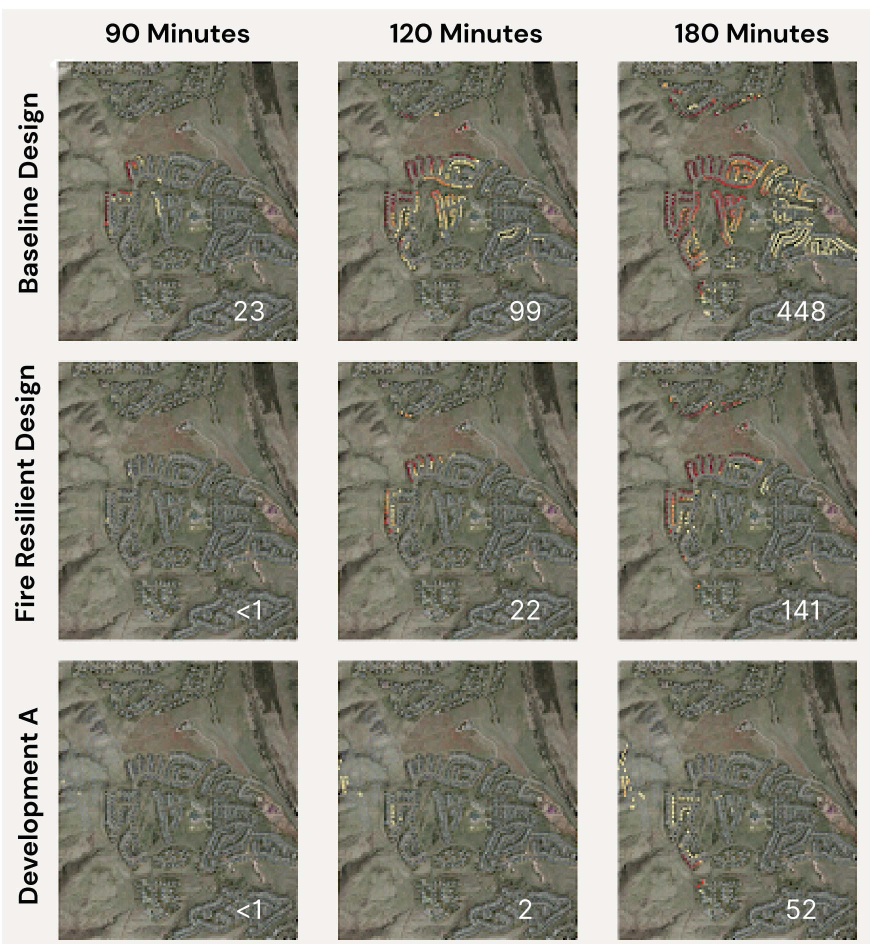
The ignition risk of structures in the new fire-resilient developments is not zero; however, it is anticipated to be very low due to the limited ways for structures to ignite after the comprehensive mitigation plan. Indeed, as shown in Table 2, the modeled ignition risk of the average structure within the new resilient development is less than 20% of the average ignition risk in the baseline community. Moreover, and perhaps more importantly, the resilient developments reduce the likelihood of structure ignition in the existing downwind community, even when no mitigations are performed in that community. Development Plan A (Table 2) reduces the ignition probability in the downwind community by 91%. The differences in structure ignition risk between baseline and Development A highlights the opportunity represented by integrated fire planning when designing fire-adapted communities that meet both regional housing supply targets and fire resilience objectives.

Risk Reduction and Fire Response Times

While strategically located community- and parcel-level mitigations result in direct reductions in the likelihood of structure ignition, their primary purpose is to slow the fire's progression, providing additional time for firefighters to arrive and initiate defensive actions. In a hypothetical setting where the wind did not stop and firefighters did not respond, given enough time, the most extreme wildfire scenarios will result in near-total destruction of even of the most resilient communities. However, in the real world, all critical fire weather wind[26] events are time limited[27,28] and a regional firefighting response is en route. As such, by taking actions to both increase the time required for fire to reach a community and also increasing the time required for wildfire to transition to urban fire, mitigations allow for the arrival of additional firefighting units and reduces the available, and finite amount of time during which fire can burn under extreme weather conditions.

Figure 5 shows the probability of structure ignitions at several points in the incident lifecycle for the traditionally designed community, the resilient design community, and the new, master-planned development upwind of the existing community. Note that both the locations of greatest fire activity and the number of structures ignited at each timestep vary between the three different designs as fire finds and exploits vulnerabilities.

Figure 5: Structure Ignition Probabilities Comparison



Structure ignition probabilities for three different community designs at three different time steps in the incident lifecycle.

Modeled Ignition Probability

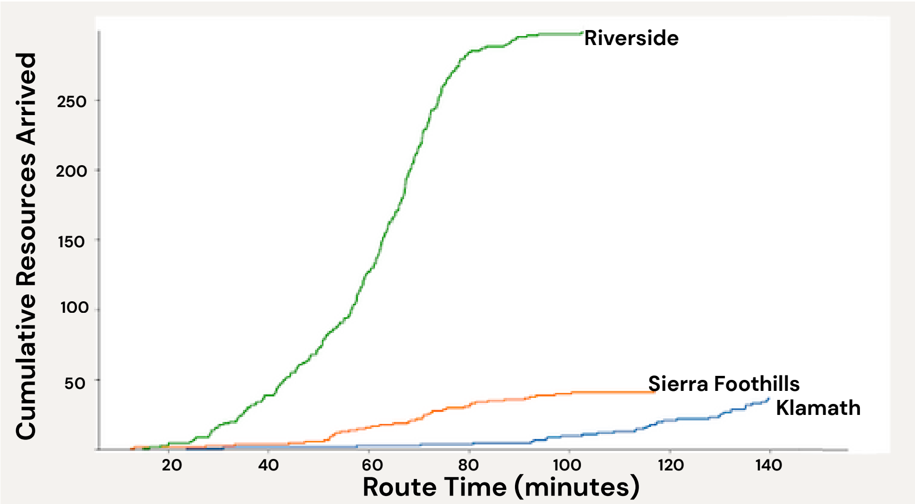
- 90 - 100
- 70 - 90
- 50 - 70
- 30 - 50
- 10 - 30
- 0 - 10

Careful analysis of regional fire response time highlights the ways in which the pace and scale of fire spread through the built environment within a community interact with the pace, scale, and capabilities of arriving regional fire resources. When the availability of the regional firefighting response exceeds the scale of fire spread, firefighters are very likely to prevent the initiation of an urban fire. Conversely, when there are insufficient firefighting resources at the critical place and time[29] capable of matching the scale of the incident, fire is likely to exploit the community's weaknesses and urban fire may be initiated.

Response capabilities vary greatly by region; locations near metropolitan population centers tend to have access to more and more varied firefighting resources with shorter response times. In contrast, rural communities located further from urban centers generally have access to fewer resources, many of which will take additional time to mobilize and orient, due to limited mutual aid agreements and longer travel times[30]. Figure 6 shows an example of the estimated cumulative fire response curves for three locations in California - the Klamath watershed in northern California, the southern Sierra foothills, and western Riverside County. Due to its proximity to the Los Angeles and San Diego metropolitan areas, the Riverside location has access to numerous responders very quickly.

The amount of mitigation required to achieve wildfire adaptation for a given community varies significantly based on the availability and timing of regional resources. Communities should plan their pre-fire mitigations to, at a minimum, strike a balance between the number of resources available for fire suppression and the number of potentially involved buildings at each point in the incident lifecycle. We argue that this factor is often overlooked and should be considered an important part of a comprehensive plan to mitigate the likelihood of urban conflagration.

Figure 6: Estimated Cumulative Fire Response Times

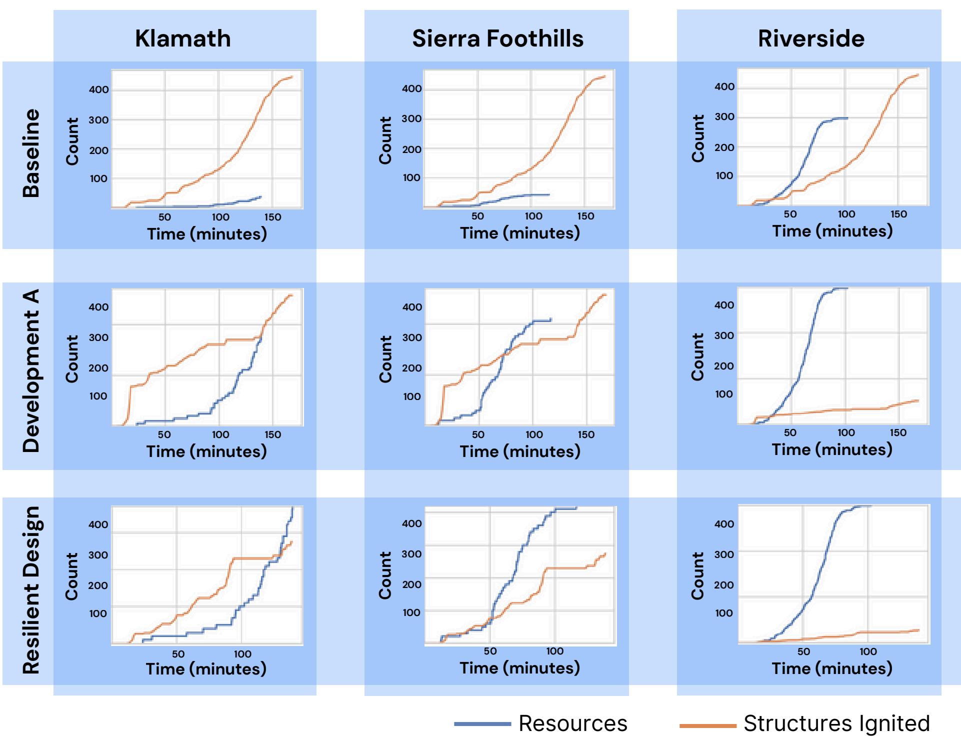


Estimated cumulative fire response times for three locations in California, chosen to illustrate the different patterns in fire response around the state.

Figure 7 illustrates the relationship between the community's location relative to regional firefighting resources and its design configuration and potential for conflagration-level fire spread. In Figure 7, each row represents a community design configuration, and each column represents one of the three locations shown above (Riverside, Sierra Foothills, and the Klamath Watershed). The blue curve shows the estimated cumulative number of firefighting resources at each point in time; the orange curve illustrates the average cumulative structure ignitions modeled at each timestep. When the blue curve (resources) is below the orange curve (ignitions), fire is likely to spread rapidly in the built environment because the fire exceeds the capabilities and availability of firefighters at that point in time.

Conversely, when the blue line is above the orange line, fire is likely to be slowed and stopped by firefighting interventions, because firefighters are available in sufficient quantities to prevent cascading ignitions and rapid spread through the built environment. The scenarios shown in Figure X clearly demonstrate the value of community design and pre-fire risk reduction activities in relation to the time required for a sufficient quantity of firefighting resources to arrive.

Figure 7: Fire Response and Ignition Curves by Design Scenario



Estimated cumulative fire response times for three locations in California and cumulative structure ignition curves for three design scenarios. From top to bottom, design scenarios include the baseline traditional design, with no risk mitigation measures, the addition of a new, fire-resilient development on the edge of the existing community, and the implementation of fire-resilient design principles within the existing community.

Risk Reductions and Insurability

New fire-adapted communities can help address regional affordable housing needs by increasing the supply of new construction. They can also reduce the wildfire threat to existing communities by forming a durable non-burnable buffer that separates vulnerable communities from surrounding areas capable of carrying wildfire. In this way, communities can reduce the actuarial risk of wildfire loss for the purpose of insurability. When insurers can confidently underwrite properties and developments with limited potential for large-scale wildfire losses, insurance becomes more available, and over time may also become more affordable.

In California and many other states, wildfire risk is shared across the market with incentives to encourage coverage in all areas[31]. The cost of insuring a parcel in a high-risk neighborhood is shared by lower-risk parcels across the state. High-risk parcels that cannot find coverage on the admitted market are often insured by FAIR plans, which represent a growing portion of coverage in many states with high wildfire losses[32]. Losses on parcels insured by these FAIR pools are shared by all admitted carriers in the state[33]. As a result, through insurance availability and pricing all communities are inextricably linked to the aggregate wildfire risk and losses across the state.

Conclusion

The wildfire crisis reflects the deep connection between wildfire risk legacy communities, housing supply and affordability, and the availability and pricing of insurance. While wildfire is an inevitable and beneficial feature of our landscape, community level loss to the resulting urban fire is not. We argue strongly against the sprawling development of low-density single-family homes in the wildland. Instead, we submit that the thoughtful construction of high-density, affordable, fire-resilient communities can withstand and strengthen regional wildfire resilience.

While residents, planners, and regulators have promoted limiting development to reduce wildfire risk, we argue that where one builds is less relevant than how one builds and that fire-adapted new developments can withstand exposure to wildfire. Indeed, resilient developments may be an efficient path to wildfire safety for existing communities that struggle to overcome the physical, financial, and motivational challenges associated with retrofitting the built environment. By incorporating fire science principles into the regional planning process and ensuring comprehensive, layered approaches to risk mitigation within the new developments, new developments help limit fire exposure and magnify the impact of local fire suppression resources.

We urge policymakers, developers, and planners to consider these factors when proposing solutions to California's wildfire-impacted housing and insurance crises.

Community Level Mitigations Rubric

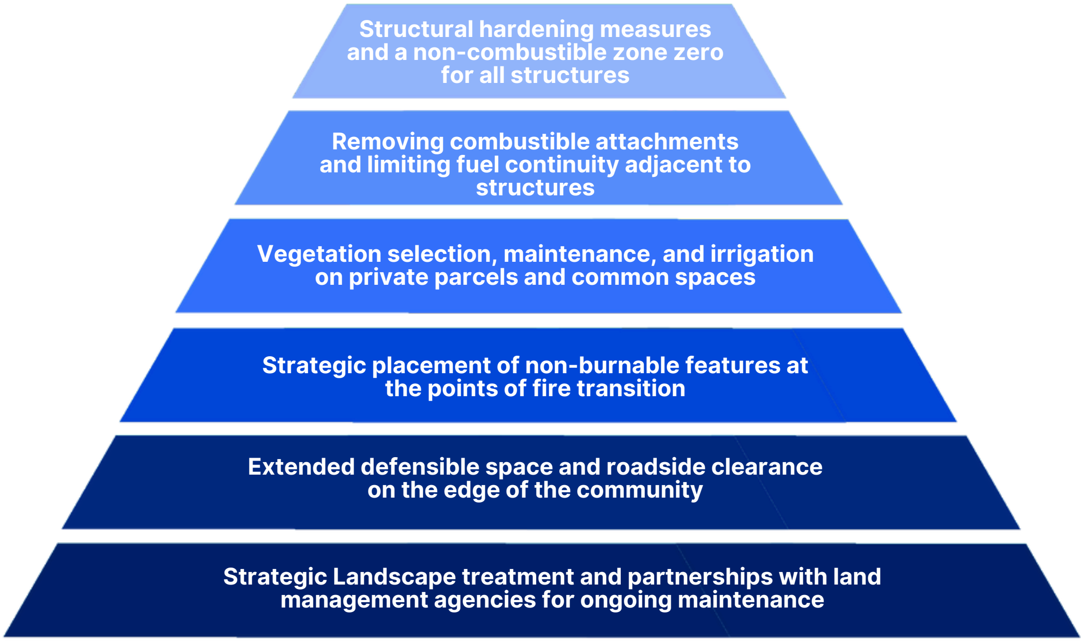
Working from the house outwards, a systematic approach includes parcel level mitigations:

- Structural hardening measures that reduce the likelihood of direct ignition, such as the use of Class A ignition-resistant roof coverings, vent screens that prevent the intrusion of embers into the attic and foundation vents, and ignition-resistant siding that prevents ignition upon direct flame contact, and double-paned, tempered windows among other features[25];
- A non-combustible home ignition zone/zone zero buffer around the home to prevent the fire from reaching the structure and reduce the likelihood of embers igniting combustible materials directly around the structure;
- Removing any combustible attachments, such as fences, carports, or gazebos, that may transmit fire to the structure from other areas of the parcel;
- Vegetation maintenance, irrigation, and clearance in areas further from the home, reducing the continuity of receptive fuel beds and ground fire behavior as it spreads towards the structure;

It also includes community level mitigations to keep ground component fire out of the built environment and reduce near community ember production:

- Effective placement of non-burnable features, such as orchards, trails, and parks, commercial areas, golf courses and water features at points of entry to interrupt fire transition to structural fuels;
- Roadside clearance and vegetation maintenance along roads and paths to create fire breaks that reduce the likelihood of fires crossing roadways;
- Extended defensible space, such as mowing, grazing, fuel modifications, and forest thinning, around the edges of the community to create a low-combustibility buffer around the community;
- Landscape-scale vegetation management or strategically-located treatment areas (SPLATS) to reduce the rate of fire spread towards the community by converting head fires to flanking fires.

Figure 8: House-out Approach to Systematic Wildfire Resilience



About XyloPlan

XyloPlan is a wildfire intelligence and modeling company dedicated to bridging the gap between science, development, and resilience. We partner with developers, planners, and insurers to bring clarity and confidence to building in wildfire-prone regions. Our platform transforms cutting-edge wildfire science into actionable insights—modeling how fires are likely to spread, where intervention matters most, and what design decisions can measurably reduce risk.

At the core of our work is a scenario-based approach that captures how fire behaves at the community scale, including structure-to-structure ignition, fire pathways, ember threats, and response timelines. This level of resolution helps our partners design and site developments that not only withstand local fire conditions but actively contribute to regional risk reduction.

We believe that the path to wildfire resilience is not retreat, but smarter planning. By integrating risk-aware community layouts, ignition-resistant construction, defensible space, and coordinated vegetation management, developers can help solve California's housing crisis without exacerbating wildfire vulnerability. Our tools and data support approvals, de-risk insurance conversations, and ensure that today's housing investments are built to last.

To learn more about our work or request a site-specific wildfire risk assessment, visit info@xyloplan.com.

About Dave Winnacker, XyloPlan Chief Wildfire Risk Officer

Dave Winnacker brings over two decades of operational fire service leadership to XyloPlan. As Fire Chief of the Moraga-Orinda Fire District (2017–2024), he spearheaded wildfire preparedness initiatives across high-risk communities. Dave has served in key statewide roles, including as Western Fire Chiefs Association California Director, Chair of the California Fire Chiefs WUI Task Force, and advisor on the AB9 and AB642 mandated wildfire mitigation committee and wildfire mitigation modeling workgroup. He is a Hoover Institution Veteran Fellow at Stanford University, where his research focuses on the intersection of wildfire risk and property insurance. A Marine Corps Infantry officer from 1997–2004, Dave continues to serve in the reserves. Prior to co-founding XyloPlan, he was a co-founding advisor at ZoneHaven, the evacuation platform now used widely across California.

About Scott Farley, XyloPlan, Head of Research and Development

Scott Farley leads XyloPlan's modeling and technical development with a focus on applying scientific rigor to wildfire risk analysis. A former wildland firefighter with the U.S. Forest Service, Scott combines real-world fireline experience with deep expertise in geospatial data science. His background includes roles as a software engineer and machine learning specialist at Mapbox and as founder of Willow Labs, a wildfire analytics consultancy. Scott holds a master's in GIS and physical geography from the University of Wisconsin–Madison and a BA in geography from UC Berkeley. His work powers XyloPlan's unique ability to simulate the speed, direction, and consequences of fast-moving fires.

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Science-Guided Design Framework for Community Development

This checklist provides a framework for science guided design geared for developers looking to create new housing developments in high risk areas. Through this process, planners and developers can gain a better understanding of the site's unique risk factors and develop specific mitigation strategies that address those risks.

1. Evaluate historical and projected future fire weather and fire activity in the area of the development.
    a. What mesoscale patterns drive fire weather in the area? What times of year do those patterns occur?
    b. From what direction does fire weather originate? What fuel corridors align with these weather patterns to drive fire growth toward the development site?
    c. In what ways is climate change projected to affect the region's fire weather patterns over time?
    d. What landowners are responsible for the land around the site? Which partnerships will be most important for maximizing fire resilience on the site?
    e. What areas around the site have environmental considerations that may limit traditional fuel reduction activities?

2. Create extended defensible space.
    a. Create an extended defensible space buffer around the community sized to match local conditions with particular emphasis on entry points where wildland fire is most likely to transition into the community.
    b. Select from a native fire-resilient plant palette. Choose plants that exhibit low intensity and low rates of spread, balancing other objectives such as erosion control and wildlife habitat as necessary. Develop a maintenance schedule to mimic the natural fire regime.
    c. Limit the height and continuity of vegetation within the extended defensible space buffer. Break continuity using walking paths and trails. Consider grouping plantings to compartmentalize areas of intense fire activity.
    d. Maintain the extended defensible space buffer regularly. Remove dead and down material frequently. If possible, irrigate this area, prioritizing the areas where a transition from vegetation to structure is most likely.

3. Place low-combustibility landscape features at the periphery of the site.
    a. Place low-combustible amenities, such as golf course fairways, orchards, vineyards, and parks, upwind of the community to create a buffer between vegetative fuels likely to carry fire and the community's residential buildings.
    b. Place non-combustible amenities, such as parking lots, water features, and sports fields at strategic locations that minimize the potential for fire transition into the community.
    c. Consider placing a perimeter road between the vegetation and the community to facilitate firefighter access and further separate the community from the wildland vegetation.

Science-Guided Design Framework for Community Development

4. Create compartmentalization within the buildings.
   a. Group buildings into compartments of 5 to 20 structures.
   b. Choose low-volume, fire resilient vegetation species to occupy the areas between compartments and irrigate and maintain these areas regularly. Consider using non-combustible features such as cul-de-sacs, parking, or pocket parts to achieve compartmentalization goals.
5. Create fire-resistant structures.
   a. Build to a wildland-urban interface standard such as the International WUI code or California Building Code Chapter 7A. Depending on the location, this may be required by law.
   b. Ensure robust defensible space around structures, including a fully non-combustible 0-5' zone around each structure.
   c. Eliminate connective fuel corridors within the built environment by minimizing the use of combustible fences and hedges.
6. Ensure long-term sustainability.
   a. Create CCRs that ensure ongoing funding for widespread mitigation and compliance.
   b. Incorporate annual inspection and compliance mechanisms.
7. Create durable plans to maximize the capabilities of fire suppression resources.
   a. Plan for and test evacuation in advance of a fast-moving wildfire. Ensure adequate notifications and alerting for all residents.
   b. Work with fire jurisdictions to establish operational preparedness plans that incorporate the fire resilience features of the development.

By grounding design decisions in fire science and site-specific risk dynamics, developers can transform high-risk areas into wildfire-resilient communities that not only withstand future threats—but actively reduce risk for the broader region. This framework offers a path forward for building safer, smarter, and more sustainable housing in a changing climate.

Ready to put science into action? To learn more about our work or request a site-specific wildfire risk assessment, visit info@xyloplan.com.