

Wildfires have created instability within risk transfer markets. Here's a path forward

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Wildland–urban (WU) fires can devastate lives and communities, overwhelm emergency response efforts, and exhaust sheltering and recovery resources. Rapid fire spread into communities accounted for 78% of structure loss over 2001–2020, and rates of structure loss from such wildfires increased by 160% from 2010 to 2020 over the prior decade (1, 2). These fires carry enormous societal costs, including mortality, morbidity, loss of critical infrastructure and services, home destruction, and loss of insurance coverage (3, 4).

The escalating frequency and damage of catastrophic WU fires are accelerating faster than social systems can adapt, presenting disruptive and systemic risks. Among the most pressing: the destabilization of the insurance industry. This crisis stems from a failure to accurately capture and model risk in the built environment, including fire spread into development and the structure-to-structure nature of WU fire loss. To effectively translate wildfire hazard into a quantifiable built environment risk, policymakers and researchers need a comprehensive and collaborative systems approach that prioritizes advanced risk modeling (5), mandates changes to the built environment through stricter codes, and coordinates efforts across all levels of government and industry.

How did we get here? A long-standing desire to reduce perceived threats and increase the value of residential development in fire-prone landscapes perpetuated a cycle of fire exclusion. Aggressively suppressing fire in the western United States

The frequency and damage from Wildland–urban fires like those around Los Angeles in January 2025—including in the Palisades area pictured here—are accelerating faster than social systems can adapt. Image credit: Dave E. Calkin.

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has allowed excess flammable vegetation to accumulate, exacerbating hazard (6, 7). Climate change made things worse by increasing fire activity and fire season duration (8). Landscapes loaded with highly combustible fuels, including the homes themselves, represent a debt that has become due.

Across society, risk is often managed through its transfer from individuals to insurance companies. That puts risk in the hands of well-informed and capitalized experts. But for homeowners, the security of rising property values enabled by risk transfer and fire suppression is crumbling before their eyes.

Financial Risks

This was starkly demonstrated by this year's Eaton and Palisades WU fires in Los Angeles, California, collectively destroying over 16,000 structures and signaling major disruption to wildfire risk transfer markets and land management. Prior to these fires, there were already signs of instability in the risk transfer markets used by home hazard insurers and their risk transfer backup, the reinsurers (9). The retail home insurers are caught in the middle between their need for reinsurance to cover catastrophic loss potential that they themselves cannot cover, and insurance commissioners and state laws that typically use historical loss data to determine the prices that insurers are allowed to charge.

Reinsurers can respond to the increasing expense of catastrophic loss events by not covering retail insurers in areas deemed too high risk. And, as a result, some retail insurers have dropped policy holders and refused to offer or renew policies in those high-risk areas. Since virtually all lenders require insurance as part of mortgage agreements, this can lead to noninsurability of homes in certain areas, or to the cost of insurance being so high that the total monthly mortgage payment exceeds the reach of borrowers.

Increased financial burdens mean that homeowners will face the prospect of foreclosure or a need to sell their homes, uprooting families and jobs in the process. Further, this devaluation could ripple through municipal bond markets (10), with significant implications for the ability of communities to finance capital improvements and other critical infrastructure needs.

Fear of such profound impacts to the residential housing market has caused state governments to collectivize wildfire and WU fire risk through Fair Access to Insurance Requirements (FAIR) plans. Also known as insurance of last resort, these state-run plans provide property insurance to high-risk homeowners unable to obtain coverage through traditional markets. The number of homeowners reliant on such programs is rapidly expanding, with the total exposure of the California FAIR plan rising from \$115 billion to \$433 billion between 2020 and 2024 (11). While providing a short-term solution to the insurance protection gap, FAIR plans may create long-term problems by subsidizing insurance coverage and doing little to discourage development in high-risk areas.

Risk Transfer and Instability

Homeowners, developers, insurers, and policymakers all rely on a relatively stable natural environment. The belief of most of these stakeholders that wildfire risk was manageable created new value in a comparatively benign and stable market

environment, leading to substantial flows of capital into residential development on lands that historically experienced wildfire. These actors achieved financial stability through risk transfer by distributing risk across large numbers of insured entities and transferring risk forward in time through fire suppression.

That is no longer the case. The changes in climate, landscape conditions, and human settlement discussed above have pushed the built environment system far from its previous equilibrium—it is now more volatile and less predictable. This means that legacy practices of pricing risk from historical data are insufficient and that we need more sophisticated forward-looking approaches.

Deployment of accurate forward-looking risk modeling is essential; otherwise, a cycle may perpetuate where risk is poorly estimated and therefore cannot be effectively mitigated or transferred. Destabilization of the risk transfer economy will continue as large-scale losses mount and insurers increasingly pull out of large markets.

An Uncommon Hazard

The challenge isn't that the Eaton or Palisades WU fires were unforeseeable events. Firefighters and others understand well the problematic combination of ignitions near development, Santa Ana winds, and built-environment conditions favorable to rapid fire spread, even going back to the Bel Air–Brentwood and Santa Ynez fires of 1961 (12). The Wildfire Risk to Communities project identified areas within the Palisades and Eaton fires as having extreme risk, as well as many other areas recently affected by WU fires, including Ocean County, New Jersey (13). Similar high-risk conditions exist throughout the Los Angeles basin and, in fact, throughout the United States (14). It's a question of when, not if, the next WU fire disaster unfolds. Rather, the problem relates to our long-standing inability to appropriately translate wildfire hazard into a specific, quantifiable built-environment hazard, which then allows insurers and reinsurers to accurately price the risks.

Most of our risk models and data are for wildfires. But WU fires are different because vulnerabilities propagate and compound losses—the structures and nearby vegetation become the primary fuel sources driving the fire's expansion. That makes risk in these extreme events harder to assess, as it depends on a complex interplay of hazards, exposures, and vulnerabilities through structure-to-structure ignition. Assessing WU fire risk requires information that we don't yet have. That includes how likely a structure is to ignite a given other structure; how much heat and embers it will generate if it does ignite; and how it, in turn, exposes nearby structures and vegetation (15). This makes structure-to-structure ignition a key focus for research because it logically interconnects to all other risk components, especially during high-wind events.

WU fires are especially hard to model because wildfires can make the transition to urban conflagrations through a combination of routes (such as contact with flame and embers); they have more damage potential and response complexity; and they require targeted risk management (Fig. 1). Some models have been developed that demonstrate credible emulation of historical WU fire events, and these are growing more sophisticated (16–24). These simulations better capture dynamic interactions between weather, fire

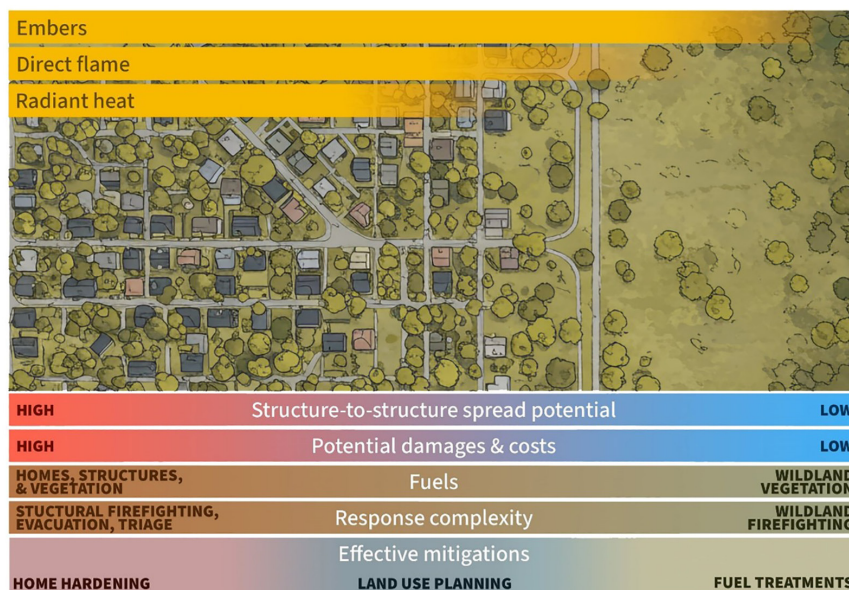


Fig. 1. Representation of exposure mechanisms in wildland-urban fires that can initiate urban conflagrations and corresponding implications for structure-to-structure spread potential, damage potential, hazardous fuels, response complexity, and mitigation efficacy.

behavior, and characteristics of the built environment than do wildfire risk models. And they can run on larger scales than physics-based models.

Key Needs

Nonetheless, there are scientific, technical, social, and practical barriers to surmount before we can use such models to better price and act on WU risk. To address these gaps, three key needs must be met.

The first key need is to bridge two parallel science-technology data gaps: the development of built environment fuel datasets and the advancement of basic fire science and engineering to enable the parameterization of such datasets in WU fire spread models (25). Advanced remote sensing and computer vision technologies increasingly offer these kinds of data. For example, fine-scale representations of the built environment can identify construction materials or classify roof geometries.

While this offers more realistic representations of structure vulnerability, data on the burning characteristics of these features remain scarce. And we need them to differentiate how they influence hazard and exposure. This takes large-scale burning experiments. Current capabilities are inadequate to repeatedly burn an entire neighborhood to capture how homes spread fire to other homes. That would take significant investment.

Most models rely, therefore, on data from real fires, and the rate at which we'll attain this kind of observational data is necessarily constrained by the rate at which WU fire events occur. Practically, this means the focus should be on better collaboration and cooperation among fire researchers to expand the amount, quality, and availability of attainable data gathered by experimental tests, remote sensing, home inspections, expert systems, crowdsourcing, and insurance participation. The field must also develop and deploy sensors, analogous to seismometers, that can capture heat fluxes and gather more data on potential for ignition at quantifiable and measurable limits.

The second key need is to expand model validation efforts. To date, the performance of WU fire spread models has been

evaluated only retrospectively for a small set of salient extreme loss events, with less known about model performance under events of varying intensities and consequences, and even less about predictive accuracy against uncertain future conditions. Incremental improvement can stem from the study of fire progression and loss maps from an expanded set of recent fires, providing an opportunity to establish open benchmark datasets, against which models can be evaluated.

Third, there is a need to integrate practices and insights from natural hazards engineering, beginning with development of a common language to talk about the strength and intensity of the WU fire hazard. There are no widely accepted notions of a structure's ability to withstand given fire exposures (capacity), nor are there common definitions of exposure in terms of fire intensity and duration (demand). Embracing such generalizable concepts could support broader community adoption and standardization of scenarios and metrics for risk modeling, as well as community design.

For WU fires, we could develop quantifiable demand parameters such as heat flux and temperature in low- and high-risk regions. This could help engineers to use materials that can withstand those demands. Improvements in WU fire risk modeling will unlock broad applications, not just for insurance markets, but also for home and community hardening, emergency response, disaster recovery, land use planning, and utility operations (26). We will undoubtedly gain better understanding of WU risk, not least because we will learn more from future events.

Built Environment as the Crux

What was once largely thought of as a wildlands and wildfire management problem—leading to fire control as the solution—needs to be understood as one where fire is both natural and inevitable, and with a shifted focus to structural vulnerability and ignition resistance of communities (27). Providing more accurate risk information is a necessary, but likely insufficient, step to catalyze this kind of change. It may even have unintended consequences by devaluing land values, scaring off buyers and lenders, and pushing up insurance rates (28).

Codes and guidelines for wildfire resilience have been developed and implemented in several states (29). However, the wealth generated by the built environment serves as the tax base for cities and counties, creating misaligned incentives. Even where codes exist, much of the housing stock was built before they came into force. The cost of retrofitting existing housing is poorly understood, and few programs exist to support it.

Reducing the risk of WU fires may take stricter measures: construction standards that increase cost, greater defensible space, improved emergency access through wider roadways, restricted or prohibited development in areas that are simply too hazardous to build upon, and even managed retreat.

To effectively address WU fires, we need more collaboration and coordination across disciplines, agencies, researchers and practitioners (30). A good start would be a shared roadmap for WU risk model development, use, and translation to on-the-ground action. This could potentially be led by a federal, inter-agency coordinating body with experience in wildfires and hazard resiliency, including engineering, fire ecology, natural resource management, urban planning, and community development. It could then provide states, counties, and communities with grants, technical assistance, and resources to mutually mitigate risk to both the natural and built environment.

The Community Wildfire Defense Grant program, housed within the US Department of Agriculture Forest Service, already provides grants directly to communities and local organizations for hazardous fuels reduction projects and to update Community Wildfire Protection Plans. This program could be expanded to include much needed support for home hardening, infrastructure improvements, and evacuation planning. By providing resources and capabilities to identify the most at-risk areas, fire spread pathways into communities, and their unique exposures and vulnerabilities,

community leaders can apply building codes, regulations, ordinances, targeted fuels reduction, and land use planning to (re)design communities with an understanding of where opportunities exist to minimize threats from WU fires.

Ultimately, for enhanced understanding of WU risk to translate into effective risk management, a much broader set of issues beyond data, science, technology, and engineering must be addressed. We argue that a systems approach is necessary, beginning with improving linkages between entities working in this space and understanding the built environment as a system with complex interacting hazards and vulnerabilities. Further, we need to consider community capacities and fire impacts beyond structure loss (e.g., core community functions such as schools and hospitals; public health impacts from smoke and other pollutants; and displaced people), learning from applications in other natural hazards (31, 32).

Risk modeling will only lead to better outcomes if it's embedded within broader processes of risk communication and behavioral change and engagement with community members, research funding entities, practitioners, risk transfer markets, and other sectors.

There is little support for a status quo that produces thousands of uninsured homeowners and frequent catastrophic wildfires, yet meaningful change has been difficult. The WU fire problem is simultaneously nobody's problem and everyone's problem, so it lacks clear ownership, coordination, and a unified strategy. To effectively address WU fire risk, a comprehensive, multisector effort is needed, involving collaboration from local to federal levels and across both public and private sectors.

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