FIREBREAK

Wildfire Resilience Strategies for Real Estate

Urban Land Institute

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ABOUT THE URBAN LAND INSTITUTE

The Urban Land Institute is a global, member-driven organization comprising more than 45,000 real estate and urban development professionals dedicated to advancing the Institute's mission of providing leadership in the responsible use of land and in creating and sustaining thriving communities worldwide.

ULI's interdisciplinary membership represents all aspects of the industry, including developers, property owners, investors, architects, urban planners, public officials, real estate brokers, appraisers, attorneys, engineers, financiers, and academics. Established in 1936, the Institute has a presence in the Americas, Europe, and Asia Pacific regions, with members in 80 countries.

The extraordinary impact that ULI makes on land use decision-making is based on its members sharing expertise on a variety of factors affecting the built environment, including urbanization, demographic and population changes, new economic drivers, technology advancements, and environmental concerns.

Peer-to-peer learning is achieved through the knowledge shared by members at thousands of convenings each year that reinforce ULI's position as a global authority on land use and real estate. In 2019 alone, more than 2,400 events were held in about 330 cities around the world.

Drawing on the work of its members, the Institute recognizes and shares best practices in urban design and development for the benefit of communities around the globe.

More information is available at uli.org. Follow ULI on Twitter, Facebook, LinkedIn, and Instagram.

RESEARCH CONTRIBUTORS AND PROCESS

ULI is grateful to the Kresge Foundation for its support of this project and ULI's Urban Resilience program.

To better understand how wildfires are affecting real estate and land use, ULI's Urban Resilience program interviewed more than 50 real estate developers, designers, land use policymakers, nonprofit leaders, and wildfire experts. The authors also worked with a team of ULI member advisers with expertise in wildfire resilience and related topics, as well as with colleagues from the ULI Greenprint Center for Building Performance, the ULI Building Healthy Places Initiative, ULI San Francisco, ULI Colorado, and ULI Idaho to draft this report. A full list of the organizations that shared their knowledge and perspectives in interviews, nominated case studies, edited the text, provided supporting materials, and otherwise advised on the creation of this report is provided in the Report Team and Acknowledgments sections.

The potential for unconscious bias may affect this research. The authors and the project team hope that the collaborative contributions of many to this report provide a robust and well-rounded perspective and reduce the potential for bias.

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CONTENTS

VIEW FROM THE WEST: A ULI MEMBER PERSPECTIVE

Wildfires have always been a part of the U.S. landscape, particularly in the drier West. But this year stands out because massive, destructive wildfires—fueled in part by extreme weather and changing climate conditions—have broken records across the region and raised important questions regarding how the real estate industry can help communities thrive despite repeated fires.

The toll on human lives, the landscape, and economies is personal. The specter of wildfires looms large here in Montana, where I live. We're always on edge as we move toward the start of wildfire season.

When the wildfire smoke blew in this fall, we shut the windows and doors in our non-air-conditioned home and turned on three HEPA filters that ran 24/7. Our air quality index registered at an unhealthy 169. My sister in California readied horse trailers to help whomever needed help evacuating. My 80-year-old parents in Oregon identified an evacuation footpath in the event their one road out is blocked by fire. And, one of the places we spent summers on the McKenzie River near Vida, Oregon, is completely gone, burned by the Holiday Farm fire.

Wildfires became a national concern this season, with smoke reaching my ULI colleagues all the way in Virginia. We also saw the compounding effects of wildfires with other conditions, especially the coronavirus pandemic. First responders and evacuees risked contracting the virus as they worked and sheltered in close proximity. Temporary housing for those who needed it was difficult to find amid social distancing recommendations, simultaneous multiple large evacuations, and the country's ongoing housing affordability crisis and housing shortage. In addition, the communities affected by wildfires must recover during a significant economic depression.

And what of economies and real estate? Wildfires cause massive destruction and affect our ability to insure assets, endangering the real estate industry's ability to secure financing. In the long run, the interruption risk has major impacts on residents and tenants and their willingness to be in wildfire-prone locations. This gets to the heart of the dilemma—whether we have fiscally stable, healthy, thriving, and sustainable communities because municipalities rely on tax revenues. And that leaves those of us living in fire-prone areas with one existential question: Where do we go from here?

In the short term, we hope for a break in the weather and relief for the millions who have been affected by the fires. We also need to make sure that wildland firefighters have the resources to do their jobs safely and effectively. Then, once the worst of the 2020 fire season is behind us, we must take a long, hard look at how we can make our communities safer from and more resilient to future wildfires.

This is where the best practices detailed in this report and the expertise provided by ULI members are so crucial. Wildfire-resilient development and design choices made at the asset level protect structures and

ULI/MOLLY MCCABE

A hazy sky and unhealthy air quality in Montana as wildfires burn nearby in August 2020.

inhabitants, reduce fire spread through communities, and protect value for owners and investors. ULI members are uniquely situated to share lessons learned from their experience implementing wildfire resilience tactics and to build support for wider implementation.

In addition to preparing their own developments, ULI members can partner with their communities to make planning and development decisions—before the fires start—to give communities the best chance to thrive. These discussions may include advocating for best practices related to policy or for design addressing the community scale, but also they are likely to include difficult decisions related to how and where to build, and how to best support housing affordability and access in the face of wildfire vulnerability.

Wildfire resilience, accessibility, community design, and fiscal responsibility should function as windows through which we can see and make future planning, physical design, and ongoing operations decisions. Resilience requires a collaborative process, constantly refined and ever evolving. The time to act is now.

Molly McCabe
President, HaydenTanner
Cofounder, the Lotus Campaign
Member and Chair Emeritus, ULI Responsible Property Investment Council

INTRODUCTION

THE 2020 WESTERN U.S. WILDFIRE SEASON began early, and by September, 100 large wildfires burned in 12 states.[1] These wildfires—as well as the catastrophic events of 2017 and 2018—are remarkable in the scale of their destruction and because many of the fires occurred in or near developed areas.[2]

Climate change is leading to more frequent and catastrophic wildfires, and the real estate and land use industry can help manage the increasing risk by implementing best practices in wildfire-resilient building design, land use, and community education.

U.S. DEPARTMENT OF AGRICULTURE

In August and September 2020, Californians suffered through more than 30 days of poor air quality, record heatwaves, and active wildfires, including the Bobcat fire that was less than 25 miles from Los Angeles—one of the country's most populous areas.[3] The August Complex, SCU Lightning Complex, and LNU Lightning Complex fires grew into the largest, third largest, and fourth largest wildfires, respectively, that California had experienced.

Oregon evacuated more than half a million people in September 2020 (about 10 percent of the state population)[4] including communities just east of Portland. Washington declared a statewide emergency, and Seattle was covered in a "massive smoke plume."[5] The August Grizzly Creek fire forced the closure of I-70, Colorado's main east-west throughway, with such significant potential economic consequences that the fire briefly became the number one national containment priority.[6] Smoke from these wildfires also traveled thousands of miles, reaching Midwest and Mid-Atlantic states, and was prevalent enough to darken skies in Chicago.

In 2018—the previously worst wildfire season in the United States—utility companies escalated power shutoffs (a long-established technique to prevent electrical equipment from sparking wildfires in high-risk conditions), with widespread consequences for daily life and regional economies. And then the first "climate change bankruptcy" filings occurred—that of insurer Merced Property and Casualty in 2018 due to claims from the Camp fire and that of Pacific Gas & Electric (PG&E) in 2019 after one of its transmission lines sparked the disaster.

About 29 million people in the United States have a high probability of being affected by an extreme wildfire[7]—fires that are likely to occur and are difficult to control—and at least 4.5 million homes are at high risk from wildfire across the United States.[8] Though this total represents a relatively small amount of structures compared with the country's entire building stock, protecting them requires a significant amount of specialized capacity and financial resources, especially as wildfires become more commonplace and extreme.

Bigger, hotter, and more frequent wildfires are causing increasing amounts of infrastructure destruction, economic hardship, and trauma across the United States, affecting large regions including even the most prepared flame-affected communities as well as adjacent areas that received evacuees and

"We must rethink how we're developing our projects to be resilient to compounding events like extreme heat and poor air quality from wildfires. We know from the 2020 wildfire season that those improvements are much more important to do. We can't wait."

BRIAN STRONG, CHIEF RESILIENCE OFFICER, CITY AND COUNTY OF SAN FRANCISCO

WILDFIRES: WHERE AND HOW THEY HAPPEN

Fire is a naturally occurring global hazard that is greatly influenced by the local built environment. "Wildfires" are unplanned or uncontrolled fires. Wildfires also are called "wildland fires," "vegetative fires," or "bushfires." They affect most nations and are most common where there is a defined dry season and sufficient precipitation in the wet season to grow vegetative fuels, such as in the United States, Canada, Mexico, Australia, Chile, Greece, Portugal, Spain, Angola, Zambia, and the Democratic Republic of Congo. Fires are increasingly common in nations that have little history with fire, including in the tropics and central Europe.

Wildfires burn structures through direct flame contact, by coming close enough that the flames' heat ignites structures, and when wind-driven embers land on structures and ignite. Extreme wildfires can also generate "fire whirls" or "firenados" that travel at hurricane and tornado-like speed and cause wind damage.

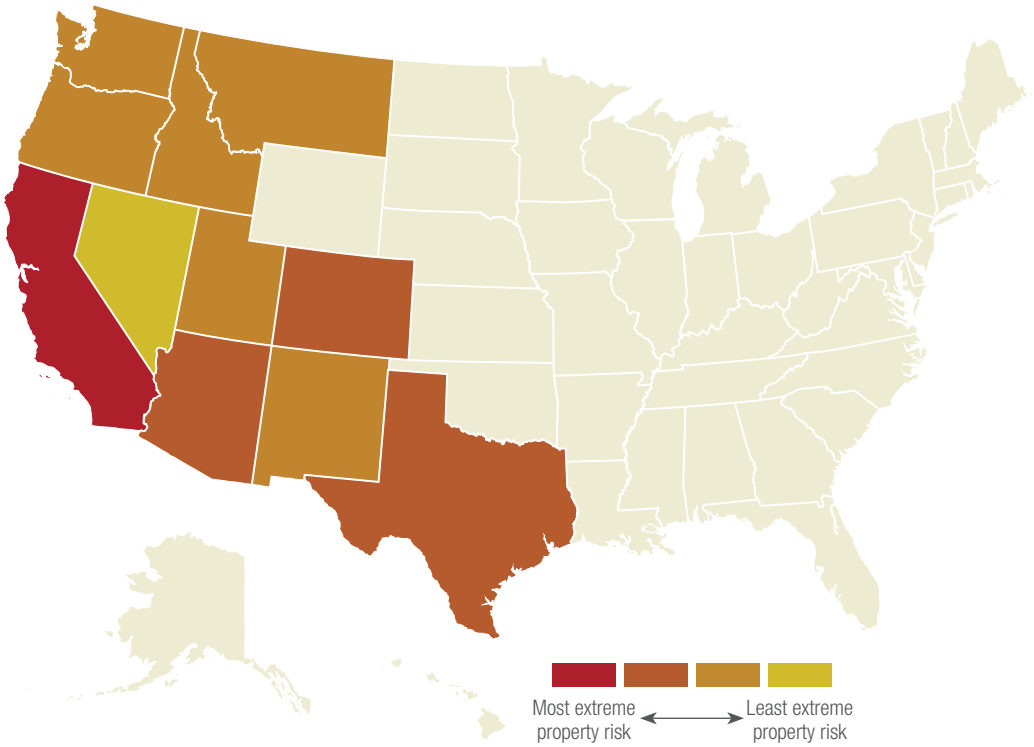
Fuels, weather, and topography drive wildfire behavior. Plants are the primary fuel source for wildfires, so plant community characteristics influence structure survival and fire movement. As renowned wildfire expert and University of California professor Richard Minnich has said, "Fuel, not ignitions, causes fire. You can send an arsonist to Death Valley and he'll never be arrested."[9]

FLICKR/ALBERTA ENVIRONMENT AND SUSTAINABLE RESOURCE DEVELOPMENT

Wildfires occur in most nations. Here, a rolling forest fire burns in Alberta, Canada, in May 2011.

Wildfires that burn through hilly or mountainous terrain also make post-fire landslides and floods more likely by burning away slope-stabilizing vegetation, charring soil so it is less permeable, and creating large amounts of loose debris and ash. "We often have these compounding scenarios. A flood after a wildfire sounds ridiculous, but it's not unusual," says Kate Cotter, CEO of the Bushfire Building Council of Australia.

States and Metropolitan Areas with Highest Wildfire Property Risk



Metropolitan areas with highest wildfire property risk

1. Los Angeles, CA
2. Riverside, CA
3. San Diego, CA
4. Sacramento, CA
5. Austin, TX
6. San Francisco, CA
7. Denver, CO
8. Truckee, CA
9. Oxnard, CA
10. Colorado Springs, CO
11. San Antonio, TX
12. Santa Fe, NM
13. Redding, CA
14. Salinas, CA
15. Houston, TX

Source: Adapted from CoreLogic and Verisk.

implemented strict preventative measures. The occurrence of wildfires, the scale of their consequences, and how they have changed in recent decades are directly related to current climate and development trends as well as to historical land-management strategies. Climate change and the housing affordability crisis especially are exacerbating the severity of wildfires and the difficulty of managing them.

Wildfires, Land Use, and Real Estate

Every state in the United States has some amount of wildfire risk because every state has a wildland-urban interface (WUI, pronounced "WOO-ee")—areas where development intermixes with or is adjacent to natural areas with abundant vegetative wildfire fuel. "One of the big concerns is that if we keep building out into the wildland-urban interface—and that's happening nationwide now—we are spreading our ability to suppress fires and to protect property," says Mike Pellant, president at Rangeland Solutions and previously a fire expert for the Bureau of Land Management.

Most wildfires occur in these rural and suburban WUI areas. However, fires in the WUI have extensive impacts on nearby urban centers, as well as on broader regions. For example, urban centers rely on the water and energy infrastructure located in wildfire-risk areas and city dwellers often suffer hazardous air quality from wildfire smoke. Housing needs and prices in metro areas also can increase overnight when displaced disaster-affected communities are searching for emergency shelter.

The causes of and resilience strategies for wildfires are closely related to the United States' housing affordability crisis. Rising land and housing costs in urban centers—as well as consumer desire to live in natural areas—have led to homebuying and development in less-pricey areas that are at extreme risk from wildfire, placing more people and infrastructure in harm's way. When wildfire evacuations and disasters do occur, they increase demand for housing that already is in short supply, which is especially challenging for those with lower incomes or place-based livelihoods that are inaccessible during fires. Balancing these economic and development realities against constituent needs during and after wildfires, local governments are struggling with the increasing decision-making pressures and costs associated with wildfire prevention, suppression, and adaptation.

Likewise, the increasing likelihood of and escalating damages from wildfires creates tremendous economic pressure and risk for the real estate sector. For developers, hazardous air quality and electricity outages often lead to business interruptions, construction delays, and increased costs for asset features such as advanced air filtration technology and backup-power systems. Investors and owners may experience increasing insurance premiums or the potential inability to secure insurance because of wildfire risk. Repeating catastrophic fires that cause mass displacement also increase the risk of long-term or permanent population shifts and corresponding depressed real estate value.

In addition, climate change is extending the fire season and making the conditions for destructive fires more likely to occur. By midcentury, the annual area burned by wildfires could increase two to six times from the present because of climate change.[10] Also, wildfires complicate the achievement of sustainability goals because the transition from fossil fuels to electrification increases dependence on the transmission infrastructure that can ignite wildfires.

WILDFIRE RESILIENCE STRATEGIES

This report presents wildfire resilience best practices at the site and district scale; however, these strategies are not truly exclusive or limited to those geographies because the approaches often apply at multiple scales. Creating surrounding buffer zones with little to no burnable materials is, for example, one method to defend an individual structure as well as a small town. In addition, widely implemented site-level solutions create more wildfire-resilient communities and regions.

Site-scale best practices (page 25) include the following:

- Low-risk siting, arrangement, and orientation
- Defensible space around buildings
- Ember-resistant structures
- Nonflammable and nontoxic building materials
- Wildfire safety education and community engagement

District-scale best practices (page 32) include the following:

- Wildfire hazard and vulnerability assessments
- Community wildfire protection plans
- Comprehensive and regional planning
- Strategic density in lower-risk areas
- WUI codes and standards
- Urban forestry and landscaping ordinances
- Large-scale resilient land management and restoration
- Strategic and well-planned recovery from wildfire events

In addition, novel solutions like asset-level wildfire safety bunkers, resilience hubs, and realigned funding incentives for less-risky development at a community scale may become best practice. Public leaders, planners, and utilities also are increasingly focused on creating and updating utility and transportation infrastructure for enhanced wildfire resilience and function in times of crisis as well as to provide daily community benefits. Best-practice climate mitigation policies that slow the pace or reduce the severity of climate change also help address a major root cause of destructive wildfires.

Although wildfires traditionally are the responsibility of emergency responders and forest managers, real estate developers, urban planners, and public leaders increasingly are aware of the land use drivers of wildfires; they are concerned about the consequences of wildfires; and, they are coordinating site, district, and regional scale resilience efforts. "Wildfires are a topic of discussion on almost every project. In some cases, it's a central theme of the development and design because we're all affected by these fires every summer," says Antonio Pares, principal at architectural and landscape design firm Mithun.

Real estate developers are protecting new housing and commercial buildings by minimizing on-site sources of ignition, hardening structures against embers and flames, and consolidating buildings while conserving open space as buffer zones to protect developed areas. Also, developers are leveraging their agreements with subcontractors and homeowners associations to enforce and educate tenants about fire-safe landscaping. Many developers actively participate in or support wildfire resilience recognition programs such as Firewise USA.

Though federal and state resources are critical to managing wildfires on a national scale, wildfire and real estate industry experts recognize that local municipalities and counties have control over the land use and development patterns in high-risk WUI areas. Local governments are responding by considering wildfire hazards in comprehensive planning, enacting enhanced building codes and standards for at-risk areas, and funding wildfire suppression and response. Mitigating wildfire risks while achieving sustainability and quality of life goals, such as reducing greenhouse gas emissions and increasing housing opportunity and affordability, is an aspiration of and challenge for many public leaders.

Private- and public-sector leaders interviewed for this report agree unanimously that collaboration is integral to wildfire-resilient development. "We need to coordinate all these efforts and make them work well together," says Kate Cotter, chief executive officer of the Bushfire Building Council of Australia. "We can make those places viable and sustainable. We can bring in investment. People can get insurance coverage. We can make these places stand up through a disaster." Cross-sector coalitions of local, state, and federal officials as well as business leaders, scientists, and community groups are engaging in sustained efforts to reduce wildfire risk and impacts via resilient site design and land stewardship.

"The 2017 North Bay fires disaster was really a housing disaster. Almost 6,000 homes were destroyed."

LARRY FLORIN, CHIEF EXECUTIVE OFFICER, BURBANK HOUSING

KEY TAKEAWAYS

This report explores why wildfire is a significant risk factor and planning consideration across the United States. The report also explores how the real estate community is responding with design methods, policies, and partnerships to mitigate the building damage, economic loss, and community trauma caused by wildfire, and what more can be done in the future. As wildfire risk continues to escalate due to the impacts of climate change, continued action based on recognition of the interconnected nature of development and resilience will be critical. Key research findings include the following:

Climate change: Hotter temperatures and reduced or more sporadic rainfall create drier vegetative conditions conducive to fire. Accordingly, climate change increases wildfire risk and will lead to a longer fire season with more instances of larger, less predictable, and more destructive fires. Hotter, drier climates also can make wildfires possible or much more likely to occur in locations that historically had little fire risk.

Location: Wildfire risks exist in every U.S. state and the risks are highest in WUI areas where development coincides with naturally occurring fire pathways, significant climate-change impacts, and substantial amounts of accumulated vegetative fuel. Although risk is greatest in the WUI, wildfires are not only a risk in suburban and rural areas. Urban areas may be affected by poor air quality, utility disruptions, and population change or, in some cases, directly threatened by wildfires.

Community and market disruption: Repeated evacuations, building loss, employment interruption, and the day-to-day stress of living with poor air quality, without electricity, or under threat of wildfire can harm individuals and disrupt entire communities. Low-income communities are often most vulnerable, given the burden of emergency and recovery expenses as well as the likelihood that lower-value homes do not incorporate resilient technologies. As longer and more intense fire seasons become the new normal, repetitive losses, insurance shifts, and population displacement could also lead to long-term changes in regional economies and real estate markets.

Housing affordability: Wildfires both influence and are affected by the housing affordability crisis. Demand for suburban living and the high costs of urban housing contribute to new development in high-risk WUI areas. Furthermore, wildfires reduce the already short supply of housing and exacerbate affordability and access problems, especially when there is a sudden need for temporary housing. Local governments are grappling with this tension and seeking solutions to address housing need and access, especially in high cost-of-living regions.

Market outlook: The real estate industry is increasingly aware that infrastructure and people in high-risk areas are almost certain to be threatened by wildfire or to be affected by secondary impacts like smoke, power outages, or evacuations. Most developers continue to experience consumer demand in areas at risk from wildfire and are focused on integrating preventative and mitigating measures into new construction.

SHUTTERSTOCK

Thick smoke and ash from dozens of wildfires burning across the western United States turn skies orange over San Francisco in 2020.

If destructive seasons continue and policies change regarding insurance availability or disaster relief, investors and homeowners may also reassess their investment strategy in wildfire-prone areas.

Best practice: Resilient development, land, and infrastructure management can significantly decrease the negative outcomes of wildfire events. Wildfire resilience approaches include structure hardening, defensible space and vegetation management, strategic density in lower-risk areas, hazard-informed comprehensive and regional planning, evacuation route planning, and tenant and community engagement.

Regulatory approach: Government agencies in wildfire-prone areas, especially at the state and local level, are trying to balance the growing costs of managing wildfires and increasing risks to people and infrastructure while preserving the community identity and economic vitality of their jurisdictions. Though most wildfire-related land use policy is voluntary or incentive-based, state and local policymakers are demonstrating an increased willingness to impose regulations to manage wildfire impacts and costs.

Public/private partnerships: Coordination is integral to wildfire resilience at site, community, and regional scales. Developers are consulting public-sector fire experts earlier in the permitting, design, and development process and are supporting and promoting large-scale land restoration and management to limit wildfire consequences. Government agencies rely on the private sector to implement many of the development best practices for reduced wildfire vulnerability and may seek out more opportunities for jointly funded and implemented interventions in the future. Nongovernmental organizations add critical capacity on community engagement, wildfire education, vegetation management, and postfire recovery.

WILDFIRE RISK

DEVELOPMENT PATTERNS, CLIMATE CHANGE, AND LARGE-SCALE FORESTRY MANAGEMENT are the three most significant influencers of wildfire risk and impacts in the United States. Together these drivers determine which places and people in the United States are most at risk and how that risk level is likely to change over time.

Wildfire risk exists in every U.S. state, especially where development is co-located with vegetative wildfire fuel. Among the states that have experienced destructive fires near developed areas in recent years are Arizona, California, Colorado, Florida, Idaho, Kansas, Minnesota, New Mexico, Oklahoma, Oregon, South Carolina, Tennessee, and Washington.

CITY OF AUSTIN FIRE DEPARTMENT

WHERE WILDFIRE IS A CONCERN IN THE UNITED STATES

Every U.S. state has some amount of wildfire risk.[1] The highest-risk states are those with natural historical fire patterns, significant climate-change impacts, a substantial amount of accumulated vegetative fuel, and those with large existing or expanding WUI areas.[2]

Thirteen western states are the most commonly affected by wildfires as measured by historical amount of acreage burned, loss of life, actual property damage, and probability of property damage.[3] The 13 states (listed in order of most to least acreage burned between 2002 and 2018) are Alaska, California, Idaho, Texas, Oregon, Nevada, Montana, Arizona, New Mexico, Washington, Oklahoma, Utah, and Colorado. Florida and Wyoming complete the top 15 states by recent acreage burned.

California, Texas, and Colorado, respectively, have the most total property value and the most homes in areas at high and extremely high risk from wildfires.[4] In Colorado, half of the population lives in wildfire-prone areas, which is a 50 percent increase from 2012 to 2017.[5] The top four metropolitan areas at high and extremely high risk from wildfires are all in California (Los Angeles tops the list), with Austin, Texas, the ranking fifth.

High Property Risks in the Wildland-Urban Interface

The most at-risk communities in every U.S. state typically are those located in WUI areas. WUI describes any area where the built environment, typically residential development, is co-located with wildland vegetation. WUI areas experience the most wildfire destruction of any land use type in the United States.[6]

The WUI accounts for at least 10 percent of U.S. land area[7] and it contains about 34 percent of all single-family homes.[8] There are about 43.4 million homes in the WUI, compared with more than 135 million homes nationwide.[9]

Together with the nearby businesses, that represents about $1.3 trillion of property

Properties at High Risk

Properties at high to extremely high risk from wildfires, by state:

State	Number of properties
California	2,054,900
Texas	717,800
Colorado	373,900
Arizona	242,200
Idaho	175,000
Washington	160,500
Oregon	153,400
Montana	137,800
Utah	136,000
New Mexico	131,600
Nevada	67,100

Source: Adapted from Verisk.

CALIFORNIA WILDFIRE RISK

Natural characteristics, climate change, and significant development have combined to make California the epicenter of wildfire risk in the United States. By the end of this century, "California's wildfire burn area likely will increase by 77 percent."[10]

The number of days in California with extreme (95th percentile) fire risk have doubled in the past four decades due to higher average temperatures and a 30 percent reduction in precipitation during the historical fire season.[11] According to California's Fourth Climate Change Assessment (2018), some of the highest-risk wildfire areas will be those in mountainous areas adjacent to electrical utility infrastructure, which is often bringing in out-of-state renewable energy.[12]

"Since the 1950s, Southern California has experienced the highest losses in property and life in the United States [from wildfires], averaging 500 homes per year."[13] And since 2012, the average number of homes lost to wildfire in California has jumped to more than 5,000.[14] In addition to the loss of life, property, and business activity caused by these fires, the state has spent at least $4.7 billion on firefighting from its emergency fund over the past 10 years.[15]

ANDREA BOOHER/FEMA

On average, California has experienced the highest losses of property and life in the United States from wildfires. The state is also a leader in establishing wildfire-resilient building and landscaping codes, which have reduced losses in recent wildfire events.

About 2 million California homes are at risk from wildfires, representing 14.5 percent of the state's houses, and slightly less than half of the 4.5 million total homes at high risk in the United States.[16] Moreover, "since 1993, almost half of California's new homes have been built in fire hazard areas;"[17] now, there are more buildings in most burn sites than there were before fires.[18] Other significant natural hazards in the state, including earthquakes and sea-level rise, constrain the choice of development location.

value.[19] Since 2000, "WUI fires have significantly affected communities in states across the country, including Arizona, California, Colorado, Florida, Idaho, Kansas, Minnesota, New Mexico, Oklahoma, Oregon, South Carolina, Tennessee, and Washington."[20]

People and structures in WUI areas are at high risk from wildfires because there are more fire ignitions in the WUI and because wildfires are more difficult and expensive to fight in those areas. A U.S. Forest Service study found that 59 percent and 60 percent of threatened and destroyed buildings, respectively, in the 48 conterminous states are in the WUI.[21] Moreover, "six of the 10 most expensive fires in the past 100 years were WUI fires."[22]

People are responsible for starting about 84 percent of all wildfires, therefore, the greater the number of people living in an area (and the more wildfire-sparking human infrastructure), the greater the chance of accidental and intentional fires. For example, when a vehicle being driven in Shasta County, which is about 200 miles north of San Francisco, blew a tire and the wheel rim hit the road pavement, the sparks ignited the 2018 Carr fire, which burned for five weeks and scorched 229,641 acres, causing $1.6 billion in damages, including destroying about 1,000 homes and killing eight people, three of whom were firefighters.[23]

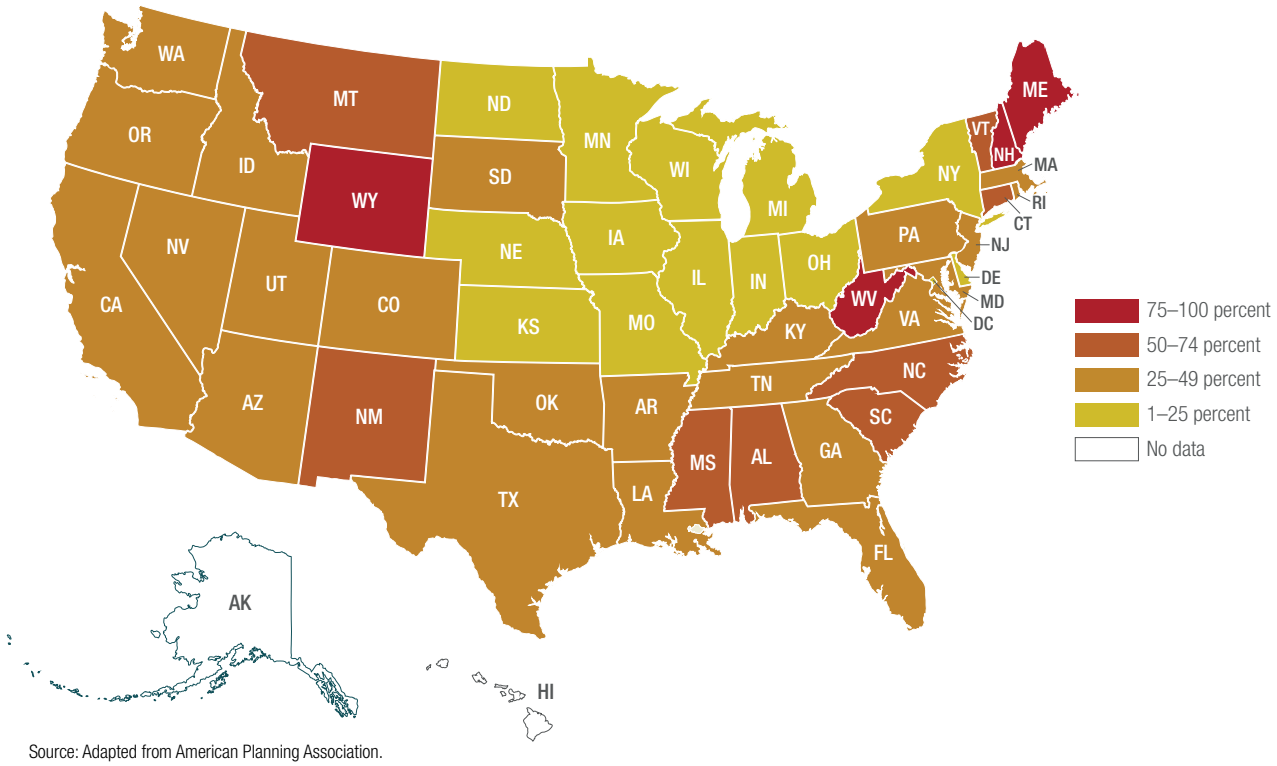
A 2017 analysis found that human-started wildfires have "tripled the length of the fire season, dominated an area seven times greater than that affected by lightning fires, and were responsible for nearly half of all area burned."[24] And once WUI wildfires start, built structures and human possessions such as telephone poles, houses, cars, and propane tanks can burn hotter than vegetation.[25]

WUI areas are common at the edges of cities and in rural areas with significant amenities. The eastern United States has very populated WUI zones and the most WUI by land area, especially in the northeast coastal areas and the southeast Appalachian region.[26] Western states generally have the highest proportion of homes in the WUI.[27] The Midwest has a smaller proportion of homes in the WUI because agricultural land tends to have less wildfire-fueling vegetation.

"The problem we're tackling with wildfire is that the built environment is already built in high-risk areas."

MICHELE STEINBERG, WILDFIRE DIVISION DIRECTOR, NATIONAL FIRE PROTECTION ASSOCIATION

Percentage of Homes in the WUI



Source: Adapted from American Planning Association.

Individual and Community Wildfire Vulnerability

Residents in fire-prone areas live at elevated risk of danger from wildfire flames and smoke, and they contend with the potential for evacuation and property damage. About 99 million people—one-third of the U.S. population—live in the WUI.[28] The natural local wildfire risk as well as planning characteristics and governance emergency response capacity (the ratio of households to evacuation routes and the existence of a robust emergency alert system, for example) are influential determinants of individual and community vulnerability.[29]

Socioeconomic factors—such as wealth, race, age, occupation, citizenship status, language, overall health, and mental and physical ability—are also significant factors. Vulnerable individuals and communities are more likely to struggle to evacuate ahead of wildfires and to experience more severe or sometimes longer durations of loss of property, livelihoods, and services. In addition, these communities are at greater risk of fatalities and injuries during wildfires.

In contrast, socioeconomically secure individuals and communities have more resources to ensure life safety, protect property, and cope with disaster costs. They also have the advantage of being able to secure private fire protection, suppression, and recovery resources—a practice that is becoming more common.[30] Those with higher incomes also are more likely to have fire insurance, which is critical for rebuilding.

A 2018 analysis of wildfire vulnerability found that "census tracks that were majority Black, Hispanic, and Native American experience 50 percent greater vulnerability compared with other census tracks."[31] The researchers cite many interrelated potential reasons for this discrepancy including income and housing quality. Lack of trust in government, extending to emergency service officials, is also a factor, particularly for those who are undocumented or in the United States on a temporary legal basis.

People who are less mobile—because of physical ability, health, age, lack of transportation options, or other reasons—may also have more difficulty evacuating out of danger zones or finding emergency lodging. Similarly, those who are less connected with government services or do not have English as a first language may not have equal access to evacuation guidance or disaster assistance. Officials may be able to issue evacuation notices or even preevacuation notices well in advance of a wildfire moving into a populated area, providing all residents the opportunity to plan and evacuate. However, sometimes residents have very little warning because fires spark near populated areas or weather and wildfire behavior change quickly, threatening new communities.

People with fewer financial resources also may live in lower-quality, less-resilient housing. For example, mobile homes, even when built to code, are at greater wildfire risk because of close spacing and construction materials.[32] Individuals with low incomes or those with

"Resilience is about residents. It's about the people. It's about protecting life."

THOMAS COVA, EVACUATION EXPERT AND PROFESSOR OF GEOGRAPHY, UNIVERSITY OF UTAH

CALIFORNIA NATIONAL GUARD

A firefighter hand clears brush to reduce wildfire risk. Those who are regularly exposed to wildfire conditions, including first responders and outside workers, are at increased risk from long-term health stressors such as respiratory disease or cancer—likely related to chronic smoke and contaminant exposure.

BURBANK HOUSING

The 2017 Tubbs fire destroyed Journey's End mobile park (a housing type particularly vulnerable to wildfires) in Northern California. Residents have priority placement in new, affordable multifamily units that are designed with wildfire resilience features.

limited time from working multiple jobs may also struggle to afford or to complete the preventative maintenance that can deter flames from reaching and destroying a home. Renters are ineligible for most federal disaster assistance, which is typically geared toward homeowners.

For homeowners and renters who are not wealthy, the loss of a home can be financially devastating unless there is significant and rapid rebuilding assistance. Nonprofit developer Burbank Housing recognized this following the 2017 Tubbs fire, which burned the 162-unit Journey's End mobile park in Santa Rosa, California.

Journey's End "was a source of low-income housing," says Larry Florin, Burbank Housing CEO. "One of the things we realized early on was that even if we rebuilt the park, it would be very difficult for the folks who had lived there to put together the money to buy a new coach to move back." Burbank Housing Development Corporation, in partnership with Related of California, is redeveloping the site with affordable multifamily units with priority placement given to Journey's End residents. "It was the best chance that the population being served had to be able to move back to that site," says Florin.

Firefighters, including those who choose the occupation and those who work while they are incarcerated, are also at increased risk from wildfire. In addition to the acute risks, firefighters are at increased risk from long-term health stressors such as respiratory disease or cancer, which is likely related to chronic smoke and contaminant exposure.[33]

California, Arizona, Nevada, Wyoming, and Georgia have inmate firefighting programs.[34] In California, which has the largest program, 40 percent of those fighting wildfires are incarcerated, and this program has added significant capacity and saved the state about $100 million annually.[35]

Those who work as inmate firefighters volunteer for the work although the American Civil Liberties Union points out that "prison is an inherently coercive environment; there's very little that is truly voluntary."[36] Incarcerated firefighters are paid between $1.45 and $6.12 a day, compared to nonincarcerated firefighters who earn an average annual base salary of $91,000.[37]

At least in one instance, a state has sought to prolong sentences citing the necessity of firefighting labor provided by those serving time as a legal argument to try to delay prisoner releases.[38]

Socioeconomic factors—such as wealth, race, age, occupation, citizenship status, language, overall health, and mental and physical ability—are significant factors in extent of wildfire risk faced.

ADAM DUBROW/FEMA

Debris flows commonly occur after wildfires. The flood control districts of the seven Southern California counties—Los Angeles, Orange, Ventura, Santa Barbara, Riverside, San Bernardino, and San Diego—have built an extensive network of more than 200 concrete barriers in the region's mountains to mitigate debris flows and protect neighborhoods.

Once released from prison, individuals often face barriers that prohibit them from using their skills working professionally as firefighters or emergency medical technicians. In September 2020, California implemented new policy enabling nonviolent offenders who worked as inmate firefighters to petition county courts to expunge their records and reduce parole time. The intention of the policy is to remove barriers to employment.

Product Types at High Risk

Infrastructure not built to strict protection standards or structures located in fire-prone areas are at high risk of direct damage from wildfires. A significant proportion of destroyed structures are usually residential because homes are commonly located in high-risk WUI areas.

"The problem we're tackling with wildfire is that the built environment is already built in high-risk areas," says Michele Steinberg, wildfire division director at the National Fire Protection Association (NFPA). Most existing structures ignite and burn more readily because they are not built to relatively recent wildfire codes that help prevent ember intrusion and flame spread.

Industrial and commercial properties may be at higher risk from wildfires if there are significant flammable materials, such as large wooden shipping pallets or flammable chemicals, on site. More than structural damage, a prevalent concern among owners and operators of commercial property is business continuity. "In commercial, I think there's concern about wildfires, but not to the same degree as residential, which tends to make up the majority of the urban-wildland interface," says Antonio Pares, principal at Mithun. "The concern may be for commercial is resilience in being able to maintain operations. The issue has become hard to dismiss."

Power outages are another concern for the commercial sector. "Our wildfire season is usually during the summer, so there's a real possibility that we could have interactions of issues with particulate matter in the air, issues with heat intensity, and issues with potential power outages," says Sarah Hong, building performance engineer at Colorado-based Group 14 Engineering.

Military sites can be similarly susceptible because of on-site materials and location. For example, in 2019, firefighting was complex and dangerous during a 3,000-acre wildfire that threatened a training center near Fort Greely, Alaska, that had unexploded ordinances on site.[39] Other times, training sites are vulnerable because they are located in remote, wildfire-prone areas. "For us, wildfire risk is one of the largest considerations," says Charles Baun, an Eagle City council member in Idaho as well as a member of the National Guard Bureau's Environmental Advisory Committee. "We develop an integrated natural resources management plan; it's how we integrate the military training activities with the area that we train in."

Wildfires also cause extensive and expensive damage to energy and water infrastructure. Energy infrastructure can also cause wildfires when high winds bring down equipment or when equipment comes into contact with vegetation or other wildfire fuels. Alarmingly,

"It's less common that we see a lot of commercial structures [damaged or destroyed by wildfires], and it's more common that we see a lot of residential, but that is changing. . . . We are starting to see not just homes but whole communities starting to expand out into wildfire-prone areas."

DANIEL GORHAM, RESEARCH ENGINEER, IBHS

these utility-caused wildfires tend to be larger and harder to suppress because the factors that cause electrical equipment to start fires are also the conditions in which fires spread most rapidly.[40]

Wildfire can directly damage water infrastructure by burning and melting equipment (including meters and underground pipes) as well as by indirectly contributing to debris flows, which damage infrastructure and directly contaminate reservoirs. Ash, combined with the increased runoff from heavy storms after vegetation has burned away, can actually "pave" a forest after a significant wildfire.[41] "It's not just the fire," elaborates town council member Vickie Wendt from Arizona. "Many homes escaped the original Goodwin fire in 2017. . . . Then the monsoons came along and the flash floods, and mudslides literally were lifting homes off foundations."

DEVELOPMENT TRENDS CONTRIBUTE TO INCREASED WILDFIRE RISK

Driven by consumers' desire to live in beautiful, natural areas and by the widespread affordability crisis in cities, more building is happening in areas with wildfire risk, particularly in the WUI. And, driven predominantly by market demand and pricing in some areas, the conversion of agricultural to developed land also is adding to WUI growth.

Only 14 percent of the WUI is developed, and it is the fastest-growing land use type in the United States. "Between 1990 and 2010, new houses in the WUI increased from 30.8 to 43.4 million (41 percent growth), and land area of the WUI increased from 581,000 to 770,000 square kilometers (3 percent growth)."[42] Put another way, about "43 percent of all new houses are built in the WUI."[43] In the western states, the WUI has expanded by 60 percent since 1970.[44]

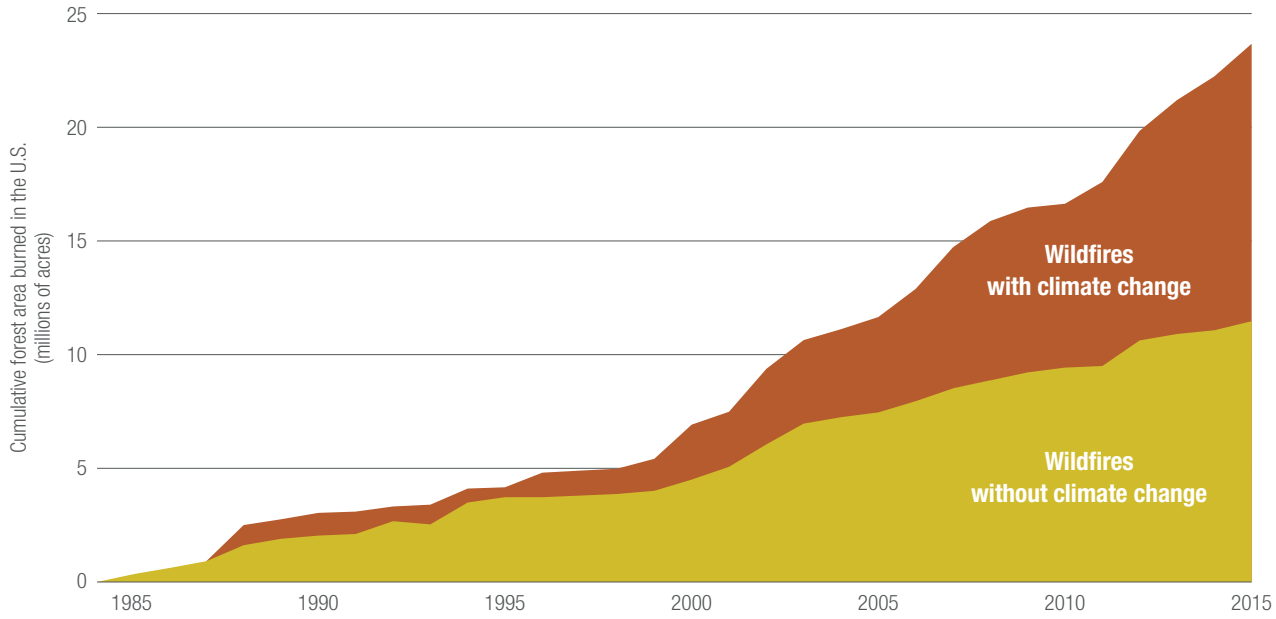
Within the WUI, an increasing number of homes also are built directly in or within 30 miles of protected natural areas, creating risks for occupants and wildfire prevention and response complexities for officials. Growth in and near protected natural areas outpaced general national growth by 7 percent between 1940 and 2000.[45]

"We're going to develop in the WUI because that's where people want to be," says Steve Thompson, a former developer and current principal at Capasiti Consulting. "They're willing to pay extra to be there. Customers will pay a premium for trees and views." A 2020 study

SHUTTERSTOCK

Homes in the wildland-urban interface are desirable for their beautiful, natural locations and often fetch a price premium for that reason. Even so, residential development in the WUI is still typically less expensive than property in urban centers, which is contributing to growth in wildfire-prone areas.

Climate Change Increases Area Burned by Wildfire



Source: Data from the Fourth National Climate Assessment.

of house prices and wildfire risk factors in Colorado Springs similarly found that property values were highest on ridgetops, where wildfire risks are extreme, because of the demand for expansive views.[46]

Following consumers and residential development, experts also report increasing commercial development and wildfire impact in WUI areas. "It's less common that we see a lot of commercial structures [damaged or destroyed by wildfires], and it's more common that we see a lot of residential, but that is changing. . . . We are starting to see not just homes but whole communities starting to expand out into wildfire-prone areas," says Daniel Gorham, wildfire research engineer for the Insurance Institute for Business & Home Safety (IBHS). In response, wildfire best practices for commercial structures is an emerging area of focus for research organizations, trade groups, and insurance companies.

Housing affordability challenges also incentivize homeowners to search for housing further and further from urban cores, increasing development pressure and incentives in WUI areas, which are often less expensive.

CLIMATE CHANGE INCREASES WILDFIRE RISK

Climate change has dramatically affected, and is likely to continue influencing, wildfire characteristics and impacts. A hotter, drier climate will lead to more frequent, intense, and unpredictable fires.

In the western United States, the annual area burned could increase two to six times from the present by the middle of this century because of climate change.[47] And, in the Southeast, "the potential for very large fires (greater than 5,000 hectares) may increase by 300–400 percent by midcentury."[48]

"With increases in temperature and changes to precipitation patterns, the fire situation is just going to get worse and worse. There's no question in my mind that climate change is already affecting what's happening with wildfires, and I'm afraid to say we haven't seen the worst yet," says wildfire expert Mike Pellant.

Today, wildfires burn more area, cumulatively affecting double the amount of land than they did before the mid-1980s. Wildfires often coincide with heatwaves and droughts.[49] In fact, 96 percent of the 500 most disastrous large fires of the past decade have occurred

"With increases in temperature and changes to precipitation patterns, the fire situation is just going to get worse and worse. There's no question in my mind that climate change is already affecting what's happening with wildfires."

MIKE PELLANT, PRESIDENT, RANGELAND SOLUTIONS

WILDFIRE CONTRIBUTIONS TO CLIMATE CHANGE

Wildfires influence climate change because they release significant amounts of carbon dioxide (CO_2) and other greenhouse gases[50] as well as damage forests and soils that act as carbon sinks.[51] Some experts estimate that because wildfires release greenhouse gases, the emissions from repetitive catastrophic wildfires could be enough to compromise state emissions reductions progress.[52]

Plant growth post-wildfire does uptake carbon, but the carbon released in areas that burn repetitively can outweigh the carbon storage achieved by new growth.[53] Similarly, rebuilding structures requires significant amounts of new materials, which themselves are carbon intense. Globally, wildfires contribute 5 to 10 percent of annual global CO_2 emissions each year,[54] but that number is likely to increase if wildfires continue to intensify and burn more area.

SHUTTERSTOCK

Catastrophic wildfires cause the release of carbon dioxide and other greenhouse gases that otherwise would be absorbed by healthy forests and soils and help mitigate climate change.

during periods of unusually hot and/or dry weather.[55]

The direct impacts of climate change—a warmer, drier climate—are the reason for more than half the documented increases in drier vegetation (i.e., wildfire fuel) that have occurred since the 1970s.[56] For example, the city of Paradise, California, which was burned in 2018 by the Camp fire, had not experienced significant rain for the preceding 211 days.[57]

In addition, warmer temperatures lead to less snowpack and, therefore, drier soils; and they lead to improved conditions for insect pests like bark beetles, which kill trees and create still more fuel for wildfires. "It doesn't take much," said Jennifer Balch, a fire ecologist at the University of Colorado in an interview with NPR. "With just a little bit of drying you get a substantial increase in the amount of burning."[58]

Wildfire risks also are increasing because the climate-change fueled alterations in temperature, vegetative fuels, and snowmelt have increased the length of the fire season. Averaging across the United States, wildfire season used to be about four months, and now wildfire risks are high for six to nine months each year.[59] According to the U.S. Forest Service, fires have burned well outside of the typical fire season throughout California, Arizona, New Mexico, Tennessee, and New Jersey in recent years. The U.S. Forest Service now officially plans for "the fire year" rather than "the fire season." Lastly, climate change may also lead to more lightning strikes, the main natural cause of fire ignition, especially in the Southeast, which is already a global lightning hotspot.[60]

Together these climate-change impacts increase the occurrence of megafires, which are defined by the U.S. Interagency Wildfire Center as those wildfires that cover more than 100,000 acres but more commonly are becoming thought of simply as large, immensely destructive fires. In the western United States, "large fires are almost seven times more frequent than they were three decades ago, driving an increase in area burned by large fires of 1,200 percent."[61]

Historical Fire Suppression Raises Today's Risk

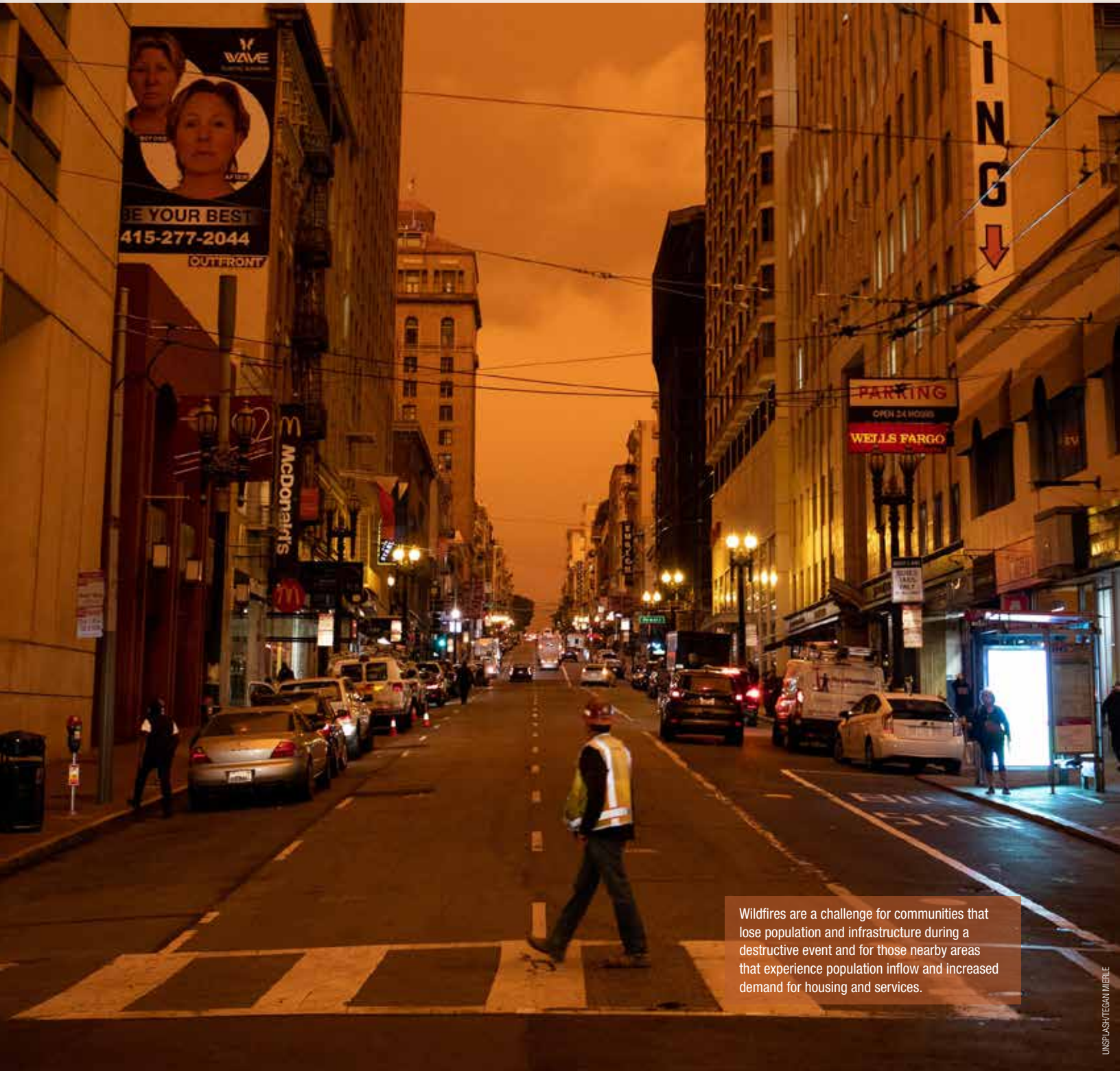
In addition to climate change, the experiences of communities in wildfire-prone areas and advances in science have demonstrated that past U.S. federal land management policy—to suppress all fires as quickly as possible—causes bigger and more intense fires by allowing vegetative fuels to accumulate. Suppression was the main strategy for much of the 20th century, in large part to protect rural timber-based economies.[62]

"We're dealing with what's been a 20th century model for about 100 years now. Wildfire suppression has been the main goal, and that's changed how our forests grow and the fuel that remains within them," says Jeremy Klemic, landscape architect at SWA.

Climate change is increasing the length of the fire season. Averaging across the United States, wildfire season used to be about four months, and now wildfire risks are high for six to nine months each year.

COMMUNITY AND INDUSTRY IMPACTS

DRIVEN BY CLIMATE CHANGE, accelerating WUI development, and a legacy of fire suppression, wildfires' impacts on communities and the economy are significant. In addition to the direct impacts, related to public health and structural damages, an array of downstream effects can raise concerns about the long-term safety and economic viability of communities in wildfire-prone regions.



Wildfires are a challenge for communities that lose population and infrastructure during a destructive event and for those nearby areas that experience population inflow and increased demand for housing and services.

UNSPLASH/TEGAN MIERLE

HEALTH AND SAFETY

Wildfires directly cause physical and psychological harm and—through infrastructure damage and community displacement—can erode the support structure of many individuals and communities. Local leaders involved in wildfire resilience efforts are themselves often community members affected by wildfires, adding personal difficulties to professional challenges.

Some of the most common and impactful health effects of wildfires include direct fire fatalities and injuries, mental and emotional trauma, increased health care costs, and exacerbation of underlying medical conditions, such as cardiovascular issues. In terms of psychological impacts, wildfires measurably increase the rates of post-traumatic stress disorder, depression, suicide, substance abuse, insomnia, anxiety, and domestic violence.[1]

Air Pollution from Wildfire Smoke

Air pollution from smoke is a life-threatening health effect of wildfires and an extremely widespread and expensive problem in urban and rural communities. Smoke, which is composed of a combination of gases and fine particulate matter from burning material, can be an acute issue during and immediately after a fire. Smoke also can be a chronic risk for those regularly exposed to it including first responders and agricultural workers as well as people challenged by homelessness who have few if any clean air shelter options. Identifying the long-term effects of chemicals in smoke that are released from burning or melting infrastructure is an area of emerging research.

For building owners and property managers, wildfire smoke can endanger staff and tenants, cause physical damage to property, and be a reason to suspend business operations.

Even urban centers that are not immediately at risk from wildfire flames are significantly affected by wildfire smoke. During the September 2020 wildfires, San Francisco, Seattle, and Portland, Oregon, each periodically had the worst air quality in the world.

For many major markets, wildfire smoke is projected to be a more frequent concern as climate change increases the number of wildfire burn days.

During the September 2020 wildfires, San Francisco, Seattle, and Portland, Oregon, each periodically had the worst air quality in the world.

MITHUN

Maceo May, a 105-unit, all-electric residential development in San Francisco, is designed with an energy recovery ventilator with a MERV 13 filter, operable windows, and ceiling fans for every residential unit as well as a community space powered by on-site solar to maintain indoor air quality and continue operations during wildfires, heat waves, and power outages. Read more at developingresilience.uli.org/.

COMPOUNDING THREATS: WILDFIRES AND COVID-19

The coronavirus pandemic and associated economic recession increased the difficulty and costs of responding to the record-setting 2020 wildfires and may worsen the impacts for years to come. The virus significantly affected wildfire emergency response by increasing demand for personal protective equipment, reducing firefighting capacity through illness, and requiring a wholesale rethink of emergency shelter strategy to maintain social distancing. The result was slower and more dangerous firefighting and more expensive evacuations (hotel rooms rather than mass shelters or encouragement to stay with friends and family); as unemployment climbed, public revenue decreased, and governments dug into emergency funds.

In addition, wildfire smoke irritates lungs and makes people more prone to infections like COVID-19. Research released in April 2020 demonstrated that COVID-19 fatalities were higher in areas with poor air quality. Emergency and public health officials warned residents who had or were recovering from COVID-19 to stay indoors when air quality deteriorated and to designate a "clean room" to reduce exposure to wildfire smoke.

The stress caused by multiple wildfire impacts and changing workplace expectations to reduce COVID spread (for those with remote work capability) points to the likelihood of long-term consequences for individuals and communities. Research reviewing the aftereffects of natural disasters has shown that "a human crisis" of mental and emotional challenges persists long after the immediate public health and economic crisis from a disaster event have ended. And, with increased opportunities for remote work due to COVID-19, several interviewees also shared stories of family, friends, or colleagues relocating temporarily out of state (or, in some cases, out of the western region) to escape the wildfire smoke.

EMERGENCY EVACUATIONS AND COMMUNITY DISPLACEMENT

There are at least two community-level perspectives with severe wildfire events—the directly affected communities that lose population and infrastructure during a wildfire and those nearby areas that experience population inflow. Communities directly affected by wildfire flame are often challenged to cope with the immediate costs and logistics of an emergency response and by postevent disaster-funding searches, debris cleanup, rebuilding, and future planning. Communities near but outside the directly affected area will not receive disaster funding but often they will need to quickly provide housing and services to a suddenly much larger population.

Short-Term Wildfire Displacement

As the size and unpredictability of wildfires increase, so do the size and difficulty of mandatory and recommended evacuations. For example, displaced by the flames and evacuation orders from the 2018 Colorado Silver Creek wildfire, which ignited in July then flared again later that summer, about 500 residents lived in a tent encampment from July through September that year while the fire was contained.[2] Local resources were strained; external funding helped provide the infrastructure needed to provide for public health (although businesses that were able to meet these needs—such as mobile food and hygiene providers—prospered).

The mass evacuations have a clear life-safety benefit. For example, almost 200,000 people were evacuated out of the path of the 2019 Kincade fire, which spread rapidly after ignition in Northern California, and as a result, there was not one fatality during that fire. Afterward, in an interview for the *Los Angeles Times*, Jorge Rodriguez, a public information officer in Sonoma County, emphasized the importance of that success and also spoke to the difficulty of securing sufficient emergency shelter. "Because of the vast number of people evacuating, where do you put them? Who's going to take them in?"[3]

Overnight Growth in Transient Population

Often, communities near but not directly in the path of wildfires very quickly receive large numbers of displaced persons. The population of Chico, California, for example, which is about 15 miles from Paradise, jumped 20 percent the night after the Camp fire.[4] However, these receiving communities often experience challenges because of the population influx;

"Wildfire issues are not localized anymore."

BRIAN STRONG, CHIEF RESILIENCE OFFICER, CITY AND COUNTY OF SAN FRANCISCO

they are typically not eligible for disaster relief funds even though they house a displaced population, which can strain services, infrastructure, and housing supply.[5]

Businesses are also affected by wildfire-driven in-migration. Some of those impacts are a positive—more people bring more business. Businesses that are out of the flame path frequently open their facilities temporarily to shelter their own employees and employees' families as well as displaced community members. During the 2018 fires, many hotels in Los Angeles offered a one-night free stay to those who could show proof of residence and evacuation from that season's wildfires.[6] Airbnb made a similar offer during the 2019 Kincade (Sonoma County) and Tick (Santa Clara, California) wildfires,[7] and the Red Cross used a similar hoteling strategy for its clients during the 2020 wildfire season to minimize exposure to and transmission of the coronavirus that would be more likely to occur in mass shelters.[8]

Long-Term Wildfire Displacement and Gentrification

Residents of fire-affected areas can be displaced over a large geographic area and this displacement can be for years, or even permanently, if there was significant housing loss, which heightens the difficulties experienced by individuals and by the receiving and recovering communities. For example, the U.S. Department of Finance estimates that 3,000 people left Sonoma County in the year after the 2017 fires.[9] And after the Camp fire, a public and crowd-sourced Facebook group for survivors documented that most stayed in California, but that 25 percent moved out into 29 different states.[10] Residents who live in burned areas and secure temporary housing in nearby towns may then have significantly longer commutes to work or to school, and that creates new traffic dynamics and challenges at the community level.

Postevent rebuilding takes time, and it can be difficult to estimate how many people plan to return. In Paradise, where the 2018 Camp fire destroyed 90 percent of the structures and displaced 83 percent of the residents, predicting the future population is a critical question for local leaders leading the rebuilding effort. "You have to plan for a certain density of people," says former city manager Lauren Gill. "And it's a chicken and egg problem. The industry won't come back if they think people won't come back and people won't come back without a place to live."

FLICKR/CALIFORNIA OFFICE OF EMERGENCY SERVICES

In October 1991, a wildfire burned into Oakland, California, causing 25 fatalities and destroying 3,500 homes, contributing to the displacement of residents who were predominantly Black, Hispanic, and/or had low incomes.

Though it is difficult to generalize about recent trends when recovery is not yet complete, "the past is clear. Fires produce gentrification," said author and Californian historian Mike Davis in a 2018 interview with the *Los Angeles Times*.[11] Davis was speaking about the 1991 Oakland firestorm, which predominantly burned in the wealthier, more forested, eastern side of the city. According to Davis, the postfire rebuild further excluded lower-income residents from the neighborhood because many homes were rebuilt larger and at higher price points.[12] Residents in the hills of East Oakland were predominantly White and residents living in other sections of the city were predominantly Black and Hispanic.[13]

STRUCTURE DAMAGE AND RESIDENTIAL VALUE CHANGES

The effects of wildfire events on home and rent value are complex. Recent post-wildfire damage reports and housing studies show that there can be reductions in home and rent value in burned areas, as well as an increase in mortgage defaults, but that home and rent prices generally hold steady or increase after destructive fires.

Repetitive Losses and Damaged Scenery Decrease Property Value

A widely circulated and cited study from 2008 that measured the price effect of repetitive wildfire events demonstrates that the first fire reduces house prices by about 10 percent and the second fire reduces house prices about 23 percent, with prices rebounding within a few years—unless the fire burn scar is visible from the home.[14]

Developer experience matches the empirical evidence on the importance of undamaged views, especially in higher-priced or vacation markets. Developer Davis Scholl says, "In Arizona's second-home forest communities, a lot of people are faced with 'If this house or community burns down, do I want to rebuild in what looks like a charred moonscape?'. . . Once the forest is gone, it is not a place you want to vacation to for a lot of years." Similarly, demand and price decreased for luxury summer rentals in Malibu, California, because of consumer concerns about safety and lack of accessible amenities following the high-profile 2018 fires.[15]

Short Supply Increases Home and Rent Prices

The neutral or upward trend in home and rent prices after some wildfire events is likely due in large part to the significantly decreased supply of available homes. Wildfires cause massive amounts of structure loss each year. Individual fire events have destroyed almost every structure in some cases; 80 percent of structures in Malden, just outside of Spokane, Washington, were burned within a few hours in September 2020.[16]

Alarmingly, structure loss due to wildfires is increasing. NFPA estimates that of all fire types (structural as well as wildfire), wildfires caused 34 percent of structure loss in the decade before 2015 but as much as 96 percent of structure loss due to fire in the years following.[17] On average, "in the 2000s, the average number of structures lost was 2,300 per year. From 2010 to 2017, the average was 4,300 per year."[18]

The Camp fire destroyed close to 19,000 structures in Butte County, and the medium home price increased 15 percent in Chico, California, where many moved following the fires. In fact, Chico briefly became "the hottest housing market" in the country according to Realtor.com. Supply can decrease significantly in more populated metropolitan areas, too; for example, after the 2018 Woolsey fire affected Los Angeles and Ventura County, the number of homes on the market was 23 percent lower after the fire.[19]

However, the pattern of where price increases occur post-wildfire is not consistent. A 2019 assessment by Core Logic of home values after wildfires in California notes that price increases occurred sometimes only in flame-affected communities and surrounding areas and other times only in areas unaffected by direct flames.[20]

Post-Wildfire Residential Insurance Changes

In response to catastrophic events and increasing potential loss profiles, insurers are raising premiums, limiting policy coverages, and decreasing policy renewals for properties in some wildfire-prone areas. In some very high-risk locations, insurers have also refused to issue new homeowner policies.[21] In contrast, several insurance companies—led by United Services Automobile Association (USAA), which was the first to establish a discount program—offer premium reductions for homes in recognized wildfire-resilient communities.

"In some communities after significant fires, insurance becomes a big issue. It comes up almost everywhere we work including in Washington, Oregon, Arizona, and Colorado," says Molly Mowery, executive director of Community Wildfire Planning Center. "It's fair to say fire is playing a significant role in insurance discussions, but it's an uneven outcome for many communities based on many factors."

Until recently, wildfire losses were considered by reinsurers to be low risk and predictable in the context of overall catastrophe losses.[22] However, using tools such as satellite data and drones, insurers' ability to assess local fire risk has increased as have insured losses from wildfire events.

Insurers' ability to assess local fire risk has increased as have insured losses from wildfire events.

Homeowners insurance rates have increased, or policies have been dropped, because of wildfires in Washington, Montana, Colorado,[23] and Oklahoma,[24] but the most significant changes have occurred in California.

After the 2017 and 2018 wildfire seasons, homeowners insurance in California increased 50 percent more in wildfire zones than elsewhere,[25] and property and casualty insurance premiums overall rose as much as 500 percent. These rate hikes provide a new incentive against living in high-risk areas and introduce a significant financial burden. Insurers have also eliminated at least 340,000 policies in fire-prone areas throughout the state.[26]

Governments that use insurance to mitigate the annual changes in fire-suppression costs are also directly affected by the premium increases. Premiums for Oregon's insurance policy covering emergency fire costs "increased significantly" after large payouts in 2013 and 2014.[27] Similarly, the ratio of Californian utilities' premiums to coverage was reported to have quadrupled between 2017–2018 and 2018–2019.[28]

Recognizing the social equity implications and potential economic repercussions of

home insurance becoming widely unavailable, governments are exploring solutions, including regulation. In 2013, the governor of Colorado introduced a controversial—and eventually unimplemented—home risk-rating system, for example.[29] California has several requirements in place including that insurers must cover about 36 months of temporary housing in the case of a federally declared disaster and, in 2019, a temporary one-year ban prohibiting insurers from dropping policies on homes in high-risk areas.[30]

Post-Wildfire Recovery Booms and Price Increases

Both flame-affected and nearby communities often experience short-term recovery booms driven by reconstruction. Santa Rosa, California, for example, lost about 3,000 homes within the city limits in the 2017 wildfires, and about 1,700 were in some stage of being rebuilt 18 months after, representing a significant amount of economic activity.[31] Local economies can experience positive long-term effects of these recovery booms if contracts are awarded to local companies.[32]

In locations where wildfires have caused regional damage—like in Northern California—the scale of the reconstruction has created competition for labor and materials. "We bid a 50-unit multifamily in September 2017. The wildfires hit in October, and they canceled all the bids. Then we rebid in December, about two to three months later. The costs had gone up $2.5 million on a $25 million project, so costs had gone up 10 percent from before the fire to after the fire. And the costs haven't gone down since," says Larry Florin, a housing developer.

Susan Hartman, community development director in Paradise, emphasizes that these cost increases are not the result of new or stricter building codes. "This town has had to do WUI construction since 2011. Building to these wildfire standards is not new to us, and we've been able to provide affordable housing. It's not the land values that are going up; it's regional competition for construction materials. We're fighting for the same builders and building materials with [other] rebuilds." Developers and public officials also report that rebuilding project costs can be higher and timelines longer in remote areas that are difficult to access.

"It's not the land values that are going up; it's regional competition for construction materials. We're fighting for the same builders and building materials with other rebuilds."

SUSAN HARTMAN, COMMUNITY DEVELOPMENT DIRECTOR, PARADISE

REBUILDING TO EXISTING OR NEW CODES

Planners and public leaders face a conundrum about whether to require that destroyed or significantly damaged structures be rebuilt to existing or new, more resilient wildfire codes and standards. Policymakers face the same dilemma for increasing regulations on existing buildings. "We have a major affordable housing issue, so we are being thoughtful of the wildfire codes we put in place, so they don't have unintended consequences," says Karen Hughes, assistant director of planning and community development in Missoula County.

Decision-makers recognize that structures built to best-practice codes survive wildfires at higher rates (see Building Codes Protect Structures on page 30) and that these requirements may help protect the life safety and economic vitality of individuals and communities in the long run. However, updating building codes can add additional costs for property owners and be especially burdensome to community members with lower incomes.

Insurance payouts have a huge influence on affordability and rebuilding decisions, too. Current insurance policies provide for rebuilding exactly what was destroyed, not for rebuilding to current standards or for making sustainability or resilience improvements. For local leaders, requiring wildfire-destroyed structures to be rebuilt to higher resilience standards without the support of insurance payments creates a barrier that could discourage community members from returning to rebuild.

In addition, "whether or not you increase the [resiliency] standards and building requirements, the cost of building back even to the existing WUI standard and labor and material costs today is just de facto more expensive than when the house was built," says Megan O'Hara, principal at Urban Design Associates.

According to Edith Hannigan, land use policy manager for the California Department of Forestry and Fire Protection (CALFIRE), wildfire code standards today are still sometimes seen as flexible or possible to exempt after catastrophic events. However, "that's happening less and less now that we've seen some of these big fires," says Hannigan. "Jurisdictions are becoming stricter about enforcement and are much less likely to exempt it [a burned down building] from WUI standards during rebuilding."

ECONOMIC IMPACTS

In addition to direct infrastructure damages, wildfires also can have secondary consequences that affect local and regional economies. A study by the National Institute of Standards and Technology (NIST) calculated that, each year, wildfires impose a total U.S. economic loss ranging from $63 billion to $285 billion. That includes everything from suppression efforts to property damage and postfire flood control.[33]

Debris Removal

Debris removal is one of the first steps during a wildfire recovery, and it is one of the most expensive and difficult processes that municipalities manage postdisaster. Wildfire debris includes materials like charred building rubble as well as sediment and trees, and often cleanup is further complicated when debris is contaminated with heavy metals and toxins. For example, the debris removal and cleanup from the 2018 Camp fire cost about $1.3 billion.[34]

Catastrophic wildfires have caused so much damage and necessitated such large and long-lasting recovery efforts that public leaders report that the recovery operations also sometimes strain local infrastructure. For example, the constant use of large recovery machinery can damage roads.

Lost Economic Activity and Decreased Tax Revenues

Lost economic activity because of wildfires (as measured by lost business economic activity, unemployment insurance, commercial property damage, and lost tourism) is significant but can vary greatly. For example, a study by North Carolina State University calculated lost economic activity from a large 1998 fire in eastern Florida and a 2003 fire in San Diego and quantified losses of $1,864 per acre and $6,516 per acre, respectively.[35] The lost economic activity in the San Diego region that year represents a 10 percent decrease in gross productivity, resulting largely from "a loss of 24 commercial buildings, a $32.5 million drop in tourism, and almost 5,000 people out of work."[36]

Wildfires especially decrease economic activity in tourism and agricultural sectors. In 2002, for example, Colorado's tourism sector lost $1.7 billion in a record-breaking fire season, and a survey of visitors planning to travel to California in 2018 found that 11 percent had canceled their trips because of fire concerns.[37]

One area of great concern for public leaders is lost or decreased tax revenue—such as sales and property taxes—because of population displacement. For example, an economic hit to Paradise because of the Camp fire was the sharp decrease in gas tax revenue, which left the town with fewer resources for road repairs.

Negative Financial Impact of Preventative Blackouts

Though preventative power shutoffs might have tremendous positive long-run value in terms of avoided wildfires, they also are significantly damaging to local businesses and economies in the short run. This preventative tactic is not new; San Diego Gas and Electric has implemented periods of de-energization since 2007 to avoid sparking wildfires.[38]

The infamous 2019 public safety power shutoff (PSPS) in California by PG&E caused an estimated $2 billion in losses from wide-ranging consequences such as closed schools and disrupted high-profile medical research.[39] Three million people in California were without power at some point during summer 2019 because of PSPS, raising life-safety as well as economic concerns.[40] PG&E reported receiving 146 claims for losses, 25 of which were specifically for business impacts because of PSPS.[41]

Utility executives also have announced that these periods of grid de-energization are likely to be more frequent in both the near and long terms, making energy resilience a critical component of holistic wildfire resilience. Bill Johnson, the former CEO of PG&E, estimated in 2019 that power safety shutoffs would continue for at least a decade.[42]

"Because known fire locations are becoming increasingly urbanized, the vulnerabilities can lead to greater loss potential—to people, property, and entire industries."

STEVE BOWEN, DIRECTOR, METEOROLOGIST, AND HEAD OF CATASTROPHE INSIGHT, AON

("HOW WILDFIRES HAVE SPARKED CHANGE IN THE POWER INDUSTRY," *THE ONE BRIEF*)

ELECTRICITY INFRASTRUCTURE, LOW-CARBON REAL ESTATE, AND WILDFIRE RESILIENCE

Increasing the resilience of electric infrastructure—a significant amount of which is in wildfire-prone WUI and rural areas—could mitigate the chances of fire ignition and spread, increase the security of critical communications, improve service reliability, create more widespread backup-power options, and limit potential wildfire infrastructure damage. Such large-scale grid improvements are not only necessary to improve wildfire resilience but also are needed to address countrywide aging equipment, capacity bottlenecks, and increased storm and climate impacts—all while demand is increasing.[43]

For electric utilities, managing infrastructure is critical to limiting damages; utilities' largest wildfire exposures are from the liabilities they may incur if their assets are found to have been responsible for igniting a fire.[44] In California, for example, utilities are only able to raise rates to cover disaster costs if the Public Utilities Commission approves the increases, and that is only approved if the commission finds that the utility "reasonably and prudently operated" its equipment.

> **"Resilience is increasingly becoming an issue in the electricity sector and for the ongoing energy transition. . . . However, the push to decarbonize means we're increasingly dependent on electricity."**
>
> KEVIN BREHM, MANAGER, ROCKY MOUNTAIN INSTITUTE

Significant grid updates present opportunities to create an energy system that is low or zero carbon and renewable. However, transitioning to more renewable energy sources and greater electrification—key strategies in progressive green building and transportation policies—also creates a need for more electric infrastructure, setting up a potential conflict between achieving sustainability and wildfire resilience goals.

Developing a more wildfire-resilient and low-carbon electrical system involves a series of tough decisions and tradeoffs with large-scale infrastructure updates. Undergrounding transmission wires, for example, would very effectively decrease the chances of them sparking a wildfire; however, doing so is costly and potentially makes the transmission wires vulnerable to other hazards such as earthquakes or construction accidents. Similarly, installing and enabling more widespread use of generators—a type of distributed energy resource that typically runs on diesel fuel—would limit the negative effects of preventative de-energizations but would increase greenhouse gas emissions.

Emerging technologies such as batteries and on-site solar offer enhanced storage capacity and renewable, low-carbon power locally without the need for as many high-voltage transmission lines. However, though there are individual assets across the United States that have successfully integrated these emerging technologies, the grid and infrastructure are not yet advanced enough to integrate one-off projects on a large scale.

Wildfire-Resilient Energy Solutions

Strategies for improving the wildfire resilience of the electrical grid include some well-established tactics such as energy efficiency and vegetation management as well as further development and implementation of emerging technologies.

- **End-use efficiency**
  - Minimizing energy demand keeps a stressed grid functioning longer and allows for critical services to be met even when power generation is limited. End-use efficiency is a cost-effective strategy familiar to many in the public and private sectors.
  - Utility companies are longstanding stakeholders in reducing energy demand and they are expanding efficiency incentive programs because of wildfires. Utility efficiency and incentive programs can include rebates on energy efficient equipment to reduce energy usage, free or reduced-cost LEDs and smart thermostats for residential customers, or large-scale tenant improvement rebates or financing programs to help commercial clients install more efficient upgrades.
  - The wide range of policies being implemented at the local level to achieve emission-reduction targets include stricter energy codes, mandatory energy and emissions benchmarking, building-efficiency ratings, mandated compliance with emissions targets, building energy-performance standards, all-electric building ordinances, and mandatory renewable energy targets.
- **Electric-grid hardening**
  - Hardening the electric grid could prevent fires from igniting, speed postevent recovery, and generally improve service reliability.
  - Grid hardening refers to a set of traditional resilience strategies implemented by utilities to strengthen physical infrastructure. Strategies include undergrounding wires, protecting or replacing vulnerable utility poles, insulating power lines, removing overhanging tree branches or other nearby threats, and installing smart sensors to more quickly identify and isolate issues.
- **Distributed energy resources (DERs) and backup power**
  - DERs generate small amounts of power over a wide geographic area. They reduce power flow through the grid, lessening the chances that overloaded transmission lines will sag, come in contact with vegetation, and spark a fire. DERs include

on-site solar, battery energy storage, microgrids, and backup emergency generators.

– Although individual DER technologies may be well developed, linking them to the grid at a large enough scale to change from the current centralized system to a distributed one is a major challenge. Managing the input of DERs into the wider grid is another challenge for utilities, which often do not have an inventory of DERs or control over when and how much power DERs contribute.

Implementation Trends

Maximizing energy efficiency remains one of the most important wildfire resilience strategies that the real estate sector can implement. In 2019, about one-third of all energy use in the United States was consumed in residential and commercial buildings.[45] Lowering the demand for energy through building efficiency has the regional impact of reducing the need for the electric infrastructure that can spark wildfires and for the expensive protection of additional assets during an event. Reducing emissions through efficiency also would mitigate climate change (and climate-driven wildfire risk) and reduce the energy use from running air conditioners and filters that are more likely to overload the grid during fires and heatwaves.

Increasingly, developers and designers are considering DERs, especially backup-power capacity and the ability to "island" off grid, in new development. Speaking of a 220-unit senior living project under development in Northern California, Mithun principal Antonio Pares emphasizes that backup power is a main design consideration. "There's a lot of discussion about whether to have emergency generators that run the entire community or just a part of it to create an emergency evacuation zone . . . because of the immediate threat of fire to the structures, evacuation challenges with a less-than-mobile community, and also the impact of the fires in the region every summer in terms of air quality."

Governments also are interested in scaling up emerging energy technologies to enhance wildfire resilience, reduce the frequency and impacts of de-energization, and meet their greenhouse-gas-emissions reduction goals. Improved regional infrastructure planning is an additional tool to reduce wildfire risks, balance sometimes competing priorities, and minimize the disruption of preventative de-energizations. "One way to reduce wildfire risk is by co-locating energy supply resources closer to the consumers who use energy, so we lessen dependency on larger transmission infrastructure. The long distances and varied terrain of transmission is where some of our greatest vulnerabilities to risk lie related to disruptions and that is valuable in terms of understanding infrastructure planning," says Neil Webb, director of markets and growth at Ramboll.

STONE EDGE FARM

Pictured above, a microgrid, solar array, and fuel cells at the Stone Edge Farm Vineyards and Winery in Northern California continued operating despite dark, ash-filled skies from the 2017 wildfires and during de-energizations in 2019.

STRUCTURE SURVIVAL: BEST PRACTICES AT THE SITE SCALE

DEVELOPERS, ENGINEERS, DESIGNERS, AND LANDSCAPE ARCHITECTS are implementing innovations to improve the chances that structures will survive a wildfire. Driven by knowledge of long-standing wildfire risks, the exposure of high-profile recent disasters, and by client expectations, "there's a huge change in how developers are looking at what are they putting out there and how are they planning," says Arlene Tendick, principal at A.N.T. Strategic Communications, which represents many California-based development firms.

Wildfire resilience best practices are evidence-based and can help avoid losses, lower insurance premiums, and in some cases lead to higher sales and rental prices. Here, houses are clustered to reduce wildfire exposure and firefighting difficulty, nearby vegetation is cleared to prevent flame spread, and recreational trails are valuable amenities that double as firebreaks.

JONNU SINGLETON/SWA GROUP

BEST PRACTICES

Best practices for wildfire resilience at the site level range from the initial structure siting and hardening with fire-resistant or nonflammable materials to ongoing maintenance to minimize on-site wildfire fuels. These tactics can provide business benefits such as higher sales and rental prices, lower insurance premiums, and avoided losses to developers and owners. Tenants and homeowners can benefit from safer, high-quality shelter as well as avoided losses.

In addition to prioritizing wildfire-resilient design and land management, some developers are doubling down by making sure there are firefighting resources on site beyond what is required. For example, several interviewees said they preserved ponds or installed extra water storage on site where helicopters can refill for aerial wildfire fighting to support the overall firefighting effort and a rapid on-site response.

Siting, Arrangement, and Orientation

Structures at the top of hills, at the base of canyons, located on steep slopes, or in historically burned areas can be at high fire risk because the characteristics of their siting will encourage rapid wildfire spread. "Housing pattern and location are consistently the most important factors in determining whether a home will be destroyed by a fire," explains Alexandra Syphard, chief scientist for Vertus Wildfire Insurance Services and senior research scientist with the Conservation Biology Institute.[1]

FLICKR/NICOLÁS BOULLOSA

The Agile Village in Santa Rosa, California, features accessory dwelling units for community members affected by the 2017 Tubbs fire. The units are rented at below-market rates and are surrounded by fire-safe landscaping, including noncombustible materials like crushed gravel instead of more flammable plant material.

According to the Federal Emergency Management Agency (FEMA), "in the absence of a strong wind, wildfire follows topography, burning primarily upslope and up-canyon."[2] Accordingly, building on level ground and with a significant setback (FEMA recommends at least 50 feet) from wildfire vegetation will reduce risk.

Orienting the structure and its openings (such as doors, windows, and vents) so that the least amount is exposed toward the most likely location of a fire is another best practice. For example, orienting the narrowest part of the structure toward and limiting the number of windows facing the likely fire direction can minimize the chances of ignition and ember intrusion, respectively.[3]

Similarly, having multiple, large enough, and well-placed entrances and exits to a property enables successful evacuation and can help protect the structure. "Instead of homes on the side of the cliff, for example, [it's possible to] wrap the road around the crest below. That gives them more prime lots with great views, and a firebreak. We've actually seen it work in real fire situations," said Jim Smalley, manager of wildland fire protection for NFPA.[4]

Defensible Space: Protecting the Structure Ignition Zone

Maintaining a zone of noncombustible material—including plant and nonvegetative items—around a structure increases the chance it will survive a wildfire. For this reason, many municipalities require mandatory defensible space (of varying distances) arounds homes and other structures in WUI areas.

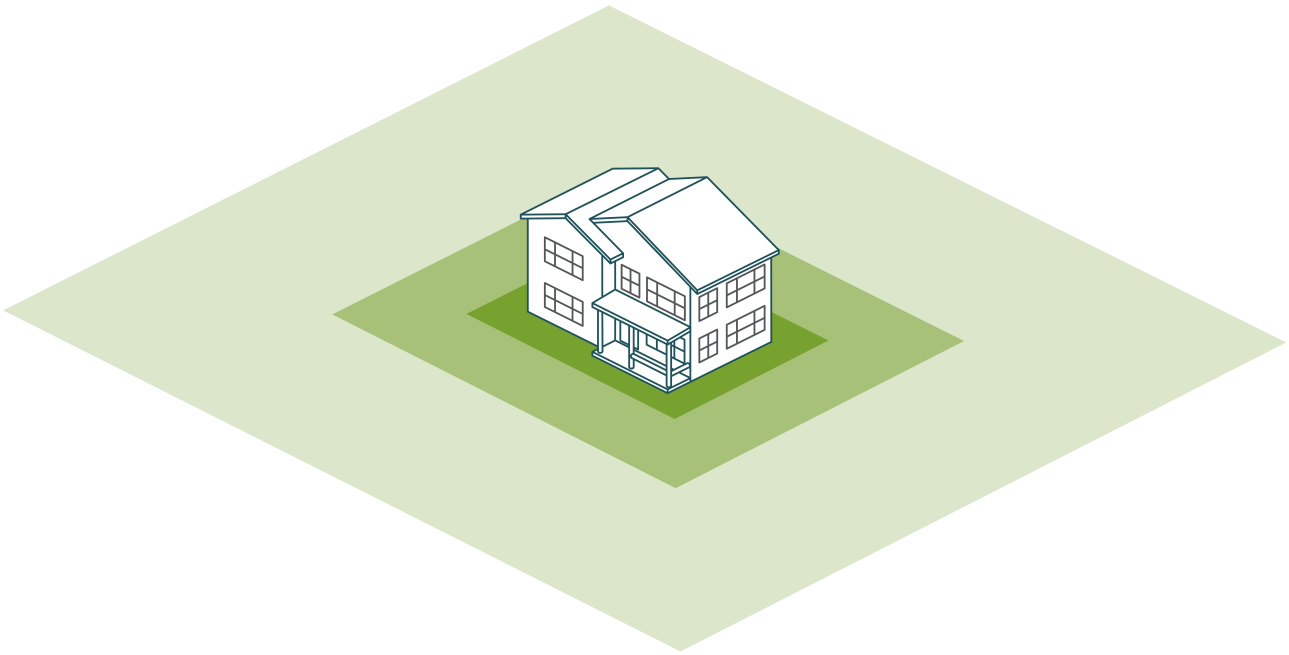
CONSTRUCTION SAFETY

Wildfire can be a risk during construction in the extremely dry areas of the United States. David Scholl of Vintage Partners develops mainly in suburban and rural Arizona and remarked that "most of our fire worries are construction fires being in a dusty and dry environment. . . . It's usual that as part of any construction site kickoff meeting with stakeholders and contractors, a large amount of time goes into getting buy-in and consensus amongst everybody on practicing safe construction techniques. . . . Most of our job sites always have several large water trucks on site."

Other best construction practices include being aware of the fire risks in the area, limiting the use of torches or hot equipment on high fire-risk days, regularly mowing vegetation, dampening vegetation, and installing water towers if city firefighting infrastructure does not yet exist so that firefighters can respond quickly if needed. These and other practices are typically covered during the permitting process or addressed via insurance partners before construction can begin.

"These practices do add a cost, but it's something that desert development is used to," says Scholl. "And we have other areas in this environment where we can save money."

Defensible Space around Buildings



IMMEDIATE ZONE
Create a noncombustible zone with a wildfire-resistant structure and by eliminating exterior combustibles

INTERMEDIATE ZONE
Decrease fire behavior by creating firebreaks through strategic site layout and landscaping

EXTENDED ZONE
Interrupt fire and keep flames low by removing debris, clearing small trees, widely spacing vegetation canopy tops, and limiting combustibles near outbuildings

On the basis of the principles of how buildings ignite and burn, NFPA recommends a three-ringed buffer of defensible space extending outward from the structure: the immediate zone (zero to five feet from a structure), the intermediate zone (five to 30 feet away), and the extended zone (30 to 100 feet away). In the immediate zone, the priority is hardening the structure and eliminating as many exterior combustibles as possible. Best practice is to use the intermediate zone to create firebreaks—such as installing paved pathways or widely spacing vegetation so fire cannot jump between plants. And the purpose of the extended zone is to limit flame height by, for example, mowing grasses, removing debris, and clearing combustibles alongside any detached outbuildings.

"By creating defensible space, we do two things. One is we give the structure a better chance of surviving a wildfire and two, we give our first responders an opportunity to be protected while they're trying to suppress the fire on the structure," says Bob Betts, who leads the Prescott Area WUI Commission.

Not adequately following defensible space recommendations is linked to some of the most damaging wildfires. For example, a NIST after-action analysis of the Camp fire found that wooden fences on residential properties, especially ones that extended into the immediate zone five to 10 feet from houses, were one of the main factors that enabled flame to spread and destroy buildings.

One challenge is that it is difficult, or in some cases next to impossible, to completely achieve the defensible space recommendations in places where structures are packed tightly together.[5] In such dense developments, following defensible space guidelines at a neighborhood- or district-scale level is critical.

Resisting Ember Attack

Resisting ember intrusion into and ignition of structures is an essential resilience design strategy. Wind-borne embers can blow up to a mile ahead of a wildfire, causing "spot fires," which account for up to 90 percent of wildfire

"If we seal up homes really well, it's great for energy efficiency as well as protecting from ember penetration."

KATE COTTER, CEO, BUSHFIRE BUILDING COUNCIL OF AUSTRALIA

home ignitions. For example, after the 2017 Goodwin fire in Arizona, council member Vickie Wendt remembers "the fire didn't reach this far, but afterwards, I went out and I was finding embers the size of poker chips in the middle of our town."

Best practices to resist ember attack include covering vents and eaves with noncombustible fine mesh screening (corrosion-resistant metal mesh, for example), adding screening under decks and similar structures to prevent embers from collecting underneath, and steep roofs so embers more easily roll off with less time to ignite. In an analysis of California structures lost because of wildfires between 2013 and 2018, enclosed eaves, vent screens, and multi-paned windows were found to survive at higher rates, likely because these features prevented the intrusion of wind-blown embers.[6]

"Those kinds of really nuanced factors make a huge difference," agrees Antonio Pares, principal at Mithun. One evidence-based best practice that Pares follows is to orient vents horizontally because "the windblown ember is much more likely to go into a vertical surface (because the ember is being blown horizontally directly at the vent) than it is to go into a horizontal surface that's parallel to the direction of the forces of the wind."

Property maintenance—such as regularly removing vegetative debris from roofs and gutters—is also fundamental to preventing ember-ignited fires. "It's all about the embers," says Kate Cotter, CEO of the Bushfire Building Council of Australia. And "if we seal up homes really well, it's great for energy efficiency as well as protecting from ember penetration."

PROTECTING INDOOR AIR QUALITY

Thoughtful building engineering, design, and operations help limit the intrusion of wildfire smoke and preserve indoor air quality. In addition, ensuring indoor air quality and ventilation is general best practice for occupant health and provides evidence-based returns on investment for improved productivity and decreased sick time, tenant retention, and higher commercial property values. Strategies to maintain indoor air quality when wildfire smoke is a concern include the following:

Engineering and design solutions

- Install high-performance air filters such as MERV 13 systems.
- Size ventilation systems to accommodate those high-performance air filters and to ensure there is no air bypass around filter banks.
- Consider a central ventilation system, with a reduced number of filter banks to maintain.
- Consider passive-house design principles to reduce the infiltration of unfiltered air.
- Consider constructing a "resilience hub" with backup power to support HVAC and high-quality filtration. This hub could be a large space for office, multifamily, or essential-service buildings or a designated room in single-family residences.

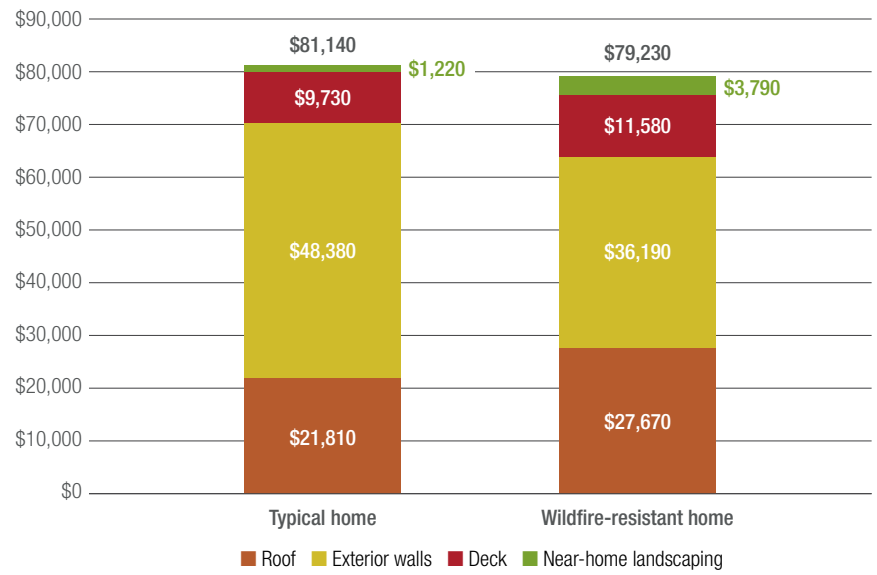
Operations and maintenance solutions

- Ensure ventilation and HVAC systems are well maintained and functional.
- Install gauges to indicate when air filters need replacing.
- Install CO_2 and PM 2.5 sensors in critical spaces to provide real-time feedback on air quality.
- Run certified air cleaners and purifiers during periods of poor outside air quality.
- Limit outside air intake by keeping windows and doors shut.
- Educate occupants about the proper use of natural and mechanical ventilation systems, and how they can be used to respond to different hazards (i.e., infectious aerosols versus particulate matter from wildfire smoke).

In addition to well-developed air-quality building standards, local governments are responding to the wildfire threat of poor air quality by opening pilot clean-air shelters fitted with advanced air filters. In September 2020, for example, Seattle and King County operated healthy-air shelters for people experiencing homelessness as smoke from California and Oregon wildfires blew across the Puget Sound region.

Michael Levinson
Principal/Multifamily Housing Team Leader
Group14 Engineering, PBC

Construction Costs: Typical versus Wildfire-Resistant Single-Family Homes



Source: Adapted from Headwaters Economics.

Research by Headwaters Economics demonstrates that new single-family homes built to best-practice wildfire resilience building codes can be constructed for about the same cost as a typical, nonresilient home. The study assumes a 2,500-square-foot single-family home, using data from RSMeans, a national database of construction materials, labor, and contractor overhead, as well as profit costs with metrics from over 700 cities.

Nonflammable and Nontoxic Building Materials

Nonflammable materials help prevent the ignition of structures, and if they do catch, they help limit the fire spread between buildings. "There's a huge array of products that can be used. You can build a fire-resistant home out of readily available and affordable materials," says Steinberg of NFPA. Nonflammable materials include fiber-cement siding, stone, brick, stucco, and composite boards that are slower to ignite and burn.[7] Rammed earth and block systems made from recycled materials are other, less commonly used possibilities.

The roof is one of the most vulnerable parts of any structure to wind-blown embers because of its large surface area. Class A fire-rated roofs can be composed of materials like asphalt fiberglass composition shingles and concrete tiles. Some roofs are even built with additional materials under the roof covering to provide another layer of protection for the house.

Ideally, building materials would be nontoxic as well as nonflammable during and after wildfire. According to Gavin Horn, a research engineer with the UL Firefighter Safety Research Institute, "one of the largest changes we've seen is the shift in materials from natural fibers to more synthetic materials in our built environment. . . . Several compounds we're concerned about can be released into the air as byproducts of combustion during the fires."

Speaking about the aftermath of the California 2017 Tubbs fire, Pepperwood Foundation president Lisa Micheli says, "One of the most traumatic things after this fire came through was that every single structure was basically a toxic waste site. We're trying to get away from building with materials that turn into toxic waste. It's really hard to do. It's hard to replace PVC."

In addition, achieving both wildfire resilience and sustainability goals with building materials can be a challenge, requiring extra upfront research. "The brute force approach of using concrete or concrete block is noncombustible. But because of the high-embodied carbon emissions of concrete, it's not a very climate-friendly approach," says Mithun principal Antonio Pares, referencing the carbon emissions released during concrete's production. Cement, an ingredient in concrete, accounts for about 8 percent of global CO_2 emissions.[8]

Wildfire Safety Education and Community Engagement

Private- and public-sector entities are leveraging wildfire education to make property maintenance manageable, to prepare for emergencies, and to advertise the value of resilient development including the co-benefits

> **"One of the most traumatic things after this fire came through was that every single structure was basically a toxic waste site. We're trying to get away from building with materials that turn into toxic waste."**
>
> LISA MICHELI, PRESIDENT, PEPPERWOOD FOUNDATION

of amenity spaces. Wildfire resilience education and engagement programs can be advanced by a range of stakeholders including committed groups of individuals, nonprofit organizations, homeowners or Realtors' associations, property management companies, or local governments. With more than 1,500 recognized sites in 43 participating states, Firewise USA is the most popular wildfire education and recognition program in the United States. Administered by the NFPA with support from the U.S. Forest Service, U.S. Department of the Interior, and the National Association of State Foresters, Firewise USA provides standards and a framework around which both individual structures and communities can be better prepared for wildfires.

Those strategies include many of the best practices discussed previously such as defensible space. Developers also speak highly of the program, saying it protects their investment, encourages tenant and homeowner engagement in wildfire mitigation, and that it has been proven to work.

Maintaining a wildfire-prepared structure and preventing the accidental ignition of fires requires frequent upkeep and attention, something that is required as part of program recognition. Developers, owners, and property managers also report that robust tenant engagement programs can help residents determine that potential higher prices or additional fees intended to offset the costs of reducing wildfire risks are not only warranted but in their interest.

RETURN ON INVESTMENT

Developer and community experience as well as academic research indicate that best practices can prevent losses, improve property value, reduce insurance premiums, and protect tenants.

Building Codes Protect Structures

Structures built to wildfire-informed building codes survive at higher rates, depending on the characteristics and severity of the wildfire. In Paradise, for example, "of the 350 homes built

WILDFIRE BUNKERS

Shelter-in-place fire safety bunkers are more common internationally in high-risk countries like Australia, but they are also available and produced in the United States. Fire safety bunkers are heavy-duty shelters installed underground and constructed out of nonflammable material that are designed to protect a small group of people for a short time while a wildfire moves through an area. These bunkers are expensive to buy and install, costing about $20,000 per unit. Although bunkers are effective for the short term, they are an option of last resort.

WIKIMEDIA COMMONS

Features like steep roofs to dislodge embers and ignition-resistant materials can be required by building codes to help structures survive wildfires at higher rates. California's Building Code Chapter 7A, implemented in 2008, is widely regarded as a best-in-class wildfire resilience measure.

to California's Chapter 7A code, 51 percent survived compared with 18 percent of the 12,100 homes built prior to 2008" when the code was enacted.[9]

For those jurisdictions that have adopted codes to address wildfire hazards, many are based on one, or a combination, of three wildfire building codes that are widely regarded as setting the level of best practice: the International Code Council's Wildland Urban Interface Code (IWUIC), the National Fire Protection Association's Standard for Reducing Structure Ignition Hazards from Wildland Fire (Standard 1144), and California's Building Code Chapter 7A–Materials and Construction Methods for Exterior Wildfire Exposure. A 2019 report on mitigation savings by the National Institute of Building Sciences found that if all new homes in the WUI were built to comply with the 2015 IWUIC, it would result in a 4:1 benefit-to-cost ratio.[10]

Managed Vegetation Decreases Damage and Improves Property Value

Managing vegetation near buildings can be critical for their survival and well-landscaped areas can improve structure value. Plants differ in how readily they ignite and how hot and long they burn. Cedar trees, pitch pines, bamboo, eucalyptus, and palm trees are examples of highly flammable plants.[11] "We liken palm trees to catcher's mitts because the trees just catch and transfer fire embers," says Jeremy Klemic, landscape architect with SWA. Further, the vertical and horizontal arrangement of vegetation influences fire behavior.

Though there are no completely fire-resistant plants, those with high water content, no or little sap, and those that grow close to the ground are safer.[12] Entirely eliminating plants near structures or at least choosing these types of lower-risk plants can help prevent structure ignition and slow the spread of wildfires. Post-wildfire reports conducted in Arizona, Southern California, British Columbia, and elsewhere consistently document that areas that receive fuel reduction before the event sustain lower levels of structural damage.[13]

At a site scale, the Flagstaff Fire Department found that homebuyers pay more for homes near forests with medium canopy closure and moderate tree density. "Market value increases an average of $200 or more for each quarter-acre of land that is thinned around a home or property, and a buffer of thinned vegetation around a home can increase the overall market value by $40,000."[14]

The Value of Firewise USA Recognition

Properties and communities that achieve Firewise USA recognition are recognized by the development community and validated by academic research to have additional value in the marketplace. A survey of 20,000 Idaho households conducted in 2015 and 2016, for example, concluded that 15 percent of respondents said "yes" they would pay a premium for a community that followed Firewise USA standards and 36 percent said "maybe."[15]

Depending on their insurance company, homeowners can also receive a premium discount if they live in a Firewise-recognized community. USAA became the first company to begin offering this benefit, launching the program in 2014. In July 2020, USAA extended the safety incentive to four new states, making homeowners in Firewise USA–recognized communities automatically eligible for premium discounts in 11 states across the United States.[16]

At a community level, a U.S. Forest Service investigation found that "buildings closest to existing Firewise communities sustained lower rates of destruction than [those at] further distances" across the United States.[17] And a cost/benefit analysis in Colorado Springs concluded that "mitigation efforts resulted in $517 in benefits for every $1 spent in the three neighborhoods with the greatest impacts."[18]

"As developers, we need to be smarter about choosing the right materials and the right landscaping for our homes."

STEVE THOMPSON, PRINCIPAL, CAPASITI CONSULTING

PROTECTING THE COMMUNITY: DISTRICT-SCALE SOLUTIONS

IN THE FACE OF INCREASING WILDFIRE RISKS, public officials, planners, and developers are advocating for and implementing land use policies to increase community resilience. “Wildfire risk has risen to the top of our city leadership’s radar. It’s something we take really seriously,” says Justice Jones, wildfire mitigation officer for the city of Austin. Although communities have historically preferred voluntary wildfire resilience programs, many municipalities prioritizing wildfire resilience are gradually implementing more incentives and requirements.

Local governments are struggling with the increasing decision-making pressures and costs associated with wildfire prevention, suppression, and adaptation. Moreover, some wildfire resilience practices can lead to difficult tradeoffs, and decision-makers are searching for programs and strategies that reduce risk and serve regional housing and economic development needs.

ULI COLORADO

Public decision-makers recognize that local governments have the most control over development and land use in the WUI and, therefore, that they are uniquely able to implement wildfire resilience strategies, some of which could also help achieve other public health, housing, and economic goals. Hazard assessments, comprehensive planning, building and landscape ordinances, zoning codes, education campaigns, and the formation of partnerships are all wildfire resilience best practices that are the purview of local government.

However, some wildfire resilience practices can lead to difficult tradeoffs; the potential decision to restrict new development in high-hazard zones, for example, could reduce housing attainability in the immediate area even if that policy might in the long run shift people and infrastructure to safer locations. Likewise, potential policies that restrict rebuilding in high-risk locations contradict the common community desire to return home to normal and could lead to concerns about reduced property value. Public officials and land use practitioners continue to grapple with these questions and are searching for programs and strategies that reduce risk and serve regional housing and economic development needs.

Deciding Where to Build

The implications of deciding where to build extend far beyond avoiding wildfires and include community planning issues like social cohesion, racial equity, food access, walkability, traffic, and cost of living, among many other factors. However, the increasing impacts of wildfires as well as their natural tendency to re-occur in hot, dry environments—and to be sparked by people and infrastructure—have elevated discussions about the difficulty of deciding where—or not—to build.

The possibility of limiting future growth or reducing footprint in areas at high wildfire risk has received tremendous press coverage. Bloomberg led with "California's Wildfire Epidemic Is Blamed on Bad Building Decisions," and *Wired* published "Please Stop Building Houses Exactly Where Wildfires Start." CNN highlighted the eerie orange, smoke-filled sky in California, Washington, and Oregon in September 2020 writing, "It Looks Like the Apocalypse."

The real estate industry is increasingly aware that infrastructure and people in high-risk areas are almost certain to be threatened by wildfire and the industry is focused on preparing for that eventuality by building to coexist with fire. Dan Richter has led this approach at the Avimor development in Boise, reasoning, "it's not a question of if wildfires are going to burn. All the land here burned at one time or another. We just have to minimize that risk."

Public officials are grappling with the same reality and are considering how to leverage planning tools that encourage development in less-risky locations while adding housing to address the affordability crisis and to grow local tax revenue. Although most current policies do not wholesale reduce or limit growth in high-risk areas, public entities are increasingly turning to policy requirements related to structural design, rather than voluntary or incentive mechanisms, to prepare communities for wildfires. For example, Austin city officials say they "haven't pushed" to more specifically limit development in high-risk areas because they have high confidence in the robustness of their other polices such as the city's building codes and a new WUI code[1] (see case study on page 52).

In addition, some state leaders have proposed programs promoting more restricted development in wildfire-prone areas. For example, if a 2019 state bill in California had been approved, it would have instructed local governments to limit housing built in very high fire-hazard zones without adequate defensible space enforcement, evacuation options, and response capacity.[2]

Lauren Gill, former city manager of Paradise, points out the potential consequences of eliminating new development in high-risk wildfire areas, especially for housing opportunity: "this entire town—like many others—is in an extreme high-fire zone, and we are the affordable housing hub in the region. From urban to rural it gets more affordable. You can't just say, 'let's not build in any of these less expensive areas.'"

Similarly, "suggesting that a community be banned from rebuilding is largely a nonstarter," says Edith Hannigan, land use policy manager for CALFIRE. "We don't have buyout programs or anything like that yet so this conversation may change if those were available."

"We need to be thoughtful of chronic wildfire impacts and how we get ahead of them by becoming more intentional about choices in building materials, zoning, ingress/egress, business exposure, and risk to shore up communities for the long term."

MOLLY McCABE, PRESIDENT, HAYDENTANNER AND COFOUNDER, THE LOTUS CAMPAIGN

Defensible Space around Communities

Source: ULI-adapted image from Jonnu Singleton/SWA.

Planning tools such as comprehensive plans, WUI standards, subdivision requirements, and landscaping ordinances can help create more wildfire-resilient communities characterized by development concentrated in lower-risk areas and protected by well-maintained defensible space and firebreaks.

In either case, several report interviewees emphasized that other types of changes in local planning and development policy could foster more affordable development in high-cost, lower-risk regions. Local city regulations can incentivize development in more urban settings by creating a more robust and predictable approval process.

Creating Defensible Communities: Planning Tools for WUI Development

Though municipalities have not prohibited WUI development, some have leveraged planning tools such as site layout or subdivision requirements to encourage the clustering of structures and maximization of defensible space. For example, Larimer County, Colorado, has subdivision requirements in wildfire-prone areas related to the location, arrangement, and density of new structures.[3]

Municipalities also commonly limit uses that would add significant additional hazards like flammable materials. The 2035 Comprehensive Plan for Douglas County, Colorado, encourages "low-impact, nonurban land uses" in environmental hazard areas such as land susceptible to wildfires.[4] However, even these less-populated or lightly staffed land uses need to be aligned with robust wildfire prevention, emergency response, and evacuation resources given the speed with which wildfires can travel.

In addition, some municipalities are leveraging comprehensive plans and other related tools to protect undeveloped land in a community-scale defensible space strategy. For example, Austin has designated almost 30 percent of city land for conservation, which limits the number of future structures that can be in those areas, some of which have high wildfire hazards.[5] The U.S. Environmental Protection Agency recommends a similar strategy of establishing "community protection zones of open, green space at least 100 to 300 feet wide [to] separate homes from wildlands" through land purchases or easements.[6]

> **"Environmental resilience and housing and public safety requirements have to fit together, particularly in the WUI where you can't isolate those issues."**
>
> LISA MICHELI, PRESIDENT, PEPPERWOOD FOUNDATION

Paying for Wildfires

Planners and public officials are looking to resilient land use solutions to mitigate the rising costs of wildfires and to realign incentives to ensure more equitable and sustainable funding strategies. A central concern is who pays for wildfire mitigation, response, and recovery—and what services are cut, or what fees are implemented, or taxes raised to cover costs.

Government at all levels is caught in a "wildfire funding trap" where the rising cost of fire suppression is met by taking money from wildfire mitigation budgets, which ultimately leads to more devastating and expensive wildfires. Larger, more extreme wildfires, a longer fire season, and more structures to protect drive up firefighting costs. Federal agencies cover wildfire suppression costs on federal land (about two-thirds of the total firefighting cost across the country) and supplement states, which usually pay for firefighting on state and private lands. The result is that "fire protection in the WUI is largely a state and local responsibility."[7]

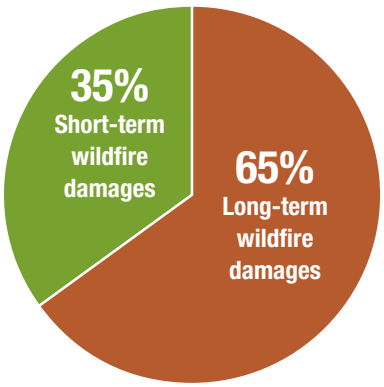
Several interviewees point out that because states often supply significant firefighting resources, especially to rural or unincorporated areas without their own fire departments, local governments as well as property owners do not internalize the full costs of their land use and development decisions.

Even so, an analysis by nonprofit Headwater Economics concludes that "nearly half of all wildfire costs are paid at the local community level by government agencies, nongovernmental organizations, businesses, and homeowners. . . . Short-term expenses such as relief aid, evacuation services, and home and property loss comprise around 35 percent of total wildfire costs."[8] An analysis of recent wildfire costs in Arizona by the Western Forestry Leadership Coalition has similar findings, concluding that "the true costs of wildfire are shown to be far greater than the costs usually reported to the public, anywhere from two to 30 times the more commonly reported suppression costs."[9]

DISTRICT-SCALE SOLUTIONS

Many local governments are going above and beyond the planning necessary to receive federal wildfire disaster funding. In addition to completing planning efforts such as community wildfire protection plans that are required or incentivized at the federal level, policymakers are increasingly leveraging climate resilience best practices such as data-informed planning to better protect their communities from wildfires. "We're trying to incorporate a shift from fire prevention to fire preparedness," says Adriane Beck, director of Missoula County's Office of Emergency Management.

Wildfire Damages: Comparing Short- and Long-Term Costs



SHORT TERM

- Home and property loss: 21 percent
- Suppression costs (federal): 8 percent
- Immediate road and landscape stabilization: 3 percent
- Aid relief and evacuation: 2 percent
- Suppression costs (state/local): 1 percent

LONG TERM

- Degraded ecosystem services: 34 percent
- Long-term landscape rehabilitation: 16 percent
- Declined property values: 8 percent
- Energy and infrastructure: 4 percent
- Human casualties: 1 percent
- Tax, business, natural resource loss: 2 percent
- Other: 0.1 percent

Source: Adapted from Headwaters Economics.

Even though the immediate damages caused by wildfires are extremely costly, research demonstrates that the long-term economic impacts can actually be higher, especially at the local level. Headwaters Economics reached this conclusion after studying the damages from five wildfire events—the Hayman (2002); Old, Grand Prix, and Padua Complex (2003); Schultz (2010); Rim (2010); and Loma (2016) fires—and reviewing other post-wildfire economic impact analyses. The research demonstrates that the total costs of wildfires in the long term are often unaccounted for by traditional fiscal metrics.

INCENTIVIZING COMPACT DEVELOPMENT

Housing advocates are pushing for more compact and infill development as solutions to housing affordability and wildfire challenges. "We have to make land use and development decisions that don't put people in harm's way. It goes back to density," says Peter Quintanilla, urban design studio leader with Michael Baker International. Though sometimes challenging, denser and infill development provide an alternative to further WUI development. Infill is also a recovery strategy to help post-wildfire communities rebuild on scorched, now empty lots.

Compact development has many co-benefits including providing for healthy and more walkable lifestyles, lowering collective infrastructure costs, and mitigating climate change by reducing greenhouse gas emissions from traffic.

One complicating factor mentioned by several interviewees is that infill is often transit-oriented development (TOD) where density makes TOD financially feasible. TOD reduces development costs for parking and contributes to many individual and community health and sustainability benefits. However, wildfire evacuations are accomplished almost exclusively by personal vehicle, so infill in higher-risk zones including at the edges of urban areas would likely require more parking than is typical of TOD areas, potentially limiting affordability, health, and sustainability benefits.

ULI COLORADO

In September 2019, ULI Colorado convened a technical assistance panel to help Jefferson County and the Evergreen Legacy Fund reduce barriers to redevelopment of a historic downtown area. Considering local flood and wildfire risks, the panel provided recommendations related to structure hardening, zoning overlays, connectivity, financing, and resilience.

Wildfire Hazard Assessments

Identifying and mapping wildfire hazards is the basis for land management and development policies. Regular map updates are a critical component to reflect the impacts of climate change and to accurately represent development changes, which can be rapid in WUI areas. In addition to guiding development, the hazard assessment process also is often a tool for building political support for hazard mitigation.

Typically, wildfire risk is addressed in the private sector as part of comprehensive climate-risk assessments—at either the asset or portfolio level. Climate assessments have become a best practice for developers and real estate investors, and some firms in very high-risk areas have commissioned specific wildfire analyses evaluating, for example, how the risk to an asset already in a wildfire hazard zone will change over time.

Many state and local governments in wildfire zones publish hazards maps. Interviewees report that the most useful public datasets include projections of future wildfire hazards, which is crucial for real estate investors and owners who have longer asset hold times or are thinking ahead to ensure a successful asset sale. For example, San Diego County maintains an interactive public wildfire-severity hazard map that includes recent notable fires and considers how the hazard will change over the next 30 to 50 years.[10]

California is a national leader in wildfire data. As part of the state's Fourth Climate Assessment, scientists included projections of acres burned at high resolution and how that will change over time under different climate scenarios. "The California projections also take into account how the population and land use is changing. The data provides a very nuanced understanding," says Sue Kemball Cook, climate scientist and principal at Ramboll.

Planners report that expanding wildfire analyses to multiple hazard types is critical to understanding climate risk at a district scale. "Our GIS team is mapping the watershed vulnerability in Austin and the post-wildfire impacts . . . to better understand the continuity of utilities and the potential costs if we have a high-intensity rain event and a major wildfire since the city owns and manages our utilities. Looking into the future has been one of our goals in establishing best practices," says Justice Jones.

Community Wildfire Protection Plans

Community wildfire protection plans (CWPPs) are a best practice adopted by many municipal and county governments to establish a wildfire strategy and coordination process. CWPPs give local governments some decision-making

"Data availability for future year assessments is a critical need."

SUE KEMBALL COOK, CLIMATE SCIENTIST AND PRINCIPAL, RAMBOLL

power about what happens on nearby federal lands, they determine the local legal definition of WUI areas, and they are a prerequisite for certain categories of federal funding.[11] Nongovernmental and private entities like homeowners associations can also write CWPPs.

About 75 percent of western states have CWPPs,[12] thousands of local jurisdictions have adopted them, and developers are also beginning to leverage CWPPs. "We're starting to see developers, especially those adjacent to federal land, utilize the CWPP as a way to bring together parties to look at wildfire risks in and around that community," says Stephen Miller, professor of real estate, land use, and environmental law at the University of Idaho.

Comprehensive and Regional Planning

Planning officials can leverage their comprehensive planning processes to integrate consideration of wildfire hazards and disaster planning into development priorities—and vice versa. "Growth policy [and comprehensive plans] are the base, and the CWPP is an issue plan that's connected and more specific," summarizes Karen Hughes, assistant director of planning and community development for Missoula County.

Comprehensive plans typically include information about how climate change will affect local wildfires and how local land use and hazard mitigation are connected. For example, the 2035 Comprehensive Plan for Palm Coast, Florida, establishes that the city will "carefully consider all land uses in areas at risk from wildfire" and support local Firewise USA recognition.[13]

The Missoula County Growth Policy (2016) is another example for how to systematically connect comprehensive planning and wildfire risk. Missoula County's growth policy includes

"Incentivizing infill development and denser development rather than suburban or semirural sprawl helps accomplish multiple community planning goals."

EDITH HANNIGAN, LAND USE POLICY MANAGER, CALFIRE

DENSITY AND WILDFIRES

Density can be a risk factor for wildfire ignition and spread as well as a strategy for encouraging growth in lower-risk areas. There is a bell-shaped curve relationship between wildfire ignition and the number of people and the amount of wildfire fuel in an area. In areas with low density, a small population, and abundant wildfire fuel, there are fewer chances for people and infrastructure to spark fires. In dense, highly developed areas with a large population (and more fire suppression resources) but little vegetative fuel, fires are less likely to spread. "Fire frequency tends to be highest in intermediate housing density," summarizes Alexandra Syphard, chief scientist for Vertus Wildfire Insurance Services as well as senior research scientist for the Conservation Biology Institute.[14]

Once a fire ignites, high density can be a risk factor, allowing building-to-building fire spread, especially if the structures are of easily combustible materials. "Another factor that has impacted exterior spread of fires is that the average size of homes being built today is larger than in the 1950s," says Horn from UL Firefighter Safety Research Institute. "At the same time, in many places, lot sizes are smaller . . . so, if there's a fire in one building, you may increase risk for building-to-building spread."

However, "you can have clustered homes and more density if you have the right mitigation," says Paradise fire chief Jim Broshears. Sprinkler suppression systems (which can be expensive) as well as zoning, building-lot size, and setback requirements are municipal regulatory solutions to address potential building-to-building flame spread.

SHUTTERSTOCK

Pepperdine University in Malibu, California, has wildfire-resilient site density: it has clustered buildings and it is surrounded by 200 feet of well-maintained defensible space.

The practice of clustering buildings into high-density developed zones and creating a surrounding buffer zone of well-maintained open space with no structures is another established best practice. Pepperdine University in Malibu, California, epitomizes this site design. Pepperdine's buildings are densely clustered on about 300 acres, surrounded by 200 feet of well-maintained defensible space, while the university's remaining 500 acres have no structures.[15]

However, developers, planners, and public officials who advocate for higher density in postdisaster communities or in rural areas where a low-density lifestyle is valued can be perceived as opportunistic. Several interviews emphasized the need for more real-world examples of appealing, "place-appropriate" density in the WUI.

PUBLIC/PRIVATE PARTNERSHIPS

Interviewees unanimously emphasized that wildfire resilience requires a significant amount of cross-sector coordination at project, district, and regional scales. "All of our progress is built on partnerships and collaboration," says Carrie Stewart, division chief for Austin's Wildland Fire Department.

On a project level, multiple entities are involved in permitting, designing, and constructing new residential and commercial structures. Especially for large master-planned developments in WUI areas or near forestlands, developers and owners often coordinate with local, state, and federal officials. "You cannot address wildfire with just the fire department," says Stephen Miller, University of Idaho law professor and wildfire expert.

In addition, public/private partnerships are critical for coordinating the vegetation and structure maintenance that protects properties and makes neighborhoods safer and less susceptible to ignition. For example, after the 2010 Fourmile Canyon fire in Colorado, Boulder County created the Wildfire Partners program to help homeowners follow defensible space requirements and complete wildfire mitigation work on their properties. The program is staffed by local government officials along with representatives from insurance company Allstate, which provides discounts to homeowners who complete the program.[16]

Following that model, the Vail Board of Realtors (VBR) initiated and funded a similar pilot program called REALFire, which has since been supported by the state through tax breaks and by Eagle County in a close administrative partnership with staff time and expertise. "The catalyst was a number of dramatic wildfires with significant damage in 2012. It's also to help the area and hopefully keep insurance rates reasonable," says Mike Budd, former chair of VBR.

At a district and regional scale, public/private partnerships and cross-sector coordination are integral for coordinating forestry management and development. For example, local communities, 13 businesses, tribes, and the U.S. Forest Service collaborated to create a new forest management program after the 2002 Rodeo-Chediski fire, which burned 468,000 acres and 400 homes in eastern Arizona.[17] The group established a 10-year contract to remove hazardous vegetation from the area's pine forests, and a significant amount of the vegetative material is used by Arizona utility SRP to generate electricity at the Snowflake White Mountain Biomass Power Plant in Tempe, Arizona.[18]

information about local wildfire hazards, sets three goals specific to development and wildfire risk, and stipulates that any developments in WUI areas must comply with additional roof, access, vegetation, water supply, and fire protection design standards.[19] The county also leveraged the growth policy to update its Pre-Disaster Mitigation Plan and its CWPP, ensuring that general land use is aligned with comprehensive natural-hazard mitigation as well as wildfires specifically.

One of the challenges of comprehensive planning, particularly in high-risk areas where there is both a sense of urgency and a need to strategically develop buy-in for planning solutions, is determining which planning solutions to prioritize. "It's not like you do 10 percent of the recommended best practices, so therefore you get exactly 10 percent better with mitigation," says Molly Mowery of Community Wildfire Planning Center. "There's not an easy formula [for how much is enough] . . . often people ask for 'the one tool.' There's not an answer for [that] because one action by itself does not guarantee that it will have a massive effect. All the other vulnerabilities would still exist, and that's why a comprehensive approach is necessary."

Like comprehensive planning, regional planning has the potential to align resilience efforts and development. Regional plans can include elements of large-scale land management, infrastructure protection, and wildfire resilience.

For example, the Flagstaff Regional Plan for 2030 considers wildfire and flood resilience, infrastructure protection, and regional collaboration. The plan applies to the 525-square-mile metropolitan area and, according to the city, is the basis for policy, including for the capital improvement plan, annual work plans and budgets, development appraisals, and private development plans.[20]

WUI Codes and Standards

WUI codes and standards are designed to protect life and property in high-risk wildfire areas. Implemented at the local level, WUI codes and standards are often modified from model codes per local conditions, wildfire risks, development patterns, community needs, and political dynamics.

Flagstaff, Arizona, for example, adopted a modification of the International Wildland-Urban Interface Code in 2008. Flagstaff is built into the world's largest ponderosa pine forest,[21]

and the fire department works with community development staff to require hazard mitigation for wildfires on all WUI properties prior to development.

The geographic scope of WUI regulations is often determined by the wildfire hazard assessment and the local legal definition of a WUI, which is set by the CWPP. WUI codes and standards establish wildfire mitigation requirements of new development and significant renovations including for building materials and construction, vegetative standards, and emergency vehicle access as well as innovative tactics such as preidentified areas of refuge.[22] WUI regulations also help establish property maintenance standards, which are critical for wildfire prevention and mitigation. WUI codes augment and typically reference other local regulations such as fire or building codes.

Some communities implement zoning overlays in addition to or as an alternative to a WUI code, especially if detailed hazard mapping is financially or technically (because of limited existing data) out of reach for municipalities.[23] For example, Colorado Springs' WUI requirements include a hillside overlay zone that requires "additional fuels management, fire protection systems, roof coverings, and other hardened structure features" in steep sloped areas.[24] Flagstaff has incorporated a resource protection overlay zone into its zoning code to better protect natural areas, including steep slopes and forests,[25] and all land zoned "forest resource" in Oregon must automatically comply with wildfire mitigation requirements.

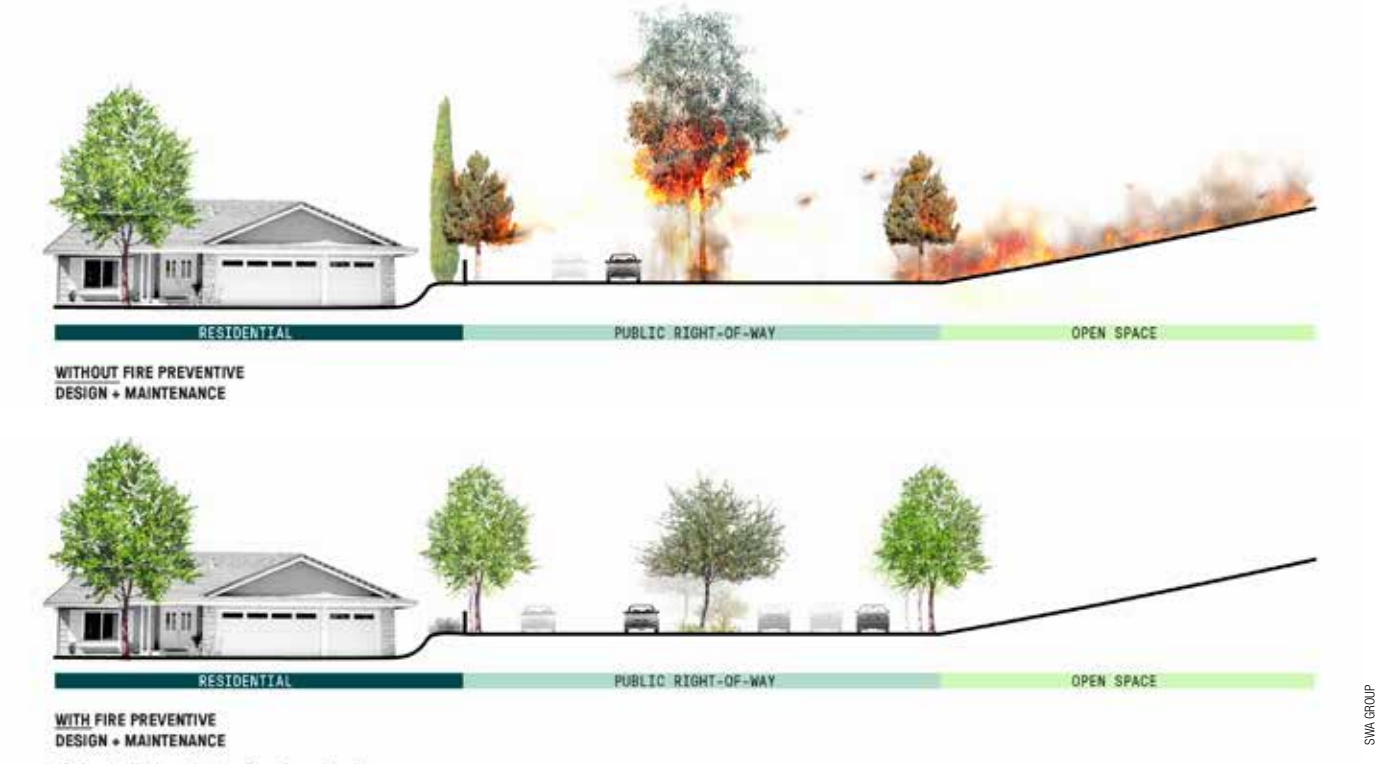
Urban Forestry and Landscaping Ordinances

States, local governments, utilities, and private landowners can leverage urban and regional forestry management plans to enhance wildfire resilience. Forestry management plans describe the characteristics of an area, the external influences or drivers of change, the long-term conservation or development strategy, and action steps for achieving that vision. These plans formalize goals, establish performance metrics, help prioritize resources, and can catalyze partnerships.

For example, the city of Thousand Oaks, California, updated its Forestry Master Plan in 2017 to consider wildfire risks as well as other climate hazards such as extreme heat and drought. Thousand Oaks is located between

"One of our best wildfire mitigation tools is to get back some semblance of the native plant community."

MIKE PELLANT, PRESIDENT, RANGELAND SOLUTIONS



Vegetation without preventative fire design and maintenance standards is characterized by highly flammable plants, placed in proximity, and/or a vertical arrangement allowing flames to drift, causing a "crown fire," or travel upward into the canopy. In contrast, wildfire-resilient landscaping is characterized by adaptive, fire-resistant plants spaced to reduce fire spread and the removal of "ladder fuels" such as lower tree limbs to prevent flame growth.

two large areas of open space; the plan states "this condition results in the need for caution—to protect open spaces from the impact of development, and to protect development from potential threats from open space (wildfires, in particular)."[26] The plan recommends fire-resistant plants at the city's periphery in the WUI and prioritizing nonflammable native plants. The plan also focuses on plants along roadways noting that transportation infrastructure can act either as a fire-boundary between development and wildfire or as a conduit, depending on the adjacent plant community.

After two wildfires affected the town of Ruidoso, Arizona, for example, it began requiring residents to remove trees that could contribute to wildfires.[27] Similarly, "in the forests in northern and eastern Arizona, there's ordinances that require pine needles get raked up every spring in prep for fire season. You drive down the streets of planned communities in the mountains, and you see hundreds of bags of pine needles stacked," says Arizona developer David Scholl.

Impact Fees

Municipal fire impact fees are a long-standing tactic to supply the increased resources needed for fire prevention and suppression with significant new development. For example, impact fees have been established by 12 fire protection districts in Colorado, with several new impact fees pending local approval. The residential fees in these 12 districts "range from $510 per unit to $2,026 per unit . . . and the commercial fees range from $0.24 per square foot to $1.64 per square foot."[28] Some of these fees have been in place for close to two decades; for example, the Grand Fire Protection District's Emergency Service/Fire Impact Fee program was established in 2003 to "offset the district's growth-related costs resulting from residential and commercial development."[29]

Developers have also begun to impose similar fees through homeowners associations or by raising residential sales prices to cover the cost of resilient design features and ongoing wildfire prevention activities (see Avimor case study on page 46).

Prescribed Burns

Applicable on private and public lands, prescribed or controlled burns involve deliberately setting and using a fire to meet specific land management objectives such as reducing hazardous fuels. Ahead of the fire, the management team will implement a fuels reduction program via mechanical and manual means and then create a "prescription" of conditions that must be met for the prescribed fire to proceed safely.

"In a wildfire situation, you have very little control over where fire goes. With prescribed fire, it's a planned, controlled event. Fire managers and states really do a good job of managing activity to ensure that prescribed burns are a safe practice," says Mark Melvin, chair of the Georgia Prescribed Fire Council.

Many Native American tribes have long used fire for agroforestry and for wildfire fuel reduction. "We call it 'cultural burning' . . . [because] when we burn, we burn to perfect this resource to supply resources for our culture," says Ron W. Goode, tribal chairman of the North Fork Mono Tribe and an advocate for the use of fire.[30] Two tribes in Northern California, the Karuk and Yurok, have partnered with the Forest Service to conduct burns on public, nontribal land, and California's Forest Management task force is monitoring the results in consideration of a larger-scale burn strategy.[31]

Georgia, Florida, Louisiana, and Kansas are national leaders in prescribed burning. Fort Benning, Georgia, has used prescribed burning for more than 30 years. As a result, Fort Benning has experienced fewer instances of wildfires, stabilizing "at or below 100 wildfires per year, in contrast to the 300 to 500 wildfires earlier in the record" before consistent prescribed burning.[32] In addition, because they are usually low to the ground and smaller than wildfires, "a prescribed burn generates way less smoke and particulate matter than a wildfire," says Shan Cammack, a biologist with the Georgia Department of Natural Resources.

Prescribed burning is practiced on smaller scales in other areas, too. The Pine Valley Golf Club in New Jersey, for example, is a longtime user of prescribed fire to optimally manage vegetation and to reduce the risk of potential wildfire spread if one should ignite in the nearby Pinelands natural area.[33] Recognizing this risk, New Jersey enacted the Prescribed Burn Act in 2018, directing state agencies to increase use of this land management tool.[34]

"We're trying to incorporate a shift from fire prevention to fire preparedness."

ADRIANE BECK, DIRECTOR, MISSOULA COUNTY OFFICE OF EMERGENCY MANAGEMENT

Community education as well as limiting and addressing the impacts of wildfire smoke are two challenges that need to be addressed with every prescribed burn. Continued development in the WUI also makes managing prescribed burning much more complex.

Improving Wildfire Recovery and Rebuilding

Public leaders, developers, and community groups are innovating tactics to help communities recover from the record destruction and geographic scale of recent wildfires. However, many community and real estate industry leaders emphasize that planning recovery procedures and goals ahead of wildfires could help accelerate the pace of rebuilding, contribute to solving the housing affordability crisis, achieve long-term sustainability goals, and set the foundation for more resilient future development.

"Developers and builders' priority is to eliminate uncertainty. Time lost while waiting for new regulations to be adopted is extremely expensive because they can't start planning until they know what the requirements will be," says Megan O'Hara, principal at Urban Design Associates.

Minimizing displacement and expediting home rebuilding is a central component of many post-wildfire recovery initiatives. After the 2017 October fires, which included the Pocket, Tubbs, Nuns, and Atlas fires, Sonoma County waived restrictions on tent and RV camping near fire-affected areas. The city also established a resilience permitting center to streamline property damage assessments and approvals. As a result, the combined county and city permit departments have enabled 3,861 homes, or 75 percent of the homes lost in the fires, to start the rebuilding process as of February 2020.[35]

CALIFORNIA ARMY NATIONAL GUARD/CAPTAIN WILL MARTIN

A community gathering to discuss post-wildfire rebuilding. Many community and real estate industry leaders emphasize that planning recovery procedures and goals ahead of wildfires could help accelerate the pace of rebuilding.

Sonoma County also created the Office of Recovery and Resiliency, which coordinated the creation of a Sonoma countywide recovery and resiliency framework. The framework is a regional effort that integrates long-term resiliency goals with short-term recovery needs and the existing strategic plans. The countywide plan establishes a collaborative recovery vision among multiple municipalities and ensures that town action plans are aligned.[36]

Some municipalities have suggested practicing for wildfire recovery the way many public and private leadership teams drill for emergency response scenarios. For example, San Diego County's *Resilience Review Report 1-19: Wildland Fires* establishes this goal to practice and evaluate its 2019 County Operational Area Recovery Plan.[37]

Similarly, some public officials from disaster-affected communities say that planning ahead for what happens after a destructive wildfire might emerge as a more trauma-informed approach. These leaders report business continuity challenges (government decision-makers often need to evacuate or find temporary housing elsewhere just as constituents do) and that making big-picture community planning decisions immediately after shocking and traumatic events can feel inappropriate and be politically unwelcome.

"Recovery planning should be as extensive as disaster planning and should be documented

WORKFORCE DEVELOPMENT AND WILDFIRE RECOVERY

An innovative construction training program in Northern California is a potential replicable model for providing education and job assistance to disaster-affected individuals as well as skilled local labor and rebuilding assistance to the wider community.

La Luz Center ("la luz" is Spanish for "the light") is a Sonoma Valley resident-founded organization that aids members of the local Latino community by providing Spanish-language information, food, financial support, and mental health counseling.[38] About 30 percent of the area's population is Latino,[39] and many from La Luz Center's clientele were displaced by and lost their jobs because of the 2017 wildfires. The center recognized that there would be an increase in local construction jobs during the rebuilding effort and created the Building Trades Training Program (BTTP) to prepare its clients to apply for those opportunities.

BTTP is jointly led by the La Luz Center, Santa Rosa Junior College, and the Sonoma County Office of Education. BTTP runs a bilingual eight-week training course several times a year that includes hands-on training with tools and basic construction equipment. La Luz Center also provides BTTP students with job application assistance. BTTP graduated its first class in May 2018 and has since had more than 100 participants. The program has helped meet the immediate needs of its participants and has provided a long-term benefit to the community.

BOND FUNDING FOR WILDFIRE RESILIENCE

Municipalities have used bonds to fund post-wildfire forest management, and new public/private partnerships are seeking to expand this strategy. In response to the 2010 Schultz fire, for example, Flagstaff issued $10 million in bonds—voter-approved financing that passed with record-setting support. The bond funded a suite of fuels mitigation and watershed protection efforts. This was the first time a municipality funded fuels mitigation work on national land via a voter-approved bond.

However, expanding the use of bonds to large-scale forest management has proved challenging. A significant barrier is the lack of skilled and available labor to implement funded projects quickly enough to guarantee a competitive rate of return for investors.

In 2018, a collaboration between public- and private-sector agencies issued the first forest resilience bond (FRB) to pilot a new way to finance forest restoration and to capitalize on the benefits of wildfire resilience. The $4.5 million bond will fund restoration of 15,000 acres in Tahoe National Forest. "Beneficiaries of the restoration work such as the U.S. Forest Service, water and electric utilities, and state governments make cost-share and pay-for-success payments over time (up to 10 years)" to create returns for investors based on successful project outcomes.[40] The Rockefeller Foundation is the main financial support behind the project. FRB is unique in that it creates a potential structure for cost sharing and monetizing co-benefits.

in scenarios so that outcomes can be tailored to the severity of the disaster and/or the resources available," advises Katie Simmons, disaster recovery director for Paradise. "Recovery is not a linear, unhalting process; it is a layered, segmented, start/stop reality of healing from community trauma while juggling projects that can be handled locally versus those contracted out for scale, depending on the funding source. Preparing for the negative impacts of recovery while celebrating milestones, such as road repairs following debris removal, can extend recovery planning out decades but keep the community moving forward toward a brighter future." Simmons also points out that this approach provides time to "be more thoughtful around sustainability."

COMMUNITY INVESTMENTS WITH DEMONSTRATED VALUE

Best practices in wildfire-resilient land use preserve life and property, lower municipalities' wildfire fighting costs, and help avoid expensive business interruptions. In addition, "social resilience is important, and you build it up over time if you live in a stable place. But the only way you get to live in stability in a place that is also prone to natural disasters like wildfires is to mitigate the risk and build better," says urban planner Peter Quintanilla.

Avoided Losses and Sustaining Communities

There is inherent and quantitative value of wildfire resilience at a community scale in avoiding loss—including loss of life and quality of life as well as loss of community cohesion and economic opportunity.

Emphasizing the impacts of planning, in an after-action analysis of the 2011 Bastrop fire in Texas, county emergency manager Mike Fisher credited the CWPP as one of the most successful efforts his community had undertaken. "Because of our pre-planning, our first responders—right in the face of an enormous, very intense fast-burning fire—were able to successfully evacuate roughly 5,000 people over a period of about four hours. I personally feel that because of the Community Wildfire Protection Plan and because of that planning and training, we were successful in saving hundreds if not thousands of lives."[41]

Reducing unhealthy air-quality days is another area where avoided impacts would significantly help individuals and communities. Air pollution—from all sources—costs the United States about 5 percent of the country's gross domestic product each year.[42] U.S. hospitals record between 5,200 and 8,500 admissions for respiratory symptoms stemming specifically from wildfires each year, and the cost of that health care need is tremendous. Health care costs due to air pollution from wildfire smoke can be as high as $130 billion a year.[43] Further, research released in June 2020 shows that smokier wildfire seasons in Montana lead to worse influenza seasons.[44]

The importance of avoiding secondary and downstream impacts also has become more apparent as the frequency and impacts of wildfires have increased. For example, food

"Recovery planning should be as extensive as disaster planning."

KATIE SIMMONS, DISASTER RECOVERY DIRECTOR, PARADISE

security—as well as the health of agricultural laborers, 71 percent of whom are Latinx in California—came to national attention in August 2020 while at least 12 wildfires were burning in the state. California produces two-thirds of the fruits and one-third of the vegetables consumed in the United States,[45] and produce companies were struggling to complete the harvest, raising the possibility of lower production, profit loss, and food price increases for consumers. The fires prevented harvesting in many areas and, therefore, many working in the agricultural sector lost incomes or their jobs for the season. Where work did continue, employees were exposed to unhealthy, smoky air—in addition to the coronavirus risk.[46]

Strategic Density Limits Risk and Wildfire Suppression Costs

Urban density theoretically limits development in the WUI, reducing risk and creating more clearly defined and defensible zones on a regional scale. This strategy mimics the strategies that planned-community developers are using to promote efficiency and incorporate high-yield opportunities: clustered infrastructure lowers installation and maintenance costs, allows for more efficient land management in areas without development, and enables the prioritization of firefighting resources when an event does occur.

The cost efficiency of this strategy is backed by research: a Headwaters Economics study for the Montana Legislature reported that suppression costs were highly correlated with the number of houses threatened by wildfire and the pattern of those houses (e.g., a dense subdivision added less cost than the same number of houses dispersed over a wider area),[47] Similarly, a recent study of wildfires in Wyoming found that protecting just one isolated home can add $225,000 to the overall cost of fighting a fire.[48]

Density can also help achieve other community sustainability and quality of life goals. Sprawl is a driver of climate change, especially because of greenhouse gas emissions from commuting traffic.[49] Higher-density transit-oriented development is a common strategy for climate mitigation and for increasing health through walkability. When strategically developed, transit-oriented development can also reduce inequities in commuting costs and time, which is especially helpful for people with low income who are the most likely to use public transportation.[50]

Retrofit Programs Protect Lives and Property

Retrofit programs pay off in avoided injuries and fatalities, property loss, and business interruptions. The wildfire resilience retrofits that are most effective against wildfires are likely to be roof and exterior walls because those are the most vulnerable parts of a building. However, those upgrades are typically expensive and smaller changes are likely more financially feasible.

A National Institute of Building Sciences mitigation savings study finds that retrofitting buildings to comply with the 2018 IWUIC would have a benefit-to-cost ratio of 2:1 across the United States and that federal grants supporting this work have a return ratio of 3:1.[51] In addition, in extremely high-risk areas, the study estimated that the benefit-to-cost ratio of retrofitting properties to wildfire code could be as high as 6:1.[52]

Wildfire Education Pays Off

Wildfire education generates a positive return on investment for communities as well as for developers and property owners. For example, Florida has a wildfire education program that includes wildfire hazard assessments as well as television programming and printed materials. A U.S. Forest Service analysis of the program concluded that each dollar of preventative wildfire education spending resulted in "an average of $35 in avoided wildfire suppression expenditures ($5.36) and avoided wildfire damages ($29.64)."[53] A review of wildfire education programs conducted on tribal lands had a similar conclusion.[54]

Wildfire education is especially important when combined with other preparedness and resilience efforts. "We need people who have already built in the WUI to understand the hazard. They need to prepare. That is a huge piece of resilience," says Michele Steinberg. "If the worst happens and homes burn down, if people are not financially prepared, they're not coming back. We saw that happen in Butte County; there was a huge diaspora of people who didn't have the ability to come home and rebuild. Financial preparedness is a huge wildfire resilience aspect that the real estate industry ought to be thinking about."

Each dollar of preventative wildfire education spending resulted in an average of $35 in avoided wildfire suppression expenditures and avoided wildfire damages.

REGIONAL LAND MANAGEMENT SOLUTIONS

Well-maintained forests and open space are integral to the wildfire safety of rural and developed areas, and landscape architects, fire experts, and public leaders are beginning to advocate for a new wildfire management approach based on forest health and forest resilience.

"We have switched from fuel reduction to forest health. Where the fire came from and where future fires will come from is part of a larger view of forest resilience. A healthy forest doesn't throw embers like what we saw during the Camp fire," says Jim Broshears, fire chief in Paradise.

Although the most expensive and destructive fires occur in the WUI, most wildfires still occur in remote and undeveloped areas, and part of protecting developed areas is ensuring that these wildland fires do not spread to developed areas. "It's important to work in areas that are outside of the immediate development because it will pay off in reduced losses and also it makes it safer for fire suppression personnel," says Mike Pellant, president of Rangeland Solutions.

Private landowners are critical stakeholders in regional land management solutions. Individuals and private firms own about 61 percent of U.S. land as of 2020 and that percentage is increasing.[55] In comparison, the federal government owns 28 percent, state and local governments own 8 percent, and tribes own 3 percent.[56]

Forest health is an immediate concern for investors and developers with large areas of inventory land in wildfire risk areas. "You have an investment, and you don't want to lose that. Fire can reduce the value of land really quickly, so you need to have defensive posturing," says Steve Thompson, a former developer and now principal with Capasiti Consulting in high-risk British Columbia. Thompson recommends focusing on preventing wildfires and, if they do occur, being ready to limit their spread.

Landowners, developers, and communities also may be able to combine the vegetation management on large holdings with revenue-generating opportunities through logging and the sale of timber. "It's business 101," says Melissa Kroskey, technical director at WoodWorks. "Our forests are healthiest when there is a demand for our wood and forestry products." Recognizing the combined potential of the emerging trend of mass-timber buildings, wildfire risk reduction, and economic development, the California Government Operations Agency hosted a mass-timber competition in 2019 to "stimulate demand for buildings constructed using mass timber and generate investor interest in potential in-state production capacity while advancing its climate change and green building objectives."

Managing remote natural lands also contributes to the safety and quality of energy and water infrastructure. Managing vegetation

HELLER PACIFIC, RMW ARCHITECTURE AND BERNARD ANDRÉ PHOTOGRAPHY

ULI Sacramento's Infill 2019 Project of the Year, the four-story 110,000-square-foot ICE Block I, is a mixed-use speculative office and retail development that was one of the first contemporary, timber-framed mid-rise structures in Northern California. Mass-timber advocates say more wood construction (in low-wildfire-risk areas) would grow a timber market and reduce wildfire fuels in forests.

reduces the possibility that plants will come into contact with high-voltage wires and potentially spark fires. In addition, most of the United States' urban, industrial, and agricultural water supply comes from forested land, and healthy forests are more likely to provide a consistent source of high-quality water.[57]

> **"We look at pre-fire mitigation as the biggest and best investment we can make."**
>
> ERIC HOWELL, FOREST SERVICE MANAGER, COLORADO SPRINGS UTILITIES

Colorado Springs Utilities, which provides electric, natural gas, water, and wastewater services, has a comprehensive forest management program for wildfire prevention and to protect the watershed.[58] The utility dedicated $2.5 million to a forest management budget after the 2012 Waldo Canyon fire caused $12 million in water infrastructure damage. In an article about the decision, the utilities' forest service manager Eric Howell said, "We look at pre-fire mitigation as the biggest and best investment we can make."[59] The utilities' forestry program is executed via a cooperative agreement with the Colorado State Forest Service and includes funding regional forest health assessments, restoration projects, and prescribed burns.

Likewise, Denver Water is investing $33 million between 2010 and 2022 in a Forests to Faucets partnership to restore and protect watersheds from wildfires.[60] These land management efforts were a critical component of preventing the 2018 Buffalo Creek fire from reaching 1,400 residences (collectively valued at $1 billion) in Silverthorne, Colorado.[61]

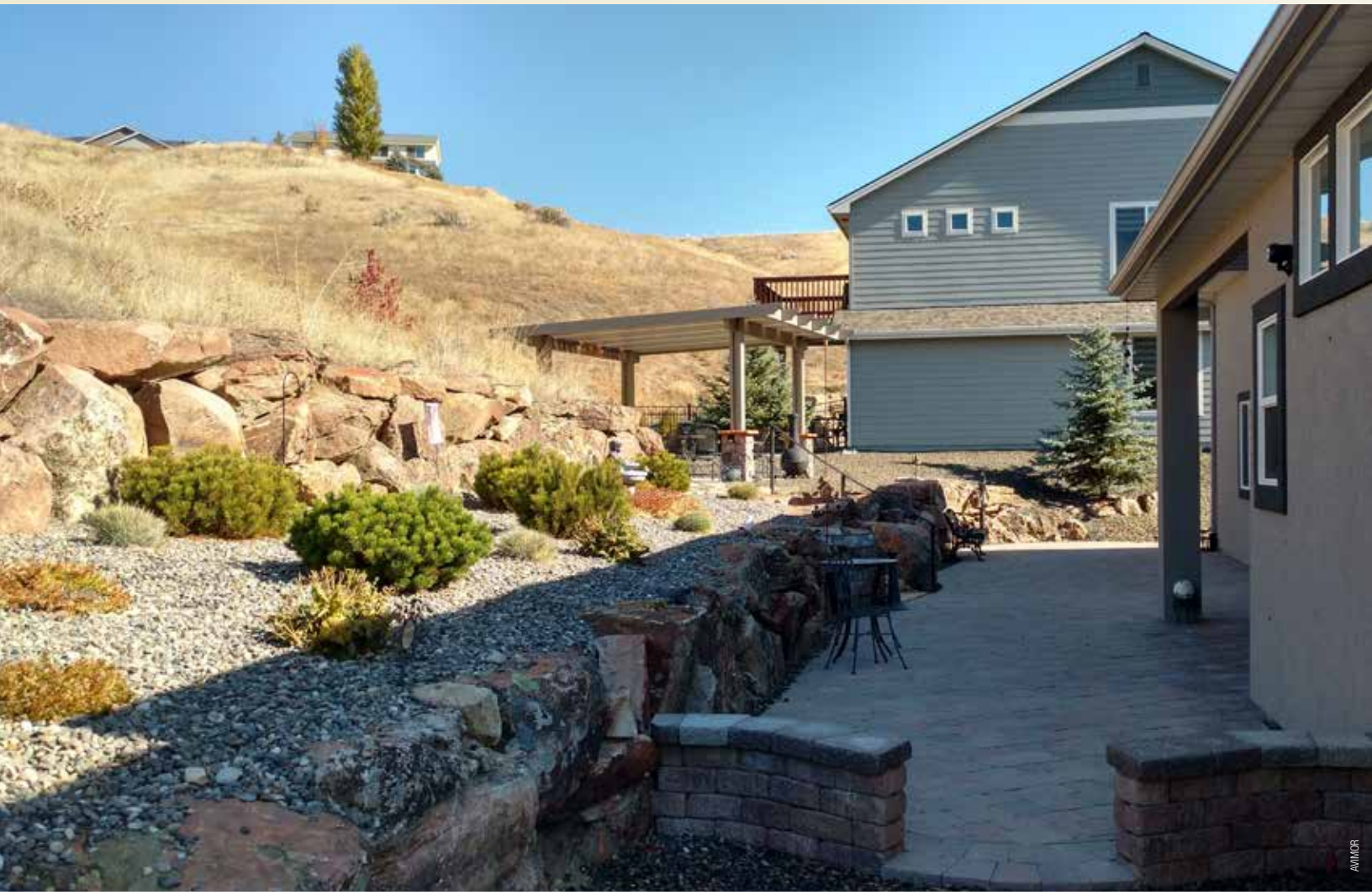
CASE STUDIES IN WILDFIRE RESILIENCE

THIS SECTION PROFILES A SELECTION OF REAL ESTATE PROJECTS, POLICIES, AND PROGRAMS that have prioritized wildfire resilience. All have realized successful business outcomes and contributed to the health and safety of the local community.

The real estate industry is increasingly aware that infrastructure and people in high-risk areas are almost certain to be threatened by wildfire, and the industry is focused on preparing for that eventuality by building and implementing land use regulations to better coexist with fire.

JONNU SINGLETON/SWA GROUP

AVIMOR DEVELOPMENT | Boise, Idaho



Houses at Avimor have ignition-resistant cementitious siding, class A roofs, and landscaping that adheres to Firewise USA standards.

> **"Proactive management of fuels in the adjacent open spaces coupled with Firewise landscaping guidelines and structural requirements save money, protect homes, and save lives."**
>
> DAN RICHTER, MANAGING PARTNER, AVIMOR DEVELOPMENT

Avimor is a 35-square-mile development in the foothills of Boise, Idaho, where resilience strategies have helped attract homeowners and commercial tenants while limiting damages from two wildfire events. Wildfire resilience is top of mind in Boise, which had 32 wildfires within two miles of the city's border between 2000 and 2015.[a] Also, "the growth trend in this area is very fast. Boise is the major metro area, and it's surrounded by several smaller cities that meld into one area. We're running out of room quickly," says Charles Baun, wildfire expert and owner of ECS Inc., which consulted on the project.

In addition to expanding wildland-urban interface (WUI) development, "we estimate we're about 20,000 homes short of meeting the need in the valley, and Ada County is expected to grow by a few hundred thousand people by 2040," says Dan Richter, managing partner for Avimor Development.

Avimor is the second community in Idaho to be a nationally registered Firewise USA community, and one of the first in the nation to earn the recognition as a new large development. Development started in 2004, was approved in 2006, and the first residential unit was completed in 2008. Avimor has 600 homes and several commercial buildings completed or under construction as of July 2020. With 300 homes constructed each year, it will gradually expand to 10,000 homes and become the largest development in the county over the next 60 years.

WILDFIRE RESILIENCE STRATEGIES

The Avimor leadership team hired a consultant to update the original site plan to make the development more wildfire resilient and the team worked closely with the local fire districts (Eagle and Boise) on the overall approach. The consultant's first step was to map and classify vegetation across Avimor's 35,000 acres to model fire risk, while also identifying and mitigating impacts to habitat and wildlife in the region.

Avimor has centralized development within large expanses of open space and it has recreational trail and road networks that act as fuel breaks and buffers. These transportation corridors also provide defined, easily accessible points for wildland firefighters and their equipment to access the surrounding foothills and open space.

As part of the planning process, the development team identified and mapped all the access points for firefighters, which makes response easier, faster, and potentially safer. The team also developed several on-site landscaping and fishing ponds that dual-function as dipping stations for firefighting helicopters.

The development team also created a wildland fire plan, a recreation plan, a noxious and invasive weeds plan, and a wildlife plan—most of which are above planning requirements. Avimor was the first development in Ada County to write its own fire plan. "NFPA 1144 standards [Standard for Reducing Structure Ignition Hazards from Wildland Fire] are guided toward single units that are surrounded 360 degrees by woodlands or other WUI areas. It's not developed around planned communities or subdivisions, so we developed a new standard that incorporated the infrastructure found in these types of higher-density developments," says Baun.

Avimor's buildings have cementitious siding and class A roofs. Residential units located on the development's periphery are required to have their landscape plan reviewed and approved by a certified Firewise USA specialist. Once units and landscapes are installed, the residents participate in an on-site review with the specialist to go over the Firewise aspects of the home and landscape plan, with a follow-up audit every five years.

In addition, Avimor charges tenants a fire impact fee. Homeowners contribute $10 each month to the Avimor Stewardship Organization to fund significant wildland improvement projects.

BUSINESS OUTCOME

Avimor reports that wildfire resilience was a "negligible cost increase" on new structures and a worthwhile upfront investment, especially because retrofitting homes and buildings to Firewise USA standards at a later point would have been significantly more expensive. The team saved money by not installing internal sprinkler systems—given the area's topography, internal sprinkler systems might have been ineffective in the event of a fire because of the lack of water pressure. "Our prices are on par with homes being built in the valley where they don't do all this wildfire resilience or have the open space. People feel like they're getting a bargain here," says Richter.

Across the development, the fire-adapted landscaping uses 60 to 80 percent less water than conventional designs in the region, and the site layout of clustered and buffered density contributes to cost efficiencies and resilience. Areas adjacent to the development are also mowed regularly to create strategically placed fuel breaks to slow external wildfires. "The slopes come back looking so much better. There's a real difference between the slopes that have never been mowed and those that we treat," says Richter. Tenants also appreciate the careful land stewardship and Firewise USA programs and turn out in significant numbers for volunteer trail maintenance and native vegetation planting days.

Avimor has weathered two recent fires—one in 2016 and one in 2018—that were started by vehicles on nearby roads. In both cases, the fire was directly adjacent to the property, but no people or structures were harmed.

AVIMOR

Avimor charges tenants a $10 monthly fire impact fee to help offset the costs of improving nearby wildlands for recreation and maintaining the nearby natural areas to reduce the potential of a destructive wildfire.

a. R. Miller, Jaap Vos, Eric Lindquist, Deanna Smith, Scot Oliver, and Tyre Holfeltz, *Wildfire Planning Guide for Idaho Communities*, prepublication final draft shared with ULI, January 2020.

RANCHO MISSION VIEJO | Orange County, California

The views and access to backcountry recreation provide a high quality of living for Rancho Mission Viejo residents, while the location of houses in lower-lying areas provides protection from wildfire.

> **"Consideration of wildfires has been a part of every major land use decision we've made since we started considering developing the property."**
>
> JAY BULLOCK, VICE PRESIDENT OF PLANNING AND ENTITLEMENT, RANCHO MISSION VIEJO

Rancho Mission Viejo, located in Orange County, is the largest new community in California, and wildfire resilience is a central component of its site layout, building design, and marketing strategy. A long-standing project to convert 25 percent of a 23,000-acre, privately owned ranch, Rancho Mission Viejo (the Ranch) implemented many wildfire resilience tactics before they became state and county requirements. The remaining 75 percent of the site is protected as a habitat preserve, known as the Reserve at Rancho Mission Viejo.

When complete, the Ranch will be home to about 35,000 residents. About 10,000 residents live in 4,000 homes on the site as of July 2020, and the site is approved for 14,000 homes and 5 million square feet of retail and commercial office space.

"Rancho Mission Viejo is at the far urban edge of unincorporated Orange County, adjacent to the city of San Juan Capistrano. There have been wildfires in and around the Ranch. Consideration of wildfires has been part of every major land use decision we've made since we started considering developing the property," says Jay Bullock, vice president of planning and entitlement for Rancho Mission Viejo.

WILDFIRE RESILIENCE STRATEGIES

Data-informed planning drives the wildfire resilience strategy at Rancho Mission Viejo, which includes a fire master plan, conservation of open space, building guidelines, and strict landscaping and defensible space protocols. The development team began with a fire behavior modeling study, using the Behave software system, to assess risk throughout the entire ranch.

The results of the study inform the Ranch Plan Fire Protection Program, which was created in 2007 in partnership with the Orange County Fire Authority and the California Department of Forestry and Fire Protection (CALFIRE) as the county's first pilot test of community wildfire protection plans. The protection program includes requirements for noncombustible construction materials and standards for automatic fire sprinklers everywhere in the community—not just in the riskiest areas.

In addition, "our site density works in the direction of safety," says Bullock. Residential areas range in density, yet are clustered in neighborhoods. Each neighborhood is surrounded by a 110-foot-wide fuel modification zone (a mix of no vegetation, fire-resistant vegetation, and irrigated vegetation), which is extended to 170 feet near higher-risk areas. Certain plant species (such as pines, eucalyptus, and palms or anything with peeling bark) are prohibited. The typical site plan calls for five- to 10-foot residential backyards of mostly nonvegetated hardscape.

BUSINESS OUTCOME

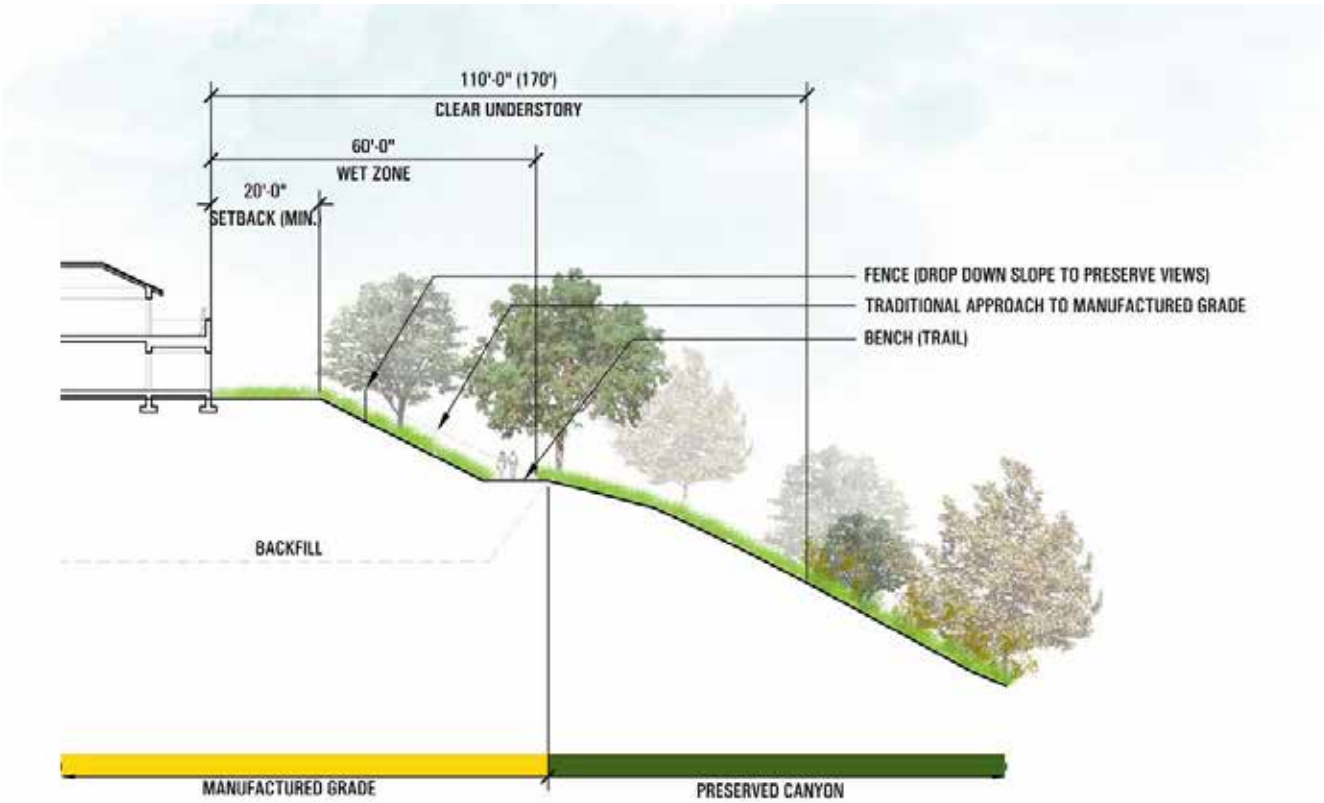
The additional construction cost of making each Rancho Mission Viejo home wildfire resilient was initially between $4,000 and $10,000 when compared with the typical construction cost of a similar, but less wildfire resilient, home.

However, "as wildfire resilient construction techniques and materials become the new normal, the additional cost per home may be down to $1,000 or $2,000—far below the costs builders were facing when the state first introduced these requirements. It's the cost of doing business in the wildland-urban interface," says Bullock.

Much of the Ranch is in the wildland-urban interface because of its adjacency to the Reserve at Rancho Mission Viejo, a large habitat preserve that will ultimately grow to encompass nearly 21,000 acres of Rancho Mission Viejo land.

"The Ranch doesn't feel like anywhere else in Orange County," says Bullock. "Ranch residents love the access to open space and the beautiful backcountry views of the Reserve, but with this comes the expectation of homebuyers that wildfire has been considered."

The development team implemented landscaping standards above and beyond local requirements to ensure that buildings are protected by defensible space.



RANCHO MISSION VIEJO/SWA GROUP

PEPPERWOOD PRESERVE | Sonoma County, California

Pepperwood Nature Preserve's office, staff housing, and environmental education facilities are designed to be fire resistant, and their materials are carefully selected to be nontoxic to support occupant health and to reduce recovery hazards if wildfire damage should occur.

> **"One goal was to build as nontoxically as possible, and the other goal was to build in as much fire-resistant capacity as possible."**
>
> LISA MICHELI, PRESIDENT, PEPPERWOOD FOUNDATION

Pepperwood is a research institute that manages a 3,200-acre field station and produces cutting-edge conservation science. The preserve serves as a living laboratory for wildfire-resilience land management in Northern California. Since the October 2017 Tubbs fire, Pepperwood also has become a model for resilient rebuilding.

The Tubbs fire, which at the time was the most destructive fire in California's history, burned right through Pepperwood. "There's been a lot of development in that fire corridor, so the building up of fuels, the natural patterns of fire, the terrain, the fuel types . . . they all exacerbated it. It was a devastating, catastrophic fire," says Antonio Pares, principal at Mithun, whom Pepperwood hired for the rebuild.

"With a really short turnaround time for evacuation, the Tubbs fire was a life and death situation for members of my team. And we lost six structures that night," says Lisa Micheli, president of the Pepperwood Foundation.

The only major Pepperwood structure to survive the Tubbs fire was the Dwight Center for Conservation Science, which was the newest building on the property and had been fabricated out of steel and built into the lee side of a hill. The remainder of the structures, including Pepperwood's office and environmental education facilities, were built in the 1950s or earlier and were primarily constructed of traditional redwood shingle.

WILDFIRE RESILIENCE STRATEGIES

Pepperwood is rebuilding three structures. A 2,000-square-foot barn and office, a 1,900-square-foot residence for an on-site manager, and a 3,000-square-foot duplex for other staff and visiting scientists that will cost approximately $1 million, $1.5 million, and $2.5 million, respectively, to rebuild. The rebuild team considered if the structures should be rebuilt on the same locations and decided their locations were optimal and necessary for their uses (although the footprint of one of the residences was reduced).

Other initial steps included analyzing the historical fire patterns in the area and establishing priorities. "We had two goals. One was to build as nontoxically as possible and the other was to build in as much fire-resistant capacity as possible," says Micheli.

The new buildings have a mix of noncombustible metal exteriors and cement fiber panel cladding as well as cement plaster walls and dense black locust decking to reduce flame spread. The buildings also have zero-VOC (volatile organic compound) clay walls in some areas and in others, low-VOC paint. The surrounding landscape is beautiful and carefully planned but includes little vegetation as part of creating defensible space.

In acknowledgment of the affordability concerns, Pares says the rebuild has "a nuanced approach where you're really thinking about how fire acts in relationship to a structure," which led to including many preventative measures for ember ignition such as optimal screening of openings, placement and orientation of vents, and eliminating structural depressions where embers could collect.

BUSINESS OUTCOME

Results from the Tubbs fire demonstrate that the land management strategies that Pepperwood practices and studies do have a positive effect. Staff noticed that the only areas not severely burned in 2017 were those that had previously been treated with prescribed, controlled burns to reduce vegetative fuel. Pepperwood's response to the Tubbs fire also helped prepare it to survive the 2019 Kincade fire. "In 2019, only about half the property burned. We were able to prevent the fire from getting to the rebuild sites," says Micheli. Ongoing construction on three buildings was also able to continue in 2020 because fire rebuilds are considered essential businesses and were not halted for the coronavirus pandemic.

Pepperwood now serves as a focal point for the protection of the wider community. It is part of a fire camera network, with two cameras that provide virtual, real-time data to firefighters about onsite conditions. The California Department of Forestry and Fire Protection (CALFIRE) used Pepperwood as a staging area to fight the Kincade fire—the cameras were vital sources of information and assisted CALFIRE in preventing the fire from progressing further in that area.

The rebuild has led to many lessons learned for a team that does not specialize in large-scale construction projects, let alone complicated rebuilds. With more upfront knowledge about total cost, Micheli says, "I probably would have scaled back on some of the houses' amenities." However, she thinks the extra resilience measures are worth the cost, saying, "What we're getting are incredibly resilient structures that are going to be in use for the next century of our organization."

The total cost of the rebuild is about $5 million, including an estimated $1.25 million in sustainability and resilience improvements over what insurance would cover.[a] Pepperwood launched a capital campaign to raise the difference and received large legacy gifts from several donors. The resulting structures will exceed local code requirements and are of significantly higher quality and resilience than the original buildings, especially with regard to the nontoxic materials.

Figuring out the insurance claim was a lengthy and difficult process that involved eight individuals negotiating for more than 12 months. Micheli's advice to other property owners is to make sure that they have detailed site information before a disaster occurs, as one way to mitigate the difficulty of the process.

Antonio Pares's main lesson learned on the design side is "to keep the buildings as simple as possible . . . and address the vulnerabilities of a traditional structure" to ember ignition.

PEPPERWOOD/EARTHTONE CONSTRUCTION

In rebuilding structures burned by the 2017 Tubbs fire, the design team proposed simple building typologies to minimize the sites where embers could collect—a deterrent against future structure damage.

a. Guy Kovner, "Pepperwood Preserve Readying for $5 Million Wildfire Rebuild Project," *Press Democrat*, May 13, 2019. https://www.pressdemocrat.com/news/9575963-181/greener-cleaner-better-pepperwood-preserve?sba=AAS.

AUSTIN'S HAZARD-BASED WUI CODE | Austin, Texas

Austin is the largest municipality outside of California to adopt a wildland-urban interface code.

> **"All of our progress is built on partnerships and collaboration and helping others understand their roles in wildfire risk reduction and how we can support them."**
>
> JUSTICE JONES, AFD WILDFIRE MITIGATION OFFICER

According to the International Code Council, Austin is the largest municipality outside of California to adopt a wildland-urban interface (WUI) code. A highly urban city with more than 60 percent of its existing structures located within 1.5 miles of the WUI (predominantly along its eastern and western edges), Austin's WUI code was developed in response to a record-breaking fire season in 2011.

In 2011, driven by severe drought, the number of wildfires, acres burned, homes destroyed, and lives lost for the state of Texas and the city of Austin were unprecedented. Excluding fires only responded to by local fire departments, Texas experienced 31,453 wildfires in 2011 that burned 4 million acres and destroyed 2,947 homes. Austin was particularly affected by the Bastrop County Complex fire, which began on September 4 just east of Austin.

Resilience improvements were made in Austin following the 2011 fire season, including the formation of a Joint Wildfire Task Force with Travis County and the establishment of the first Wildfire Division within the Austin Fire Department (AFD) to help facilitate wildfire recovery and implement related projects. AFD coordinated the drafting and approval of the new WUI code.

The successful collaborative process in Austin for developing a best-in-class WUI code and fostering stakeholder buy-in—despite initial skepticism—serves as a valuable model for other urban and rapidly developing areas that carry high wildfire risk.

WILDFIRE RESILIENCE STRATEGIES

One of the resilience strategies used in Austin was ensuring the WUI code was based on the best available local and national wildfire data.

"We have a great GIS team that has mapped the WUI within the city and what risks are there for different areas of the city," says Carrie Stewart, division chief of AFD's Wildfire Division.

As part of its wildfire resilience efforts, the city maintains a public interactive WUI map on its website. AFD's Wildfire Division also reviewed after-action reports from major fires, including California's Camp fire in 2018, to evaluate how polices and structure characteristics affected damages.

Developing the code was also an extensive participatory process involving public, private, and community stakeholders. Active development stakeholder groups included the Real Estate Council of Austin, the Greater Austin Homebuilders Association, and the Austin Board of Realtors.

"All of our progress is built on partnerships and collaboration and helping others understand their roles in wildfire risk reduction and how we can support them," says Justice Jones, AFD wildfire mitigation officer.

The new WUI code includes best-practice ignition-resistant standards for both new and remodeled structures, including measures for ember protection and structure hardening.

"Now, if we do have another fire in the WUI and people want to rebuild, they'll be required to do so based on best practices and standards," says Mark Baker, AFD's WUI coordinator, who had a leading role in developing the WUI code.

Residents and developers with existing structures do not have to make structural upgrades, but they are required now to maintain defensible space. The code also requires safe storage of combustible materials. Alongside wildfire hazards, the WUI code development team also considered equity and affordability challenges.

OUTCOME AND LESSONS LEARNED

On April 9, 2020, the Austin City Council voted unanimously to approve the new 2015 International Wildland-Urban Interface Code, making Austin the first major city in the state of Texas to adopt such a measure; it will go into effect on January 1, 2021.

Council member Jimmy Flannigan also referenced the context in which the vote took place. "Nothing is going to stop a wildfire from starting, certainly not a pandemic, and we need to make sure we're doing everything we can to be prepared for it," he said.[a]

Those in Austin say the new WUI code improves the environmental resilience and will reduce the potential for wildfire-related losses.

"The adoption of the WUI code stands out because of the nature of Texas, and planning and private property rights. That was a real success to be able to accomplish that and to head off unsafe development," Baker says.

The city estimates that implementing the code will cost $1.65 million, including $1.2 million for staff time and inspections, $100,000 for outreach and education, $50,000 for ongoing operations, and $300,000 for one-time costs.

The development of the WUI code began in 2016 and took four years to finalize. Regarding lessons learned, Jones says, "A lot of our challenges were overcoming internal perceptions and biases towards what wildfire mitigation would mean and the impacts of that. To address those, we worked diligently to be transparent, and to establish and use best practices."

Baker also points to Austin's data-driven approach as integral to success. "We wouldn't have been able to get the WUI code adopted if we didn't have a really strong understanding of where the risk is and where that code would apply," he says.

CITY OF AUSTIN FIRE DEPARTMENT

Managed vegetation to reduce fire ignition and spread is one of the best practices required in Austin's new WUI code that will help prevent structure loss in the WUI. Here, cleared vegetation is made into wood chips for easier removal from the property.

a. Jessi Devenyns, "Austin Has a New Wildland-Urban Interface Code," *Austin Monitor*, April 13, 2020. https://www.austinmonitor.com/stories/2020/04/austin-has-a-new-wildland-urban-interface-fire-code/.

PARADISE LONG-TERM RECOVERY PLAN | Paradise, California

URBAN DESIGN ASSOCIATES

After the 2018 Camp fire caused significant damage in Paradise, California, an extensive public engagement process with hundreds of participants helped establish the community vision and priorities for recovery.

> **"We're looking to focus on wildfire safety and how it pertains to housing."**
>
> SUSAN HARTMAN, COMMUNITY DEVELOPMENT DIRECTOR, PARADISE

The town of Paradise, California, is becoming a leader in postdisaster recovery planning driven by necessity after the devastating 2018 Camp fire and by residents' commitment to return to their home community. With a pre-fire population of more than 26,000, Paradise is in Butte County about 90 miles northeast of Sacramento in the foothills of the Sierra Nevada, where almost all of the land area is classified as "very high" risk of wildfire.

The Camp fire started November 8, 2018, burned for two weeks, and was contained on November 25, thanks to the efforts of more than 1,000 firefighting personnel. Before the Camp fire, many fire experts recognized Paradise for having best practices, such as a wildland-urban interface (WUI) code and a robust evacuation plan. Unfortunately, the Camp fire "just didn't give people a chance," says Thomas Cova, wildfire evacuation expert. "It was a direct hit, [igniting just 10 miles northeast], and even when the ignition started, there already wasn't enough time to get everyone out. It was a dire scenario."

The Camp fire took the lives of 85 Paradise residents, displaced tens of thousands of people, destroyed 19,000 homes, businesses, and other structures, and caused smoke damage in 1,300 of the remaining 1,800 structures. In a survey as part of the recovery planning process, more than 65 percent of residents indicated that they plan to return to Paradise.

The official town-led recovery planning process began in January 2019. It is funded by the Butte Strong Fund of the North Valley Community Foundation, of which the local, privately owned Sierra Nevada Brewery is a significant contributor, and by a U.S. Economic Development Association grant. Paradise's recovery process and resulting long-term recovery plan incorporates many best practices in wildfire resilience, documents the priorities and recommendations widely supported by residents, and may serve as a template for other wildfire-affected communities.

WILDFIRE RESILIENCE STRATEGIES

The process of developing the plan was as much a part of the community's recovery as the resulting recovery priorities. The town is leading the overall recovery effort and hired Urban Design Associates (UDA) to conduct a community engagement process to inform the long-term recovery plan, known as the "community vision." Originally, UDA planned a three-step engagement process. Principal Megan O'Hara says the town and UDA quickly "discovered that we needed a step zero—relieving pressure." In the first step, the team helped clearly communicate the existing requirements for rebuilding individuals' homes. The following process then moved into listening, testing ideas, and deciding on recommendations and recovery projects.

The engagement team began by building relationships with local stakeholders and distributing relevant information about rebuilding procedures to help the community and notify it of the planning process. UDA launched the "Make it Paradise" website to act as a central repository of information. The town hired a public relations firm to lead the messaging and to manage the website. The engagement team created social media hashtags like "#paradisestrong" and "#paradiseproud" and the slogan "Uniting, Growing, Rebuilding" to promote the effort.

The process officially launched in February 2019 at a regularly scheduled council meeting with about 550 participants. Attendees participated in small facilitated discussions of 15 to 20 people, reporting on the top strengths of Paradise, weaknesses (before or after the fire), and opportunities as a result of the disaster.

Over the next five months, UDA hosted listening sessions and conducted one survey in which local participants provided feedback on Paradise's strengths, weaknesses, and opportunities. Most meetings were hosted locally and in person, with one virtual meeting for those displaced out of the immediate area. The engagement team recruited about 40 volunteer California State University, Chico, staff and faculty to receive facilitation training and then to help facilitate the listening sessions.

UDA completed the next step, testing ideas, on the basis of the information gathered at the listening sessions and the survey results. "Every time someone said something in any small group meeting, it was written down as a discrete comment," says O'Hara. UDA counted the themes and organized the answers into like responses. Twenty-one themes rose to the top and were grouped into five categories.

Those five categories are the pillars of the long-term recovery plan's vision to make Paradise a safer, more welcoming, stronger, better, and greener community. Residents and stakeholders helped define the plan's 40 recovery projects, each with a suggested recovery priority, cost estimate, a potential project advocate, and potential funding sources. UDA also evaluated and recommended to Town Council 20 potential additional building-design standards to expand Paradise's existing WUI code and improve fire resilience.

OUTCOME AND LESSONS LEARNED

Over the course of five months, the recovery planning team hosted seven listening sessions, which were attended by 300 to 800 attendees each. The virtual session drew about 50 participants. The team also provided updates on the planning process and other relevant information to 15,000 residents who signed up to receive email updates.

Though the community vision exemplifies many aspects of new urbanism, it is meant first and foremost to reflect community goals and priorities, which were unique to Paradise. For example, "a walkable downtown was one of the visions we heard from community members," says O'Hara. Residents also prioritized improved evacuation routes. The "make it safer" pillar includes a recovery project to widen roads and build a pedestrian and bike system that doubles as secondary access/egress for emergency vehicles when needed—an example of an adaptation that leverages critical infrastructure to double as social (or community) infrastructure.

The Paradise Town Council adopted the long-term recovery plan in June 2019 and intends to use the document as a decision-making tool for lining up funding for about 40 recovery projects. The council also adopted seven new recommendations to its WUI code intended to make future residential and commercial properties more wildfire resilient. In addition to continuing the recovery operations and necessary fundraising, Paradise is organizing for a general plan update in 2021. "We're looking to focus on wildfire safety and how it pertains to housing," says Susan Hartman, community development director.

URBAN DESIGN ASSOCIATES

Paradise's recovery plan includes widened roads with a more robust pedestrian and bike system that doubles as secondary access/egress with additional capacity for faster emergency response and resident evacuation.

PRESCOTT AREA WILDLAND URBAN INTERFACE COMMISSION | Prescott, Arizona

Prescott Area WUI Commission leaders and resident volunteers celebrate the completion of Project Andrew, which helped the local community achieve Firewise USA recognition and create a more wildfire-resilient forest. The project was conducted to reduce risk and in honor of the fire-suppression efforts of Granite Mountain Hotshot elite firefighters during the 2013 Yarnell fire.

"If you have the proper forestry stewardship, you can have beautiful forests that are not as dangerous."

BOB BETTS, DIRECTOR, PAWUIC

The Prescott Area Wildland Urban Interface Commission (PAWUIC) is a uniquely structured nonprofit that, with strong county and city support, is leading vegetation management and equitable funding programs to enhance wildfire resilience in Arizona.

Community members formed PAWUIC after the Dude fire in Payson, Arizona. A lightning strike ignited the Dude fire in June 1990 after a three-year drought and during a heatwave where temperatures reached as high as 122 degrees Fahrenheit.[a] Among other impacts, the fire led to the deaths of six inmate firefighters. Separate from the work of the PAWUIC, their deaths led to the nationwide adoption of a new professional firefighting safety model known as LCES (for lookouts, communication, escape routes, and safety zones).[b]

"It was decided afterwards that people who live here in the WUI area were not paying attention to the dangers," says Bob Betts, longtime director of the PAWUIC. "Leaders from the Prescott National Forest, the city of Prescott, and Yavapai County all got together and said we ought to be more forward looking on what we should be doing."

PAWUIC launched as a six-person grassroots nonprofit and has gradually developed into a well-established nonprofit staffed collaboratively by federal, state, city, tribal, business, and community volunteers. It has an annual operating budget of $300,000. Most of PAWUIC's funding is from state Department of Forestry and U.S. Forest Service grants, but PAWUIC also participates as a partner on collaborative, multiyear grants from other sources.

WILDFIRE RESILIENCE STRATEGIES

PAWUIC's focus is vegetation management and wildfire fuels reduction on public and private lands. Two such vegetation management projects that exemplify PAWUIC's work are the Bradshaw Cross Boundary Project and Project Andrew.

The Bradshaw project encompasses the Prescott area, which includes about 141,156 acres in one of the largest wildland-urban interface (WUI) areas in the U.S. Southwest. The U.S. Department of Agriculture is providing $1.5 million for six local, state, and federal partners, including PAWUIC, to conduct fuels management. PAWUIC is partnering with the Prescott Fire Department to hand thin and remove fuels.

Project Andrew was another collaborative effort designed specifically to help the community achieve Firewise USA recognition in honor of Andrew Ashcraft, one of 19 Granite Mountain Hotshot elite firefighters who died in 2013 while fighting the Yarnell fire.[c] In collaboration with the Prescott Fire Department and Arizona Department of Forestry and Fire Management (AZ DFFM), PAWUIC conducted home wildfire assessments and tree thinning on 17 acres.

PAWUIC and the town of Dewey-Humboldt also worked together to create an innovative financing method for vegetation management for town residents with low incomes. Dewey-Humboldt is adjacent to the Prescott National Forest to the west and state forestland to the east and has two Firewise USA–recognized communities within its boundaries. In addition, the Blue Hills area of town is extremely high risk with only one feasible entrance and exit route in the event of an evacuation for 650 residential properties. Most of the homes are made of flammable building materials and are surrounded by grasses and highly flammable bushes.

To conduct risk mitigation in Dewey-Humboldt, PAWUIC won a $250,000 wildfire hazardous fuels grant from AZ DFFM that is structured as a 90/10 percent split. Homeowners provide 10 percent upfront to begin the risk reduction work. A representative of Dewey-Humboldt Firewise then inspects the property to ensure the abatement is correctly completed and submits a confirmation to the town for review. Dewey-Humboldt advances the remaining 90 percent of the money to the homeowner to pay the abatement contractor, and PAWUIC reimburses the town for that expense.

"The town acts like a bank but charges no interest and is only out of pocket for three to four months," says town council member Vickie Wendt. The first grants through this program were issued in 2016. In 2020, the Dewey-Humboldt Firewise Committee took over responsibility from the town, continuing the same process of reimbursing residents to enable risk mitigation.

OUTCOME AND LESSONS LEARNED

Since 2007, PAWUIC has been awarded and then distributed more than $18 million to reduce wildfire fuel on private property. It has helped 43 local communities representing more than 18,000 parcels receive Firewise USA recognition. Also, PAWUIC has successfully advocated for homeowners insurance premium reductions for local Firewise communities. In October 2016, PAWUIC wrote the United Services Automobile Association (USAA), which at the time offered discounts in New Mexico, Colorado, and Texas, and requested the company expand the program to Arizona. According to Bob Betts, USAA approved the expansion within 60 days.

The Bradshaw project is credited separately with helping "protect 28,000 homes for more than 53,000 residents, land management strategies on 8,600 acres of public and private land, and improved critical [wildlife] habitat."[d] And, Project Andrew "is an example showing that if you have the proper forestry stewardship, you can have beautiful forests that are not as dangerous. When you have forests with fuels all clumped together, you end up with catastrophes," says Betts.

Betts's advice for other communities is to focus on the cross-sector collaboration. "If you can get, as we've done, a number of communities and all of the agencies involved (the city, the county, the Firewise districts, the Forest Service, the Bureau of Land Management, the state forestry agencies) to all come together, then there's this comradery," says Betts. "For most people, that mentally cements that vegetation management is a good thing to do because all those people who are going to protect me when the next fire comes through are right here with me, fighting the good fight."

In addition to wildfire resilience, the work of PAWUIC and its partners helps protect the regional economy. Outdoor recreation and tourism are significant sources of revenue for the Prescott region, and these industries depend on forest health.[e]

PAWIC

An innovative financing program, supported by grants won through PAWUIC, enables residents with low incomes to afford professional vegetation management and has helped reduce wildfire risk near 650 residential properties.

a. National Wildfire Coordinating Group, "Dude Fire – June 26," July 2020. https://www.nwcg.gov/committee/6mfs/dude-fire.

b. Tom Story, "Remembering the Dude Fire," *AZ Central*, June 26, 2015. https://www.azcentral.com/story/behind-the-lens/2015/06/26/dude-fire/28981819/.

c. Yavapai Firewise, "Community Firewise Days," Prescott Area Wildland Urban Interface Commission, 2020. https://yavapaifirewise.org/firewise-days.

d. USDA Natural Resources Conservation Service, "USDA Invests Millions to Protect Arizona Communities from Wildfires, Restore Forest Ecosystems, Improve Drinking Water," Bulletin, March 20, 2019. https://content.govdelivery.com/accounts/USDANRCS/bulletins/2382711.

e. USDA Natural Resources Conservation Service, "Cross Boundary Basin Project." https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd475266.pdf.

CONCLUSION

WILDFIRES ARE BECOMING BIGGER, MORE FREQUENT, MORE DESTRUCTIVE, AND LESS PREDICTABLE because of the impacts of climate change as well as land use decisions and historical fire suppression. In the face of increasing wildfire risk, development and land use professionals have a critical role in helping reduce the negative outcomes of wildfire events and in supporting community resilience efforts.

Jurisdictions across the United States have already begun to implement best practices in wildfire resilience. Moreover, many interviewed for this report emphasize that they expect land use and development to increasingly consider wildfire hazards in the near term, helping reduce risk and set communities up to thrive in the long run.

PIXABY

Wildfires are increasingly affecting highly developed areas—whether directly by burning through or near town centers or via the downstream impacts of hazardous air quality, increased housing pressure, business interruptions, environmental destruction, and the growing amount of resources dedicated to fire suppression and recovery. Also of concern is the possibility that wildfires will increasingly affect multiple neighboring states, as they did during the 2020 wildfire season, overtaxing emergency response and housing capacity and creating a tremendous need for community public health and recovery aid on a regional scale.

Building wildfire-resilient communities requires development and land use professionals to participate in hazard reduction and the implementation of resilience best practices at the site, district, and regional scales. These methods have the potential to reduce wildfire risk but they are not enough in isolation; local governments also need to adequately resource and strategize for community preparedness, emergency response, and postevent recovery.

Many interviewed for this report emphasized that they expect land use and development to increasingly consider wildfire hazards in the near term. "There's going to be continued pressure to make things safer," says Jay Bullock at Rancho Mission Viejo.

Professionals in the real estate industry can ensure that wildfire risks are considered in built-environment decision-making. Design interventions such as hazard-aware siting, noncombustible building materials, defensible space, and fire-resilient landscaping have the potential to resist ember attack, prevent structure destruction, and limit the possibility of building-to-building fire spread.

At a community scale, public officials are increasingly integrating wildfire hazards into land use policy, such as California's Chapter 7A building code, Missoula County's hazard-informed growth planning, and Austin's WUI code. More compact development with surrounding wildfire buffers to shift people and infrastructure out of extremely high-risk areas may become preferred as communities grapple with the long-term effects of repeated, catastrophic fires. "Incentivizing infill development and denser development rather than suburban or semirural sprawl helps accomplish multiple community planning goals," says Edith Hannigan, CALFIRE land use policy manager. Exploring policies that reduce or restrict development also is likely to lead to tradeoffs and difficult decisions, which policymakers are grappling with and considering in the context of housing affordability and economic development goals.

Developers, Realtors, public officials, utilities, insurance companies, and nonprofits are already forming public/private partnerships to aid in wildfire resilience efforts. For example, developers are formalizing partnerships with local Firewise USA organizations, like at the Avimor development in Idaho. In Colorado, Realtors, insurance firms, and public officials are collaborating to create new systems for homeowner education, voluntary site assessment, and premium reductions. Many interviewed for this report noted the successes of these partnerships and advocated for them to be expanded, especially regarding housing solutions, funding mechanisms, and long-term planning.

Experts who live and work in fire-prone communities say that more proactive planning ahead of wildfires could limit their damage and expedite recovery. "We need to really look at implementing some serious and significant site fortification methods. We also need to mandate emergency planning for all jurisdictions and housing providers in a rigorous way. . . . At [the] end of [the] day, this is our problem together. It's all of our problem to solve," says Laurie Schoeman of Enterprise Community Partners.

"Based on what we've seen happen across the West with megafires amid climate change, the environment is ripe to try to do something different."

ADRIANE BECK, DIRECTOR, MISSOULA COUNTY OFFICE OF EMERGENCY MANAGEMENT

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NOTES

Introduction

1. National Interagency Fire Center, National Preparedness Update, September 12, 2020. https://www.nifc.gov/fireInfo/nfn.htm.
2. Matthew Foley, "The High Cost of Wildfires," *National Fire Protection Association Journal*, November–December 2019. https://www.nfpa.org/News-and-Research/Publications-and-media/NFPA-Journal/2019/November-December-2019/Features/Large-Loss/Wildfire-Sidebar.
3. Matthew Bloch, Scott Reinhard, Bryan Pietsch, and Lucy Tompkins, "California, Oregon, and Washington Fire Tracking and Air Quality Maps," *New York Times*, Accessed September 12, 2020. https://www.nytimes.com/interactive/2020/us/fires-map-tracker.html.
4. Jason Wilson and Maanvi Singh, "Oregon Fires Put 500,000 Under Evacuation Orders as US Blazes Kill 15," *Guardian*, September 10, 2020. https://www.theguardian.com/world/2020/sep/10/wildfires-us-california-oregon-washington-latest-death-toll.
5. Mike Carter, Sandi Doughton, and Scott Hanson, "Wildfires Rage as Seattle Area Braces for 'Super-massive' Plume of Smoke," *Seattle Times*, September 20, 2020. https://www.seattletimes.com/seattle-news/dry-windy-weather-helps-wildfires-keep-raging-across-washington-state-thursday/.
6. Michael Elizabeth Sakas, "Firefighters Battle Massive Fires in Colorado," NPR, August 18, 2020. https://www.npr.org/2020/08/18/903616294/firefighters-battle-massive-fires-in-colorado.
7. Ian P. Davies et al., "The Unequal Vulnerability of Communities of Color to Wildfire," *PLOS ONE* (November 2, 2018). https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0205825.
8. Insurance Information Institute, Facts + Statistics: Wildfires, 2020. https://www.iii.org/fact-statistic/facts-statistics-wildfires.
9. U.S. Global Change Research Program, "Chapter 6: Forests," in Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II, 2018. https://nca2018.globalchange.gov/chapter/6/.
10. Fourth National Climate Assessment. Chapter 6: Forests. 2018. https://nca2018.globalchange.gov/chapter/6/.

Wildfire Risk

1. Molly Mowery et al., *Planning in the Wildland Urban Interface*, American Planning Association, April 2019.
2. Robert Bailey and Jaclyn Yeo, *The Burning Issue: Managing Wildfire Risk*, Marsh & McLennan Companies, 2019.
3. Dr. Tom Jeffery et al., *2019 Wildfire Risk Report*, CoreLogic, September 12, 2019. https://storymaps.arcgis.com/stories/cb987be2818a4013a66977b6b3900444.
4. Jeffery et al., *2019 Wildfire Risk Report*.
5. Kevin Brehm, Mark Dyson, and Emily Goldfield, *Working Together Toward a More Resilient Future: A Community-Based Approach Toward Energy Resilience in the Roaring Fork Valley*, Rocky Mountain Institute, May 2020.
6. Alexandra Syphard, "Housing Patterns, Wildfire, and Community Vulnerability: Historical Perspectives and Future Possibilities," presentation at Living with Fire Symposium, May 2018. https://youtu.be/3SqZYWG1uHY.
7. Miranda H. Mockrin, "Mapping the WUI: Where Housing Meets Wildland Vegetation," Rocky Mountain Research Station, U.S. Forest Service, USDA, April 2015. https://www.fs.usda.gov/rmrs/projects/mapping-wildland-urban-interface-wui-where-housing-meets-wildland-vegetation.
8. Ray Rasker, *The Wildland-Urban Interface: The Problem, Trends, & Solutions*, Headwaters Economics, August 31, 2018. https://headwaterseconomics.org/wp-content/uploads/wildfire_homes_solutions_presentation.pdf.
9. U.S. Census Bureau, "American Community Survey: Selected Housing Characteristics, 2018 ACS 5-Year Estimates Data Profiles," TableID: DP04. https://data.census.gov/cedsci/table?d=ACS%205-Year%20Estimates%20Data%20Profiles&tid=ACSDP5Y2018.DP04.
10. Wildfires and Climate Change: California's Energy Future," a report from Governor Newsom's Strike Force, April 12, 2019. https://www.gov.ca.gov/wp-content/uploads/2019/04/Wildfires-and-Climate-Change-California%E2%80%99s-Energy-Future.pdf.
11. Patty Glick et al., *The Protective Value of Nature: A Review of the Effectiveness of Natural Infrastructure for Hazard Risk Reduction* (Washington, D.C.: National Wildlife Federation, 2020).
12. Susan Cagle, "California's Wildfire Risk Keeps Getting Worse. Now a Decade of Blackouts Lies Ahead," *Guardian*, January 13, 2020. https://www.theguardian.com/business/2020/jan/13/californias-wildfire-risk-keeps-getting-worse-now-a-decade-of-blackouts-lie-ahead.
13. Alexandra D. Syphard et al., "Housing Arrangement and Location Determine the Likelihood of Housing Loss Due to Wildfire," *PLOS ONE* 7(3) (March 28, 2012). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3314688/pdf/pone.0033954.pdf.
14. Insurance Information Institute, Facts + Statistics: Wildfires, 2020. https://www.iii.org/fact-statistic/facts-statistics-wildfires.
15. Julie Cart and Judy Lin, "California's Worsening Wildfires Explained," Cal Matters, August 20, 2020. https://calmatters.org/explainers/californias-worsening-wildfires-explained/.
16. Insurance Information Institute, Facts + Statistics: Wildfires, 2020. https://www.iii.org/fact-statistic/facts-statistics-wildfires.
17. Mike Davis, "The Case for Letting Malibu Burn," Excerpt from *Ecology of Fear: Los Angeles and the Imagination of Disaster* (1998) published on Longreads, 2018. https://longreads.com/2018/12/04/the-case-for-letting-malibu-burn/.
18. Robert Bailey and Jaclyn Yeo, *The Burning Issue: Managing Wildfire Risk*, Marsh & McLennan Companies, 2019.
19. National Institute of Building Sciences, "Mitigation Saves: Retrofitting Buildings in the WUI Saves $2 for Each $1 Invested," 2019. https://cdn.ymaws.com/www.nibs.org/resource/resmgr/reports/mitigation_saves_2019/ms_v3_retrofit_wui.pdf.
20. Molly Mowery et al., *Planning in the Wildland Urban Interface*, American Planning Association, April 2019.
21. H. Anu Kramer et al., "Where Wildfires Destroy Buildings in the US Relative to Wildland-Urban Interface and National Fire Outreach Programs," *International Journal of Wildland Fire* 27(5): 329–41 (2018). https://www.fs.usda.gov/treesearch/pubs/56376.
22. Stephen R. Miller et al., "Wildfire Planning Guide for Idaho Communities," pre-publication final draft shared with ULI, January 2020.
23. Elita Goyer and Lorraine Dechter, "National Park Service Releases Review of Carr Fire," Action News Now post, April 2019. https://www.actionnewsnow.com/content/fire-watch-stories/National-Park-Service-releases-review-of-Carr-Fire-508775641.html.
24. Jennifer K. Balch et al., "Human-Started Wildfires Expand the Fire Niche Across the United States," *PNAS* (March 14, 2017). https://www.pnas.org/content/114/11/2946?ijkey=7309d83d1cea5af51a5b3ba4738d8c8ab388075e&keytype2=tf_ipsecsha.

25. USDA Forest Service, Northern Research Station, "Most California Wildfire Is in Wildland-Urban Interface Area with Less Fuel, More People," *Science Daily*, September 24, 2019. https://www.sciencedaily.com/releases/2019/09/190924131527.htm.

26. V. C. Radeloff et al., "The Wildland-Urban Interface in the United States," *Ecological Applications* 15(3): 799–805 (2005). https://www.nrs.fs.fed.us/pubs/jrnl/2005/nc_2005_radeloff_001.pdf.

27. Susan I. Stewart, Volker C. Radeloff, and Roger B. Hammer, "The Wildland-Urban Interface in the United States," The Public and Wildland Fire Management, 2016. https://www.fs.usda.gov/treesearch/pubs/18710

28. Mila Alvarez, "The State of America's Forests: Communities at Risk from Wildfires," U.S. Endowment for Forestry and Communities, 2018. https://www.arcgis.com/apps/MapJournal/index.html?appid=82c9a07d6a7147a98b4efbe68428defb#:~:text=In%202010%2C%20WUI%20areas%20had,of%20wildfire%20than%20other%20regions.

29. Dennis Wagner and Pamela Ren Larson, "Where Will the West's Next Deadly Wildfire Strike? The Risks Are Everywhere." *AZ Central*, July 28, 2019. https://www.azcentral.com/in-depth/news/local/arizona-wildfires/2019/07/22/wildfire-risks-more-than-500-spots-have-greater-hazard-than-paradise/1434502001/.

30. Eric Varian, "While California Fires Rage, the Rich Hire Private Firefighters," N*ew York Times*, October 26, 2019. https://www.nytimes.com/2019/10/26/style/private-firefighters-california.html.

31. Ian P. Davies et al., "The Unequal Vulnerability of Communities of Color to Wildfire," *PLOS ONE* (November 2, 2018). https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0205825.

32. Dennis Wagner and Pamela Ren Larson, "Where Will the West's Next Deadly Wildfire Strike? The Risks Are Everywhere." *AZ Central*, July 28, 2019. https://www.azcentral.com/in-depth/news/local/arizona-wildfires/2019/07/22/wildfire-risks-more-than-500-spots-have-greater-hazard-than-paradise/1434502001/.

33. Gavin Horn, telephone interview by Elizabeth Foster, May 1, 2020.

34. Jamie Lowe, "The Incarcerated Women Who Fight California's Wildfires," *New York Times*, August 31, 2017. https://www.nytimes.com/2017/08/31/magazine/the-incarcerated-women-who-fight-californias-wildfires.html.

35. WBUR–FM, "Prisoner Workers Like California's Inmate Firefighters are 'Uniquely Vulnerable,' ACLU Lawyer Says," August 15, 2018. https://www.wbur.org/hereandnow/2018/08/14/california-inmate-firefighters-wildfire.

36. David Fathi, "Prisoners Are Getting Paid $1.45 a Day to Fight the California Wildfires," ACLU, November 15, 2018. https://www.aclu.org/blog/prisoners-rights/prisoners-are-getting-paid-145-day-fight-california-wildfires.

37. Nicole Goodkind, "Prisoners Fighting California's Wildfires on the Front Lines, But Getting Little in Return," *Fortune*, September 1, 2019. https://fortune.com/2019/11/01/california-prisoners-fighting-wildfires/.

38. David Fathi, "Prisoners Are Getting Paid $1.45 a Day to Fight the California Wildfires," ACLU, November 15, 2018. https://www.aclu.org/blog/prisoners-rights/prisoners-are-getting-paid-145-day-fight-california-wildfires.

39. Energy Realpolitik, "Is the United States Prepared for Wildfires?" Council on Foreign Relations, blog post from Energy Realpolitik, September 11, 2019. https://www.cfr.org/blog/united-states-prepared-wildfires.

40. Carolyn Kousky, Katherine Greig, Brett Lingle, and Howard Kunreuther, "Wildfire Costs in California: The Role of Electric Utilities," University of Pennsylvania Risk Management and Decision Processes Center, August 2018.

41. Adam Rogers, "After the Napa Fires, a Disaster-in-Waiting: Toxic Ash," *Wired*, October 29, 2017. https://www.wired.com/story/napa-fire-ash/?mbid=BottomRelatedStories.

42. Molly Mowery et al., *Planning in the Wildland Urban Interface*, American Planning Association, April 2019.

43. Adam Rogers, "Please Stop Building Houses Exactly Where Wildfires Start," *Wired*, March 3, 2018. https://www.wired.com/story/please-stop-building-houses-exactly-where-wildfires-start/.

44. Molly Mowery et al., *Planning in the Wildland Urban Interface*, American Planning Association, April 2019.

45. Volker C. Radeloff et al., "Housing Growth In and Near United States Protected Areas Limits Their Conservation Value," *PNAS* 107(2): 940–45 (January 12, 2010). https://www.pnas.org/content/107/2/940.

46. USDA, "The Impact of Wildfire Risk on Housing Prices," Rocky Mountain Research Station, U.S. Forest Service, USDA, September 12, 2020. https://www.fs.fed.us/rm/value/The%20Impact%20of%20Wildfire%20Risk%20on%20Housing%20Prices.html.

47. U.S. Global Change Research Program, "Chapter 6: Forests," in *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, Volume II, 2018. https://nca2018.globalchange.gov/chapter/6/.

48. Robert Bailey and Jaclyn Yeo, *The Burning Issue: Managing Wildfire Risk*, Marsh & McLennan Companies, 2019.

49. U.S. Global Change Research Program, "Southeast and the Caribbean: Increasing Temperatures." In *National Climate Assessment*, 2014. https://nca2014.globalchange.gov/report/regions/southeast#narrative-page-16981.

50. NOAA, "The Impact of Wildfires on Climate and Air Quality." https://www.esrl.noaa.gov/csl/factsheets/csdWildfiresFIREX.pdf.

51. U.S. Global Change Research Program, "Chapter 6: Forests," in *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, Volume II, 2018. https://nca2018.globalchange.gov/chapter/6/.

52. Bob Berwyn, "How Wildfires Can Affect Climate Change (And Vice Versa)," InsideClimate News, August 23, 2018. https://insideclimatenews.org/news/23082018/extreme-wildfires-climate-change-global-warming-air-pollution-fire-management-black-carbon-co2.

53. U.S. Global Change Research Program, "Chapter 6: Forests," in *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, Volume II, 2018. https://nca2018.globalchange.gov/chapter/6/.

54. Bob Berwyn, "How Wildfires Can Affect Climate Change (And Vice Versa)," InsideClimate News, August 23, 2018. https://insideclimatenews.org/news/23082018/extreme-wildfires-climate-change-global-warming-air-pollution-fire-management-black-carbon-co2.

55. David Bowman et al., "Human Exposure and Sensitivity to Global Extreme Wildfire Events," *Nature Ecology & Evolution* 1, 0058 (February 6, 2017). https://www.nature.com/articles/s41559-016-0058.

56. John T. Abatzoglou and Park Williams, "Impact of Anthropogenic Climate Change on Wildfire Across Western US Forests," *PNAS* 113(42) (October 18, 2016). https://www.pnas.org/content/113/42/11770.

57. Andrew Hay, "Deadly 'Megafires' the New Normal in California," Reuters, November 13, 2018. https://www.reuters.com/article/us-california-wildfires-megafires/deadly-megafires-the-new-normal-in-california-idUSKCN1NI2OG.

58. Christopher Joyce and Ashely Westerman, "Megafires More Frequent Because of Climate Change and Forest Management," NPR, November 12, 2018. https://www.npr.org/2018/11/12/666951838/megafires-more-frequent-because-of-climate-change-and-forest-management.

59. Deb Schweizer, "Wildfires in All Seasons?" USDA Forest Service (blog), June 27, 2019. https://www.usda.gov/media/blog/2019/06/27/wildfires-all-seasons#:~:text=What%20was%20once%20a%20four,becoming%20part%20of%20the%20norm.

60. Interview with Shan Cammack, May 21, 2020.

61. Robert Bailey and Jaclyn Yeo, *The Burning Issue: Managing Wildfire Risk*, Marsh & McLennan Companies, 2019.

62. Forest History Society, "U.S. Forest Service Fire Suppression." https://foresthistory.org/research-explore/us-forest-service-history/policy-and-law/fire-u-s-forest-service/u-s-forest-service-fire-suppression/.

Community and Industry Impacts

1. Robert Bailey and Jaclyn Yeo, *The Burning Issue: Managing Wildfire Risk*, Marsh & McLennan Companies, 2019; and Genevieve Belleville, Marie-Christine Ouellet, and Charles M. Morin, "Post-Traumatic Stress Among Evacuees from the 2016 Fort McMurray Wildfires: Exploration of Psychological and Sleep Symptoms Three Months After the Evacuation," *International Journal of Environmental Research and Public Health* 16(9): 1604 (May 2019). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6540600/#:~:text=The%20interview%20confirmed%20that%2029.1,with%20PTSD%20after%20a%20disaster.
2. Jennifer Brown and Jason Blevins, "Wildfires in Colorado Cost $130 Million in 2018," *Colorado Sun*, November 1, 2018. https://coloradosun.com/2018/11/01/wildfire-costs-colorado-2018/.
3. Maria Ganga, "Kincade Fire Creates 200,000 Evacuees," *Los Angeles Times*, October 29, 2019. https://www.latimes.com/california/story/2019-10-29/la-me-kincade-fire-evacuation-san-francisco.
4. Zurich Insurance, *California Fires: Building Resilience from the Ashes*, December 2019. https://www.zurichna.com/-/media/project/zwp/zna/docs/kh/wildfire/california-wildfire-report.pdf?la=en&hash=AB77A5B3CFC40E2C50ADB7F7.
5. Emilie Mazzacurati, "Economic Impacts of Bushfires: What California's Wildfires May Foreshadow in Australia," FourTwentySeven, January 29, 2020. http://427mt.com/2020/01/29/economic-impacts-of-bushfires-what-californias-wildfires-may-foreshadow-in-australia/.
6. Jayme Deerwester, "Los Angeles Hotels Offer Free and Discounted Rooms to Wildfire Evacuees," FirstCoast News, November 14, 2018. https://www.firstcoastnews.com/article/news/nation-now/los-angeles-hotels-offer-free-and-discounted-rooms-to-wildfire-evacuees/465-a1f58cf7-6671-46e3-ba7a-6ca9dac2b547.
7. Elizabeth Wolfe and Saeed Ahmed, "Airbnb Hosts Are Offering Free Housing to Thousands of California Wildfire Evacuees," CNN, October 29, 2019. https://www.cnn.com/2019/10/29/us/california-wildfire-airbnb-free-housing-trnd/index.html.
8. Alicia Rubin, "American Red Cross Announces Plan to Utilize Hotel Rooms for Wildfire Evacuees Amid COVID-19," KDRV.com, NewsWatch 12, July 10, 2020. https://www.kdrv.com/content/news/American-Red-Cross-announces-plan-to-utilize-hotel-rooms-for-wildfire-evacuees-amid-COVID-19-571712171.html.
9. Mary Callahan, "Homeless Population Declines 2% in Sonoma County, Despite Sharp Jump in Homeless Youth," *Press Democrat*, June 28, 2019. https://www.pressdemocrat.com/article/news/homeless-population-declines-2-in-sonoma-county-despite-sharp-jump-in-hom/?sba=AAS.
10. Michael Finch II, "Housing Affordability Drops Steeply in Butte County After Camp Fire," *Sacramento Bee*, April 2, 2019. https://www.sacbee.com/news/california/fires/article225559885.html.
11. Sarah Parvini, "As California Wildfires Displace Low-Income Residents in Wine Country, Tech Industry Continues to Bolster Bay Area Wealth," *Los Angeles Times*, December 5, 2018. https://www.latimes.com/local/lanow/la-me-ln-california-income-poverty-census-20181205-story.html
12. Parvini, "As California Wildfires Displace Low-Income Residents in Wine Country, Tech Industry Continues to Bolster Bay Area Wealth."
13. Interview with Robert Ogilvie, September 1, 2020.
14. Sophie Yeo, "Why Some Home Prices Rebound Quickly After a Forest Fire," Pacific Standard, October 18, 2018. https://psmag.com/environment/why-some-home-prices-rebound-quickly-after-a-forest-fire; Paige Blankenbuehler, "Wildfires Don't Hurt Real Estate Markets," *High Country News*, October 4, 2018. https://www.hcn.org/articles/wildfire-wildfires-dont-hurt-hot-real-estate-markets.
15. Julia Falcon, "How Malibu's Real Estate Market Has Changed After Last Year's Wildfires," *Housing Wire*, July 22, 2019. https://www.housingwire.com/articles/49600-how-malibus-real-estate-market-has-changed-after-last-years-wildfires/.
16. Mark Katkov, "Fast-Moving Wildfire Destroys 80% of Small Town in Eastern Washington State," NPR, September 8, 2020. https://www.npr.org/2020/09/08/910578980/fast-moving-wildfire-destroys-80-of-small-town-in-eastern-washington-state.
17. Matthew Foley, "The High Cost of Wildfire in 2018," *National Fire Protection Association Journal*, November–December 2019. https://www.nfpa.org/News-and-Research/Publications-and-media/NFPA-Journal/2019/November-December-2019/Features/Large-Loss/Wildfire-Sidebar.
18. Ray Rasker, *The Wildland-Urban Interface: The Problem, Trends, & Solutions*, Headwaters Economics, August 31, 2018. https://headwaterseconomics.org/wp-content/uploads/wildfire_homes_solutions_presentation.pdf.
19. Julie Falcon, "How Malibu's Real Estate Market Has Changed After Last Year's Wildfires," *Housing Wire*, July 22, 2019. https://www.housingwire.com/articles/49600-how-malibus-real-estate-market-has-changed-after-last-years-wildfires/.
20. Frank Nothaft, "Wildfires and Housing Markets," CoreLogic Economic Outlook, CoreLogic Insights (blog), July 2019. https://www.corelogic.com/blog/2019/07/wildfires-and-housing-markets.aspx.
21. Sophie Quinton, "As Wildfire Risk Increases in Colorado and the West, Home Insurance Grows Harder to Find," *Denver Post*, November 28, 2018. https://www.denverpost.com/2019/01/02/wildfire-risk-homeowners-insurance/.
22. Robert Bailey and Jaclyn Yeo, *The Burning Issue: Managing Wildfire Risk*, Marsh & McLennan Companies, 2019.
23. Christopher Flavelle, "As Wildfires Get Worse, Insurers Pull Back from Riskiest Areas," *New York Times*, August 20, 2019. https://www.nytimes.com/2019/08/20/climate/fire-insurance-renewal.html.
24. Ben Miller, "Home Insurance Rates Surge in Colorado," *Biz Journals*, March 29, 2018. https://www.bizjournals.com/denver/news/2018/03/29/home-insurance-rates-surge-in-colorado-why.html.
25. Gireesh Shrimali, "In California, More Than 340,000 Lose Wildfire Insurance," *High Country News*, October 22, 2019. https://www.hcn.org/articles/wildfire-in-california-more-than-340000-lose-wildfire-insurance.
26. Shrimali, "In California, More Than 340,000 Lose Wildfire Insurance."
27. Robert Bailey and Jaclyn Yeo, *The Burning Issue: Managing Wildfire Risk*, Marsh & McLennan Companies, 2019.
28. Bailey and Yeo, *The Burning Issue: Managing Wildfire Risk*.
29. Sophie Quinton, "As Wildfire Risk Increases in Colorado and the West, Home Insurance Grows Harder to Find," *Denver Post*, November 28, 2018. https://www.denverpost.com/2019/01/02/wildfire-risk-homeowners-insurance/.
30. Zurich Insurance, *California Fires: Building Resilience from the Ashes*, December 2019. https://www.zurichna.com/-/media/project/zwp/zna/docs/kh/wildfire/california-wildfire-report.pdf?la=en&hash=AB77A5B3CFC40E2C50ADB7F728728001&hash=AB77A5B3CFC40E2C50ADB7F728728001.
31. Marisa Kendall, "From Disaster to Building Boom? Why Developers Are Eyeing Santa Rosa," *Mercury News*, April 9, 2019. https://www.mercurynews.com/2019/04/09/from-disaster-to-building-boom-why-developers-are-eyeing-santa-rosa/.
32. John M. Diaz, "Economic Impacts of Wildfire," Southern Fire Exchange Fact Sheet 2012-7. https://fireadaptednetwork.org/wp-content/uploads/2014/03/economic_costs_of_wildfires.pdf.
33. Douglas Thomas et al., *The Costs and Losses of Wildfires*, National Institute of Standards and Technology Special Publication 1215, November 2017. https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1215.pdf.

34. Theresa Cottom, "California Completes Year-Long Camp Fire Cleanup Effort," *Waste Today*, November 10, 2019. https://www.wastetodaymagazine.com/article/california-completes-year-long-camp-fire-debris-cleanup-effort/.

35. John M. Diaz, "Economic Impacts of Wildfire." Southern Fire Exchange Fact Sheet 2012-7. https://fireadaptednetwork.org/wp-content/uploads/2014/03/economic_costs_of_wildfires.pdf.

36. Diaz, "Economic Impacts of Wildfire."

37. Robert Bailey and Jaclyn Yeo, *The Burning Issue: Managing Wildfire Risk*, Marsh & McLennan Companies, 2019.

38. Herman K. Trabish, "De-energize and DERs: The Tough Options Wildfire Pose for California Utilities," Utility Dive, February 20, 2019. https://www.utilitydive.com/news/the-hard-choice-californias-wildfires-have-forced-on-its-utilities-and-a/548614/.

39. Emilie Mazzacurati, "Economic Impacts of Bushfires: What California's Wildfires May Foreshadow in Australia," FourTwentySeven, January 29, 2020. http://427mt.com/2020/01/29/economic-impacts-of-bushfires-what-californias-wildfires-may-foreshadow-in-australia/.

40. Amber Todoroff, "Last Energy and Natural Resource Committee Hearing of 2019 Explores Grid Resilience to Wildfire," Environmental Energy Study Institute, January 7, 2020. https://www.eesi.org/articles/view/last-energy-and-natural-resource-committee-hearing-of-2019-explores-grid-resilience-to-wildfire.

41. Herman K. Trabish, "De-energize and DERs: The Tough Options Wildfire Pose for California Utilities," Utility Dive, February 20, 2019. https://www.utilitydive.com/news/the-hard-choice-californias-wildfires-have-forced-on-its-utilities-and-a/548614/.

42. Lisa Pickoff-White, "PG&E Power Safety Shutoffs Could Continue for 10 Years, Says CEO," KQED, October 18, 2019. https://www.kqed.org/news/11781060/pge-power-safety-shutoffs-could-continue-for-10-years-says-ceo#:~:text=PG%26E%20Power%20Safety%20Shutoffs%20Could%20Continue%20for%2010%20Years%2C%20Says%20CEO,-Lisa%20Pickoff%2DWhite&text=PG%26E%20CEO%20and%20President%20Bill,wildfires%20during%20dry%2C%20windy%20conditions.

43. American Society of Civil Engineers, "2017 Infrastructure Report Card: Energy." https://www.infrastructurereportcard.org/cat-item/energy/#:~:text=Much%20of%20the%20U.S.%20energy,turn%20of%20the%2021st%20century.&text=Without%20greater%20attention%20to%20aging,and%20more%20frequent%20power%20interruptions.

44. Robert Bailey and Jaclyn Yeo, *The Burning Issue: Managing Wildfire Risk*, Marsh & McLennan Companies, 2019.

45. U.S. Energy Information Administration, "How Much Energy Is Consumed in U.S. Buildings?" June 15, 2020. https://www.eia.gov/tools/faqs/faq.php?id=86&t=1.

Structure Survival: Best Practices at the Site Scale

1. Alexandra Syphard, "Housing Patterns, Wildfire, and Community Vulnerability: Historical Perspectives and Future Possibilities," presentation at Living with Fire Symposium at Pepperwood Preserve, May 2018.

2. FEMA, "Selecting the Construction Site," Technical Fact Sheet No. 3, September 2008. https://www.fema.gov/media-library-data/20130726-1651-20490-7160/fema_p_737_fs_3.pdf.

3. FEMA, "Selecting the Construction Site."

4. Matthew Power, "How to Build Fire-Proof Homes," Builder Online, April 19, 2003. https://www.builderonline.com/building/safety-healthfulness/how-to-build-fire-proof-homes_o.

5. Sophie Quinton, "As Wildfire Risk Increases in Colorado and the West, Home Insurance Grows Harder to Find," *Denver Post*, November 28, 2018. https://www.denverpost.com/2019/01/02/wildfire-risk-homeowners-insurance/.

6. Alexandra Syphard and Jon Keeley, "Factors Associated with Structure Loss in the 2013–2018 California Wildfires," *Fire* 2(3): 2–19 (September 2019). https://www.mdpi.com/2571-6255/2/3/49/htm.

7. Matthew Power, "How to Build Fire-Proof Homes," Builder Online, April 29, 2003. https://www.builderonline.com/building/safety-healthfulness/how-to-build-fire-proof-homes_o.

8. Lucy Rodgers, "Climate Change: The Massive CO2 Emitter You May Not Know About," *BBC News*, December 17, 2018. https://www.bbc.com/news/science-environment-46455844.

9. Zurich Insurance, *California Fires: Building Resilience from the Ashes*, December 2019. https://www.zurichna.com/about/news/news-releases/2020/california-wildfire-report-offers-insights-to-build-resilience.

10. National Institute of Building Sciences, "Mitigation Saves: At the WUI, Complying with the 2015 IWUIC Provides $4 Benefit for Each $1 Invested," 2019. https://cdn.ymaws.com/www.nibs.org/resource/resmgr/reports/mitigation_saves_2019/ms_v3_exceeds_iwuic.pdf.

11. FIRESafe Marin, Fire-Hazardous Plants. https://firesafemarin.org/plants/fire-hazardous/advanced-search/55.

12. CALFIRE, "Prepare for Wildfire: Fire-Resistant Landscaping," 2019. https://www.readyforwildfire.org/prepare-for-wildfire/get-ready/fire-resistant-landscaping/.

13. Patty Glick et al., *The Protective Value of Nature: A Review of the Effectiveness of Natural Infrastructure for Hazard Risk Reduction* (Washington, D.C.: National Wildlife Federation, 2020).

14. Kristiane Huber, "Resilience Strategies for Wildfire," Center for Climate and Energy Solutions, November 2018. https://doi.org/10.1371/journal.pone.0033954.

15. Stephen R. Miller et al., *Wildfire Risk Planning Guide for Idaho Communities*, pre-publication final draft shared with ULI, January 2020.

16. Michele Steinberg, "Major Insurer Adds Wildfire Safety Incentive for Members in Idaho, Montana, Washington, and Wyoming," NFPA Xchange (blog), July 27, 2020. https://community.nfpa.org/community/fire-break/blog/2020/07/27/major-insurer-adds-wildfire-safety-incentive-for-members-in-idaho-montana-washington-and-wyoming.

17. H. Anu Kramer et al., "Where Wildfires Destroy Buildings in the US Relative to the Wildland-Urban Interface and National Fire Outreach Programs," *International Journal of Wildland Fire* 27(5): 329–41 (2018). https://www.fs.usda.gov/treesearch/pubs/56376.

18. Kristiane Huber, "Resilience Strategies for Wildfire," Center for Climate and Energy Solutions, November 2018.

Protecting the Community: District-Scale Solutions

1. Phone interview, Austin Fire Department, June 4, 2020.

2. Lauren Sommer, "These Big Plans to Protect California Homes from Wildfire Fell Short in the Legislature," KQED, September 26, 2019. https://www.kqed.org/science/1948013/california-lawmakers-plans-to-protect-homes-from-wildfire-fall-short.

3. NFPA, "Community Wildfire Safety Through Regulation: A Best Practices Guide," 2013. https://www.nfpa.org/-/media/Files/Public-Education/By-topic/Wildland/WildfireBestPracticesGuide.ashx.

4. Office of Sustainable Communities, "Smart Growth Fixes for Climate Adaptation and Resilience," U.S. Environmental Protection Agency, January 2017.

5. Kristiane Huber, "Resilience Strategies for Wildfire," Center for Climate and Energy Solutions, November 2018.

6. Office of Sustainable Communities, "Smart Growth Fixes for Climate Adaptation and Resilience," U.S. Environmental Protection Agency, January 2017.

7. Ross Gorte, "The Rising Cost of Wildfire Protection," Headwaters Economics Research Paper, June 2013. https://headwaterseconomics.org/wp-content/uploads/fire-costs-background-report.pdf.
8. Headwaters Economics, *Full Community Costs of Wildfires*, May 2018.
9. Western Forestry Leadership Coalition, *The True Cost of Wildfire in the Western U.S.*, April 2009. https://www.blm.gov/or/districts/roseburg/plans/collab_forestry/files/TrueCostOfWilfire.pdf.
10. ReadySanDiego, Wildfire Hazard Map, San Diego County Office of Emergency Services. https://www.readysandiego.org/wildfire-hazard-map/.
11. Stephen R. Miller et al., *Wildfire Planning Guide for Idaho Communities*, pre-publication final draft shared with ULI, January 2020.
12. Dennis Wagner and Pamela Ren Larson, "Where Will the West's Next Deadly Wildfire Strike? The Risks Are Everywhere," *AZ Central*, July 28, 2019. https://www.azcentral.com/in-depth/news/local/arizona-wildfires/2019/07/22/wildfire-risks-more-than-500-spots-have-greater-hazard-than-paradise/1434502001/.
13. City of Palm Coast, "Chapter 6: Conservation and Coastal Management Element," City of Palm Coast 2035 Comprehensive Plan. http://docs.palmcoastgov.com/residents/comprehensive-plan/chapter%206%20coastal%20and%20conservation%20management%20element%202035%20gops.pdf.
14. Alexandra D. Syphard et al., "Housing Arrangement and Location Determine the Likelihood of Housing Loss Due to Wildfire," *PLOS ONE* 7(3) (March 28, 2012). https://doi.org/10.1371/journal.pone.0033954.
15. Alissa Walker, "Why Pepperdine Stays Put When Wildfires Rage," Curbed Los Angeles, November 20, 2018. https://la.curbed.com/2018/11/20/18097889/wildfire-pepperdine-malibu-shelter-in-place.
16. Sophie Quinton, "As Wildfire Risk Increases in Colorado and the West, Home Insurance Grows Harder to Find," *Denver Post*, January 2, 2019. https://www.denverpost.com/2019/01/02/wildfire-risk-homeowners-insurance/.
17. National Wildlife Federation, "Increased Risk of Catastrophic Wildfires: Global Warming's Wake-Up Call for the Western United States," 2008. https://www.nwf.org/~/media/PDFs/Global-Warming/NWF_WildFiresFinal.ashx.
18. SRP, "Snowflake White Mountain Biomass Power Plant," 2020. https://www.srpnet.com/about/stations/snowflakebiomass.aspx.
19. Missoula County Office of Emergency Management, "2017 Update to Pre-Disaster Mitigation Plan," March 2017. https://www.missoulacounty.us/home/showdocument?id=25947.
20. City of Flagstaff, "How This Plan Works: Introduction," Flagstaff Regional Plan, January 5, 2017. https://www.flagstaff.az.gov/DocumentCenter/View/48412/III-How-This-Plan-Works?bidId=.
21. Flagstaff Fire Department, "Flagstaff Wildland Urban Interface Code," Presentation. https://www.flagstaff.az.gov/DocumentCenter/View/12947/WUI_Orientation?bidId=.
22. Molly Mowery et al., *Planning in the Wildland Urban Interface*, American Planning Association, April 2019.
23. NFPA, "Community Wildfire Safety Through Regulation: A Best Practices Guide," 2013. https://www.nfpa.org/-/media/Files/Public-Education/By-topic/Wildland/WildfireBestPracticesGuide.ashx.
24. Department of Local Affairs and University of Colorado Denver, "Land Use Tool: Wildland-Urban Interface Code," Planning for Hazards, Land Use Solutions for Colorado. https://www.planningforhazards.com/wildland-urban-interface-code-wui-code#dd-contents-1404.
25. Headwaters Economics, "Flagstaff, Arizona: Leveraging Partnerships and Public Support to Tackle Growing Wildfire Concerns," January 2016. https://headwaterseconomics.org/wp-content/uploads/Planning_Lessons_Flagstaff_Manuscript.pdf.
26. City of Thousand Oaks (California), "Forestry Master Plan," April 2007. https://www.toaks.org/custom/Documents/PublicWorks/FMPReport.pdf.
27. Dennis Wagner and Pamela Ren Larson, "Amid Winding Mountain Roads, A Village Pushes Back Its Encroaching Fire Threat," *AZ Central*, July 22, 2019. https://www.azcentral.com/in-depth/news/local/arizona-wildfires/2019/07/22/wildfire-risk-ruidoso-new-mexico/1388369001/.
28. Timberline Fire Protection District, "Fire Protection Impact Fee Nexus Study," March 4, 2020. https://www.colorado.gov/pacific/sites/default/files/193072-TFPD%20Impact%20Fee%20Study%20Final%20Report_03-04-2020.pdf.
29. Grand Fire Protection District No. 1, "FAQs about Fire Impact Fees," April 8, 2019. https://grandfire.org/permit-apps-fees/impact-fees.
30. Public Media Group of Southern California, "Tending the Wild: Cultural Burning," video via KCET, 2020. https://www.kcet.org/shows/tending-the-wild/episodes/cultural-burning.
31. Lauren Sommer, "To Manage Wildfire, California Looks to What Tribes Have Known All Along," NPR, August 24, 2020. https://www.npr.org/2020/08/24/899422710/to-manage-wildfire-california-looks-to-what-tribes-have-known-all-along.
32. Patty Glick et al., *The Protective Value of Nature: A Review of the Effectiveness of Natural Infrastructure for Hazard Risk Reduction* (Washington, D.C.: National Wildlife Federation, 2020).
33. Disha Raychaudhuri, Michael Sol Warren, and Maya Miller, "The Threat of a Destructive Wildfire in South Jersey Is Growing," NJ.com, June 4, 2019. https://www.nj.com/news/2019/06/the-threat-of-a-destructive-wildfire-in-south-jersey-is-growing-is-enough-being-done-to-prepare.html.
34. Raychaudhuri, Warren, and Miller, "The Threat of a Destructive Wildfire in South Jersey Is Growing."
35. Advisory Services panel briefing on wildfire, economic, and energy resilience in Sonoma County. Prepared for ULI by RCPA, March 2020.
36. Office of Recovery and Resiliency, "Sonoma County Recovery & Resiliency Framework," County of Sonoma, 2018.
37. County of San Diego, *Resilience Review Report 1-19: Wildland Fires* 2019. https://www.readysandiego.org/content/dam/sdc/oes/emergency_management/plans/Resilience-Review-Reports/SDC_RESILIENCE%20REVIEW%20REPORT_WILDLAND%20FIRES_FINAL_20190909.pdf.
38. Dr. Anthony Leiserowitz, "After deadly flames receded, a nonprofit helped Sonoma Valley recover," *Yale Climate Connections* (Podcast), May 26, 2020. https://yaleclimateconnections.org/2020/05/after-deadly-flames-receded-a-nonprofit-helped-sonoma-county-recover/.
39. La Luz Center, "About Us," 2019. https://www.laluzcenter.org/copy-of-about-us-10.
40. Blue Forest Conservation and Encourage Capital, *Forest Resilience Bond: Fighting Fire with Finance*, September 2017. https://static1.squarespace.com/static/556a1885e4b0bdc6f0794659/t/59c1157f80bd5e1cd855010e/1505826201656/FRB+2017+Roadmap+Report.pdf.
41. Texas A&M Forest Service, "2011 Texas Wildfires: Common Denominators of Home Destruction." https://tfsweb.tamu.edu/uploadedFiles/TFSMain/Preparing_for_Wildfires/Prepare_Your_Home_for_Wildfires/Contact_Us/2011%20Texas%20Wildfires.pdf.
42. Ellis Robinson, "How Much Does Air Pollution Cost the U.S.?" Stanford Earth, September 19, 2019. https://earth.stanford.edu/news/how-much-does-air-pollution-cost-us#gs.hpgzma.
43. Neal Fann et al., "The Health Impacts and Economic Value of Wildland Fire Episodes in the U.S.: 2008–2012," *Science of the Total Environment* 610–611: 802–09 (2018).
44. CDC, "Make It Your Business to Fight the Flu: A Toolkit for Businesses and Employers." https://www.cdc.gov/flu/pdf/business/Toolkit_Seasonal_Flu_For_Businesses_and_Employers.pdf.
45. California Department of Food and Agriculture, "California Agricultural Production Statistics," 2019. http://www.cdfa.ca.gov/statistics/.

46. NPR, "California Fires Result in Job and Income Loss for Seasonal Workers," October 29, 2017. https://www.npr.org/2017/10/19/558847348/california-fires-result-in-job-and-income-loss-for-seasonal-workers.

47. Ross Gorte, "The Rising Cost of Wildfire Protection," Headwaters Economics Research Paper, June 2013. https://headwaterseconomics.org/wp-content/uploads/fire-costs-background-report.pdf.

48. Stephen R. Miller et al., *Wildfire Planning Guide for Idaho Communities*, pre-publication final draft shared with ULI, January 2020.

49. Adam Rogers, "The West Is on Fire. Blame the Housing Crisis," *Wired*, July 17, 2017. https://www.wired.com/story/wildfire-housing-crisis/.

50. Monica Anderson, "Who Relies on Public Transit in the U.S.," Pew Research Center, April 7, 2016. https://www.pewresearch.org/fact-tank/2016/04/07/who-relies-on-public-transit-in-the-u-s/.

51. National Institute of Building Sciences and Multihazard Mitigation Council, *Natural Hazard Mitigation Saves: 2019 Report*, December 2019. https://cdn.ymaws.com/www.nibs.org/resource/resmgr/reports/mitigation_saves_2019/mitigationsaves2019report.pdf.

52. National Institute of Building Sciences, "Mitigation Saves: Retrofitting Buildings in the WUI Saves $2 for Each $1 Invested," 2019. https://cdn.ymaws.com/www.nibs.org/resource/resmgr/reports/mitigation_saves_2019/ms_v3_retrofit_wui.pdf.

53. David T. Butry and Jeffrey P. Prestemon, "Economics of WUI/Wildfire Prevention and Education," in *Encyclopedia of Wildfires and Wildland-Urban Interface (WUI) Fires*, ed. Samuel Manzello, 2019. https://www.srs.fs.usda.gov/pubs/ja/2019/ja_prestemon02.pdf.

54. Butry and Prestemon, "Economics of WUI/Wildfire Prevention and Education."

55. Christopher Ingraham, "American Land Barons: 100 Wealthy Families Own Nearly as Much Land as That of New England," *Washington Post*, December 21, 2017. https://www.washingtonpost.com/news/wonk/wp/2017/12/21/american-land-barons-100-wealthy-families-now-own-nearly-as-much-land-as-that-of-new-england/.

56. Headwaters Economics, "Public Land Ownership in the United States," June 2019. https://headwaterseconomics.org/public-lands/protected-lands/public-land-ownership-in-the-us/.

57. U.S. Forest Service, "Legacy of Severe Wildfires on Stream Water Quality," U.S. Forest Service, USDA, October 12, 2018. https://www.fs.usda.gov/inside-fs/delivering-mission/sustain/legacy-severe-wildfires-stream-water-quality.

58. Pam Radtke Russell, "California Towns Rebuild After Wildfires with Resilience in Mind," ENR California, April 10, 2019. https://www.enr.com/articles/46681-california-towns-rebuild-after-wildfires-with-resilience-in-mind.

59. Russell, "California Towns Rebuild After Wildfires with Resilience in Mind."

60. Phone interview with Christina Burri, September 21, 2020.

61. Denver Water and U.S. Forest Service, "Proactive Fuel Breaks Protect Nearly $1 Billion in Homes, Infrastructure During Summit County Wildfire," press release, June 26, 2018. https://www.fs.usda.gov/inside-fs/proactive-fuel-breaks-protect-nearly-1b-homes-infrastructure-during-wildfire.

BIGGER, HOTTER, AND MORE FREQUENT WILDFIRES are causing increasing amounts of community trauma, infrastructure destruction, and economic hardship across the United States. This report explores how the real estate industry is responding to wildfire risks with building design, land use policy, and community resilience solutions.

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