



California fires: Building resilience from the ashes

December 2019



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Cover photo:
Yosemite National Park, California
Autumn 2018

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Foreword



Many in California have made an uneasy peace with wildfire risk. The increasingly disastrous wildfires there and elsewhere suggest more unease is needed. Unease often motivates people to act — and action on wildfire resilience is in everyone's interest.

Two of the four wildfires studied in this report, the Camp Fire in 2018 and the Tubbs Fire in 2017, were the most destructive wildfires in California's recorded history. The risks and impacts of California's wildfires go beyond that state, which has one of the most productive economies in the world. And California isn't alone in suffering devastating wildfires that have cost lives.

In recent years, wildfires in the West, hurricanes in the East and other severe weather events have more than doubled the annual number of billion-dollar disasters in the U.S.* Many of the same factors are exacerbating the impacts of wildfires and hurricanes: rising temperatures, changes in precipitation patterns and expanded development among them.

That is one reason this new study on the 2017 and 2018 wildfires in California leveraged the award-winning Post-Event Review Capability (PERC) methodology. The Zurich Flood Resilience Alliance developed the PERC framework in 2013 to uncover and share lessons in resilience from hurricanes and other flood events. The open-source methodology, involving rigorous research and analysis, has been used to produce 14 post-event reviews of flood disasters around the globe thus far. In 2019, the PERC framework is being applied for the first time to wildfires; three reviews are being published on wildfire disasters in Alberta (Canada), California and Tasmania (Australia).

For the California wildfire review, Zurich collaborated with the nonprofit Institute for Social and Environmental Transition (ISET-International), which played an integral role in developing the PERC methodology, and with DuPont as part of its sustainability commitments. I'd like to thank our partners in this California study for their invaluable expertise and commitment.

Conversations with people who experienced the disasters are essential to our post-event reviews, and we are grateful to the Californians who met with us to share their stories, many of them unforgettable. We also thank the many local and state officials, community members, researchers and nonprofit leaders who contributed their time and insights to this report.

As chief claims officer for Zurich North America, I believe these post-event reviews can help people shift their mindsets from post-disaster relief to pre-event resilience. A feature in the California report highlights individuals who, as a part of an organization or team, are helping to lead that shift within their areas of influence. These five Resilience Trailblazers include **Brian D'Agostino**, director of fire science and climate adaptation at San Diego Gas & Electric; **Maeve Juarez**, a wildland fire specialist for the Montecito Fire District; **Phil Phillips**, senior vice president for administration and chief administrative officer at Pepperdine University in Malibu; **Timothy Sharkey**, operations manager for the entrepreneurial/tech hub Chicostart in Chico; and **Kathleen Walk**, general manager of the Hampton Inn & Suites in Agoura Hills.

Their roles differ, but they all recognize how individual actions can help reduce the broader impacts of wildfires. We dedicate this review to all the people who contributed to California's resilience in the 2017 and 2018 wildfires and who continue to work toward wildfire resilience today.

All the best,



Paul Lavelle
Chief Claims Officer
Zurich North America

* Dennis, B., and Mooney, C. "Wildfires, hurricanes and other extreme weather cost the nation 247 lives, nearly \$100 billion in damage during 2018." Washington Post. 6 February 2019. <https://www.washingtonpost.com/climate-environment/2019/02/06/wildfires-hurricanes-other-extreme-weather-cost-nation-lives-nearly-billion-damage-during/>

Executive summary

“Those who study wildfire have long argued that we need to reshuffle our relationship to it – move from reflexively trying to conquer fire to designing ways for communities to outfox and withstand it.”¹

- Jon Mooallem, The New York Times

For the most part, communities across the U.S. are aware of the natural hazards they face and plan accordingly. Coastal communities plan for floods and hurricanes, while communities along fault lines plan for earthquakes and mountain communities plan for winter blizzards. However, systematic planning for wildfires has lagged far behind. California regularly ranks as the most wildfire-prone state. It has made effective strides in reducing wildfire risk, in part by mapping wildfire hazard zones and requiring that new builds in certain zones adhere to specific fire-resistant standards. Yet, even in California, more needs to be done.

The 2018 California wildfire season, which exceeded the impacts of the already extremely destructive 2017 wildfire season, clearly illustrates that there is room for improvement when it comes to building resilience to wildfires. We can no longer hope to solely fight these fires and stop them in their tracks before they consume homes and lives. Instead, we need to change our behavior and begin to reconsider where and how we live in and close to our fire-prone forests, not just in California, but throughout the U.S. and globally. Indeed, in recent years Australia, Canada, Greece, Russia, Spain, South Africa, Bolivia and the U.S., among other countries, have experienced devastating wildfires. Identifying best practices and opportunities to build wildfire resilience in any one of these locations is of value to all.

In the U.S., both the likelihood of wildfires occurring and the number of homes exposed to wildfires have increased since 1940.² According to Verisk’s 2017 Wildfire Risk Analysis,³ 4.5 million U.S. homes were identified at high or extreme risk of wildfire, with more than 2 million in California alone. This risk was starkly displayed in 2017, when fires destroyed more than 10,800 structures in California,⁴ a higher tally than the previous nine years combined. Yet the 2018 wildfire season surpassed the 2017 season, becoming the deadliest and most destructive wildfire season ever recorded in California. A total of 8,054 fires burned over 1.8 million acres, the largest area of burned acreage recorded in a fire season,⁵ and over 17,800 structures were lost.⁶

This study, the result of collaboration between Zurich North America, DuPont and the nonprofit Institute for Social and Environmental Transition (ISET-International),⁷ looks in detail at four of the most destructive California wildfires of 2017 and 2018. It is

based on interviews with impacted households and businesses; with people involved in risk reduction, response and recovery at the city, county and state levels; and with researchers and the nonprofit sector. The purpose is to identify lessons learned from the fires and provide tangible recommendations for enhancing wildfire resilience.

Our key findings are rooted in the recognition that communities in California, across the western U.S., and globally, are facing a “new normal” of wildfire risk. Increasing temperatures, changes in precipitation timing and amounts, and continued development in wildlands increase the potential for catastrophic wildfires similar to those that ravaged California in 2017 and 2018. While communities increasingly acknowledge this new reality, current mitigation and preparedness actions inadequately address the scope of the risk. Indeed, today’s actions are based on yesterday’s normal rather than on the new intensifying paradigm of wildfire hazards faced by communities across the wildland-urban interface (WUI) today.

How and where we develop are key to living safely with our new normal. Part of the “how” includes increased uptake of mitigation best practices including controlled burns and thinning, increased maintenance of defensible space, expanding California’s fire-resistant building codes to apply far more broadly, and incentivizing “smart growth” in the WUI. Success will require coordination among federal, state and local governments and stakeholders, in concert with private homeowners, recognizing that wildfire safety requires action and shared responsibility across scales.

Building the capacity of communities to face the new normal also calls for going beyond business as usual. Potential fire severity is a challenge to predict and assess. Consequently, we must prepare for worst-case scenarios, in part by reducing our existing risk, avoiding creating risk, and planning not just for immediate response but also for recovery. In doing so, we need to recognize that the true cost of a wildfire goes far beyond its immediate impacts and invest more extensively and willingly in pre-event and preventive action.

What is the Post-Event Review Capability?

The trends are clear: Impacts from natural hazard events are intensifying. These trends inspired the Post-Event Review Capability (PERC), a methodology developed by the Zurich Flood Resilience Alliance. Post-event reviews are a proactive effort to learn from weather-related disasters soon after they happen, through research and dialogue with authorities, affected people and organizations. The studies seek to answer questions related to aspects of hazard resilience, risk management and catastrophe intervention. They look at what has worked well and what has gone wrong during large-scale hazard events, resulting in actionable recommendations for the future. Since 2013, the PERC methodology has been used to analyze flood events across the globe, including in Western Europe, the U.S., Nepal and Peru. In 2019, the award-winning* PERC methodology was extended to study wildfires in the U.S., Canada and Australia. For the library of post-event reports, please visit <https://floodresilience.net/PERC>.

*2019 Business Insurance Innovation Award; 2019 National Hurricane Conference Outstanding Achievement Award

1 Mooallem, J. “We have fire everywhere”: Escaping California’s deadliest blaze.” The New York Times. 31 July 2019. <https://www.nytimes.com/interactive/2019/07/31/magazine/paradise-camp-fire-california.html>

2 Strader, S. M. Nat Hazards (2018) 92: 543. Spatiotemporal changes in conterminous US wildfire exposure from 1940 to 2010. Natural hazards, 92(1), 543-565. https://docs.wixstatic.com/ugd/fc36a1_9415de656b0445b09ba1022078f8a6d5.pdf

3 Samanta, A. “Key findings from the 2017 Verisk wildfire risk analysis.” Verisk. 12 July 2017. https://www.verisk.com/insurance/visualize/key-findings-from-the-2017-verisk-wildfire-risk-analysis/?utm_source=Social&utm_medium=Twitter&utm_campaign=VeriskSM&utm_content=842017

4 Tierney, L. “The grim scope of 2017’s California wildfire season is now clear. The danger’s not over.” The Washington Post. 4 January 2018. <https://www.washingtonpost.com/graphics/2017/national/california-wildfires-comparison/>

5 California Department of Forestry & Fire Protection. <https://www.fire.ca.gov/>; National Interagency Fire Center. <https://www.nifc.gov/>

6 Romero, D. “California had nation’s worst fire season in 2018.” NBC News. 9 March 2019. <https://www.nbcnews.com/news/us-news/california-had-nation-s-worst-fire-season-2018-n981431>

7 ISET-International is a nonprofit organization committed to building resilience and catalyzing adaptation to critical social and environmental challenges. www.i-s-e-t.org

Section I: Physical context

Within 14 months in 2017 and 2018, California experienced four of the most destructive wildfires the U.S. has ever seen: the Tubbs Fire in Santa Rosa in October 2017, the Thomas Fire in Ventura and Santa Barbara counties in December 2017 and, simultaneously in November 2018, the Camp Fire in Northern California and the Woolsey Fire in Southern California.



At the time, 2017 was the most destructive wildfire season on record, with over 9,000 fires burning close to 1.2 million acres of land.⁸ The year brought five of the 20 most destructive wildfires in the state's history, of which the Tubbs and Thomas fires were two of the most devastating. Throughout 2017, fires ravaged more than 10,000 structures in the state and killed at least 46 people.⁹ The 2018 wildfire season surpassed those figures, becoming the deadliest and most destructive wildfire season ever recorded in California, with a total of 8,054 fires burning 17,800 structures and over 1.8 million acres, the largest area of burned acreage recorded in a fire season.¹⁰

Embedded in these numbers are tens of thousands of lives and livelihoods also devastated. The Thomas Fire in 2017 contributed to powerful debris flows in Montecito that killed 23 people, while the Tubbs Fire led to an urban conflagration that destroyed thousands of homes and killed 22 people. The Camp Fire nearly wiped the town of Paradise off the map, killing at least 86 people, burning 95% of homes and businesses, and contributing to housing and infrastructure strain in nearby Chico, where the population increased 20% overnight due to the fire. Farther south, the Woolsey Fire destroyed over 1,600 structures, including a number of high-priced homes, causing damage estimated at USD 4 billion to USD 6 billion.¹¹ Widespread evacuations clogged roadways to Los Angeles and overwhelmed hotels.

This post-event review focuses on these four fires as a learning opportunity. As we explore in this report, the extreme nature of the 2017 and 2018 fire seasons, and of these four fire events in particular, was not just bad luck. All of the key factors contributing to wildfire risk are increasing. These fires highlight what is a new normal for California and for other communities across the western U.S. and serve as a warning that we need to act now to avoid even greater losses in the future. This report also identifies actions already being taken to mitigate or adapt to our changing risk, highlights successes and provides recommendations for future action. By acting on best practices and opportunities for improvement, we can reduce or avoid future loss and damage.

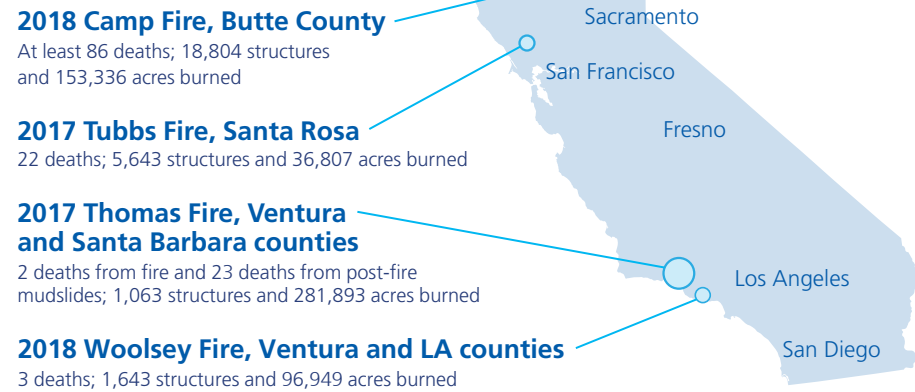
⁸ Tierney, L. "The grim scope of 2017's California wildfire season is now clear. The danger's not over." The Washington Post. 4 January 2018. <https://www.washingtonpost.com/graphics/2017/national/california-wildfires-comparison/>

⁹ Ibid.

¹⁰ Romero, D. "California had nation's worst fire season in 2018." 9 March 2019. <https://www.nbcnews.com/news/us-news/california-had-nation-s-worst-fire-season-2018-n981431>; National Interagency Coordination Center wildland fire summary and statistics annual report 2018. National Interagency Coordination Center. 2018. https://www.predictiveservices.nifc.gov/intelligence/2018_statsumm/annual_report_2018.pdf

¹¹ Lerner, M. "Total losses from Camp, Woolsey fires could reach \$19 billion: Corelogic." Business Insurance. 27 November 2018. [https://www.businessinsurance.com/article/20181127/NEWS06/912325309/Total-losses-from-Camp-Woolsey-fires-in-California-could-reach-\\$19-billion-Corel](https://www.businessinsurance.com/article/20181127/NEWS06/912325309/Total-losses-from-Camp-Woolsey-fires-in-California-could-reach-$19-billion-Corel)

Figure 1. The four most destructive 2017 and 2018 California wildfires



2017 Tubbs Fire – Napa, Sonoma and Lake counties

In October 2017, over a dozen wildfires, collectively dubbed the Northern California firestorm, scorched the northern part of the state. One of the fires, the Tubbs Fire, was ignited by a privately owned electrical system and roared across parts of Napa, Sonoma and Lake counties in Northern California. Moving at speeds later matched by the Camp Fire, the Tubbs Fire at times covered 12 miles in four hours as it traveled from Calistoga to Santa Rosa. Until it was supplanted by the 2018 Camp Fire, the Tubbs Fire in 2017 was California's most destructive fire on record. It ultimately destroyed 5,000 homes, over half of which were in Santa Rosa (population 175,000), and killed 22 people, most of them elderly.

The Tubbs Fire, named for the road near where the fire ignited, began just before 9:45 p.m. on Oct. 8. Fanned by high winds, the fire spread downhill quickly, pushing embers well ahead of the main front of the fire where they ignited numerous spot fires. A few hours after ignition, the fire reached the eastern side of Santa Rosa and eventually jumped Highway 101, leading to a chaotic evacuation in the middle of the night, with first responders going door to door to wake people. As structures caught fire, it quickly turned into an urban firestorm, wiping out entire neighborhoods.

2017 Thomas Fire – Ventura and Santa Barbara counties

Two months after the Tubbs Fire, power lines ignited the Thomas Fire on Dec. 4, 2017. Unlike the Camp, Woolsey and Tubbs fires, the Thomas Fire was the only wildfire occurring in the state when it ignited near Thomas Aquinas College, for which it was named. This allowed for the largest mobilization of firefighting resources ever in the state's history, with 8,700 firefighters deployed. Even so, the fire was pushed by strong Santa Ana winds and fueled by dry conditions. It quickly spread through Ventura and Santa Barbara counties and into parts of the city of Ventura, ultimately destroying 1,063 structures.¹² Over the course of the next month, it would burn over 200,000 acres, making it the largest fire in the history of the state (surpassed several months later by the Mendocino Complex Fire in July 2018).¹³

High winds and low humidity contributed to the fire's speed and expanse. It destroyed over 500 structures in the city of Ventura alone¹⁴ and ultimately burned across every watershed above Montecito and Carpinteria. The burn scar across these watersheds wiped out vegetation and destabilized the slopes above Montecito.

Weeks later, on Jan. 9, 2018, an intense rainstorm dumped over half an inch of water in 15 minutes over the watersheds above Montecito. The result was debris flows, a typical post-fire hazard,¹⁵ but one which was particularly devastating in this instance. Evacuation orders were issued for residents in high elevation areas in the watersheds, but not lower down. It was there, in the low-lying areas, where the toll from the debris flows was the greatest. Ultimately, the debris flows killed 23 people, destroyed over 100 homes¹⁶ and damaged over 300¹⁷ others.

2018 Camp Fire – Butte County

In the early morning hours of Nov. 8, 2018, sparks from a broken utility tower ignited a wildland fire in the Sierra Nevada foothills that would become California's most destructive and deadliest fire. Propelled by high winds and dry vegetation, the Camp Fire (named for the road near the fire's point of origin) quickly destroyed Paradise and several smaller communities nearby, including Magalia, Concow and Butte Creek Canyon.

After igniting, the fire raced through the forest, with high winds blowing embers far ahead. Landing on drought-stricken vegetation, they ignited spot fires well ahead of the fire front. Paradise, located on a wide ridge between two deep canyons on either side (Feather River to the east and Butte Creek to the west), quickly became engulfed in an urban conflagration. Over the course of a single day, the fire consumed over 18,000 structures. It caused at least 86 deaths.

Paradise had experienced wildfires nearby before, but nothing to this extent. The intense speed of the fire meant that evacuation notices occurred as the fire approached, effectively nullifying the zone-by-zone evacuation plan the town had practiced in the years leading up to this event. As fires cut off evacuation routes, the main route out of town, the Skyway Road, ground to a virtual standstill with people frantically trying to escape.

12 Carlson, C. "Thomas Fire destruction: 'The scale of it was beyond belief.'" VC Star. 10 April 2018. <https://www.vcstar.com/story/news/local/2018/04/10/thomas-fire-damage-destruction-scale/395893002/>

13 The Mendocino Complex fire, composed of the Ranch and River fires, is the largest recorded fire complex in California history to date in terms of acreage burned, at over 410,000 acres. However, the fires, which burned in a lightly populated section of Northern California's Central Valley, resulted in few casualties and only 280 structures destroyed, 37 structures damaged, and approximately \$267 million (2018) in economic damages. Consequently, in terms of attention, the fires were quickly eclipsed by the Camp and Woolsey fires later that year.

14 Carlson, C. "Thomas Fire destruction: 'The scale of it was beyond belief.'" VC Star. 10 April 2018. <https://www.vcstar.com/story/news/local/2018/04/10/thomas-fire-damage-destruction-scale/395893002/>

15 The loss of vegetation leaves slopes destabilized and more prone to sliding during rainfall events. It is typical that burn scars in populated areas are monitored for slide potential and warnings are triggered at rainfall intensities significantly lower than pre-fire levels. For example, rainfall intensities of one half-inch per hour can easily trigger a landslide on a slope, which could withstand 2 inches of rainfall an hour pre-fire.

16 Mazingo, J. "Santa Barbara County knew mudslides were a risk. It did little to stop them." Los Angeles Times. 20 December 2018. <https://www.latimes.com/local/california/la-me-montecito-debris-basins-20181220.htmlstory.html>

17 Queally, J., Etehad, M., & Mejia, B. "Death toll rises to 17 in Montecito; 100 homes destroyed by mudslides." Los Angeles Times. 10 January 2018. <https://www.latimes.com/local/lanow/la-me-ln-montecito-storm-mudflow-20180110.htmlstory.html>

2018 Woolsey Fire – Ventura and Los Angeles counties

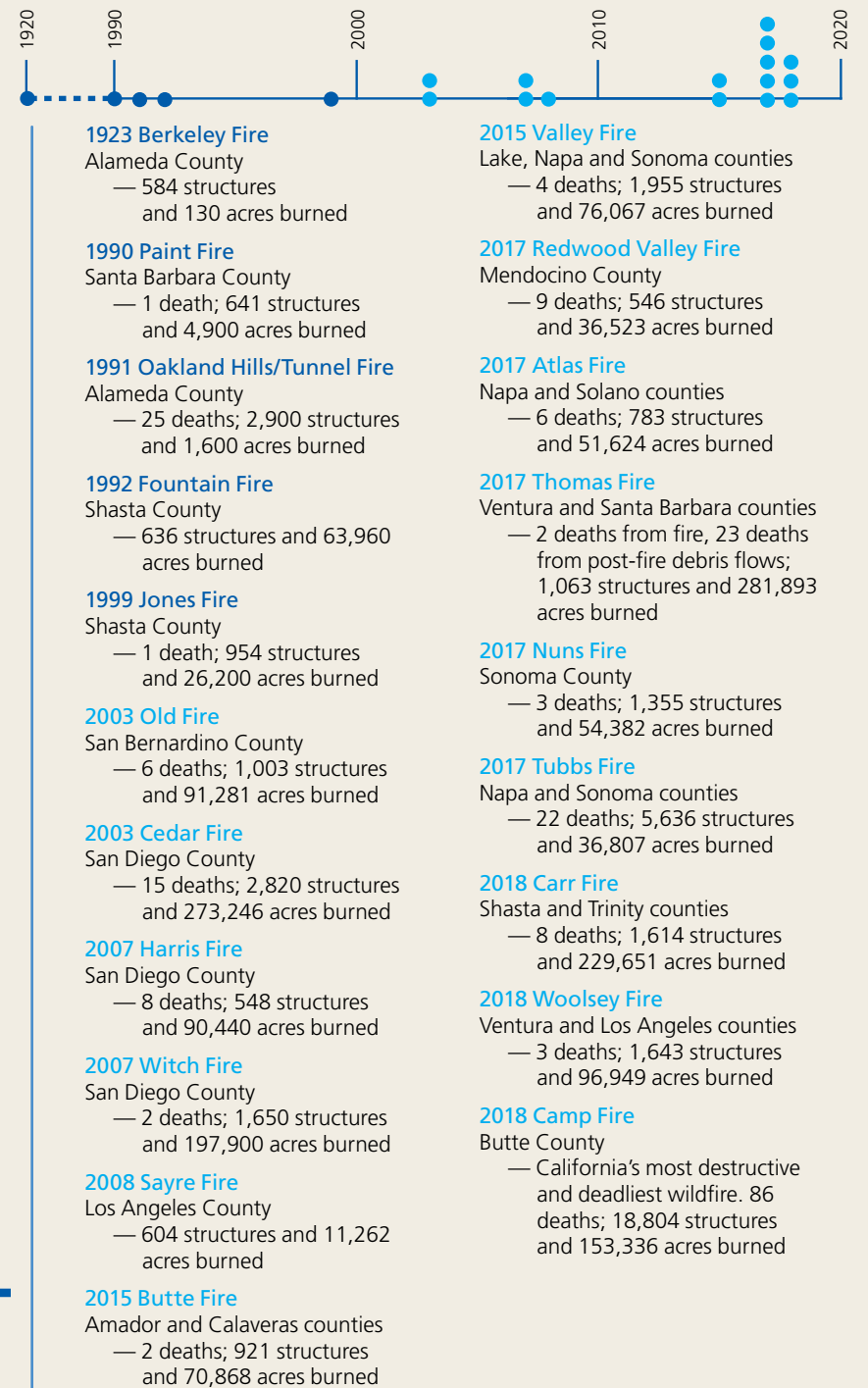
On the same day the Camp Fire ignited in Butte County in Northern California, the Woolsey Fire broke out in Los Angeles and Ventura counties in Southern California, just 21 minutes after the Hill Fire also ignited in Ventura County. Fueled by dry vegetation and driven by strong Santa Ana winds, the Woolsey Fire quickly spread, eventually burning close to 97,000 acres of land, destroying over 1,600 structures, killing three people and causing the evacuation of more than 295,000 people.¹⁸ With winds gusting up to 50 mph, the fire at one point burned at a rate of over 21,000 acres per hour.¹⁹

Firefighting resources were initially focused on the Hill Fire; incident commanders felt it had a greater immediate potential to affect lives and property. Within several hours, the Hill Fire moved into a previously burned area and slowed, allowing resources to shift to the Woolsey Fire. However, because of high winds and the slower initial response, the spread of the Woolsey Fire exceeded the capacity of ground-based crews to fight it. Aerial suppression efforts could not begin until 5 a.m. the next day, when the winds abated. Topography and vegetation exacerbated the fire's effects. Steep, chaparral-covered canyons channeled and accelerated the fire toward Malibu while complicating firefighting and evacuation. Hundreds of homes in Malibu were destroyed or damaged on both sides of the Pacific Coast Highway. As students at Pepperdine University sheltered in place, significantly aided by Pepperdine's clustered, fire-hardened architecture, much of the Malibu coast west to the community of Solommar suffered damage from the fire.

18 Woolsey Fire - 2018 California Wildfires. United States Census Bureau. November 2018. <https://www.census.gov/topics/preparedness/events/wildfires/woolsey.html>

19 St. John, P., Serna, J. & Lin II, R. G. "Must reads: Here's how Paradise ignored warnings and became a deathtrap." Los Angeles Times. 30 December 2018. <https://www.latimes.com/local/california/la-me-camp-fire-deathtrap-20181230-story.html>

Figure 2. Top 20 most destructive California wildfires



Source: California Department of Forestry & Fire Protection. 8 August 2019. https://www.fire.ca.gov/media/5511/top20_destruction.pdf

How U.S. wildfire resources are deployed

A major natural hazard event, such as a hurricane or flood, always brings an influx of resources. Wildland fires are no different. However, the coordination and planning for wildfires are noteworthy. As a wildfire grows and threatens more lives and structures, the resources to fight it must grow too. Collaborative firefighting agreements have been set up accordingly.

Initially, local level resource management kicks in. This includes resource mobilization, the activation of local Emergency Operation Centers (EOCs) and potentially the state EOC, as well as coordination with interagency dispatch centers. As local resources reach capacity, available resources from the geographic area (of which there are 10 in the U.S.) are mobilized. If area resources become stretched, the National Interagency Fire Center (NIFC) is engaged. The National Multi-Agency Coordination Group (NMAC) within the NIFC then manages and mobilizes available national level resources, including strategic support, incident management teams, air support and smokejumpers (specially trained wildland firefighters who parachute in to remote areas).²¹

The NIFC categorizes fire demand into five preparedness levels according to the resources needed. A preparedness level 5 is the most resource-intensive, where multiple geographic areas are experiencing large wildland fires and competing for resources. At preparedness level 5, fire agencies can request assistance from the military and from abroad.

Firefighters from several geographic areas assisted during the Camp and Woolsey fires in November 2018.²² Earlier in 2018, which was an extreme fire year up and down the West Coast of North America, personnel from Australia and New Zealand assisted with fires in the Pacific Northwest and Northern California.²³

21 "About us." National Interagency Coordination Center. <https://www.nifc.gov/nic/about/about.htm>

22 "Firefighters from around the U.S. travel to help in Calif. Wildfires." Fire Rescue. 14 November 2018. <https://www.firerescue1.com/mutual-aid/articles/392924018-firefighters-from-around-the-us-travel-to-help-in-calif-wildfires/>

23 Wildland fire summary and statistics annual report 2018. National Interagency Coordination Center. 2018. https://www.predictiveservices.nifc.gov/intelligence/2018_statsumm/intro_summary18.pdf



Napa County Airport, California
October 2017

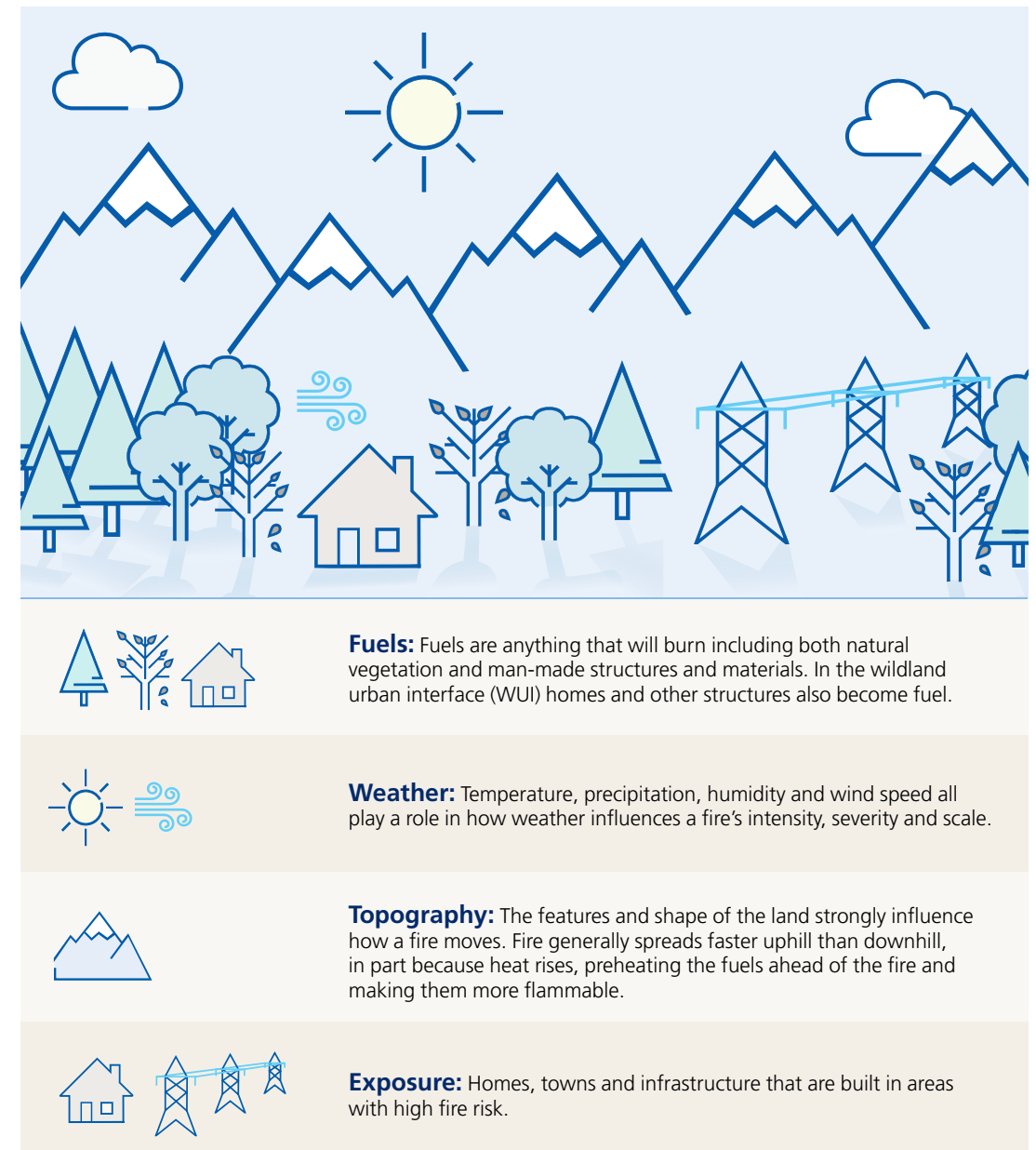
The forces behind wildland fires

In assessing wildfire hazard – the likelihood of a wildfire starting and its potential for growth – firefighters, emergency managers and researchers consider three physical and atmospheric elements: weather, fuels and topography. Traditionally, these three elements make up the “fire behavior triangle,” which describes the physical potential for fire ignition and spread.

Two other factors that determine fire risk are exposure, which is whether a person or structure is in a place where weather, fuels and topography combine to create wildfire potential; and vulnerability to the hazard, which includes such factors as whether assets are likely to ignite and burn, whether the road network is sufficient to support evacuation, whether residents physically can evacuate and know how and when to evacuate, and whether assets are insured.

Figure 3 describes how fuels, weather, topography and exposure govern the physical aspects of fire risk. How these factors are changing and the implications of those changes for fire risk are described in the following sections. The role of vulnerability in fire risk is described in Section II.

Figure 3. Four key elements contributing to wildfires



Weather

Temperature, precipitation, humidity and wind speed all play a role in how weather influences a fire's intensity, severity and scale. High temperatures primarily influence fire by drying out fuels, but they can also influence the fire itself. Fires generally ignite more readily, spread faster and burn more intensely and severely at higher temperatures than at lower temperatures. Precipitation and humidity also influence fuel moisture content. Fires are more likely to ignite after extended dry periods and when relative humidity is low.

Temperature, precipitation and humidity are changing. Headwaters Economics, a nonprofit institute focused on land management and community development, notes that "in the western U.S., the average fire season is 84 days longer than in the 1970s."²⁴ As temperatures have increased, the timing and intensity of rainfall have shifted and the period of warm, dry weather has extended. This has increased the length of the fire season, and with it the opportunity for fire ignition.

Wind speed also affects the potential for and severity of a fire. High winds dry out fuels, push the fire forward and carry embers aloft to create spot fires often miles ahead of the main fire. The hot, dry, powerful Santa Ana and Diablo winds of Southern and Northern California, respectively, are particularly effective at sustaining and spreading fires. These winds originate over the Great Basin region and coastal mountains and blow west toward the ocean in the fall. Typically, the winds start blowing roughly when the autumn rains begin. However, as precipitation patterns have changed, the dry season has extended, and the Santa Ana and Diablo winds are now increasingly beginning prior to the onset of autumn rains, when vegetation is at its driest and the potential for catastrophic fires is greatest.

Fuels

Fuels are anything that will burn, in both the natural and built environment. In the wildland environment, fuels include organic matter in the soil, fallen pine needles, shrubs and grasses, midsize trees and low branches, and crown fuels. In Northern California forests, dry evergreen needles are particularly flammable. In Southern California, the primary wildfire fuel is chaparral, nearly impenetrable, dense thickets of woody, waxy shrubs. Both fuel types are fire-adapted and ignite and burn more easily, quickly and intensely than other wildland fuels.

In much of the western U.S., wildland fuel availability has increased due to nearly 100 years of fire suppression.²⁵ By 1935, the U.S. Forest Service's fire management policy stipulated that all wildfires should be suppressed by 10 a.m. the day after they were first spotted.²⁶ Such policies have led to a buildup of fuels beyond what would be found in healthier forests that have seen less human disturbance, and bring with them an associated risk for more intense fires. More current practices of allowing fires to burn where they can do so safely, as well as conducting controlled burns, have not fully compensated for previous practices.

Fuel buildup has been further exacerbated in some ecosystems by increased tree mortality from insect infestations, extended droughts and other die-off events, which leave behind standing dead fuels, and by the introduction of invasive species, many of which are more flammable or burn differently than native vegetation. For example, the increase in invasive grasses in the chaparral ecosystem in Southern California has been implicated in the speed and intensity of the Woolsey Fire.²⁷

In the wildland-urban interface (WUI), homes, landscaping and other structures also constitute fuel. Because structures contain synthetic or petroleum-based materials, they burn differently than wildland fuels. In particular, they can burn hotter and longer, and generate larger embers. Structures built with more flammable materials (e.g., a cedar shake roof, wood or vinyl siding) are more likely to burn than those structures built with less flammable materials (e.g., asphalt shingles, concrete board siding). The denser spatial distribution of fuels in an urban environment, as compared to a wildland environment, can also result in different fire behavior, rate of movement and direction of spread.

Topography

Topography, the features and shape of the land, strongly influences how a fire moves. Fire generally spreads faster uphill than downhill because fuels are preheated by the uphill-spreading flames and heat. The steeper the slope and the greater the fuel, the faster the fire will burn and spread. Topography can channel winds, allowing fire to accelerate through canyons and other areas of locally amplified wind. For the Camp and Thomas fires in particular, topographically channeled winds significantly amplified the fire's spread, lofting embers beyond the fire front, funneling and focusing the fire to blowtorch intensity in specific drainages and neighborhoods.

Topography can also enable the fire to create its own weather; topographic features such as "chimneys" (i.e., steep gullies on either side of a hill) can draw fire up them very rapidly as the hot air rises, even creating their own winds. Topography can result in microclimates with localized moisture conditions. For example, fuels dry earlier in the season on south slopes compared with north slopes, creating a patchwork of fuels with different moisture contents.

Topography also strongly influences development patterns in the built environment. Although topography is a fixed element of the landscape, as development expands into the wildland, people are increasingly building in topographically challenging places, aided by new technologies, new building materials and an expanding utility grid. Housing and small towns are springing up in relatively remote locations at densities that would have been unthinkable even 30 years ago. Many of these newer communities are accessible only by a limited number of roads; many have only one steep, narrow ingress/egress route.

Exposure

The fourth element influencing the physical aspects of fire risk is exposure – whether people and assets are in areas that may or will burn. In California, the U.S. and globally, wildfire exposure is expanding as homes and communities are increasingly being built in areas with high fire hazard and as metropolitan areas expand into the wildland areas at their boundaries. Some of this development is driven by amenity migration, which is the movement of people to desirable semirural environments, forested areas and small mountain towns. In other cases, rising home prices and population pressures drive the development of communities to less expensive land in the WUI. The result is communities that can consist of people who are disproportionately of lower socioeconomic status, elderly or otherwise more vulnerable.

By 2010, one-third of the U.S. population lived in the WUI. This exposure – where a population is in an environment prone to wildfire – is frequently coupled with a greater vulnerability to the hazard due to more limited evacuation routes and more dangerous fire behavior as a result of more complex topography.

Implications for California wildfires

All four of the elements contributing to the physical aspects of wildfire risk – weather, fuels, topography and exposure – are undergoing changes that increase wildfire challenges. Fall rains are arriving later, after the Santa Ana and Diablo winds have already begun blowing, extending the length of the fire season. Changing precipitation patterns also are leading to longer and more severe droughts. At the same time, decades of suppression have allowed fuels to build up in wildlands, increasing the potential for hotter, faster-burning fires. And, driven by both aesthetic interest and economic pressure, more people and assets are migrating into high fire hazard areas, including areas of complicated, potentially dangerous topography.

Viewed through this lens, the 2017 and 2018 wildfire seasons in California should perhaps come as less of a surprise; they were the inevitable result of a series of trends, all of which increase our physical wildfire risk. As shown in Figure 2, 10 of the top 20 most destructive California wildfires have occurred since 2015; unless we take significant action to reduce our exposure and vulnerability, we should expect these trends to continue and intensify.

Addressing future wildfire risk, however, will require thinking critically about which risk factors we can effectively and meaningfully address, and committing to acting on those quickly and decisively.

"Climate change has rendered the term 'fire season' obsolete, as wildfires now burn on a year-round basis across the state. Coupled with the ever-increasing number of people and structures exposed to wildland fire risks, it is not surprising that the state's largest and most destructive fires have occurred in just the past three years. It is impossible to ignore the reality that wildland fires are having a greater impact than ever before."²⁸

— 2018 strategic fire plan for California, California Department of Forestry & Fire Protection

What is the wildland-urban interface (WUI)?

The wildland-urban interface (WUI) is an area of land where the built environment abuts undeveloped wildland. The interface between human and natural environments increases both the chance of fire ignition (via power lines, equipment failure, campfires, fireworks, etc.) and the potential for lives and property to be lost to wildfire.

In California, state-run agencies indicate the hazard wildfires pose to communities using hazard maps.²⁸ These maps serve as a good indicator of WUI land. Land is classified into three fire hazard severity zones – Moderate, High and Very High – reflecting the estimated exposure to wildfire based on the proximity to the WUI boundary.

The maps do not, however, take into account the way climate change affects fire risk within the WUI, nor do they consider the hazard posed by burning structures. If structures near or in the WUI ignite, they can result in cascading structural ignitions. This has led some fire researchers to question whether, realistically, an entire community should be identified as WUI if any portion of that community lies within the WUI.

24 Rasker, R. The wildland-urban interface: The problem, trends, & solutions. Headwaters Economics. August 2018.

https://headwaterseconomics.org/wp-content/uploads/wildfire_homes_solutions_presentation.pdf

25 The role of suppression in fire risk across various ecosystems is debated and multiple perspectives can be found. In interviews for this report, several forest management groups noted controlled burns and forest thinning that removes fuels can reduce fire intensity; however, these actions will not prevent fires.

26 Review and update of the 1995 Federal Wildland Fire Management Policy. National Park Service, U.S. Forest Service. January 2001. https://www.nifc.gov/PIO_bb/Policy/FederalWildlandFireManagementPolicy_2001.pdf

27 Hurteau, M. "What Trump gets wrong about wildfires, by a fire scientist." The Guardian. 13 November 2018. <https://www.theguardian.com/us-news/2018/nov/13/donald-trump-wildfires-science-forest-management>

28 California Department of Forestry & Fire Protection. <https://www.fire.ca.gov/>

29 2018 Strategic Fire Plan for California. California Department of Forestry & Fire Protection. 22 August 2018. https://osfm.fire.ca.gov/media/5590/2018-strategic-fire-plan-approved-08_22_18.pdf

KATHLEEN WALK



After safely evacuating guests, hotel manager takes steps for fire resilience

In the early dawn hours of Nov. 9, 2018, flames crackled behind the Hampton Inn in Agoura Hills as Kathleen Walk said goodbye to the last employee who had helped her wake guests and evacuate the 93-room hotel.

"Once the fire had crossed over to this side of the hill, I told everyone to go," Walk said. "My intention was to make one last sweep and go, too. But I just couldn't go. It's the owner's investment, and you hear about looting. So I got a fresh pot of coffee going."

Alone, she began typing additions to the hotel's fire emergency protocols, gleaned from the past five hours. The top two items grew out of some of the most intense moments of her experience of the Woolsey Fire.

Law enforcement had entered the hotel just after 1 a.m. and ordered an evacuation of guests. After getting the call from her night shift employee, Walk began driving back to the hotel, phoning other hotel locations on their evacuation list to see if she could send her guests to them. "No one was answering. They were full. We had people here for weddings. They don't know the area. It broke my heart."

Expanding the lodging list the hotel hands to guests in an evacuation would not solve all their challenges, but it would increase the odds of them finding an available room. So the first addition to the procedures became:

Expand the list of evacuation hotels from a 20-mile radius to a 45-mile radius.

After the evacuation, Walk had turned on the local news to see reports of embers sparking fires on roofs and elsewhere in buildings. She worried the hotel air conditioning could ignite a spark. "I didn't want the air to keep circulating in the hotel. We all know where the

water shut-offs are, but I had to look in the as-built manual to find the AC ones." That inspired the second addition to the hotel's fire procedures:

Post a map of the breakers for employees, with instructions to pull the ones for the air conditioning in the event of fire.

As she walked the building, monitoring it for smoke, she realized employees would not be able to return until the evacuation order was lifted. She worried about their lost wages. Later, she learned the hotel had business interruption insurance to help compensate not only for the hotel's lost revenue, but also the employees' income.

It was one of many resilience measures she was grateful for over the next week, as she slept in her hotel office and opened guest rooms and the hotel kitchen's reserves to the firefighters. Twice a day she'd go outside to hand out water bottles and granola bars to them. Masks from the hotel's emergency kit made that possible. "It was raining ash. The air was horrible," Walk said. "But we had fire trucks in our parking lot, so I felt safe. And they were so appreciative."

A little over a week later, employees returned to help clean up soot and ash. She insisted her employees wear masks – and quickly reordered them for next time.

"When I left the night before the evacuation, it felt safe. The fire was in Bell Canyon, over on the other side of the freeway," she said. "Everything changed so fast. I'm grateful we had procedures and supplies in place to make it through."

"Once the fire had crossed over to this side of the hill, I told everyone to go. My intention was to make one last sweep and go, too. But I just couldn't go."

- Kathleen Walk, General Manager, Hampton Inn & Suites in Agoura Hills, California

Photo courtesy of Kathleen Walk

TIMOTHY SHARKEY



Opening a door to ease the impact on small businesses displaced by the Camp Fire

Hours after the Camp Fire ignited, Timothy Sharkey recognized an impending impact that he was in a position to help address. So Sharkey, operations manager for Chicostart, an entrepreneurial and tech hub just down the ridge from Paradise, talked with Wendy Porter, Chicostart's director.

Within hours, Chicostart, on the first floor of Chico's City Hall, opened its doors to small businesses from the surrounding area that were displaced by the fire, offering office space, internet, desks, conference rooms, phones, coffee and other resources. Knowing that space might run out, Sharkey and his team reached out to Chicostart's GrowTech partners to absorb any overflow. Momentum built from there.

Over the next several months Chicostart would uphold its core mission of helping startups to succeed while also becoming a hub for businesses displaced by the fire, offering not only operational resources, but also a space to connect and build community.

For Sharkey and his team, accomplishing this meant identifying and anticipating how to flexibly use Chicostart's resources and augment them as needed. Their efforts went well beyond supporting business continuity to include:

- Developing and implementing a customer relationship management (CRM) system to help track the needs and status of businesses. Salesforce provided them with free licenses to facilitate this process through The Training Place at Butte College.

- Convening a business roundtable of companies doing wildfire-related work, including aerial firefighting, aviation engineering, geographic information system mapping, data science, environmental research, fiber cabling, construction and more. Organized by Eva Shepherd-Nicoll, Chicostart's only other employee, the roundtable participants focused on solutions and best practices for wildfire prevention, suppression, management, recovery and research. The collaboration also built connections that could expedite recovery during the next major wildfire.
- Collating and distributing disaster response and recovery resources for small businesses, to help them navigate this long, complex process.

In the first three months post-fire, Sharkey said the focus was on how to continue providing core services to existing clients while ramping up support for fire survivors. In the next three months, the focus shifted to developing strategic plans for maintaining current activities and services while scaling to meet emerging needs related to the Camp Fire.

Chicostart's ability to leverage its capabilities and adapt them to changing circumstances, to work outside of silos and to look ahead has helped the hub assist over 200 fire-impacted companies.

"We can't be everything to everyone," Sharkey said, "but we can be a resource to help people find what they need."

"We can't be everything to everyone, but we can be a resource to help people find what they need."

- Timothy Sharkey, Operations Manager, Chicostart in Chico, California

Photo of Wendy Porter (from left), Timothy Sharkey and Eva Shepherd-Nicoll, courtesy of Wendy Porter



Section II: Socioeconomic disaster risk landscape

Drivers of change: Demographics of the wildland-urban interface

Fully one-third of homes in the U.S. are now located in the wildland-urban interface (WUI), and people are moving into the WUI at a faster rate than any other area. Between 1990 and 2010, developed areas within the WUI grew 33% in terms of land area, with the number of homes increasing by 41%, from 30.8 million to 43.4 million.³⁰ In California alone, 11 million people and 4.5 million homes are in the WUI.³¹ A number of interacting push-and-pull factors drive these changes.



Yosemite National Park, California
September 2017

As population growth elevates housing costs in California and across the U.S., developers and residents are looking outside urban centers for more diverse and more affordable housing options. This trend is pushing development to the outskirts of urban centers, alongside or in forests, or nestled among the foothills of mountains.

At the same time, the desire to live in less dense areas is leading to suburbanization and the movement of higher-income residents away from the city to homes in the WUI. This latter exurbanization and amenity-driven migration is beneficial for local governments in California, as their revenue can be boosted through property taxes on new construction.

The resulting WUI communities are increasingly bimodal – that is, less affluent communities characterized by low-income workers, students and retirees looking for more affordable housing, and high-income communities of amenity migrants looking for a beautiful place to live. Caught in between are the locals who lived there for decades, many of whom are being pushed out by rising prices associated with high-income amenity migrants.

Because income and related factors play a vital role in post-disaster recovery, these socio-demographic drivers have implications for how people are impacted by and recover from a wildfire, with the more socially vulnerable communities often facing a longer and more challenging recovery than their better-off counterparts.

³⁰ Radeloff, V. C., Helmers, D. P., Kramer, H. A., Mockrin, M. H., Alexandre, P. M., Bar-Massada, A., ... & Stewart, S. I. (2018). Rapid growth of the US wildland-urban interface raises wildfire risk. *Proceedings of the National Academy of Sciences*, 115(13), 3314-3319.

³¹ Hill, A., & Kakenmaster, W. "A new normal": California's increasing wildfire risk and what to do about it." Hoover Institution, Stanford University. 24 May 2018. <https://www.hoover.org/research/new-normal-californias-increasing-wildfire-risk-and-what-do-about-it>

Living in the wildland-urban interface

Maintaining forest health and defensible space

Forest ecosystems in California, and in much of the western U.S., have a natural cycle of wildfire. In a natural system, smaller fires take place periodically and help the forest to regrow and rejuvenate. However, for most of the 20th century, the U.S. has engaged in wildfire suppression out of a fear of uncontrollable and destructive wildfires, initiated with the Peshtigo Fire in Wisconsin in 1871 and the Great Fire of 1910, which burned primarily in Idaho and Montana.

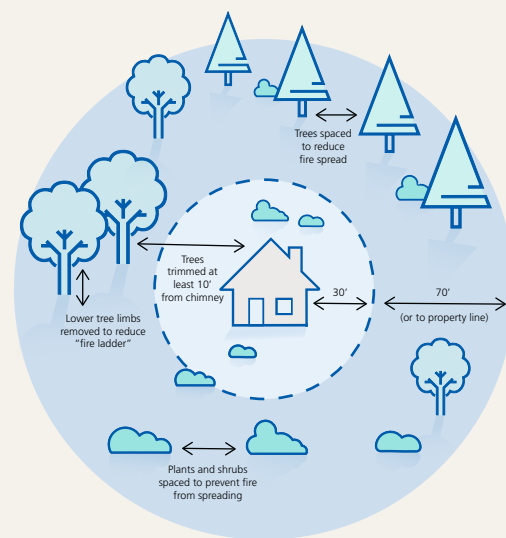
Decades of fire suppression have led to a buildup of fuel. In recent decades, a more progressive practice of prescribed burns, which are controlled fires that mimic the forest's natural wildfire cycle, has been implemented. By burning in a controlled fashion, national and state forest managers can reduce the potential for large, uncontrolled fires. National and state forest services also manage fire intensity by forest thinning. However, forest thinning must be done correctly. Simply cutting down the trees, chipping them and leaving the wood chips on the forest floor, as is sometimes done by individual homeowners, does not reduce overall fuel load; it simply rearranges it. Removing or burning the results of thinning produces a more lasting effect but requires significantly more time and resources.

Although prescribed burns and thinning can reduce the intensity of subsequent wildfires, these practices rarely prevent wildfires, and there is simply too much acreage to treat. We must mitigate strategically to reduce wildfire intensity in critical areas and also create "defensible space" around structures and assets. Defensible space (Figure 4) is cleared space that reduces the opportunity for ember ignition and provides space for firefighters to work. Defensible areas around individual structures, transportation corridors, key assets and communities can and should be maintained by the appropriate responsible parties.

Understanding and mitigating wildfire vulnerability

Living in the WUI exposes homes and residents to wildfires, but the risk involved in this exposure can be managed. Risk is a combination of a hazard, the exposure to the hazard, and the vulnerability of a person or thing (i.e., the likelihood of suffering injury or damage) as a result of the exposure to that hazard. Appropriate action can reduce both exposure and vulnerability. Doing so requires commitment at many levels.

Figure 4. What is defensible space?



"Defensible space is the required space between a structure and the wildland area that, under normal conditions, creates a sufficient buffer to slow or halt the spread of wildfire to a structure. It protects the home from igniting due to direct flames or radiant heat. Defensible space is essential for structure survivability during wildfire conditions and for the firefighters defending your home."

Source: California Department of Forestry & Fire Protection (CAL FIRE)

Individual home and business owners need, first and foremost, an understanding of wildfire hazard and exposure, an understanding of the actions required to minimize their vulnerability, and a willingness and ability to take those actions. These include using fire-resistant building materials whenever feasible, creating defensible space through landscaping and by limiting combustible materials around structures, and knowing what actions to take and when to take them when a fire threatens. However, because actions taken – or not taken – by individual property owners can place other property owners at risk, more collective action at broader scales is also required.

Municipalities and counties need to consider zoning, building materials and landscaping codes and enforcement, maintenance of city buildings and space, and city planning. In particular, zoning, planning and maintenance can be used to reduce development in the highest-hazard areas, harden existing and new development, and create defensible space. Here too, however, there are gaps where municipalities lack the authority to act and statewide action is required.

States need to consider statewide hazard mapping, zoning, building codes and enforcement. Clearly delineating expectations or requirements at the state level can ease the burden at the municipal level, provide for more effective enforcement, support the development of more viable markets for building materials, and assist the cultural shift required to encourage widespread adoption and uptake. State participation is also required to engage with large corporations and utilities, and with state and federal agencies around maintenance of public lands.

Reducing vulnerability to wildfire also requires collaborative actions. Individuals, municipalities, counties and states need to consider worst-case scenarios and develop options. Ingress and egress within and between communities should be reviewed and strengthened to support safe and timely evacuations. Preparedness and response systems and initiatives should support community members in building their situational awareness, remaining alert during fire season and preparing them to take early action. Individuals and businesses should purchase insurance and review coverages regularly. Insurers and insurance producers can support this effort through clear language about what policies do and do not cover. Finally, we need safety networks at all levels, including among individuals, nonprofit aid organizations, and state and federal governments. These could include individual savings, networks of families and friends, humanitarian aid and donations to fire survivors, state recovery funds, and Federal Emergency Management Agency (FEMA) recovery funds for individuals and jurisdictions alike.

Fire-resistant design: From Patmos, Greece, to Pepperdine University

For centuries, inhabitants of the island of Patmos, Greece, adapted their communities and homes to live with fire. Structures of stone, stucco and tile were clustered together and surrounded by pastures, making them easier to defend against a wildfire. Halfway around the world, William Pereira, a U.S. architect and landscape designer, borrowed from Patmos' approach when he designed Pepperdine University. Located in the dry, chaparral landscape of Malibu, California, Pepperdine has survived six major wildfires over the last 30 years, including the 2018 Woolsey Fire.

Similar to Patmos, Pepperdine's buildings are constructed of stone, tile and concrete, and are clustered together with stone patios. Around these structures are playing fields, lawns, roads, parking areas and well-maintained fire-resistant vegetation, which both limit the opportunity for ignition and allow room for firefighters to defend the buildings.

Because Pepperdine is a single campus, building style and land management can be consistent across the property – and that is where the school's resilience lies. One wooden structure, or one structure surrounded by unmaintained brush or flammable shrubs, would put the entire campus at risk. This is a powerful lesson for communities attempting to prevent wildfire. To maximize fire resistance, neighborhoods must be managed collectively; the community is only as resistant as the least resistant structure.

Phil Phillips, Pepperdine's senior vice president for administration and chief administrative officer, recounts the intense hours as the Woolsey Fire spread across Malibu and toward campus in one of our Resilience Trailblazer snapshots (page 22).





Photo courtesy of Maria Shalid

Wildland-urban interface building codes and California fire hazard mapping

California has already taken a leadership role in the U.S. on wildfire hazard and risk. Existing statewide fire hazard mapping provides a foundation for action, and California Fire Hazard Severity Zone Maps indicate which areas have the greatest probability and intensity of potential wildfire. The maps are divided into three zones (Moderate, High and Very High), reflecting the estimated hazard.

The maps are used by the state to show where to apply Chapter 7A of the California Building Code, which requires homes be built to certain fire-safe standards. These codes regulate how structures are constructed and what materials need to be used to limit likelihood and ease of ignition. Exteriors of structures must be fire-resistant, including roofing, exterior walls, doors and decks. Windows must be tempered glass, and attic and underfloor vents must be screened to block embers from entering interior spaces.

Fire hazard severity zones encompass more than one-third of California's land mass.³² More than 1.1 million structures, roughly one-tenth of the buildings in California, lie within the very high fire hazard severity zone,³³ and as many as 3 million homes are located within the high and very high fire hazard severity zones, many of them built before 2008.³⁴ As these homes are upgraded and new homes are built, application of the Chapter 7A standards has the potential to increase the fire resistance of housing stock. While these standards may decrease the probability of a structure catching fire, they do

not eliminate the risk altogether. External factors, such as location,³⁵ topography, maintenance of defensible space and weather, play a role in whether a code-compliant structure burns. The majority of homes that burned in the 2017 Thomas Fire were built with fire-resistant walls and roofs, for example.³⁶ However, in Paradise, homes built in compliance with Chapter 7A codes tended to fare better than those built before 2008, when the codes were enacted. Of the 350 homes built to the Chapter 7A code in Paradise, 51% survived compared to 18% of the 12,100 homes built prior to 2008.³⁷

Chapter 7A codes are currently in force in any fire hazard severity zone within State Responsibility Areas, but only within very high hazard severity zones within Local Responsibility Areas (LRAs). The assumption is that LRAs, which are cities, provide their own fire protection and are therefore effectively unburnable. This means that within cities, homes on one side of a street may follow the Chapter 7A codes while homes on the other side don't. However, large wildfires can propel a storm of embers far ahead of the front of the fire, potentially igniting spot fires and urban conflagrations across wide swaths of urbanized areas irrespective of the fire hazard severity zone.

Perceived cost is one of the barriers to adoption of the Chapter 7A codes. Although retrofitting an existing home to meet the standards is expensive, constructing a new home to fire-resistant standards does not necessarily incur additional costs and can enhance value. A 2018 study by Headwaters Economics found that constructing a new

home to comply with the International WUI Code,³⁸ which is similar to the Chapter 7A code in requiring fire-resistant construction and maintenance of buildings, vegetation and defensible space, cost approximately the same amount as constructing a similar "typical home."³⁹

32 Kasler, D., & Reese, P. "The weakest link: Why your house may burn while your neighbor's survives the next wildfire." *The Sacramento Bee*. 11 April 2019. <https://www.sacbee.com/news/state/california/fires/article227665284.html>

33 Smith, D., & Welsh, B. "A million California buildings face wildfire risk. 'Extraordinary steps' are needed to protect them." *Los Angeles Times*. 18 December 2018. <https://www.latimes.com/projects/la-me-california-buildings-in-fire-zones/>

34 California Department of Forestry & Fire Protection. <https://fire.ca.gov/>

35 Syphard, A. D., Keeley, J. E., Massada, A. B., Brennan, T. J., & Radeloff, V. C. Housing arrangement and location determine the likelihood of housing loss due to wildfire. *PLoS*. 28 March 2012. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0033954>

36 Guerin, E. "Fire-resistant is not fire-proof, California homeowners discover." *National Public Radio*. 9 December 2018. <https://www.npr.org/2018/12/09/673890767/fire-resistant-is-not-fire-proof-california-homeowners-discover>

37 Kasler, D., & Reese, P. "The weakest link: Why your house may burn while your neighbor's survives the next wildfire." *The Sacramento Bee*. 11 April 2019. <https://www.sacbee.com/news/state/california/fires/article227665284.html>

38 Quarles, S. L., & Pohl, K. *Building a Wildfire-Resistant Home: Codes and Costs*. Headwater Economics. November 2018. <https://headwaterseconomics.org/wp-content/uploads/building-costs-codes-report.pdf>

39 Ibid.

Fire-resistant building materials and techniques

Constructing homes to resist wildfires involves a multifaceted approach that draws on building construction science, industry, regulations and the expertise of diverse stakeholders from scientists and wildland specialists to local government and nonprofits such as the Insurance Institute for Business and Home Safety.⁴⁰ Using fire-resistant building materials, closing open eaves, protecting attic vents and providing a defensible space around a home to prevent ignition or curtail a fire's progress are crucial elements to harden structures and build fire-resilient communities. Here are some options:

- | | | | |
|--|--|---|---|
| <p>Roofs</p> <ul style="list-style-type: none"> Tile or metal roofs are vulnerable if they have gaps that allow debris to accumulate and provide a source of ignition for windborne embers. It is critical to seal the ends of tile and metal roofs for them to provide a strong advantage. Concrete tile, metal and Class A fire-rated asphalt shingles are more | <p>fire-resistant than wood shingles. Note that asphalt shingles can achieve a Class A fire resistance rating and prevent ember penetration, but a fire might damage them enough to require replacement.</p> <p>Siding</p> <ul style="list-style-type: none"> Materials like fiber cement siding are significantly more fire-resistant than wood and vinyl siding. | <p>Decks and patios</p> <ul style="list-style-type: none"> Composite decking or stone patios are less combustible than wood. For other fire-resistant deck materials, consult resources such as the California Office of the State Fire Marshal's Building Materials Listing Program. <p>Windows</p> <ul style="list-style-type: none"> Double-pane tempered glass windows are less likely to shatter | <p>in a fire and therefore are more likely to prevent embers from entering the house during a wildfire.</p> <ul style="list-style-type: none"> Consider metal screens as an added means to keep embers out. During wildfire events, keep windows closed so wind-driven embers cannot enter the home. |
|--|--|---|---|

In addition to fire-resistant materials, several building techniques can help harden structures and the surrounding land to fire. Soffit vents and eaves often provide an opportunity for embers to catch and ignite and to enter attic spaces. Enclosing eaves and installing vents with openings smaller than one-eighth inch reduce the potential for ignition from embers. Gutters should be periodically cleaned or even eliminated to avoid the build-up of combustible material, such as pine needles and leaves.

Structural elements also play a critical role in maintaining defensible space. Wood fences and decks attached to homes can be significant ignition sources, as can nearby structures such as sheds and carports. Removing these, hardening them or locating them 50 feet or more from the primary structure can significantly decrease the potential for igniting main structures.

Lessons from Australia: The rise of "Ready! Set! Go!"

City planning (the development of codes and how structures are built, maintained, mitigated and insured) can strongly reduce fire risk. However, it does not negate fire risk; consequently, a core element of reducing the consequences of a wildfire is planning what to do and how to act when a fire arrives.

California wildfire preparedness approaches, developed and refined over decades, were solidified from watching the challenges with Australia's "Prepare, Stay and Defend" model. In the 1990s in the Australian state of Victoria,

the Country Fire Authority developed various community training and education programs to support this approach. These were subsequently adopted by the Australasian Fire Authorities Council as the Australian national policy position. In this model, residents are advised to choose whether to "Prepare, Stay and Defend" their house from fires, or to "Prepare and Leave Early," before the fire threatens, in recognition that the greatest risk is realized when people decide to evacuate at the last minute.⁴¹

This model was quite successful in Australia until 2009, when over 100 people perished, many while defending their homes, in what are

The social nature of wildfire risk

Compared with the risk posed by many other natural hazards, wildfire risk has a particularly social nature. Earthquake damage is primarily seen structure by structure; unless an earthquake results in fire, the potential for a nearby structure to be a hazard to yours is typically limited. Similarly, for flooding, the way a neighboring property is or is not maintained will, in general, have limited impact on flood depths on your property. With those hazards, municipal, county and state jurisdictions have the responsibility to provide appropriate hazard information, building codes, planning and protective infrastructure, but individual property owners can trust that if they take that information into account, they should be reasonably safe. Wildfire is different. If you are downwind of poorly maintained lands with a significant buildup of dry fuels, your vulnerability increases, whether those lands are national forest, state or county park, or a neighbor with a shingle roof and gutters full of pine needles.

Land in the WUI is managed by a diverse set of stakeholders, including the federal, state and county governments, municipalities, and private property owners. This creates a patchwork of conditions and a host of responsible parties who need to be coordinated to act and to mitigate wildfire hazard. It also creates a multiplicity of views as to what action should be taken and where.

The reality is that for most municipalities and counties, and even for most states, they have – at best – limited influence over how wildlands are or are not maintained. This shifts the burden to those jurisdictions to maximize the benefit from action taken on the lands they do control. For counties and municipalities, this means placing an emphasis on coordinated action by owners and residents to harden their homes and businesses, and to maintain their land. Doing so reduces not only their individual risk, but that of their entire community.

now known as the Black Saturday fires. For CAL FIRE, this reinforced the value of the "Ready! Set! Go!" model.⁴² In this model, community members are encouraged to get "ready" for wildfires by creating and maintaining defensible space and mitigating their homes before a fire happens; to get "set" by making plans for what an evacuation will look like and what they will bring with them; and to "go" by evacuating well in advance of the arrival of the fire front. Launched in 2011, the program helps facilitate communication between residents and local fire departments, and informs and educates people about preparing for and evacuating in advance of a wildfire.

40 Zurich is a member of the independent, nonprofit Institute for Business and Home Safety. <https://disastersafety.org/>

41 Reynolds, B. A history of the Prepare, Stay and Defend or Leave Early policy in Victoria. Thesis, Management, RMIT University. 2017.

42 Prepare for wildfire. California Department of Forestry & Fire Protection, State of California. <https://www.readyforwildfire.org/prepare-for-wildfire/ready-set-go-campaign/>



PHIL PHILLIPS



The Woolsey Fire put Pepperdine University's shelter-in-place policy to the test. It passed.

From his time as an undergraduate and law student at Pepperdine University, Phil Phillips has witnessed five wildfires descend from the hills toward campus, never forcing an evacuation.

Pepperdine, nestled in an unincorporated enclave above Malibu, has a unique shelter-in-place protocol for wildfires. It's spelled out in Pepperdine's emergency operations manual and enabled by the campus' fire-wise design, conceived by architect William Pereira in the early 1970s. Pepperdine's shelter-in-place practice is approved by the Los Angeles County Fire Department and regularly communicated to students and families, said Phillips, Pepperdine's Senior Vice President for Administration and Chief Administrative Officer.

"We consider fire planning a moral duty," he said. "We have a responsibility to these young people and their parents."

Yet, the Woolsey Fire in November 2018 tested the shelter-in-place policy like no wildfire before. Phillips, an attorney who oversees Pepperdine's emergency planning, offered his perspective on why the campus' wildfire protocol stirred questions, but ultimately supported Pepperdine's resilience. A timeline helps tell the story.

Nov. 8

Evening: Phillips prepares for another night on campus. He spent the previous night there following a mass shooting at the Borderline Bar and Grill in nearby Thousand Oaks, which took the life of a Pepperdine student. The campus grieves as the approaching wildfire prompts the activation of the Emergency Operations Committee's wildfire plan. "So, we're experiencing two emergencies as one," Phillips said. "We literally turn to the Wildfire section of our manual and start taking action,

step by step." Otherwise, in their shock and grief, essential steps could be forgotten, such as turning on the valve to pump reclaimed water into Pepperdine's two reservoirs, used by the county fire department's air operations to replenish during a fire.

Nov. 9

Morning: The first wildfire relocation alert calls for people on campus to come to the gym or cafeteria. "We need everyone together, where we can protect them," Phillips said. The county fire department comes regularly to inspect campus spaces, vegetation and brush clearance, as well as to align on protocol, including that firefighters will arrive if a fire reaches a certain threat level for campus. "They have affirmed this is the safest place our people can be," Phillips said.

Noon: The campus safety patrol, monitoring the fire from hilltops, radios administrators to say the flames are moving slower than expected as winds shift. Students are told it's safe to leave the two relocation sites briefly and to return at 2 p.m. "We have a public safety lieutenant who is embedded with the fire department during a fire," Phillips said. That helps provide accurate information. However, this fire was especially chaotic, so updates were less frequent.

2 to 11 p.m.: Students are back in the relocation sites. Phillips and other administrators are fielding calls from people saying Pepperdine should evacuate. Phillips attributes the misinformation to confusion among non-local law enforcement who are not aware of Pepperdine's procedures and resources. At one point late in the night, officers enter one of the relocation sites and say everyone should leave. Administrators

"Not one student who experienced the [Woolsey] fire failed to re-enroll. And that says a lot about resilience."

- Phil Phillips, Senior Vice President for Administration and Chief Administrative Officer, Pepperdine University, in Malibu, California

Photo courtesy of Pepperdine University

reassure the students and officers that Pepperdine is approved to shelter in place. The campus is equipped with fire engines, wildfire-trained public safety officers, a defensible building (equipped with a generator) that can function as a command center for first responders, medical supplies including air masks, and two weeks' worth of food and water for 6,000 people.

11:30 p.m.: Throughout the night, Phillips is anxious for a call back from the county battalion chief to confirm that, when the fire comes, firefighters will be there. Eventually the call comes, and the flames, and the firefighters. Students remain safe inside the relocation centers until the fire passes.

Morning after

The fire leaves a residence hall with minor damage caused by an ember in its attic, with campus patrol extinguishing the flames before county firefighters arrived. A few windows are shattered from the heat. Some cars, landscaping and storage containers are scorched. "This was by far the most challenging and dangerous fire that we've experienced in my time here, and it was the largest, most destructive fire that Los Angeles County has experienced on record," Phillips said. "And we fared great, with almost no damage. Our plans worked really well."

Weeks after

In public hearings, some Malibu residents question why they were forced to evacuate, but not Pepperdine. Someone develops a false narrative that too much of the county resources were at Pepperdine and that's why losses occurred in Malibu. "But the fire burned in Malibu hours before the first county firefighters arrived at Pepperdine at 11:30 that night," Phillips said.

Besides protecting Pepperdine's approximately 3,600 undergraduate students from the hazards of fleeing (some don't have cars, and last-minute evacuations can be deadly), sheltering in place also avoids contributing to dangerous gridlock on the Pacific Coast Highway during a wildfire.

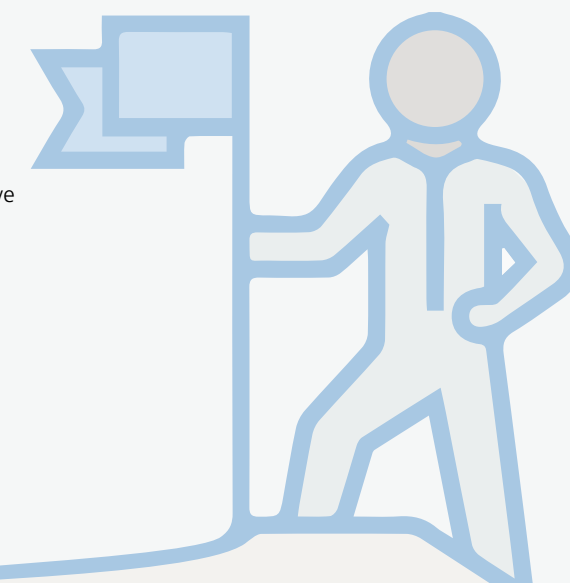
Future fires

Reviewing their plan, members of Pepperdine's Emergency Operations Committee agree on two communication enhancements. One is to seek a letter from county officials endorsing Pepperdine's shelter-in-place policy, to show to non-local law enforcement during a fire. Another is to communicate at predictable intervals via the emergency blog and other social media, even if there's nothing new to report, to allay worries and ease rumors. Example: A reporter asked administrators during the fire about a report that Pepperdine was locking in students. Phillips attributed that rumor to quick closing of doors when anyone entered or left the relocation buildings – to keep smoke out.

Overall learnings

The Woolsey Fire reinforced the foundation of Pepperdine's wildfire plan: "Emergency planning and preparation is something you've got to do in a way that's real and unique to your situation," Phillips said. "Continuously updating our plan is essential."

The next semester validated those efforts. "Not one student who experienced the fire failed to re-enroll," Phillips said. "And that says a lot about resilience."



Section III: What happened

Successes in pre-wildfire risk reduction

Wildfires are not unusual events in California. Residents, local and state governments, private businesses and nonprofits have and will continue to implement measures to reduce community risk to wildfires. In 2017 and 2018, forest management, maintenance of property and defensible space, preparedness activities, and training all helped reduce risk and contributed to successes during the wildfires. Unfortunately, the fires' extreme devastation overshadows these successes. It is important to bring these successes out of the shadows and acknowledge the differences they made, even as we explore why they were not enough.



Santa Rosa, California
October 2017

Some key successes identified by interviewees and secondary sources include:

- Forest thinning by the U.S. Forest Service north of Paradise in the year prior to the Camp Fire, which was implemented as part of a longer-term risk reduction strategy.⁴³ This thinning provided a fuel break that firefighters used to fight the fire and slow its progress, providing more time for evacuation.
- Newer homes built and landscaped to the Chapter 7A standards. They fared better on average than older homes in the Camp Fire. Many survived the fires intact, and by not igniting, served as firebreaks for homes downwind.
- The Malibu West Fire Brigade, a group of volunteer amateur firefighters who trained in advance to defend their homes and community during a wildfire. Through the support of their homeowners association, they purchased fire hoses and nozzles, turnout coats, masks, helmets and goggles. With this training and gear, they successfully protected their homes and many others from the Woolsey Fire while remaining safe themselves.⁴⁴
- Ventura, Los Angeles and Butte counties' adoption of the "Ready! Set! Go!" model, which helped lay the groundwork for a methodical evacuation plan and prepared residents to be ready for a wildfire.
- Paradise's evacuation plan. Although ultimately the fire moved too quickly for authorities to follow the planned and practiced zone-by-zone evacuation, the fire risk awareness built by that planning and practice is credited as a key factor in preventing the outcomes from being far worse.

For less intense fires, any one of these successes would have been applauded. Unfortunately, the speed, scale and intensity of the 2017 and 2018 fires eclipsed what were, in comparison, tiny successes surrounded by tragedy. However, this does not mean these were inconsequential contributions; instead, it points to the speed, scale and intensity at which we need to implement such interventions if we hope to keep up with or get ahead of our growing fire risk.

⁴³ Fidler, M. "Thinning Magalia's trees to prevent future forest fires." North State Public Radio. 14 March 2019. <https://www.myspr.org/post/thinning-magalia-s-trees-prevent-future-forest-fires#stream/0>

⁴⁴ Bermont, B. "Amateur firefighters say they saved most of their Malibu neighborhood from the Woolsey fire." Los Angeles Daily News. 11 November 2018. <https://www.dailynews.com/2018/11/11/amateur-firefighters-say-they-saved-most-of-their-malibu-neighborhood-from-the-woolsey-fire/>

The response to four fast, destructive fires

The Thomas Fire in 2017 had the greatest mobilization of resources in California to date. In contrast, when the Tubbs Fire ignited in early October 2017, firefighting resources were stretched across the state as firefighters battled a series of fires in the region. Similarly, the near-simultaneous ignition of the Camp Fire in the north and the Hill and Woolsey fires in the south in November 2018 strained resources across the state. Although all four events started well away from developed areas, they moved faster than anticipated and exhibited extreme behavior, quickly threatening homes and lives.

On Oct. 8, 2017, the Tubbs Fire rapidly moved from Calistoga to Santa Rosa, threatening the north edge of the latter city by 11 p.m. City and county first responders went door to door by 11:30 p.m. to evacuate neighborhoods, their work complicated by communications and power outages. By about 2 a.m., the fire had spread further to the west, jumping Highway 101, a multilane divided highway where in any previous event it would have been expected a firebreak could be held. Ultimately, tens of thousands of people were evacuated with very little notice.⁴⁵

Two months later, on Dec. 4, the Thomas Fire traveled quickly overnight, pushed by Santa Ana winds gusting up to 60 mph. The fire traveled 12 miles from its ignition point to the city of Ventura within hours and destroyed over 500 residences that same night. Similar to the Tubbs Fire, evacuation orders came too late if at all, leaving people to flee with little or no warning.

These experiences were repeated in 2018. The Camp Fire was first reported at 6:31 a.m. on Nov. 8. By about 7:30 a.m. embers were igniting homes in Concow, about 3 miles east-northeast of Paradise. About 27 minutes later, the first orders went out in Paradise to evacuate parts of town. Calls, texts and emails were sent via CodeRed, a private service for the city and county. The majority of residents never received evacuation notices; the city estimated that, at best, only one-third of residents were signed up for the alerts, and as the fire progressed call failure rates increased until the loss of fiber optic lines and cell towers shut down calls entirely. Although Paradise began to implement the zone-by-zone evacuation plan, within minutes it became apparent they needed to clear the entire town immediately as embers ignited dozens of spot fires.

The Woolsey Fire took several days to spread, but other challenges hampered efforts to fight the fire, including communication issues and high winds, which impeded the ability to utilize air resources. Resources were also stretched thin by the Hill Fire, which started approximately 15 miles to the west and within 21 minutes of the Woolsey Fire.⁴⁶ Additionally, the Woolsey Fire ignited in an area where responsibility fell to three agencies: Los Angeles County, Ventura County and the city of Los Angeles. Although the three agencies had trained together and signed a memorandum of understanding outlining the resources they would each allocate, the proximity of the Hill Fire to homes disrupted those plans and diverted resources until the Woolsey Fire grew in size and began to threaten more communities. Nonetheless, the slower onset allowed a somewhat more orderly evacuation. This is fortunate, as the fire ultimately forced the evacuation of an estimated 295,000 people from 105,000 residences across several communities, all served by a limited road network through rough terrain.⁴⁷

Evacuations, however, did not go smoothly in any of the four fires. For Paradise, the evacuation of the entire town resulted in gridlock. Some drivers ended up sheltering in their cars in parking lots in town; several lost their lives when their cars burned. Gridlock was similarly an issue in Santa Rosa during the Tubbs Fire. Many hospital patients and senior living facility residents were evacuated ad hoc by staff, friends and family in private vehicles. In Malibu, some residents never received notice⁴⁸ that the Woolsey Fire was approaching.

In all four fires, but particularly the Tubbs and Camp fires, as the speed and destructive nature of the fires became evident, firefighters shifted from defending homes to saving lives. As evacuees streamed into nearby communities, the receiving communities mobilized. Even among these, Chico stands out. Chico, approximately 15 miles west of Paradise, opened its Emergency Operations Center (EOC) to facilitate the response. It also provided space for Paradise's EOC in the

county and town halls, and participated in the Disaster Recovery Operations Committee. Chico also provided space for the Red Cross, the California Office of Emergency Services (Cal OES), FEMA and the National Guard to set up a base camp near the city's airport. On the other side of the airport, Chico established a center for pets rescued from the fire. For these efforts, the city drew from its own financial reserves and overextended its resources. The costs from these efforts are not reimbursable through either Cal OES or FEMA.

As with any major disaster, there were also emergent ad hoc responses. In Chico, because of the scale of the loss in Paradise, demand immediately overwhelmed local systems, services and plans. Shelters were opened, but they would not take pets; in addition, some shelters started seeing virus outbreaks. As a result, people were hesitant to go to them. Many people likely relied on friends and family for shelter, while hundreds of others resorted to camping in parking lots in Chico for several weeks.

45 Louszko, A., McNiff, E., Muldofsky, M., & Efron, L. "First responders detail harrowing evacuations when historic fire consumed Santa Rosa: 'Nature beat us handily.'" ABC News. 16 August 2018. <https://abcnews.go.com/US/responders-detail-harrowing-evacuations-historic-fire-consumed-santa/story?id=57167419>

46 Cosgrove, J. "Must reads: Firefighters' fateful choices: How the Woolsey fire became an unstoppable monster." Los Angeles Times. 6 January 2019. <https://www.latimes.com/local/lanow/la-me-woolsey-resources-20190106-htrmistory.html>

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Malibu, California
November 2018



Montecito, California
January 2018

Cascading impacts: Health concerns, insurance challenges and more

The 2017 and 2018 fires unleashed a series of cascading impacts. Following the Thomas Fire in 2017, heavy rain triggered debris flows that killed 23 people and damaged or destroyed over 400 additional homes near Montecito. In Paradise, community members who are coming back are faced with the almost complete destruction of their town and returning to a water system contaminated by benzene and other volatile organic compounds. Chico, a city of 93,000 about 15 miles west of Paradise, saw its population jump by about 20,000. The majority of the fire refugees were still there eight months later, taxing systems and services and intensifying the pre-existing housing shortage.

These were just some of the most visible and dramatic of the fires' impacts; there have been a host of other cascading environmental, economic, health and social impacts at local and regional levels. In Paradise and surrounding small towns, the destruction of both businesses and homes has wiped out the revenue base. It will be years, perhaps decades, before they fully recover, and the "recovered" towns will probably look very different, socioeconomically and culturally, from what they were pre-fire. In Santa Rosa and elsewhere in Sonoma County, the loss of housing coupled with decreased tourism in the months following the fires significantly impacted local economies and businesses. In the south, the Woolsey Fire damaged multiple wineries and vineyards throughout the Malibu Coast American Viticultural Area (a designated area that informs consumers of the origin of their wine),⁴⁹ resulting in downstream impacts on the workers and businesses that comprise the vineyard supply chains.

The physical and health impacts of the wildfires were also felt far beyond the burnt homes and communities. During a fire, smoke inhalation can lead to cardiovascular and respiratory issues, especially for those who are more sensitive, such as the elderly or those with underlying health conditions. The toxic ash from burned structures, cars and other materials can have similar negative effects. The trauma of living through a wildfire and losing a home, friends and family, as well as the disruption to a community's social fabric, can take a psychological toll, contributing to stress and anxiety.

In this landscape of new, increasing impacts, insurance is rapidly proving to be one of the most unexpected. Insurance is a principal tool for addressing risk. In exchange for a payment of an annual premium, a portion of the potential economic impacts of a given risk is transferred to someone else, typically an insurance company, which strives for a large, diverse risk pool to cover claims and maintain profitability. The 2017 and 2018 California wildfire seasons highlighted several challenges to current insurance assumptions and practices in the state, for both property owners and insurance companies.

Many homeowners impacted by the fires discovered they were significantly underinsured only after suffering losses. Of those homes impacted by the 2017 wildfires, 80% were underinsured, of which 60% were "severely underinsured,"⁵⁰ meaning that the insurance coverage purchased was significantly below the replacement cost of the home in the event of a total loss.

Insurance gaps: When costs and coverages don't meet

A variety of factors contribute to the gap in insurance coverage following a wildfire. Among them:

- Construction and labor costs often increase after a disaster due to supply and demand.
- Replacing existing homes on a home-by-home basis can be more costly than building a new home as part of a larger development.
- Many homeowners may not have informed their insurers about upgrades to their homes, which could increase the replacement cost.
- Meeting new code standards can lead to significant additional and unanticipated costs.
- Insurance companies, although required to provide complete replacement cost estimates,⁵¹ may nonetheless underestimate rebuilding costs. Their models are based on factors that include local labor rates and materials prices and may not accurately reflect external elements such as those noted above.
- People often seek the most affordable insurance, which may not provide appropriate coverage to replace their homes in the event of a total loss. Homeowners should review their policies and understand what their coverage limits are, updating them periodically.

Equally problematic for California home and business owners, the fires have highlighted that many insurers have been underpricing fire risk and in places are overexposed to that risk. Insurance claims following the Camp Fire, for example, pushed a small insurance company to insolvency.⁵² The California Department of Insurance documented that, in 2018, state homeowner's insurance companies paid out \$1.70 for every dollar they collected.⁵³ In response, insurance companies are significantly increasing rates for many customers and choosing not to renew others.

While higher premiums may more accurately reflect the wildfire risk, the increases pose a significant hardship for many homeowners. Many homeowners in high and very high fire hazard severity zones are poorer and/or retired and on fixed incomes. Even for those with more financial flexibility, covering significantly higher costs – in some cases by as much as a factor of four – is a challenge. This is often better, however, than facing no coverage at all.

The California Fair Access to Insurance Requirements (FAIR) Plan provides last-resort insurance options to homeowners unable to obtain coverage through traditional sources. However, it is priced to reflect risk, so it is not a bargain, and it only provides coverage for certain causes of loss, fire being one of them. Homeowners need to purchase other policies if they want more complete coverage.

Some communities are taking communal steps to make insurance more attainable. For example, neighborhood leaders in the Lake Tahoe Basin, in collaboration with the Tahoe Network of Fire Adapted Communities, took the risk assessment and mitigation steps necessary to be verified by Firewise USA⁵⁴ as a "Firewise community." The program is recognized by the Departments of Insurance in seven U.S. states, giving homeowners insurance discounts. Firewise also provides benefits in the form of reducing the potential for loss and in building a sense of community. Despite proven programs and approaches, many communities still do not proactively mitigate for wildfires.

How can California protect financial livelihoods, but avoid incentivizing risk?

While private flood insurance is uncommon, private insurers generally provide policies that cover fire risk. The National Flood Insurance Program (NFIP) was created by the U.S. Congress in 1968 to address the risk of flood losses and to reduce flood damage by restricting floodplain development. Congress intended that operating expenses and flood claims would be paid for through policy premiums. Instead, NFIP has inadvertently incentivized development in floodplains and along the coast in places now under increasing threat from sea level rise, in part because policy rates have been set artificially low. This has also contributed to the program's current debt of over \$20 billion (not including the \$16 billion in debt that Congress canceled in 2017).*

However, rates are increasing and some risks are no longer covered. As the U.S. government considers how to protect residents due to changes in the insurance market, it should learn from the NFIP.

If state or federal governments provide access to fire insurance at rates that are not risk-reflective, they could inadvertently incentivize increased development in the WUI much the way NFIP has incentivized development in high flood hazard areas. Ideally, government coverage would be used as a safety net for existing homeowners but would not be extended to provide coverage to new development exposed to high fire hazard. To do otherwise could encourage continued development in areas that would be safer to leave undeveloped while perpetuating the perception this type of housing is "inexpensive."

* Editorial Board. "Flood insurance reform won't be pleasant. But it's necessary." The Washington Post. 30 March 2019. https://www.washingtonpost.com/opinions/flood-insurance-reform-wont-be-pleasant-but-its-necessary/2019/03/30/8f07f198-4a72-11e9-93d0-64dbcf38ba41_story.html

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54 Firewise USA, National Fire Protection Association. <https://www.nfpa.org/Public-Education/Fire-causes-and-risks/Wildfire/Firewise-USA>



Montecito, California
January 2018

At almost nine months post-fire, communities impacted by the Camp and Woolsey fires were still in the debris removal process, estimated to be a \$2 billion to \$3 billion project.⁵⁵ As of mid-July 2019, the Consolidated Debris Removal Program had removed over 2.4 million tons of debris from Paradise and had cleared more than 7,000 properties.⁵⁶ In Los Angeles and Ventura counties, 94% of eligible properties had been cleared, with close to 400,000 tons of debris removed.⁵⁷

The large number of burned and dead trees in Paradise that need to be removed also complicates and lengthens the debris removal process. As of August 2019, 600,000 fire-damaged trees still needed to be removed from private property in and around Paradise. For some homeowners, insurance covers some or all of the cost of removing trees; others may have to bear the costs themselves, costs that sometimes exceed the value of the property itself. Paradise and other organizations are making efforts to assist property owners with tree removal. In particular, the Butte County Fire Safe Council is applying for grants and the town is working with Cal OES and FEMA to develop a program to financially help property owners pay for removal of dead trees.

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Often overlooked: How to recover

In the U.S., we rarely prepare for recovery. We tell people how and when to evacuate, but not how to return, nor how long it might be before they can come back or what returning involves. For those returning, it may mean coming back to a community irrevocably damaged by a fire, whether because of the lives lost, the infrastructure and utilities destroyed, the neighbors who decide not to return or a combination of all of the above.

Debris removal

Following a wildfire, the first step in recovery and rebuilding is debris removal, which is a herculean task that can take months to complete and can dramatically slow the pace of recovery. Not only does the sheer amount of debris (e.g., burned cars, structures, and vegetation) contribute to the slow pace of removal, so too does the toxic nature of the debris. When burned, appliances, cars, household chemicals and building materials leave behind extensive chemical contamination that presents a challenge for both debris removal and disposal.

California is unique in having a state-run debris removal program, the California Office of Emergency Services (Cal OES) Consolidated Debris Removal Program. Under this program, the state works with the city or county to conduct a two-phase debris removal process. The first phase involves the identification and removal of household hazardous materials from properties in consultation with California's Department of Toxic Substances Control and the U.S. Environmental Protection Agency.

The second phase consists of the removal of the remaining debris and requires that property owners sign a Right of Entry form to allow contractors onto their properties if they want this service. This phase also includes the assessment and removal of remaining hazards, including an evaluation of soil quality and the implementation of erosion control measures. Debris removal is finished when property owners receive a certificate indicating their property is free of hazardous materials and debris and is ready for permitting. If the city, county or homeowner chooses not to participate, owners must hire private contractors to carry out debris removal.

"You can't have a town without water": Toxic benzene in the water supply

When the Tubbs Fire burned the Fountaingrove neighborhood in Santa Rosa, it left behind not just toxic debris, but also toxic water. Benzene and other substances contaminated sections of the potable water system, leaving water unfit for drinking, cooking or bathing. Resolving the problem required the replacement of household water lines, a quarter-mile section of water main, and other water delivery equipment, at a cost of \$8 million and 11 months of effort. Yet this experience, the first time anything like this had been detected in a wildfire, now pales in comparison to the challenges in Paradise.

Paradise initially celebrated one of the few rays of hope to come out of the Camp Fire: that the potable water treatment plant was untouched by the fires. However, the celebration was short-lived. When the town restarted the system post-fire, extensive

benzene contamination was discovered – likely due to a combination of toxins released from melting plumbing and water meters and the cocktail of toxic gases released from burning homes sucked into water lines as the system depressurized during the fire. It is estimated it will take two to three years and \$300 million to test the system, and isolate and replace the contaminated sections. A water systems engineer interviewed on this topic said that solving the benzene contamination problem is the most "scientifically complex" task he has ever seen.⁵⁸

The scientific complexity is exacerbated by regulatory complexity. With the exceptions of lead and copper limits, the Safe Drinking Water Act does not apply to water that comes out of faucets. It only applies to water as it leaves the treatment plant. Consequently, state and federal regulators have been slow to respond in Paradise because contamination occurring between the plant and the tap does not fit neatly into existing regulatory boxes. Regulators have no authority to regulate water once it has entered an individual property.⁵⁹

Paradise Mayor Jody Jones has acknowledged, "You can't have a town without water."⁶⁰ While working to ensure and certify lines that are clean, the Paradise Irrigation District is providing free cases of bottled water to residents daily and is arranging clean water tanks for households and businesses as they move back to town. Their success could set the bar for future scenarios. The Santa Rosa and Paradise water system contamination challenges may have been firsts for California, but they are unlikely to be the last.

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Paradise, California
November 2018

**A choice to make:
Rebuild or pull up roots**

Whether or not people choose, and are able, to move back has implications for what a community looks like after a fire and if it resembles the community it was before. Rebuilding costs, market forces and employment opportunities often prevent former community members from moving back while simultaneously opening the door for investors and those who are willing and able to buy. This not only means that a community may not be the same community it was before a fire, but that many people lose their social networks as well as their homes in a fire.

For those whose homes survived, recovery often means returning to a neighborhood pockmarked with the empty spaces of homes that burned, to a home marred by smoke damage, to a town lacking key infrastructure and to a community deeply impacted by the wildfire. For those whose homes burned, recovery means making a decision based on a complex set of factors, including insurance coverage, expense of rebuilding, and the extent of damage. Moving elsewhere presents its own set of challenges, including relocation costs, finding employment, changing children's schools and the loss of a social network.

For those who decide to rebuild, recovery often means navigating a complex and years-long process of debris cleanup, permitting, code compliance and contracting. Almost two years out, the city of Santa Rosa and Ventura County were still in the process of recovery from the Tubbs and Thomas fires and debris flows, respectively. As Table 1 shows, even 18 months after the fire, only 273 structures in Santa Rosa had been rebuilt, while nearly 1,500 were still under construction (see Table 1). While recovery timelines are highly dependent on local resources and support, these numbers highlight how long it can take even better-resourced communities to recover from a wildfire. For low-resource communities, the recovery timeline may be even longer.

Table 1. Rebuilding Santa Rosa after the Tubbs Fire (Totals are cumulative.)

Homes destroyed by wildfire	Approximately 1,800
3 months post-fire	9 building permits issued 1 unit under construction
6 months post-fire	153 building permits issued 87 units under construction Pacific Gas & Electric Company starts undergrounding electric and gas utilities with a goal of finishing by 12 months post-fire
9 months post-fire	654 building permits issued 499 units under construction 5 units completed
12 months post-fire	1,150 building permits issued 945 units under construction 38 units completed
18 months post-fire	1,677 building permits issued 1,451 units under construction 273 units completed

Source: City Manager's Office. Santa Rosa, California. 2019 August.

The length of time and expense involved in rebuilding often forces homeowners, even those who might prefer to stay, to sell and move. In recognition of these expenses, California required insurers to cover two years of temporary housing in the case of a federally declared disaster. This length of time was extended (effective for claims that arose on or after Sept. 21, 2018) to 36 months,⁶¹ in light of the fact that 24 months was insufficient to rebuild the homes destroyed in the 2017 fires. The process of debris removal, obtaining all necessary building permits, locating and hiring contractors and subcontractors, and completely rebuilding a home is slow, at best, and further slowed when thousands of homeowners are attempting to rebuild simultaneously.

The rebuilding process can be as challenging for municipalities and counties as it is for individual homeowners. Few jurisdictions have the permitting department and inspection capacity required to meet the dramatically increased demand. To facilitate the rebuilding process and to overcome these challenges, the municipalities of Paradise, Santa Rosa and Malibu hired outside firms to provide additional resources and to support property owners in navigating the rebuilding process.

**Unscrupulous contractors:
Impediments to recovery**

In the aftermath of a disaster, communities must navigate a complex recovery and rebuilding process that is often complicated by unscrupulous contractors who are willing to take advantage of the situation. Fire survivors, already struggling to deal with response and recovery, are often easy prey for these scammers.⁶²

As homeowners receive their insurance payouts in the weeks and months after a disaster, they all too often hand over their full payment to people they believe are legitimate contractors in the hopes of rebuilding quickly, only to discover they have been deceived. These scammers will collect insurance checks from 10 to 20 families, then disappear.

There are communities, cities and nonprofits offering resources to help guide fire survivors in the rebuilding process. For example, the website of SBP,⁶³ a New Orleans-based nonprofit that formed after Hurricane Katrina, provides straightforward guidance for homeowners on avoiding contractor fraud.⁶⁴

Additionally, many fire survivors have recommended the development of a centralized reconstruction system early in the recovery process. Organizations with trained professionals who understand how to conduct rebuilds could be brought in to work with community members and help them identify legitimate contractors. Those contractors would create proposals to rebuild swaths of the community, not just one home at a time, to leverage economies of scale and to build back better. Doing so would streamline the process for the hundreds, if not thousands, of impacted community members and would take the vetting of potential contractors out of the hands of those already struggling to process their response and recovery.

Leveraging the reconstruction process to build resilience

Any loss of structures and lives is a tragedy, and emphasis should always be placed on pre-event risk reduction and planning to avoid impacts. However, once damage has been done, the reconstruction and recovery process and the money available at that time should be used as the opportunities they are to build back better, to build in resilience, and to reduce future risk.

This is perhaps not the easiest path; the primary focus post-disaster is getting things back up and running as quickly as possible. Unfortunately, the drive to return to normal often means rebuilding the same, locking in the same exposure and vulnerabilities.

Officials in Paradise, in spite of or perhaps because of the massive scale of reconstruction, are actively using the opportunity they have been given. In setting up electric lines, Pacific Gas and Electric Company (PG&E) announced it would fund undergrounding electric lines in Butte County communities impacted by the Camp Fire.⁶⁵ Paradise, the largest unsewered city in California, hopes to use the reconstruction period to install a sewer system in the central part of town. It is no small undertaking: Even if implemented during reconstruction, the construction of a sewer system could take years and cost an estimated \$85 million.⁶⁶ With the support of Urban Design Associates, Paradise has engaged in a community resilience review and is taking active steps during the recovery process to address resilience gaps, such as building standards, evacuation routes and comprehensive mitigation.

Ventura County officials are also leveraging their situation after the disaster to reduce risk and rebuild better as they face the dual challenge of rebuilding from the Thomas Fire and the subsequent debris flows. Because the Thomas Fire denuded and destabilized the slopes above Montecito, the risk of further debris flows will remain high for at least the next five years. In response, the Partnership for Resilient Communities, a nonprofit founded by private residents following the Thomas Fire and Montecito debris flows, has worked with other nonprofits, as well as with the state, private landowners, and environmental advocates, to install steel debris nets in the watersheds above town to catch future debris flows. By July 2019, they had successfully installed four nets and were in the process of fundraising to install two more.

In contrast, while some neighborhoods in Santa Rosa are required to and will rebuild in compliance with Chapter 7A codes, not all neighborhoods are availing themselves of this opportunity. Despite having been burned during the Tubbs Fire in 2017, homes in the Coffey Park neighborhood of Santa Rosa opted not to adopt the 7A codes, and the codes are not required because the neighborhood is not in a very high fire hazard severity zone. Fortunately, many homeowners and builders are choosing to incorporate some elements of the Chapter 7A codes. Given that Chapter 7A code compliance can be achieved with potentially no additional cost for new construction, not adopting the full code is a lost opportunity to build in greater fire resistance.

62 "Avoiding scams after a disaster." Insurance Information Institute. <https://www.iii.org/article/avoiding-scams-after-a-disaster>

63 Zurich contributes grant funding and volunteer hours to the disaster resilience nonprofit SBP. <https://www.zurichna.com/en/knowledge/articles/2017/04/zurich-and-sbp-help-communities-reduce-impact-of-natural-disasters>

64 "Protect yourself from contractor fraud." SBP. https://sbpusa.org/public/uploads/elearning/mod-2-contractor-fraud-web/story_html5.html

65 This is as much cosmetic as functional, however. Undergrounding lines could help reduce the risk of a fire igniting in town, but the majority of the risk is the thousands of miles of lines crisscrossing forest and open range. Nonetheless, if lines are to be undergrounded, the reconstruction phase is certainly an efficient and cost-effective time to do it.

66 Alexander, K. "Reclaiming Paradise." San Francisco Chronicle. 3 May 2019. <https://projects.sfchronicle.com/2019/rebuilding-paradise/>

61 Lara, R. "Allowance for 36 months of additional living expenses coverage after the 2017 wildfires due to delay in the rebuilding process beyond the control of policyholders." California Department of Insurance, State of California. 28 May 2019. <http://www.insurance.ca.gov/0250-insurers/0300-insurers/0200-bulletins/bulletin-notices-commiss-opinion/upload/ALE-Extension-Notice-Final.pdf>

Learning from the fires

The 2017 and 2018 fires provide opportunities for learning beyond just reconstruction. Local communities and the state are implementing lessons learned to prepare for and mitigate their risk to future wildfires. At the state level, there are several legislative proposals pertaining to housing, egress routes, vegetation management, funds for retrofitting homes and early warning systems. Following the 2018 fires, the governor of California assembled a “strike force” to develop recommendations to reduce the risk of wildfires. The report,⁶⁷ released by the governor’s office, focuses on five areas:

- Catastrophic wildfire prevention and emergency response
- Mitigating climate change through clean energy policies
- Fair allocation of catastrophic wildfire damages
- A more effective California Public Utilities Commission with the tools to manage a changing utility market
- Holding PG&E accountable and building a utility that prioritizes safety

Based on their findings, the strike force developed several proposals in each of these areas. These proposals include:

- Creating a \$21 billion fund to help stabilize the power utilities in the wake of the 2017 and 2018 fire seasons. The fund, paid for by investors and ratepayers, would assist utilities in settling claims following a wildfire, while also protecting them from going bankrupt.
- Requiring that utilities invest in safety measures, including early warning systems, and harden their infrastructure to fires.
- Mitigating climate change through the implementation of clean energy policies that reduce greenhouse gas emissions.
- Improving methodologies to assist the state in identifying at-risk communities.
- Investing in technology to monitor and reduce fire risk.
- Addressing the need to develop low-cost retrofits for homes built before 2008.

At the local level, communities across the state are looking at what happened during and following the fires and are making changes to reduce their risk to future events. Malibu created the position of a fire safety liaison following the Woolsey Fire to facilitate community engagement and outreach and to support homeowners and the community in preparing for wildfires. With the support of a grant from CAL FIRE, the city is developing a Community Wildfire Protection Plan to help strategically reduce wildfire risks. The city also requires that homeowners submit fuel modification plans to the fire department to ensure that properties are meeting defensible space requirements, including spacing of vegetation and the correct type of plants.

Paradise approved several ordinances related to the hardening of structures and defensible space. It also plans to build a more connected roadway network to streamline evacuation in the future, including the construction of a bike path that will serve as a roadway for emergency vehicles in the case of a fire. Residents have adopted the “Zone Captain System” used in Santa Rosa following the Tubbs Fire to help share information and resources, to facilitate communication with the town and to assist in community-level mitigation efforts.

Rethinking power systems

Of the 21 major fires that raged through Northern California in 2017, state officials have blamed 17 of them on equipment from PG&E, California’s largest electric utility.⁶⁸ The utility’s equipment has also been blamed for accidentally starting the Camp Fire in 2018.⁶⁹

A lawsuit filed in November 2018 blames Southern California Edison for the Woolsey Fire in a November 2018 lawsuit.⁷⁰ These facts and allegations highlight the power grid as an area of critical vulnerability for societies living in fire-prone environments. High-voltage electrical lines running through thousands of miles of increasingly flammable terrain pose an extreme fire risk, and current strategies for addressing that risk are insufficient – and controversial.

PG&E has adopted what it calls a “last resort” tactic to address this problem. In periods of extreme fire danger, when winds and temperatures are high, humidity is low, and

fuels are bone-dry, the smallest accidental spark can result in conflagration. Under such conditions, PG&E will preventively cut power. In theory, this tactic appears to be a solution. In practice, it has several weaknesses. The first is the willingness of customers to accept this solution. The New York Times, in a July 2019 article, noted that three weeks prior to the Camp Fire in Paradise: “...PG&E instituted its first, and ultimately only, shutdown of the 2018 fire season, cutting electricity during a windstorm to nearly 60,000 customers in seven counties. It took two days to restore everyone’s power; citizens and local governments fumed.”⁷¹

Shutting off power and having no fires break out will almost certainly engender this response in current culture. This is a challenge faced in every potential disaster situation. If you ask people to take action or bear hardship, at least some proportion of the population will be upset if conditions are such that they do not feel that hardship or action was warranted. We are not very good at seeing beyond what did not happen to what could have happened and celebrating the disaster avoided. This reality of human nature means that every power shutoff that successfully avoids a fire will also be protested by those who lost power – a losing proposition for the power companies – unless we can dramatically change public perception and awareness around fire risk.

The second challenge is the adaptive response of those likely to be impacted by power cuts. Some businesses and homeowners are already investing in generators. Thousands of generators distributed throughout the WUI that are operated only infrequently and are potentially poorly maintained will also pose a potential fire risk. Shifting from high-voltage lines to individual generators is likely to prove maladaptive unless wildfire-prone jurisdictions find ways to get ahead of this risk through awareness raising and training, both among their residents and local fire departments.

Beginning in 2020, California building codes require that all new homes must incorporate solar power. The codes also incentivize demand-responsive technologies, including battery storage. These are excellent first steps toward a system where, if the power needs to be turned off, impacts are minimal; eventually, they may lead to a system where long-distance high-voltage transmission lines are no longer necessary.

U.S. wildfire resilience best practices

By Ray Rasker, Executive Director, Headwaters Economics

California’s Chapter 7A building codes are only one tool in a toolbox. There are a wide variety of land use planning tools that can be adapted to wildfire. For example:

- San Diego requires a mandatory 100-foot defensible space around homes. A similar law is in place in Flagstaff, Arizona, and in other communities.
- Taos, New Mexico, prohibits development on steep slopes unless mitigation measures are met.
- Chelan County, Washington, passed a development code that requires wildfire-resistant building materials.
- Missoula County, Montana, uses detailed wildfire hazard maps to appraise new developments and reject those in high hazard areas.

As we think about tools, however, we need to be cognizant that merely pushing out information is not enough; to achieve risk reduction, we are increasingly recognizing we need to develop policies, codes and a regulatory system that implements and supports those tools.

With more than one-third of U.S. homes on wildfire-prone landscapes, the challenge is to focus on the “home ignition zone.” This is the house itself, its construction materials and the landscaping around the house.



Ray Rasker is the Executive Director of Headwaters Economics, an independent, nonprofit research group that works to improve community development and land management decisions.

Since the vast majority of homes that burn are ignited from flying embers and not direct flames, we need to focus on where the embers will land and what will catch fire. Will it be the cedar shake roof? Or the pine needles in the gutter? Maybe the wood pile stacked under the deck? Or will those flaming embers get sucked into the house through the attic vents?

Paying attention to these small details makes a huge difference. Post-fire aerial photos of neighborhoods show that some homes survive while others don’t. Clearly, some landowners are preparing for wildfire while others are not. Educational programs can teach people how to create defensible space around their homes and suggest using flame-retardant building materials. But voluntary landowner education, while important, is by itself not enough.

Imagine, for example, if we used a voluntary adoption approach to road safety – that instead of traffic laws enforced by the police, we asked people to please slow down and to consider stopping at stop signs and traffic lights to keep themselves and other people on the road safe. It would be a disaster. Instead, we have created a regulatory environment, coupled with enforcement and penalties, that collectively makes us safer even as it imposes requirements on individuals. We are at the point where we need to use this approach with wildfire; our current approach of education and voluntary uptake is not working everywhere, and is not working fast enough.

The great urban fires of the late 1800s were a wake-up call for America – we saw clearly the extent of our risk and at the same time a way to mitigate that risk, and we seized it. We developed and imposed building codes, applied zoning and enforced regulations with penalties. We installed fire protection infrastructure such as fire hydrants and taxed ourselves so that we could hire and embed full-time firefighters in our neighborhoods. Since then, as fire historian Stephen Pyne has pointed out, there have been only occasional outbreaks “akin more to a flu than an epidemic.” In urban areas, it seems we have solved the fire problem. So why not do the same in the WUI?

67 Wildfires and climate change: California’s energy future. Office of Governor Gavin Newsom, State of California. 12 April 2019. <https://www.gov.ca.gov/wp-content/uploads/2019/04/Wildfires-and-Climate-Change-California%E2%80%99s-Energy-Future.pdf>

68 Penn, I., Evans, P., & Glanz, J. “California wildfires: How PG&E ignored fire risks in favor of profits.” The New York Times. 18 March 2019. <https://www.nytimes.com/interactive/2019/03/18/business/pg-e-california-wildfires.html>

69 PG&E External Communications. “PG&E responds to Camp Fire announcement from CAL FIRE.” 15 May 2019. https://www.pge.com/en/about/newsroom/newsdetails/index.page?title=20190515_pge_responds_to_camp_fire_announcement_from_cal_fire

70 Edison International. “SCE publicly releases CPUC submission on the Woolsey Fire.” 26 December 2018. <https://newsroom.edison.com/releases/sce-publicly-releases-cpuc-submission-on-the-woolsey-fire>

71 Mooallem, J. “We have fire everywhere”: Escaping California’s deadliest blaze.” The New York Times. 31 July 2019. <https://www.nytimes.com/interactive/2019/07/31/magazine/paradise-camp-fire-california.html>

Section IV: Key insights



Angeles National Forest, California
March 2018

The California wildfires of 2017 and 2018 are the “new normal”

The phrase “a new normal” is often bandied about in the aftermath of disasters. In the case of the California wildfires, there is evidence to support that characterization. This new normal is shaping up to include increasingly intense fires spread over a longer, less predictable season. Contributing factors include increases in temperature over the past

several decades and changes in precipitation timing and intensity, leading to both extended droughts and delays in fall rains. The rains used to begin before the onset of the powerful Santa Ana and Diablo winds that, in dry conditions, can so quickly turn a spark into flames. Beyond weather, wildfire impacts on life and property are heightened

by increased development in fire-prone environments. Unless these trends change, the potential for catastrophic wildfires is likely to remain and even grow. We need to find better ways to prepare for and recover from wildfires of increased scale, intensity and regularity.

Many Californians impacted by fire are slow to take actions to reduce their risk

The 2017 and 2018 wildfire seasons in California have made wildfire danger in the state very apparent. Awareness of wildfire risk is not translating to risk-reducing action quickly enough, even among those impacted by recent fires. As they are technically not in a very high fire hazard severity zone, residents of Coffey Park in Santa Rosa who were impacted by the 2017 Tubbs Fire are allowed to rebuild without following the Chapter 7A fire-resistant building codes. Local officials felt the fire was so exceptional that stricter codes were not necessary. Paradise adopted a defensible space ordinance and approved many updates to their codes, such as requiring noncombustible gutters and forbidding the use of railway ties in retaining walls. Ancillary structures also now must be built to the WUI code and the town approved the adoption of a defensible space ordinance. But Paradise did not approve all recommended updates. The cost of retrofits and building to code, the aesthetic appeal of maintaining vegetation close to homes and the perception of recent fires being exceptional contribute to complacency and continued fire vulnerability.

Fire severity is difficult to predict and assess, complicating planning and response

Wildfire behavior is dependent on interactions between weather, fuel and local topography. Therefore, understanding the severity of a fire before it happens or as it is occurring is virtually impossible. Numerous models are available to help determine, once a fire has ignited, how it is likely to spread. These are highly effective in many, if not most, fires. However, for extremely fast-moving fires, fires driven by highly localized topography or weather conditions, and/or urban fire spread, such as the four fires explored in this study, the models are not yet sufficient to support real-time operations and inform procedures like evacuation notifications.

Because of the complex nature of fire prediction, a fire's severity is usually categorized, post-event, based on the number of deaths, acres burned, structures destroyed and damaged and burn severity (i.e., the impacts of the fire on fuels and soil). However, there is currently no measure that assesses how unusual (or not) a given fire was. Consequently, it is also hard to assess how to

recover and prepare for future events. For example, was the event exceptional and unlikely to recur in the future, or should a community prioritize rebuilding to be resilient to an event of a similar magnitude?

More data on benefits and costs of mitigation could help set priorities

Mitigation and ongoing maintenance of defensible space are effective in reducing risk. This includes the layout of towns and communities, how structures within communities are built, the materials structures are built with, landscaping of the space around structures, and how structures and landscapes are maintained. Fire hardening guidelines that have been proven to work include national Firewise USA guidelines, California's Chapter 7A building codes, and guidelines recommended by the Insurance Institute for Business & Home Safety.⁷² The challenge is not so much the availability of information, but implementation.

More data and information are needed on how different elements of mitigation interact during a fire and which elements might be more cost-effective than others. This is particularly true as California considers how to address the need for low-cost, fire-resistant retrofits. A clearer understanding of which elements of a fire-resistant structure and its landscaping have the greatest benefit would support homeowners, businesses, municipalities and others in prioritizing fire-resistant upgrades.

The costs of a wildfire far exceed its direct impacts

Wildfires are devastating in their impacts and can destroy communities and take lives. Yet the full costs go far beyond just these direct impacts. In balancing the perceived costs of wildfire mitigation, hardening structures, maintaining property and purchasing adequate insurance, we need to realistically consider the true costs of fire.

Fires have cascading effects on local and regional economies. Loss of housing impacts the housing market, and the loss of a large percentage of housing can heavily impact utilities, making repairs difficult without financial reserves. The inability of residents to return to their community or to work disrupts local labor markets; for small communities, whole supply chains and business areas can be impacted.

Even the best insurance rarely covers all costs. United Policyholders, a consumer advocacy group, estimates that two-thirds of California fire survivors are underinsured.⁷³ For businesses reliant on local clientele, both displaced families and households with less available spending money can significantly reduce business income and potentially threaten viability entirely. Disruptions in social networks, the trauma of evacuation, and loss of property can have long-term impacts on mental and emotional health on everyone in a community in the months and years following a fire.

We do not prepare people for a fire's aftermath

Disaster preparedness programs educate communities on what to do before and during a fire, but a gap exists in preparing communities for what happens after a fire. Municipal and county governments rarely plan for recovery and the financial and human resources that will be needed. Businesses, homeowners and renters do not always consider what their options might be if they are impacted or how to make sure they are best positioned to be able to make good decisions and recover well. This is particularly unfortunate because post-fire, money is being invested and small changes in how those investments are made can significantly increase resilience moving forward.

Post-disaster, there is information to support good recovery decisions, but those trying to recover are often too busy trying to get back to "normal" to actively seek that information. Federal, state, county and municipal governments, as well as nonprofits, can and should think about how they can support resilient recovery so they are prepared with readily available information, guidance and support when and where it is needed. They should also understand who the target audiences for that information are before the events. A small investment in recovery planning can contribute to substantial property owners' investment in resilience at little to no additional cost.

⁷² Prepare for Wildfire. Insurance Institute for Business & Home Safety. <https://disastersafety.org/wildfire/>

⁷³ Denning, L. "Wildfire took your home? Don't count on insurance rebuilding it." Bloomberg. 11 April 2019. <https://www.bloomberg.com/opinion/articles/2019-04-11/home-insurance-may-not-rebuild-after-wildfires-other-disasters>



Santa Barbara, California
May 2009

Ensuring adequate insurance is complex

The 2017 and 2018 California wildfires pointed to gaps in insurance in terms of coverage, awareness and communication. In particular, many homeowners impacted by the fires found out during the recovery process that their insurance payments did not meet their recovery costs. Addressing this issue is a responsibility shared by property owners, insurance companies, insurance regulators and governments.

Currently, policyholders largely determine how much coverage is adequate for their needs. However, too often homeowners focus on getting insurance at an affordable price and do not look at what is covered. Most insurers use a tool to estimate the replacement cost of the home based on the home's features, such as age and square footage. However, replacement costs can end up being significantly higher than the estimate due to various factors, including policyholders failing to inform their insurer of upgrades or expansions, surge pricing post-fire, required code upgrades and similar external factors.

On the commercial side, businesses typically carry insurance on assets but often fail to consider business interruption or other cascading impacts from a wildfire. Even those that do have business continuity insurance and other safety nets often underestimate the extent of those adverse impacts from a fire. These gaps can also affect local governments, including those that provide utility services. The Paradise Irrigation District, for example, realized only after the fire that individual home water meters were not part of their coverage and now face the full, uninsured cost of replacing the meters.

Finally, the state is caught between wanting to ensure residents are adequately covered and recognizing that requiring higher levels of coverage could price many people out of the insurance and/or home-owning market. Insurers are already raising rates in recognition of underestimated risk. Ongoing collaboration and due diligence are needed to balance risk, insurance requirements and insurability in ways that work for all parties.

Despite fires, development continues in the wildland-urban interface

Development in the wildland-urban interface (WUI) is driven by population growth and housing demand. As housing prices increase in cities, the WUI appears to be one of the more affordable options. Concurrently, the desire to live in beautiful, less-developed environments is pulling higher-income homeowners away from urban centers to smaller communities located on city outskirts and in the foothills of nearby mountains.

This exurbanization and continued development of forest land is beneficial for local municipalities as it provides new property tax revenue, which can help compensate for caps on property tax. Designed to help homeowners by keeping property taxes low, these caps now incentivize high-risk development and pass the potential costs involved with fighting and recovering from wildfire on to taxpayers.

Until economic and amenity incentives change, it is unlikely the trends toward increasing development into the WUI will change. This increases the urgency to find ways to build and live in the WUI that decrease vulnerability. This must include consideration of areas in which development should be avoided because the hazard is too high or egress is too limited, or deeper consideration of how we build when we do decide to develop in high-hazard areas. In particular, clustering structures and surrounding them with a buffer zone, similar to the Pepperdine University campus, could help reduce vulnerability, even in high-hazard environments.

There is an urgent need to fully understand the real cost of living in these areas and make this information far more transparent so that we don't later discover that our inexpensive housing has either financially ruined thousands of people or is costing us as a society far more than we can realistically afford.

Reducing risk in the wildland-urban interface is a shared responsibility

The WUI consists of a tapestry of federal, state, municipal and private lands. If one of these stakeholders fails to maintain their property, their inaction increases wildfire risk for everyone. Federal, state and local governments and utilities are becoming increasingly responsive; they face legal, political and financial consequences if they fail to be proactive. Private properties are more challenging and more numerous.

Ongoing mitigation and maintenance are key; however, particularly for individual residents, this can be technically, physically and financially challenging. Many residents in the WUI are elderly, disabled, and/or low-income, and are physically unable to maintain their property and/or financially unable to retrofit their homes. Many other residents are renters or seasonal tourists and are unaware of the risk they pose to their neighbors and community by failing to maintain their property.

As occurred in both Santa Rosa in the Tubbs Fire, and in Paradise in the Camp Fire, a single home resisting ignition can provide a shadow effect, protecting other homes. Conversely, a single home igniting puts the structures around and downwind of it at risk. As wildfire risk increases, the recognition that response requires coordinated, community-wide engagement will increase, and, ideally, so too will action.



A hero from the Montecito mudflows focuses on wildfire mitigation

Maeve Juarez is credited with saving dozens of lives⁷⁴ despite nearly losing her own during the January 2018 mudslides and debris flows in Montecito, which were triggered by heavy rains following the 2017 Thomas Fire.

It isn't the only time Juarez has helped save lives during or after a wildfire. She spent 20 years fighting fires as part of the U.S. Forest Service, most recently as a Battalion Chief with the Los Padres National Forest nearby. The Montecito Fire Protection District recruited her as a Wildland Fire Specialist in 2016. When a wildfire isn't raging, her focus now is squarely on improving Montecito's wildfire resilience.

"Our main goal is to work with communities on structure hardening and defensible space," Juarez said of herself and the other wildland fire specialist on staff, Nic Elmquist. "We respond to wildland fires during fire season, but the rest of the year we're focused on education and prevention. We view wildfire prevention as collaborative. No one thing will work, so we spend time with property owners on all aspects of prevention. Having two dedicated wildland specialists working with the public and building relationships is absolutely invaluable here."

While the tax-based funding of wealthy Santa Barbara County supports their efforts, Juarez notes that grants exist to help fund resilience programs in wildfire-prone communities. Here are some of Montecito's proactive efforts, which can be adapted to other areas and hazards.

Building permit reviews: "We're fortunate here to be able to share with residents and designers structure-hardening concepts before a home is built," Juarez said. That's because Montecito's building permit process requires Juarez or Elmquist to work with the Fire Marshal to review building plans prior to final approval. If a redwood deck is planned, for example, they would show the owner noncombustible alternatives to redwood. On a tile roof, they suggest concrete caps on the ends so embers cannot get in. They recommend fire-resistant paint and dual-pane windows, to provide one more layer of protection if one pane shatters from the heat of a fire.

Home visits: The fire department encourages residents to call with concerns about wildfire risks on their own or their neighbors' property. A call triggers a visit from Juarez, during which she may point out dry brush, dead trees and other wildfire fuels, such as debris in gutters or on rooftops. If residents do not have the means to remove these fuels themselves, the fire department helps.

Chipping program: The fire department's Neighborhood Chipping Program is a free service that encourages property owners in very high fire hazard severity zones to cut vegetation within three defensible space zones (0-30 feet from a structure, 30-100 feet and then 100 feet and out) and along driveways. "We then come through the neighborhood and chip and dispose of the materials for them," Juarez said.

"Having two dedicated wildland specialists working with the public and building relationships is absolutely invaluable here."

- Maeve Juarez,
Wildland Fire Specialist,
Montecito Fire District in
Montecito, California

Photo by Wendy Donahue

⁷⁴ Elam, S. "She narrowly escaped a deadly mudslide. Her heroic efforts saved dozens of lives." CNN. 22 February 2019. <https://www.cnn.com/2019/02/22/us/btc-california-fire-official-saves-lives/index.html>

Roadway clearance: During the Neighborhood Chipping, the department makes sure access and egress clearance is maintained for firetrucks and residents along main roads. "We drive the neighborhoods and any limbs that hang below 13.5 feet from the roadway are tagged for trimming," Juarez said. "We also have a contractor weed-whip grasses along all of our high roads. These efforts not only improve fire engine access, but also reduce the amount of heat that evacuating residents might be exposed to during a fire, improve visibility and expand the usable width of roadways on Montecito's narrow streets. We used to trim and weed-whip once a year, then twice. With 2019's rainfall we were on our fourth round by July."

Landscaping: The fire department offers landscaping tips and has a new demonstration garden in the station's backyard that uses rocks and drought-tolerant plants. These efforts show people they can still have a beautiful garden while being fire-wise.

Even without wildland fire specialists, informed residents in any community can implement many resilience measures. Juarez acknowledges limits to effectiveness if neighbors don't do the same. In a wildland-urban interface, Juarez said evidence suggests that a focused investment in wildfire resilience is worthwhile.

"While any loss is tragic, Montecito lost just seven primary residences in the Thomas Fire, and the damage overall was significantly less than models indicated in our 2016 Community Wildfire Protection Plan," Juarez said. "This demonstrated how the district's proactive actions over the past 20 years contributed to the successful defense of our community."



Section V: Recommendations

Wildfires do not respect jurisdictional boundaries. Preparing for, responding to and recovering from wildfires should not, either.

Actions based on lessons learned from the 2017 and 2018 wildfires must and will be taken by those directly involved with the fires at local and state levels, shaped by local and state priorities, available resources, and political and public will. These recommendations in no way seek to supersede those efforts. Instead, these are offered as a summary of the messages communicated during interviews conducted for this report and are condensed from more than 100 secondary sources reviewed as part of the study.



Apply and enforce California's fire-resistant building standards more widely

Addressing future wildfire risk will require thinking critically about which risk factors we can effectively and meaningfully address and committing to act on those quickly and decisively.

Chapter 7A of the California Building Code is an excellent first step in helping communities in the WUI reduce their vulnerability. Given that building to these codes can be done at little or no additional cost, they should now be applied and/or required much more broadly.

For example, if any structure in a community is in the wildland-urban interface (WUI), every structure in that community should ideally be built to the Chapter 7A standards. The 2017 and 2018 fires have illustrated that ignition of even one structure significantly increases the risk for all nearby and downwind structures; building codes should recognize this, too. To do otherwise misses a significant opportunity to increase the fire resilience of communities across the state.

The cost of building to the Chapter 7A standards is often cited as a barrier to adopting the code. However, a recent study by Headwaters Economics found "A new home built to wildfire-resistant codes can be constructed for roughly the same cost as a typical home."⁷⁵

This is an important finding. Construction and landscaping practices that are not wildfire-resistant are already contributing to increasing costs in insurance rates, firefighting and greater need for state support to wildfire survivors. There is reason to expect those costs will continue to rise with increasing wildfire risk. Adoption of fire-resistant construction in upgrades and in new builds, by those both in and outside currently mapped hazard areas, could help prevent the total loss of the property.

⁷⁵ Quarles, S. L., & Pohl, K. Building a wildfire-resistant home: Codes and costs. Headwater Economics. November 2018. <https://headwaterseconomics.org/wp-content/uploads/building-costs-codes-report.pdf>

Incentivize smart growth, particularly in the wildland-urban interface

The WUI is the fastest area of development in the U.S. This development will result in increased wildfire risk unless it is informed by past events. Local governments can address growth management through a number of tools. First, conducting Safe Growth Audits can help jurisdictions identify areas that are too topographically steep, heavily vegetated, prone to dangerous winds, etc., to safely develop. Policies, ordinances and plans should restrict growth in these areas.

As illustrated in Figure 5, planning and zoning can be used to develop in ways that decrease exposure and vulnerability. For example, using public lands, parks and playing fields to create buffer zones can reduce community exposure. Zoning can be used to further reduce exposure by mandating clustering of the built environment. Creating defensible space and ensuring transportation networks are interconnected and appropriately sized can reduce vulnerability. Parks and recreation centers within the city center can be designed to provide both recreational value and space to shelter in place as a last resort when conditions overwhelm the community's other plans. Codes can be used to influence building styles, building materials and landscaping.

Developers also play an important role in smart growth. Jurisdictions should incentivize developers (e.g., via tax credits and discounts on land sales) to develop in ways that allow for defensible space and road connectivity. This includes developing unused land within urban areas before expanding further into the wildland.



76 "Practice safe growth audits." American Planning Association. Zoning Practice. Issue number 10. October 2009. <https://planning-org-uploaded-media.s3.amazonaws.com/document/Zoning-Practice-2009-10.pdf>

77 Rasker, R. "The wildland-urban interface: The problem, trends, & solutions." Headwaters Economics. August 2018. https://headwaterseconomics.org/wp-content/uploads/wildfire_homes_solutions_presentation.pdf

Plan for recovery

Local governments, community groups and individuals should continue to promote wildfire preparedness, to develop and practice evacuation plans, and to build the capacity of city staff, first responders and residents to respond appropriately in an emergency. Increasingly, however, disasters are highlighting that in this planning we fail to consider recovery, leaving a significant gap post-event.

Fostering a discussion based on "What if?" scenarios can help communities think about the decisions they will face after a fire, flood, earthquake or other potential disaster. These discussions can occur in schools, in workplaces and in city departments. They can help governments, businesses and residents take concrete steps and build capacities, such as exploring existing resources and networks they can draw on, developing simple response and recovery plans, and reviewing insurance coverages. These discussions can help identify critical actions to take and key assets to protect in order to streamline recovery. These exercises can also provide space to consider how recovery could be used to build back better – thinking that is challenging post-disaster but is potentially easy to implement if planned well in advance.

Local and county governments should go beyond just this exploration and institutionalize recovery through developing and practicing recovery plans, and through building the capacity of staff to carry out tasks during the recovery. These plans should identify staff members and the recovery roles they will perform, roles that should be included in their job descriptions.

Los Angeles
October 2015



Consider the unthinkable to protect infrastructure and facilitate recovery

Water, wastewater removal, power, communications and transportation are all core infrastructure and service elements without which communities and cities cannot function. In reviewing and building resilience, special attention should be paid to how these systems can fail and what actions can be taken both in advance of a disaster and in reconstruction to increase robustness and redundancy in these areas. Doing so can help to identify gaps and potentially avoid severe complications during an event and in the recovery process.

The contamination of Paradise's water system, as one of the first such instances in North America, serves as a particularly potent lesson for water utilities around the globe. Any utility should consider possible weaknesses in critical services that may not have been factored into plans. For example, even if fire damage and benzene contamination seem unlikely, the lack of regulatory mechanisms safeguarding water quality between the water plant and residents' faucets, and the way this has slowed response to an already unanticipated and devastating impact, could also have implications in flood or drought conditions.

Thinking through the unthinkable, seeking out scenarios and experiences in other communities that provide powerful lessons, and exploring hypothetical "What if?" situations can help communities maintain provision of key services throughout and after a disaster and, in so doing, facilitate recovery. Identifying these lessons and generating actionable recommendations to avoid and prevent the impacts from future disasters are a key focus of this post-event review and others that we have conducted around the world on both wildfires and floods.⁷⁸



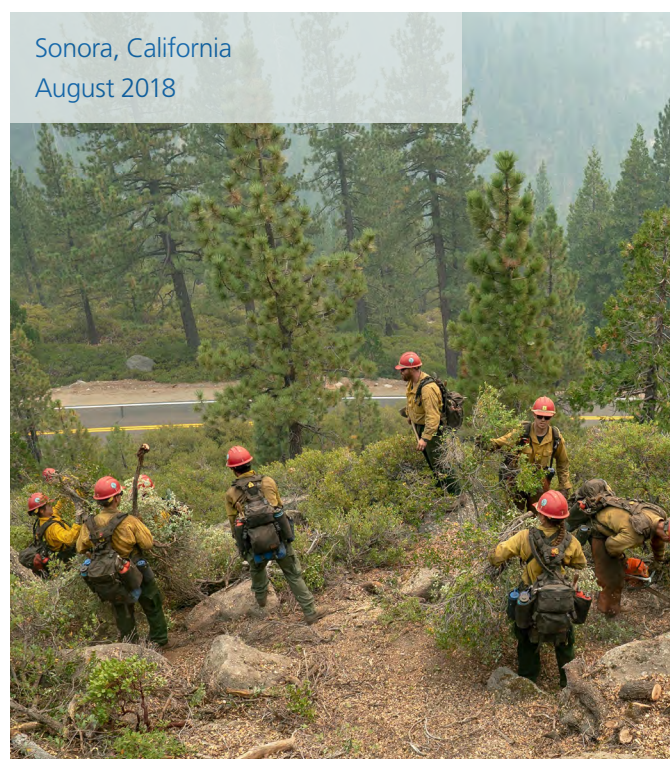
Water pipeline system repairs
September 2016

Develop a culture of wildfire mitigation to reduce collective fire risk

Fire risk can only be managed across scales through appropriate mitigation and the maintenance of defensible space at the individual, neighborhood and community levels. Because conditions on one property can either reduce or increase the fire risk of nearby properties, property maintenance in the WUI should be considered a social responsibility, ideally implemented through community networks, homeowner associations, coordinated government action and other stakeholders.

The Tahoe Fire & Fuels Team,⁷⁹ which consists of a variety of state agencies, educational institutions, local fire agencies and the U.S. Forest Service, focuses on projects to reduce wildfire fuels and to educate and support community members on wildfire adaptation measures. The program provides guidance on mitigation for communities, properties and structures through simple actions such as designing and maintaining adequate access and egress, using building materials and techniques that resist ignition, establishing community fuel breaks, and mitigating and maintaining individual properties and defensible space.

On a broader scale, community land use planning should be integrated with wildfire management. The Community Planning Assistance for Wildfire program,⁸⁰ for example, supports communities in rewriting community plans and regulations to reduce wildfire risk. Local governments in extremely high fire hazard areas should consider creating ordinances requiring homes and businesses in or near the WUI to establish and maintain defensible space for the community's safety. Insurance companies could consider discounts for property owners working with established programs to maintain defensible space, or surcharges for owners who do not, as such actions directly impact risk.



Sonora, California
August 2018

78 Post-Event Review Capability. Zurich Flood Resilience Program. <https://floodresilience.net/perc>

79 Tahoe Fire & Fuels Team. www.tahoefire.org

80 Community Planning Assistance for Wildfire. <https://planningforwildfire.org/>

Plan at the regional level for worst-case scenarios and beyond

Wildfires do not respect jurisdictional boundaries. Preparing for, responding to and recovering from wildfires should not, either. With this in mind, neighboring local, county and state governments should collaborate and prepare together, both for the immediate response to wildfire and for the potential cascading impacts resulting from related natural hazards (e.g., post-fire landslides or floods), infrastructure failure and disaster refugees.

Federal and state agencies should recognize these interconnections. The city of Chico responded as we would want and expect in a humanitarian disaster by opening their doors, activating their staff and making resources available to help Paradise. FEMA and Congress need to recognize this response as a justifiable and necessary expense that is eligible for reimbursement the same as any other expense associated with a fire. The flames may not have been in Chico, but the response to the disaster was. This will occur again, and we need systems that can respond accordingly. At the same time, local municipalities should prepare to draw on their financial reserves when a disaster hits a neighboring community. Fire is unpredictable, and a community could need help at any time.

Finally, as agencies, jurisdictions, organizations and individuals conduct this planning, they must not limit themselves only to what they have seen in the past. Each of the fires explored in this report was beyond anything ever imagined or planned. We must assume the fires of the future will follow this pattern, which means we must expand our ideas of a worst-case scenario and get much better at preparing for it if we want to minimize lives and assets lost and position ourselves well for recovery.



Santa Rosa, California
November 2017

Learn from California if you're in another wildfire-prone state

Montana, Idaho, Colorado, California and New Mexico are the top five states in terms of the percentage of households at high or extreme risk from wildfires.⁸¹ Recognizing this, even as California seeks to improve its wildfire practices, other states should learn from California's experience, both to speed adaptation to increased wildfire risk and to avoid similar disasters.

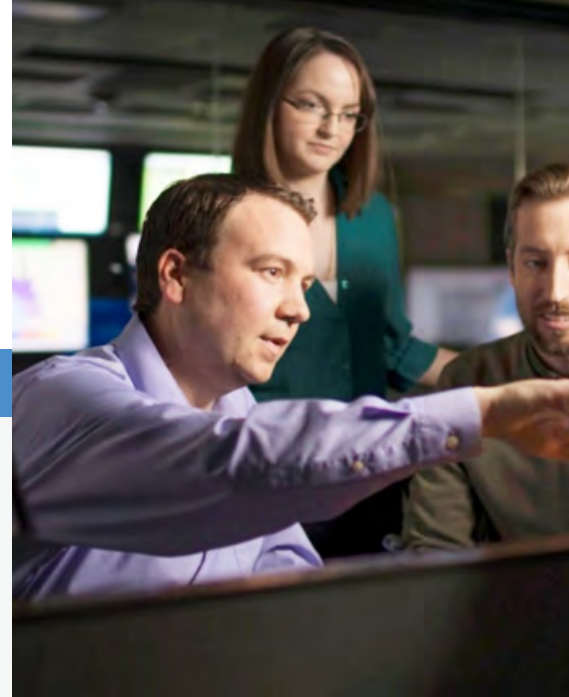
California's wildfire hazard zone mapping and Chapter 7A building codes are strong initial steps that other states can replicate. At the same time, the need to retrofit pre-2008 homes in high fire hazard areas that are not built to those standards is a challenge California is now struggling to address.

Other states have the opportunity to act now to strengthen their wildfire resilience and avoid building in further vulnerability. In doing so, states should review California's examples and adapt them to their context, improving on them where possible. In January 2019, for example, Oregon passed an amendment to its building codes, giving local municipalities the power to adopt increased wildfire hazard mitigation codes beyond those required by the state. While the state code would still be applicable and mandated, this shift provides local governments with the planning tools to impose stricter standards than those mandated at the state level if they feel they are necessary.



Multi-state members of
emergency response agencies
November 2014

81 Insurance Information Institute. "Facts + Statistics: Wildfires." Alan Westhaver. September 2019. <https://www.iii.org/fact-statistic/facts-statistics-wildfires>



How a meteorologist is helping a San Diego utility confront wildfire risk

Brian D'Agostino's career reflects the rising threat of wildfires. Graduating with a degree in meteorology in 2002, he worked for a TV station in Missoula, Montana, and lived with firefighters. "Fire is a big deal up in Montana, and I learned the basics, which helped me get my first interview at San Diego Gas & Electric (SDG&E)," D'Agostino said. The utility hired him as its first weather adviser after a devastating 2007 wildfire season. Next, he became SDG&E's first meteorologist, then its first senior manager of meteorology. Today, he is SDG&E's first director of Fire Science and Climate Adaptation. Along the way, he has helped build the largest utility-owned weather network in the world. In a Q&A, he shared how utilities and meteorologists can play a role in wildfire resilience.

Q: Your roles are unprecedented at SDG&E, and perhaps any utility. What is your mission?

A: The mission is to understand fire weather better, particularly the seasonal Santa Ana winds that raise the risk of wildfires here, and to integrate real science into mitigating fire risk. So in 2010, we built the largest utility weather network in the world. We put weather stations in fire risk areas to measure sustained winds and wind gusts. We are now at 177 weather stations in an area roughly the size of Connecticut.

The network is modeled on a nationwide network that fire agencies have, known as RAWS: Remote Automated Weather Stations. Each measures wind speed at a 20-foot height, versus the standard (higher) 10-meter height at airport weather stations. That can make a significant difference in understanding fire potential, especially when dealing with mountainous terrain like we have.

Santa Ana winds work like rapids in a river. When they go over a mountain, rapids form downwind of mountain peaks. When we started putting weather stations into the rapids areas, we were measuring winds that were two and three times as strong as what we were measuring at airports in the area.

Q: What other factors do you look at to predict fire risk?

A: Fuel moisture. Most of us have gone to build a campfire and when we try to light the branches we've collected, they just smoke. The reason is high fuel moisture content. All the heat is going into evaporating the water versus combusting the material. You need to understand fuel moisture to predict fire potential, and it changes every day. So, to measure fuel moisture, fire agencies use what is called a fuel stick. They take a piece of wood and put a sensor inside of it. It tells you, if your fuels are drying out, how quickly?

We're also interested in grass crop. Southern California can look like Ireland in March, with lush grass. That's a heat sink for any fire. We have no history of huge fires running through lush green grass. By the time we get to October or November, when we haven't seen significant rain in eight months, that's when we're concerned for the type of catastrophic fire we've seen lately.

Q: How has the weather network changed your fire risk response?

A: We used to say when the wind blows 40 mph, sound the alarm. But there are some areas where it blows 40 all the time. So we now use what's windy for that environment. We set triggers so that when it hits the 99th percentile for that area, we sound the alarm.

"We have to operate the system differently than 20 years ago to keep our communities safe."

- Brian D'Agostino, meteorologist and Director of Fire Science and Climate Adaptation at San Diego Gas & Electric

Photo courtesy of SDG&E

From there, we have reclosers, which are switches, similar to a circuit breaker on household electric lines, that shut off power when a fault occurs. We continuously monitor for faults throughout our system. Any time the system sees a fault – maybe a tree branch touched the line – the recloser senses this and shuts the system off immediately to reduce the likelihood of an ignition emanating from electric lines. In times of elevated fire potential, we do not re-energize the system until a person has inspected the entire line. That's a huge piece of what keeps the system safe. When fire

potential is extreme, we may de-energize lines in the highest-risk areas preventively until the extreme conditions have passed.

Q: How do you communicate that to consumers?

A: Mass communication is a challenge. We have an enterprise notification system, but we don't have everybody's updated phone number. What we have is what people give us. So now we're looking at leveraging social media, traditional media, community partners and other ways to communicate. There's an aspect of change management to this – educating consumers that we have to operate the system differently than 20 years ago to keep our communities safe. Last November, we had wide-scale winds of 60 to 90 mph. In that environment, all it takes is one outage to spark a fire that can threaten life and property.

As we see wildfires continue to become more deadly and devastating, it's becoming comparable to what you can see in hurricanes. We'll migrate toward treating wildfire as the disaster it's really turning into.

Q: Is burying cables feasible in highest-risk areas?

A: You won't just trench through a big canyon and over a mountain in the Cleveland National Forest. Underground lines usually go under a street and driveway. And it takes an awful long time to underground thousands of miles of power lines. There are other tools in the toolbox, such as a covered conductor, which is coated so that branches can touch the line without causing sparks to fly, or taller steel poles farther apart with really strong wires, so they won't fall and hit the ground under almost any circumstance. It's overall system hardening. It's not any one thing that's the answer. It's a mosaic of mitigations.

Q: Do you see a correlation between climate change and wildfires?

A: The biggest change I've observed, working as a scientist for 10 years, is our rainfall patterns. In December 2017, it wasn't unusual that we were seeing big Santa Ana winds, but what was unusual is that the fuels were dry in December. Usually rain in October and November means we're in the clear for wildfire by Thanksgiving. Not that time.

As for the Camp Fire, north of the Sierras in the Cascades, rain usually starts in September there. Here we were in the middle of November and you had fuels in a position that they could burn. Rainfall patterns are shifting and we're seeing more drought and rains delayed. These Santa Ana winds have lots of dry fuel to work with.

Q: Are you changing anything about how you run the network in response to rain changes and recent fires?

A: We'll never stop evolving. We now can use modems that will allow us to log into stations and report wind gusts in real time. We don't have to wait for a 10-minute read. Batteries are coming to the point that we'll be able to retrofit some stations with cameras to enhance our situational awareness. The nature of science itself, we'll never get it completely figured out. As well as we understand it today, we can always understand it better tomorrow. Utilities are a big piece of a big puzzle.



Section VI: The path forward

“Nature is increasingly finding a foothold in the unimaginable: what’s not just unprecedented but also hopelessly far beyond what we’ve seen. This is a realm beyond disaster, where catastrophes live.”⁸²

- Jon Mooallem, The New York Times

⁸² Mooallem, J. “We have fire everywhere”: Escaping California’s deadliest blaze.” The New York Times. 31 July 2019. <https://www.nytimes.com/interactive/2019/07/31/magazine/paradise-camp-fire-california.html>

As California Governor Gavin Newsom noted, “It’s not a question of ‘if’ wildfire will strike, but ‘when.’”⁸³ Across California and much of the western U.S., communities located in the wildland-urban interface are increasingly recognizing they live in fire-prone environments where their safety can no longer be guaranteed. Yet we continue to increase our exposure through development in fire-prone areas, even as temperatures rise and precipitation patterns change.

Sonoma County, California
February 2018



As a result, we are increasingly faced with a different wildfire hazard from that of the past – one that threatens more lives, livelihoods, homes, and structures. If we do not significantly change where and how we build and live, our losses will continue to grow. This is evident in what happened in Sonoma, Napa, Lake, Butte, Ventura, Los Angeles and Santa Barbara counties, and in communities such as Paradise, Malibu and Santa Rosa. Communities must begin thinking through, in detail, what the reality of a wildfire event looks like and what they can do between now and the next inevitable fire to increase their resilience.

Municipalities, counties and states must start the conversation on acceptable risk. The Camp, Woolsey, Thomas and Tubbs fires outpaced the

ability of firefighters to control the intensity and spread. At some point in each fire, the focus shifted from fighting the fire to preserving egress routes and saving lives. While the expectation is that our governments and first responders will protect us and our assets, lived experience is beginning to indicate this is unrealistic.

We need to go beyond mere acknowledgment of this new reality to action. While communities can rely on practices that have served to reduce their risk in the past, ultimately this new reality calls for dramatically new models, structures and actions – ones that go beyond, and expand on, practices of the past to ones that shift how we build our resilience to wildfires of the present and future.

We have an initial set of tested, proven solutions, including models that assess wildfire probability and movement, hazard maps to guide development, building codes and materials that resist ignition, mitigation practices that slow fire propagation. Now we need the political and cultural will to use them, even as we work to develop the next generation of solutions, the solutions we will need for tomorrow’s “beyond the worst.”

⁸³ Catastrophic wildfires, climate change and our energy future: Governor Newsom’s Strike Force progress report. Office of Governor Gavin Newsom. 21 June 2019. <https://www.gov.ca.gov/wp-content/uploads/2019/06/Strike-Force-Progress-Report-6-21-19.pdf>

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We have done our best to reflect the input and interests of our sources. However, the opinions and perspectives expressed in this report remain those of the authors alone.



This report presents a snapshot of events and responses during the 2017 and 2018 California wildfires. It is not comprehensive – much more could be said on the degree of resilience of California during the fires. What this report does provide is a collection of short, field-tested examples of resilient systems and actions and a discussion of what it is that makes those resilient. It also describes factors that limited the ability of people and systems to respond effectively, and highlights what we can learn from this to increase our resilience moving forward.

For a downloadable PDF of this report, please visit:
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