"146 fire in urban-wildland interface, Deschutes National Forest" US Department of Agriculture. Flickr/Forest Service. 2011.

Wildfire: A Changing Landscape

A Global Resilience Institute & National Fire Protection Association Assessment

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Stephen E. Flynn, PhD

Northeastern University
Global Resilience Institute

NFPA®

This report is the result of a joint project between the Global Resilience Institute and the National Fire Protection Agency and based on input from a variety of stakeholders across the United States and Canada. The findings and recommendations do not necessarily reflect the opinions of the U.S. Department of Homeland Security.

Contents

1) Executive Summary

This report is the product of a collaboration between GRI and the National Fire Protection Association (NFPA) at the request of the U.S. Department of Homeland Security. The focus of the report is to determine the impacts of wildfire on vulnerable communities and critical infrastructure. The study analyzed several disasters from the 2016 wildfire season and was informed by numerous published studies, reports, and various public- and private-sector projects addressing wildfires in North America. The report also includes a survey of existing resources on wildfire research combined with the results of a day-long workshop of experts and practitioners held at the NFPA's headquarters in June 2017.

A primary objective of the Global Resilience Institute (GRI) at Northeastern University is to help advance preparedness at multiple levels to effectively respond to both slowly emerging disruptions and sudden disasters, both human-made and naturally-occurring. It accomplishes this objective by facilitating new interdisciplinary research collaborations; working in close partnership with industry, government, communities, and non-governmental organizations; and engaging in external outreach to inform and empower bottom-up efforts that contribute to individual and collective resilience.

In 2016, the United States and Canada experienced a series of catastrophic wildfires. In May, a wildfire erupted in Fort McMurray, Alberta, Canada, forcing the evacuation of thousands of residents and ultimately burning over 1.4 million acres. In August, another wildfire swept through San Bernardino, California, destroying hundreds of buildings, disrupting critical energy and transportation infrastructure, and burning over 36,000 acres. In November, a wildfire in Gatlinburg, Tennessee required evacuations of over 14,000 people, burned nearly 18,000 acres, and took 13 lives. Among the thousands of wildfires that occurred across the U.S. and Canada in 2016, these examples particularly demonstrate the risks wildfires pose to structures, people, and infrastructure. They also exhibit the increasing risks associated with the Wildland-Urban Interface (WUI), a set of conditions and interactions within the built and natural environments that increase communities' vulnerability to wildfire.

In preparation for the workshop, participants with a variety of expertise were asked to present "Pop Up Innovations" to address wildfire challenges in urban environments that could help create safer and more fire-adapted communities and more effective fire response. In the workshop, these innovations addressed a range of issues from firefighter communication and training needs to city planning and zoning to homeowner education about wildfire risk reduction essentials. To complete the day, a panel of subject matter experts addressed current wildfire challenges in the WUI, and workshop teams tackled a set of observations that were gleaned from an exhaustive literature search. These observations included:

- **Land and fire management policies that focus primarily on suppressing wildfires rather than reducing their destructive potential have led to a buildup of live and dead plant matter (fuel) in forests and adjacent urban areas and to rapidly expanding developments that have ignored structure ignition potential. This has resulted in both more intense fires and in greater losses of homes, infrastructure, and businesses. Consequently, the cost of future suppression efforts increases, frequently at the expense of investment in mitigation.** The intensity and frequency of wildfires in the WUI are increasing due to several factors: high levels of biomass fuel in forests, changes in climatic conditions, and continuous development. Wildfire management strategies have been largely focused on protecting life and structures, rather than comprehensive fire management before, during, and after a fire. Recent wildfire disasters show the need for involvement from all levels of government, the private sector, and local communities. By leveraging resources at the federal level to connect fire management grants with preventative programs, states and local governments can better understand and implement fire adapted strategies. This process necessitates close work with the private industry, specifically with the owners and operators of critical infrastructure, and the insurance industry, which can provide valuable economic incentives for adopting resilient building strategies.

- **The risk of wildfires to homeowners and businesses will continue to rise as more structures are built in the Wildland-Urban Interface (WUI), resulting in higher costs for individual property owners, emergency responders, taxpayers, government agencies, and insurers.** As urban encroachment on wildlands continues, the risks to life and property are increasing. Despite this trend, many residents, elected officials, and business owners do not realize the extent of their vulnerability. It is important to raise and maintain awareness in fire-prone communities to their vulnerability and to promote community mitigation measures, especially in communities that have not experienced a major fire recently. The report offers several recommendations for varying stakeholders. State and local governments must plan responsibly for future development in the WUI and consider wildfires in their hazard mitigation plans. All levels of government should actively facilitate communication, education, outreach to businesses and residents in the WUI, and incentivize stakeholders to take action. Private insurers should coordinate with government agencies and forest managers to consider special tax districts for communities that conduct risk mitigation projects with insurance incentives for doing so.

- **Communities of all sizes, from small towns to major urban areas, are vulnerable to cascading effects as wildfires encroach on interdependent regional systems. The interdependency of critical functions poses risks that may not be adequately understood before a disaster.** In many cases, roads, pipelines, and electric lines cross multiple legal jurisdictions, posing challenges for public officials to adequately gauge their communities' risk levels. There is a lack of understanding about wildfires' cascading environmental effects, such as floods and mudslides. These potential risks must be considered in any community disaster plan. The report offers a few recommendations, including new working committees for state and municipal leaders to better understand interdependent infrastructure networks; federal and state coordination with local fire management professionals; continued engagement from communities outside the WUI; and the involvement of academia with emergency management professionals to help develop tools, models, and maps.

- **The complexity of wildland fire management when it involves risk to critical infrastructure poses unique challenges to emergency managers and community leaders responsible for communicating information to residents and among agencies.** Protecting infrastructure demands open lines of communication and collaboration among all levels of government, industry, and affected communities. There must also be direct communication between municipalities that are dependent on regional infrastructure which may be susceptible to wildfire damage. Communication should be continuous and persistent with a focus on the joint resources needed to overcome these challenges. Because of the complexity of the challenge, participation of all

segments of the emergency management spectrum in training exercises is critical. Communities and stakeholders that have suffered infrastructure damages from wildfires have the unique capacity to pass those lessons learned to similarly situated communities. Leaders must leverage the potential for civil society to serve as a resource and agent for building greater community and critical infrastructure resilience.

Existing strategies to promote "fire-adapted" communities need to be better tailored to the unique circumstances at the local community and individual levels. Local stakeholders need clearer standards of what it means for their communities to be fire-adapted, guidance on how to achieve and maintain that status, and incentives for doing so.

Tracking communities which are fire-adapted is difficult, because of a lack of clear criteria for being designated a "fire-adapted" community. The federal government should assist communities by facilitating and supporting the development of measurable standards for fire-adapted communities to inform public sector, private industry, and insurers. Tailoring programs to the unique circumstances in each community requires close engagement between national organizations and state and local leaders to implement community programs such as Firewise and FireSmart. Additionally, for these programs to be as effective as possible, widespread adoption must be supported by well-structured incentives for individuals, developers, public officials and whole communities.

2) Wildfire Project Overview

The **Global Resilience Institute** at Northeastern University (globalresilience.northeastern.edu) is committed to informing and advancing societal resilience around the globe. Communities, companies, and countries can thrive only if the systems and networks that underpin our daily lives, whether physical, technological, or social are able to better withstand, recover from, and adapt to the inevitable shocks and disruptive events of the 21st century.

Established in 2017, one of the Institute's core activities is to learn from global disruptions and through partnering with other leading academic research institutions, nonprofits and the public and private sectors, use what is learned to help devise and apply practical, interdisciplinary solutions to resilience building challenges.

The Institute's International Disaster Assessment Program was formed with funding from the U.S. Department of Homeland Security to bring together experts from across multiple disciplines in the aftermath of major disasters to identify lessons that will advance community and regional resilience. The core focus of the International Disaster Assessment Program is to support practitioners by identifying and advancing best practices that help to ensure lifeline infrastructure systems are able to adapt to, better withstand, and more rapidly recover from disruptive events. To this end, GRI leverages its post-disaster assessment teams to study real-world disasters, apply lessons learned, and provide recommendations for stakeholders throughout the homeland security enterprise.

The **National Fire Protection Association** (NFPA) (www.nfpa.org) is a global nonprofit organization, established in 1896, and devoted to eliminating death, injury, property and economic loss due to fire, electrical, and other related hazards. NFPA delivers information and knowledge through more than 300 consensus codes and standards, research, training, education, outreach, and advocacy; and by partnering with others who share an interest in furthering their mission. NFPA membership totals more than 60,000 individuals around the world. NFPA's mission is to help save lives and reduce loss with information, knowledge and passion. NFPA has promulgated wildfire safety standards since the 1920s and has delivered wildfire safety education programs and products since 1986. NFPA administers the Firewise USA™ Recognition Program as part of a cooperative agreement with the USDA Forest Service and the National Association of State Foresters.

Project Overview

This report on the current trends in wildfire in North America is the result of a collaboration between GRI and NFPA at the request of the U.S. Department of Homeland Security. While the report looks at wildfire trends in general, it focuses primarily on the effects of wildfires on vulnerable communities and critical infrastructure. The study used several events from the 2016 wildfire season in the US and Canada and drew heavily from a wealth of published studies, reports, as well as government and private sector projects dealing with wildfire in North American forests and rangelands. Because most destructive effects of wildfire on lives and property generally occur within the wildland-urban interface zone (WUI), most of the findings and recommendations of the report reflect that concern.

The United States and Canada experienced large western wildfires as well as a significant number of wildfires across the southeastern United States in 2016. These events included the partial destruction of Fort McMurray, Canada, a fire in San Bernardino County, California named the Blue Cut Fire, and a particularly intense fire in Gatlinburg, Tennessee that was the culmination of numerous separate ignitions, one of which was a wildfire that exited Great Smoky Mountains National Park. The 2016 fire season provides unfortunate but striking examples of the continued evolution of the wildfire landscape in the United States. In the recent past, much of the media's attention has focused on large, destructive wildfires confined to the western areas of the nation, frequently originating on public lands. These fires could burn thousands of acres of forest lands, but the vast open natural spaces in the western United States often mitigated the risk to structures and people. However, recent disasters including the Blue Cut and Fort McMurray fires show how increasing development adjacent to wildlands is dramatically increasing the potential for destruction of both public and private infrastructure in the West. Moreover, the 2016 fires in Tennessee, North Carolina, Georgia, and Virginia demonstrate that the inherently crowded conditions in the eastern US, where population density and urban encroachment are much more prevalent, may require rethinking wildfire policy and practice in the East. The expansion of destructive wildfires into locations that have had limited experience dealing with them suggests that variations in development patterns and climate may be introducing changes in the fire seasons and impacts that will demand corresponding changes in community policy and risk management activities.

This report combines the results of a survey of existing literature on wildfires and wildlands fire management and a day-long workshop conducted at the National Fire Protection Association's headquarters in Quincy, Massachusetts, in June 2017. Workshop participants were presented draft findings that resulted from the literature survey and recent case studies and asked to examine them in focused peer-to-peer discussions, recommending changes as necessary. The results of those discussions provide the basis for the observations and recommendations contained in this report. Additionally, several of the participants presented new and innovative ideas for addressing the WUI challenge (please see included "call-out" boxes and the full text of these idea at Appendix B).

Wildfire rampantly consumed trees along Highway 63 in Alberta Canada, 24 miles south of Fort McMurray (Image Source: Chris Schwarz, Government of Alberta /Flickr)

3) Wildfires: Background

In August 2016, the Blue Cut wildfire ravaged the area around San Bernardino, California, burning 36,274 acres and destroying 311 buildings.[1] The fire closed Interstate 15 for three days, stranding drivers on the side of the road.[2] Additionally, electric poles and lines were damaged, leaving 683 customers without electricity and interrupting the flow of hydroelectric power to Los Angeles.[3]

Three months earlier, a wildfire had swept through Fort McMurray, Alberta, Canada, forcing the evacuation of an estimated 88,000 people and destroying approximately 2,400 homes.[4] Some residents watched flames start to lick their lawns or roofs before they jumped into vehicles that became bottlenecked on the area's single evacuation route.[5] The fire ultimately burned 1,456,810 acres of land in the costliest disaster in Canadian history.[6]

These are only two of the thousands of wildfires that burned across the United States and Canada in 2016. While most of the largest wildfires occur in sparsely populated areas away from communities, these cases, and many more like them, demonstrate the growing risk to residences, people, and infrastructure as urban centers develop in proximity to wildfire-prone areas. This convergence is referred to as the Wildland-Urban Interface (WUI). The risks within the WUI are increasing as North American wildfires increase in frequency and intensity.[7]

In Canada, in 2015, 3.8 million hectares (9.4 million acres) burned in just over 7,000 wildfires across in the country.[8] Comparatively, in 2016, 5.5 million acres of land burned due to nearly 68,000 wildfires in the United States,[9] costing almost $2 billion in suppression costs alone.[10] The previous year, 2015, broke records; the 10 million acres burned that year surpassed all annual totals since the National Interagency Fire Center began keeping records in 1960,[11] and it marked the first year that suppression costs topped $2 billion.[12] The five worst years for wildfires in the United States – in terms of acreage burned – have all taken place in the past decade, increasingly requiring fire agencies to devote larger portions of their budgets to suppression costs.[13] Furthermore, according to the U.S. Forest Service the wildfire season[14] is 78 days longer in the United States when compared to forty years ago.[15] In Alberta, Canada, fire season has officially started a full month earlier in 2015 and 2016 than in previous years, due in part to drier winters.[16] The trend is expected to continue as warmer and drier conditions are being seen throughout Canada, leading to a longer fire season, more acres burned, and more large wildfires each year.[17] Canadian fire management costs have been increasing by "about $120 million per decade" since 1970, with higher cost years correlating with increased fire activity. Management costs are further expected to double from 2000 to 2040.[18]

Wildland-Urban Interface (WUI)

In 2007 in San Diego, California, two large wildfires named the Witch and Guejito fires merged, burning almost 200,000 acres, causing $1.8 billion in damage,[19] and forcing the evacuation of 500,000 people.[20] Both fires, as well as the nearby Rice fire, were ignited by a downed power line.[21] Ultimately, 1,141 homes were destroyed and two lives were lost before the blaze was finally contained.[22] The devastation caused to homes and communities brought renewed attention to the ways in which the built environment increasingly intermingles with fire prone wildlands, in an area known as the Wildland-Urban Interface.

The San Diego Fire-Rescue Department deployed 73 engines, 7 trucks, and 420 people to evacuate 200,000 civilians within the city limits and 500,000 in total (Image Source: State Farm/Flickr)

The Wildland-Urban Interface (WUI) is an area of heightened wildfire risk and forms a key part of current decision-making around wildfires. The WUI is defined by the International Association of Fire Chiefs as "areas where homes are built near or among lands prone to wildland fire".[23] More broadly, the National Fire Protection Association (NFPA) defines the WUI as a set of conditions, including types of vegetation and structures in the area, their proximity to each other, weather and climate patterns, and general topography of the land that increase communities' vulnerability to wildfire.[24] All of these factors, combined with the higher population density of areas within the WUI, make fire management and suppression more complicated. This presents a problem for firefighters and policy makers alike, as about a third of all U.S. housing units are in the WUI, with more growth anticipated.[25] The WUI environment results in unique costs for wildfire response, particularly as suppression policies are usually geared towards protecting life over property. However, despite the emphasis of life over property, according to the U.S. Forest Service (USFS), anywhere from 50 to 95% of firefighting costs result from protecting private property.[26] To address these dangers, President Obama signed an order called the Wildland-Urban Interface Federal Risk Mitigation in 2016 to work towards lessening the risks in the WUI.[27]

WHAT IS THE WUI?

According to the NFPA the Wildland Urban Interface (WUI) is a set of conditions where the proximity of homes to wildlands makes wildfires especially risky. Fire management and suppression is also much more difficult in the WUI, which contains a third of all US housing.* Key factors that determine the WUI include:**

- Types of vegetation
- Types of structures
- Weather & climate patterns
- Topography of land

*"Wildfire, Wildlands, and People: Understanding and Preparing for Wildfire in the Wildland-Urban Interface." United State Department of Agriculture. Forest Service. January 2013. Web. 12 October 2016. http://www.fs.fed.us/openspace/fote/reports/GTR-299.pdf

**Haynes, Hylton, Angela Garcia, and Rachel Madsen. "Wildland/Urban Interface: Fire Department Wildfire Preparedness and Readiness Capabilities." NFPA. November 2015.

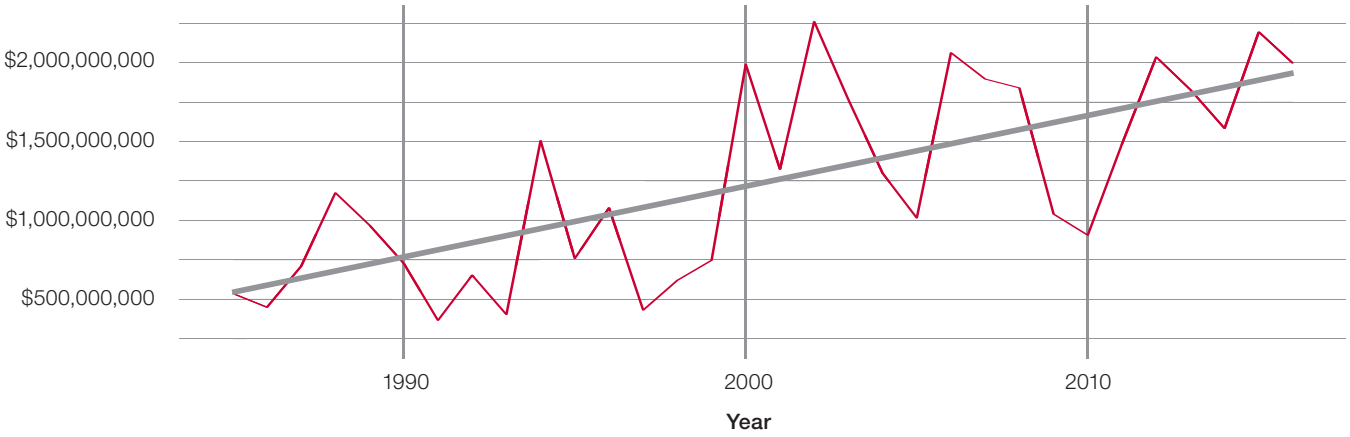
The Witch Fire of 2007 remains a key example of the unique challenges in the WUI. Aside from the evacuation of 500,000 people[28] and the $1.8 billion price tag, [29] the fire's location in the WUI resulted in cascading impacts to infrastructure and the regional economy. The fire was started by sparks from a downed power line in the 'remote' Santa Ysabel area.[30] As well as causing the massive fire, the lack of electricity made it difficult to pump enough water to fight the fires, so air stations were forced to rely on generators which require a steady stream of fuel to facilitate around the clock firefighting efforts.[31] The fire eventually forced the closure of Interstates 15 and 5, complicating the ongoing evacuations.[32] After the Witch Fire, the National Institute of Standards and Technology (NIST) used the fire as a case study for recommendations on managing fire in the WUI. NIST was particularly interested in variation across neighborhoods in their responses to the fire, and in the impact to different types of housing.[33] [34]

Another instance that highlighted the growing wildfire risks in the wildland-urban interface is the 2016 fire in Gatlinburg, a Tennessee town that borders a national park and forest.[35] The fire that swept through Gatlinburg in November 2016 resulted in the deaths of 14 people,[36] forced 14,000 people to evacuate, and burned almost 18,000 acres.[37] The flames destroyed 981 homes, which represented 16% of the town's total residences.[38] Although the wildfire initially appeared small and relatively low risk, 80mph winds caused the fire to quickly grow and disable power and phone lines.[39] The sparks from the downed lines caused multiple new fires which added to the fire,[40] and cut off communication for many residents. Consequently, many people were unaware of the need to evacuate, forcing authorities to attempt door-to-door notifications.[41] The fire also polluted the Gatlinburg water supply with soot and ash with contaminants including lead and asbestos found in local water bodies.[42]

Wildfires that occur near populated areas and infrastructure systems can have impacts felt far beyond the immediate area, such as the 2016 Blue Cut fire, which disrupted a key transportation corridor for the movement of cargo containers.[43] In addition to the 36,724 acres burned and the 315 destroyed buildings, the fire caused a 24-hour shut down of the BNSF Railway. The resulting backup caused time-sensitive shipments to be delayed for the next two days.[44] The

The San Diego Fire-Rescue Department deployed 73 engines, 7 trucks, and 420 people to evacuate 200,000 civilians within the city limits and 500,000 in total ("2007-Witch Creek-Guejito Fires." The City of San Diego. Web.). (Image Source: State Farm/Flickr)

FEDERAL FIRE SUPPRESSION COSTS *(adjusted for inflation)*



"Federal Firefighting Costs (Suppression Only)." National Interagency Fire Center. Web. https://www.nifc.gov/fireInfo/fireInfo_documents/SuppCosts.pdf.

railway shutdown, as well as the closure of Interstate 15, severely impacted shipping in the area, including to the ports of Los Angeles and Long Beach, where stacks of containers began piling up.[45] In all, the disruptions could have cost as much as $1 million a day in "additional operating costs", according to Eric Sauer, vice president of the California Trucking Association.[46] Additionally, electric poles and lines were damaged by the fire, leaving 683 customers without power and interrupting the transmission of hydroelectric power to Los Angeles.[47] In order to compensate for the lost hydroelectric power, generating companies began drawing from natural gas storage facilities.[48] As infrastructure systems become more interdependent, wildfires in the WUI pose threats to areas well beyond where the fire actually occurs, and complicates the recovery after it is put out. Urban areas are increasingly at risk of wildfire, which not only places more people in harm's way, but carries the extra complications and costs associated with fighting the fires.

Mitigation and Suppression

Smokey Bear is one of the most well-known public safety campaigns to deal with the risk of wildfires. It was introduced by the U.S. Forest Service in 1944, and brought to Canada in 1956,[49] under the slogan "only YOU can prevent forest fires".[50] This focus on prevention may have inadvertently conditioned Americans and Canadians to believe that wildfires arise from carelessness and the goal should be to always try to avoid them. However, more recently, an improved understanding of the science behind wildfires reveals that a myopic focus on preventing and suppressing all fires at their outset can produce a dangerous build-up of natural fuel that can later contribute to larger, more dangerous wildfires.[51] Historically, when there was no human fire suppression, small forest fires would occur every few years in some plant communities and burn off the fuel that accumulates on the forest floor.[52] However, when these fires are put out, brush and other fuel builds up, and less fire-resistant plant species grow and choke out the hardwoods that are more likely to survive fires.[53] Thus, when fires occur, they are larger, more dangerous, and harder to extinguish.[54] But given the decades-long campaign to prevent forest fires, the science that embraces the use of controlled fires to reduce the combustible material in wildfire-prone environments faces a difficult time in garnering public support, due to health and economic concerns. Fuel buildup is not an issue that is unique to forests and sparsely populated areas. Buildup around homes and other structures is common and especially hazardous in the WUI as leaves and other combustible materials accumulate over time.

POPUP INNOVATION: INNOVATIVE MITIGATION RESOURCES

Tony Watson – Fire Chief, Pigeon Forge, Tennessee

Currently, many fire department resources are already strained just fighting fires which prevents them from being able to assist communities with mitigating wildfire risks.

This innovative solution focuses on improving incentives for increased mitigation efforts by rural and volunteer fire departments, as well as community volunteers such as senior citizens or civic groups. Potential funding mechanisms include communities, governments, and foundations which could compensate mitigation program volunteers through grants or reimbursements. The result would be less time and money spent on battling wildfires. Such a program may also help with continuity, keeping wildfire mitigation programs from losing momentum, funding, or both over time.

One of the most common fire mitigation techniques to address the risk of catastrophic wildfires is prescribed burning. These typically involve federal agencies and private landowners agreeing to the strategic controlled burning of sections of a forest.[55] In 2016, there were 83,005 prescribed burns covering over 4 million acres in the United States, compared to about 5.5 million acres burned in uncontrolled wildfires.[56] Research on the impact of prescribed burns suggests that the cost of fire suppression is far lower if prescribed burns had been previously conducted in the area. The Merritt Island National Wildlife Refuge determined that the cost of suppressing three fires in that area, which had previously been deliberately burned, was $106,000; the projected cost without prescribed burns would have been $3.8 million.[57]

However, there are numerous constraints on conducting controlled burns. One is the Clean Air Act, where health concerns associated with the potential smoke exposure by people in the vicinity of the fire puts limits on how much can be burned. Another is the Endangered Species Act which can restrict burning both by location and time of year due to critical habitat concerns. These policies can vary by state.[58]

A firefighting helicopter expels fire retardant during the Blue Cut Fire in San Bernardino County, California (Image Source: San Bernardino County Sheriff's Department/Wikimedia).

At times, rather than suppressing fires or prescribing burns, a mitigation strategy is to allow small, monitored fires to burn on the forest floor, which helps prevent buildup of flammable material.[59] This also allows fire crews to focus on protecting buildings and infrastructure.[60] When wildfires become out of control and threaten urban areas, suppression policies mandate firefighting efforts focus on public safety first and foremost, relegating infrastructure, even critical infrastructure that is located in wilderness areas to a secondary priority.[61] Additionally, though federal and state firefighting agencies are not mandated to protect private property, political pressure and the logistics of fighting fires that span public and private land dictates that responders fight fires that threaten private property. Protecting private property raises the cost of suppression, but does not provide additional funds for federal and state agencies.[62]

Firefighters from New Brunswick Canada flown out to assist with firefighting activities in Montana during a fire in August of 2000 (Image Source: Natural Resources and Energy/New Brunswick Canada)

Rather than take mitigation steps, fire-prone regions are often left to combat wildfires after they start, which is problematic as suppression costs have been on the rise in recent years due to longer fire seasons. Additionally, by the time fires become large enough to warrant suppression on a grand scale, firefighting tactics may be ineffective at saving homes from damage or destruction. In 2015, the U.S. Forest Service expected to spend half of its total budget fighting fires; by 2025, that cost is likely to consume two-thirds of the agency's budget.[63] As suppression needs increase and require a higher proportion of funding, one consequence is that fewer funds end up being available for mitigation measures such as vegetation clearing and prescribed burns.[64] This is a dangerous and clearly counterproductive trend. In 2014 and 2015, the funds available for USFS fire prevention programs decreased by $200 million due to the high costs of fire suppression.[65] The largest and most destructive fires can account for as much as 30 percent of firefighting costs, prompting discussions over whether the federal funding mechanism for dealing with large-scale wildfires should be changed. Because fires are not classified as natural disasters in the same way that hurricanes or floods are, they are ineligible to draw on FEMA's disaster recovery funds.[66]

Suppression costs in the Blue Cut fire reached approximately $12.3 million, which included "firefighters, aircraft, bulldozers, and other equipment" required to extinguish the blaze.[67] FEMA was authorized to reimburse 75% of firefighting costs in this case.[68] During the Gatlinburg fire in Tennessee, which cost around $7 million in firefighting efforts,[69] FEMA was similarly authorized to reimburse 75% of eligible firefighting costs, including "labor, equipment, and supplies used for fighting the fire and costs for emergency work such as evacuations and sheltering."[70]

Wildfires do not adhere to political boundaries; when a fire spreads across provincial or state lines, it is valuable to have plans in place to coordinate fire suppression across multiple political jurisdictions, including international borders with Canada and Mexico. In addition, common attributes of wildfires across state or provincial lines mean that agencies can benefit from collaborating with each other. The United States and Canada have a number of national and regional mutual aid agreements.[71] This includes the "Canada/United States Reciprocal Forest Fire Fighting Agreement" which eases the movement of personnel and equipment across national borders during a wildfire.[72] There is also the Northwest Wildland Fire Protection Agreement to facilitate pre-suppression and suppression measures among five U.S. states – Alaska, Washington, Oregon, Idaho, and Montana – and five Canadian provinces and territories – Alberta, British Columbia, Saskatchewan, the Yukon, and the Northwest Territories.[73] These agreements have been put to

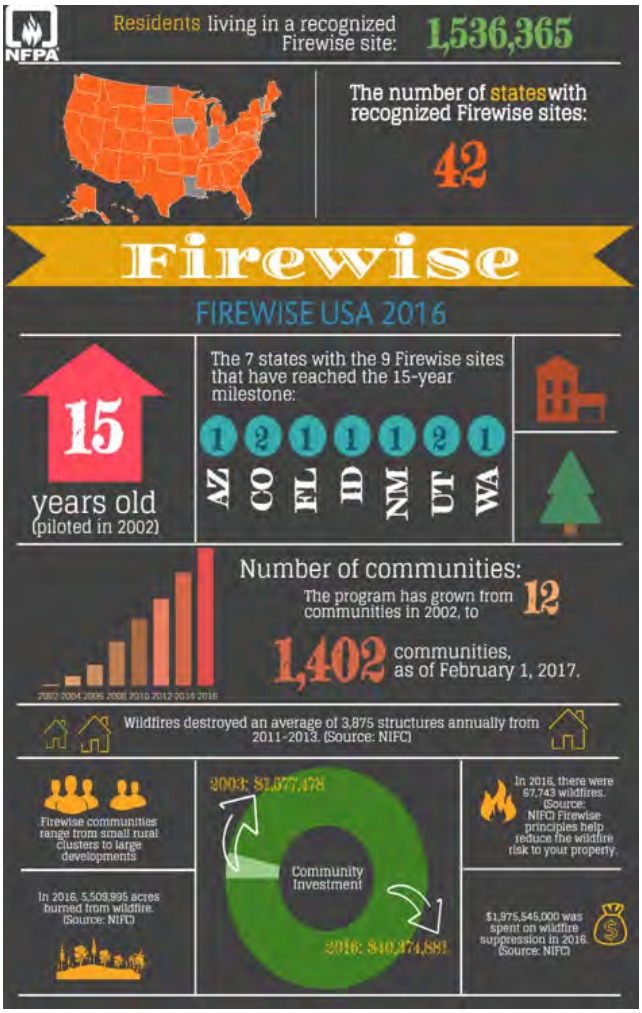
use numerous times. In 2013, after an oil train spill caused a disastrous fire in Quebec, firefighters from Maine were travelling across the border within one hour to help fight the fire.[74] In 2012, 100 British Columbia firefighters assisted 3,500 firefighters from Washington and Oregon already battling five large fires in Washington.[75] Also in 2012, Canada loaned firefighting planes, helicopters, and their accompanying crews to help fight dozens of fires in Montana.[76] Such collaboration extends beyond the US and Canada as well; Australian and NZ firefighters have been brought in to assist with firefighting efforts in the US since 2000.[77] American firefighters have also been sent to Australia in 2007 and 2009.[78]

Community Preparedness and Cooperation

In a disaster, neighbors and communities are often the first on the scene to help one another. To these ends, many local partnerships and nonprofits exist with the goal of increasing community preparedness for wildfires. There are several programs in the U.S., including the NFPA's Firewise USA ™ recognition program, which was established in 2002 and is co-sponsored by the USDA Forest Service, the U.S. Department of the Interior, and the National Association of State Foresters.[79] This program is designed to "teach people how to adapt to living with wildfire and encourage neighbors to work together and take action now to prevent losses."[80] In 2016, there were more than 1,400 active Firewise USA sites in 42 states.[81] The program has five steps:

1. "Obtain a wildfire risk assessment as a written document from your state forestry agency or fire department.
2. Form a board or committee, and create an action plan based on the assessment.
3. Conduct a "Firewise Day" event.
4. Invest a minimum of $2 per capita in local Firewise actions for the year.
5. Create a Firewise Portal account and submit an application to your state Firewise liaison." [82]

NFPA has also partnered with the insurance company USAA in providing an economic incentive that



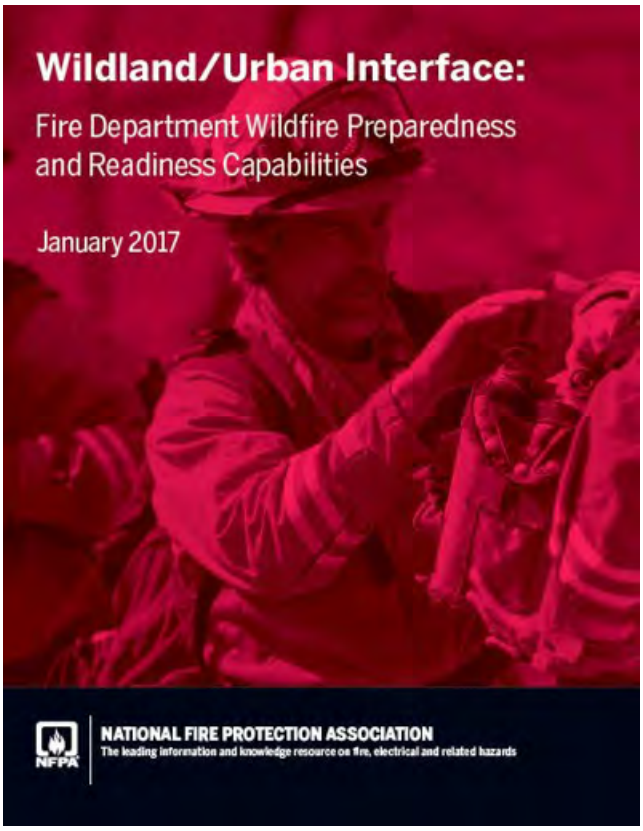
encourages greater community participation in the program. Under this partnership, USAA members who are residents of communities that have been recognized as Firewise USA sites can get a discount on their insurance.[83] Pigeon Forge, Tennessee, which is in the same county as Gatlinburg and experienced devastating wildfires in 2016, is working with the NFPA to attain Firewise recognition this year. [84] Many state forestry agencies support a variety of community wildfire preparedness efforts, including helping communities earn Firewise recognition. However, funding these projects has become increasingly difficult in the face of tight state and local budgets. Without the capital spending budget, the state of Washington will lack the resources to support 40 new Firewise USA sites in western Washington.[85] Meanwhile, Anchorage, Alaska's funding for their existing wildfire risk reduction program is slated to end on September 1st, 2017.[86]

A Canadian nonprofit organization, Partners

in Protection, has developed a program called *FireSmart: Protecting Your Community from Wildfire*. The program originated in 1993 and has developed 60-member organizations across Canada. The organization, which is based out of Alberta, has American representation on its Board of Directors, and has a partnership with the NFPA to encourage the sharing of knowledge across the Canada-U.S. border.[87] *FireSmart* is designed to increase community awareness of wildfire, teach about tools for fire protection, and share initiatives and lessons learned across jurisdictions.[88] There are many documented examples of communities reducing their wildfire risk due to lessons drawn from *FireSmart* collaboration, including the community of Logan Lake, British Columbia.[89] Efforts there included pruning wooded areas, ensuring trees were well spaced, and engaging local students in prescribed burn efforts.[90] Public interest and support for *FireSmart* has grown alongside the number of major wildfires. After the May 2016 Fort McMurray fire, the Alberta government pledged 15 million CAD per year for three years to fund *FireSmart*.[91]

The International Association of Fire Chiefs leads the *Ready, Set, Go!* program, which works to develop and improve the dialog between fire departments and community residents. It helps to build fire-adapted communities and works collaboratively with *Firewise* and provides resources and tools to residents as well as to fire departments.[92]

Fire Adapted Communities is a coalition of public and private sector partners that include the US Forest Service, the U.S. Department of the Interior, FEMA, the Insurance Institute for Business and Home Safety, the National Fire Protection Association, the International Association of Fire Chiefs, the National Volunteer Fire Council, the Nature Conservancy, the National Wildfire Coordinating Group and the Watershed Research and Training Center.[93] Founded in 2013, *Fire Adapted Communities Learning Network* is sponsored by the *Promoting Ecosystem Resilience and Fire Adapted Communities Together* organization and consists of core and affiliate members using a collaborative process that help to make member communities more fire-adapted.[94] The coalition's goal is primarily to be a learning resource, providing reference guides, lessons-learned reports and DVDs, brochures, infographics, self-assessment tools, and a *Fire Department Learning Exchange*, as well as access to fire safety experts.[95]



NFPA Report on Improving Wildland Firefighter Safety (Image Source: NFPA)

Another resource available to fire-prone communities are standards developed by the NFPA that, when adopted and enforced, can significantly enhance a community's ability to live with wildfire.[96] *NFPA 1141 – Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural and Suburban Areas* covers the requirements for the fire protection infrastructure in wildland, rural, and suburban areas where there is an intended change of land use or intended land development.[97] *NFPA 1144 – Standard for Reducing Structure Ignition Hazards from Wildland Fire* provides a methodology for assessing wildfire ignition hazards around existing structures, residential developments, and subdivisions and improved property or planned property improvement that will be in a wildland-urban interface area.[98]

The U.S. Fire Administration, which is part of FEMA, has published a guide developed by the International Association of Fire Chiefs, titled *Your Role in Fire-Adapted Communities*, which provides a template for creating a fire-adapted community including a listing of appropriate codes and standards.[99] Among these codes is the International Codes Council's

(ICC) *International Wildland-Urban Interface Code*, which provides regulations for a variety of factors that affect wildfire vulnerability. The ICC provides standards that include fire-resilient building materials, measures that can improve firefighters' abilities to protect life and structures, and guidance on how communities can build back better following a wildfire disaster.[100]

POPUP INNOVATION: FIREFIGHTER COMMUNICATION

Rebekah Fox – Assistant Professor of Communications at Texas State University

The nation's largest wildland fires are often fought by firefighters who are flown in from all around the country, who often have no prior knowledge of a region and must learn about local conditions in real time. The communication of this information, such as the dangers of local flora and fauna, or particular challenges of a region, often occurs in stressful and time constrained circumstances, after the firefighters have arrived.

This popup advocates for a digital map of the deployment area with short, embedded videos on region-specific firefighting tactics and safety information. This would improve safety and could transform transit time into productive training time.

Less formalized community cooperation includes leveraging the experience of communities who have recently experienced a fire to help out their neighboring communities. One example of this is *Wisdom Gained*, a publication from the town of Slave Lake, Alberta that served as a critical source of information for Fort McMurray. Slave Lake (population 6,600[101]) suffered a devastating wildfire in 2011 and produced the report to document the lessons they learned from the disaster and recommendations for others to support evacuation and recovery.[102] When Fort McMurray was dealing with its wildfire, the Slave Lake residents also set up a Facebook page to advise Fort McMurray evacuees in real time during the evacuation and throughout the recovery.[103] As of August 2017, this channel of advice was still active. Fort McMurray residents have credited the Slave Lake information as the most useful pieces of advice they had for informing their response and recovery efforts. They found the guidance on dealing with mental health issues and calibrating public expectations of the pace of recovery to be particularly helpful.[104] The experience of Slave Lake also facilitated closer collaboration between government officials and the general public in planning the recovery, and providing tools to Fort McMurray residents to help guide their own recovery. This case highlights the enormous benefits that can be derived from leveraging lessons learned and sharing existing knowledge across communities when responding to wildfires.

Insurance

The Fort McMurray wildfire was the largest insured disaster in Canadian history; the total payout came to about $4 billion CAD in insured damages, $1.2 billion of which was for restoring homes.[105] 2,400 buildings including 1,800 single family homes were destroyed or damaged, making the rebuilding process particularly complicated and expensive.[106] By April 2017, only 282 units were under construction, while permits had been issued for another 650 homes.[107] Many residents who were dependent on insurance to rebuild their homes faced delays as insurers worked through the 45,000 claims. Despite the continued vulnerability of the region to future wildfires, even insured homeowners often lacked the funds to 'build back better' or to undergo community planning that would help to prevent future disasters as the area rebuilds.[108]

Unlike many natural disasters, such as floods and earthquakes, wildfires are covered by standard homeowner's insurance.[109] Most policies will cover damage to a home and landscaping and temporary housing costs. Business insurance will also cover lost revenue due to damage, although not to business interruption from evacuation.[110] Costs depend, however, on location and proximity to firefighting resources. If a home is in a high-risk area for wildfires, or not near 'firefighting resources', the premium may increase.[111] Conversely, insurance premiums can be lower if the property owner has taken mitigation measures, or if the property is in a *Firewise* community.[112]

However, as insurance companies work to rebuild

Fort McMurray, the process has exposed a lack of consistency in insurance practices and payouts that have slowed the rebuilding process.[113] The longer the rebuilding process takes, the more expensive it often becomes.[114] Some homeowners have started paying for their homes out-of-pocket and then submitting claims to be reimbursed, rather than living elsewhere while their claims are processed and risking their exceeding the temporary housing limits provided in their policies.[115] There have also been problems with many residents being underinsured or lacking insurance altogether.

POPUP INNOVATION: CLOSING THE 5-FOOT GAP

Rob Galbraith – Director of Property Underwriting at USAA

The fuels in the last five feet around a house create much of the structure's vulnerability during a wildfire.

However, a thorough home evaluation from a trained professional is often time consuming and costly. Galbraith from USAA proposes developing an app that will allow individuals to photograph their homes and receive professional advice based on the photos, and the insurance companies could collect general data. This would help scale and coordinate work done in communities by local fire departments and *Firewise*.

The Insurance Bureau of Canada has partnered with the Southern Alberta Institute of Technology in a 'Build Back Better' campaign in which fire mitigation measures would be built into new homes in Fort McMurray.[116] However, many builders are unaware of these best practices and owners are reluctant to pay for them if they add to their cost.[117] In the case of one neighborhood, the rebuild is taking place in an area that was not only almost completely destroyed by a fire, but is also on a floodplain.[118] Some residents ended up rebuilding to the previous standards even in these high-risk areas because their insurance payouts were not sufficient to pay off their mortgages, leaving them unable to abandon the property and move to a new location.[119]

Insurance issues also arose in Fort McMurray's main industry: oil and gas. During the fire, approximately 1 million barrels of oil a day in production, nearly half of the region's oil sands production, was shut down due to the fires.[120] Overall, the companies experienced a loss of $1.4 billion in revenue due to 47 million barrels of oil in lost production. Most of the area's 3,900 businesses had to temporarily close, and 42,000 residents lost a total of 7.6 million work hours.[121] In the end, business insurance did not fill these gaps. Although 'business interruption insurance' can cover losses when businesses are forced to close, it does not go into effect for evacuations, which turns out to be the primary cause of business closures. Therefore, many businesses, including the oil sands, were not eligible for reimbursement.[122] This economic loss was directly experienced by the community of Fort McMurray, whose residents are predominantly reliant on the oil sands for employment and revenue.

Many small businesses that did receive an insurance payout found it was not enough to cover repairs and lost stock. This challenge was compounded by delayed payouts, forcing some owners to pay debts out of pocket while they awaited their insurance check. These businesses also experienced the additional economic burden of reduced sales as many of their community customers struggled to get back on their feet.[123]

Charred grasslands in the Cades Cove National Park after the Gatlinburg and Pigeon Forge fires.(Image Source: Heath Bailey/National Park Service).

In Gatlinburg, the most expensive properties which were damaged were mainly vacation homes and condos. One participant in the Global Resilience Institute-NFPA workshop noted that many insurance companies prioritized payouts by who paid the highest premiums; thus, many vacation homes and even some non-residential began rebuilding before some local homes owned by residents with low incomes. In addition to residents being left stranded, many felt mistreated by the insurance companies. Some smaller, local insurers were able to provide more personalized based on needs instead of automatically prioritizing those with the highest-value losses.[124]

4) Findings and Recommendations

Finding 1

Wildland fire policies that primarily focus on suppressing blazes rather than reducing the overall destructive potential of fire risk have resulted in more intense fires that often result in higher losses of homes, businesses, and infrastructure due to increased fuel and less resilient forestry lands. This in turn drives up the suppression cost of fighting wildfires, often at the expense of investing in mitigation. While communities will always have to respond to wildfires, public and private stakeholders should assign a higher priority to proactive mitigation measures that lessen the severity of future wildfires and lower the need to devote so many resources to suppression.

Urban encroachment on wildlands, high levels of biomass fuel loads in forest, and climatic changes will all contribute to a likely increase in destructive wildfires in the coming decades. Absent change, this will drive up the costs spent on fire suppression, likely at the expense of mitigation.

The scientific evidence is clear: for much of the nation, fire seasons are becoming longer.[125] [126] Over the past decade, wildfires also have been more destructive and costly in both the U.S. and Canada.[127] The overall number of emergency wildfire declarations has continued to rise. Between 1950 and 2000, FEMA and its predecessor agency, the Office of Emergency Management, issued only 11 major or emergency wildfire declarations. Since 2000 there have been 25.[128]

The costs of suppression have been increasing as the destructive consequences of wildfires have grown in recent years. In the 1990s, the average annual suppression cost to the U.S. Forest Service and Department of Interior agencies was about $730 million (adjusted for inflation). Over the last 10 years, that cost has more than doubled to over $1.6 billion per year.[129] In 2015, half of the U.S. Forest Service's budget was spent on suppression, which is projected to increase to two-thirds by 2025.[130] As a consequence, the funds available for U.S. Forest Service fire prevention programs decreased by $200 million in 2014 and 2015.[131] The Global Resilience Institute-NFPA workshop participants noted that the federal government currently bears virtually all of the burden for suppression of wildland fires.[132] The participants suggested that if these suppression costs were more evenly distributed among the federal, state and local governments, there would be likely be a significantly increased financial incentive for local governments to fully participate in proven wildlands fire adaptation programs that mitigate the fire risk within the Wildland-Urban Interface.

POPUP INNOVATION: THE RURAL FIREFIGHTER OF THE FUTURE

Hylton Haynes – Senior Research Assistant at the National Fire Protection Association

Rural and local fire departments make up 84 percent of fire departments and account for over 500,000 firefighters. Traditionally they have focused their training primarily on structural fire suppression and evacuation. Consequently, many firefighters have identified wildfires and mitigation as an ongoing gap.

This popup focuses on changing existing practices and culture to encourage rural firefighters to embrace mitigation and become resources for community mitigation efforts in the WUI. Training the nation's firefighters to carry out prevention and mitigation procedures would reduce the costs of fighting future fires and the threat to homes, businesses and residents.

Suppression inevitably costs more in the WUI, due to the need to protect lives and structures of the impacted populations.[133] Suppression in the WUI also involves considerable complications associated with the fires spanning public and private land.[134] A 2004 study found that per acre, fuel reduction by prescribed burning in the WUI costs 43 percent more than outside the WUI.[135] Fire suppression options are also limited in the WUI.[136] Urban areas near federal lands affect fire control strategies which raises costs and limits fuel control options, frequently lessening prescribed burn options and dictating costlier mechanical fuel reduction.[137] All of these issues could be better managed if state and local decisions on development planning were more mindful of the growing wildfire risk. These include embracing building codes and setting rules for housing density and road access. The federal government has little or no control over these decisions, even though it bears the brunt of the cost of suppressing wildfires when they occur.[138] Even though studies have shown suppression can be over 30 times more expensive when there are no mitigation steps taken, local and state development decisions rarely take into account these proven mitigation measure because they are attracted to the benefits of development into the wildland space with having to bear the associated costs.[139]

Wildland fire crews conduct prescribed burns, which can be a valuable mitigation measure to reduce risks from future wildfires (Image Source: National Park Service)

In general, homeowners and public officials are not well educated about the effects of fire in wildlands areas. Despite the accelerative trend of community development encroaching on wildlands, the default approach is to view wildland fires as something that automatically require immediate suppression. Prescribed burning is more widely accepted in the south, where 86% of forested lands are privately owned, than in other regions.[140] Rapid urbanization and population migration, however, may change this pattern and affect the acceptance of prescribed burns even in the south.[141] The public's reluctance to embrace prescribed burning as a forest management tool is likely to be affected by such things as proximity to critical public infrastructure, use of the wildlands for tourism or recreational activities, and any negative history arising from past wildfires.[142] In these areas, concerns about smoke and its effects on health and the economy can also lower the public acceptance of prescribed burns.[143] What communities need to understand is the failure to undertake mitigation measures such as prescribed burning practically guarantees larger, more destructive wildfires when they occur.[144]

Generating greater community involvement in wildfire preparedness is critical for mitigation. The past decade has seen an impressive growth in the number of organized efforts to promote wildfire risk awareness and fire adaptive behavior, based on a growing body of knowledge. Current measures include the *Firewise* and *FireSmart* programs, which encourage local communities to adopt measures that reduce wildfire risk, as well as *Ready, Set, Go!*, and fire-adapted community organizations. All of these important initiatives are described in detail in the background section of this report, above.

In 2003, Congress passed the *Healthy Forest Restoration Act* (HFRA) as a result of catastrophic wildfires the previous year.[145] One of the provisions of the act was to establish a *Community Wildfire Protection Plan* (CWPP), including creating a handbook to guide implementation of the plan. The CWPP is a collaborative community effort to reduce fuel and the ignitability of structures in the plan's area, using community influence on federal lands.[146] Communities with CWPP are given priority for funding hazardous fuels reduction projects that they implement under the HFRA.[147] *Firewise* communities are helping to achieve the goals of the CWPP such as reducing home ignitability and reducing hazardous fuels in the home ignition zone.[148] Research has shown that homes that adopted mitigation measures were more likely to survive wildfires than those that did not; for instance, in Fort McMurray, homes that had previously taken measures against wind-driven embers were less likely to be ignited by the wildfire than those that did not.[149]

Recommendations:

The **federal government** should invest in fire management grants that incentivize communities to support preventative programs that mitigate damages from future wildfires. These provisions should:

- be incorporated into existing or new fire prevention grants;
- be included in post-wildfire recovery plans for the awarding of federal aid;
- be informed by wildland fire experts at universities, organizations such as the NFPA and U.S. Forestry Service, and other standard development organizations (SDOs)

State and local governments should raise, as part of a broader wildfire education initiative, awareness of the benefits of investing in mitigation programs, including prescribed burns where possible.

Governments at all levels should engage with private industry to complete fire mitigation projects such as vegetation removal.

State and regional governing bodies should convene cross-sector infrastructure stakeholders to elevate awareness of their exposure to the wildfire risk and encourage them to engage with communities on:

- Understanding the risks associated with expanding community development and infrastructure system into the Wildland-Urban Interface;
- Raising awareness of the types and qualities of vegetation and wildlife in forested areas that can mitigate wildfire risk;
- Establishing protocols to follow so that the risk of catastrophic wildfire is monitored over the decades. This is especially important when a certain location does not experience large-scale wildfires frequently.
- Anticipating the economic impacts to tourism or other industries associated with a major wildfire.

State insurance commissioners should encourage insurance companies to develop incentives that give underwriting preferences to communities that adopt and implement wildfire mitigation plans.

Finding 2

The risk of wildfires to homeowners and businesses will continue to rise as more structures are built in the Wildland-Urban Interface (WUI), resulting in higher costs for individual property owners, emergency responders, taxpayers, government agencies, and insurers. As communities expand into wildfire-prone areas, stakeholders should promote responsible development in the WUI by aligning building codes, risk mitigation programs, and tax and insurance incentives.

Due to increases in urbanization and the movement of people and businesses into wildland areas, the Wildland-Urban Interface (WUI) is expanding in ways that will almost certainly elevate fire management costs.[150] The International Association

A Los Angeles mobile home park sustained heavy damage during a 2008 wildfire. Continued development in the WUI results in heightened risks for homeowners and businesses (Image Source: Wikimedia)

of Wildland Fire estimates that 2 million acres of uninhabited wildlands are converted into WUI each year.[151] While wildfires in uninhabited wildlands can have a beneficial effect to include reducing natural fuels before they lead to larger fires, the effects can be devastating when these fires occur in the WUI and affect people and property.[152]

The Gatlinburg, Tennessee fire of 2016 resulted in 14 deaths – 13 direct fatalities and one from a heart attack[153] – even though most of the 18,000 acres that burned were uninhabited federal lands.[154] Other recent wildland fires – the Valley Fire in 2015 (4 civilian lives[155]), the Bully Fire in 2014 (1 civilian life[156]), and the Yarnell Hill Fire of 2013 (19 firefighter lives[157]) – further demonstrate the risk to people residing and fighting fires in the WUI. While improvement in communications, weather warnings, and fire danger forecasts are reducing the risks to lives, U.S. civilians and firefighters continue to perish in wildfires each year.

On the property side, the average number of structures in the United States that are destroyed each year in wildfires has increased from 209 in the 1960s to over 3000 in the 2000s.[158] The Gatlinburg fire alone is estimated to have incurred approximately $842 million in losses in 2016.[159] In Canada, the Fort McMurray fire was the most expensive disaster for insurance companies in the country's history, with insurance payouts for property damage approaching $4 billion CAD.[160]

These rising risks and associated costs have implications for wildfire management and response in the future. As wildfires become more frequent in or near the WUI, rapid response with significant resources is necessary to meet the challenges of safeguarding lives and property. In the South and Northeast regions of the United States, this rapid response will fall heavily on local and state responders. Local responders, whose first concern is almost always structural fire, may not have the training or the equipment sufficient to respond to increasingly dangerous wildfires. Despite the efforts of organizations such as the National Volunteer Fire Council, local volunteer fire departments are struggling to recruit adequate numbers of volunteer firefighters.[161] The resulting limited capacity in volunteer fire services will inhibit the initial fire response capacity, particularly in the south and northeast, to suppress fires before they get out of control.[162] [163] Even with expanding mutual aid agreements across the nation,[164] extreme drought

conditions resulting in multiple simultaneous ignitions coupled with turbulent weather and rapidly spreading wildfire can quickly overwhelm even fully manned fire services.[165]

POPUP INNOVATION: SUSTAINABLE JERSEY

Maureen Brooks – Community Fire Planner at the U.S. Forest Service, Northeast

Sustainable Jersey is a nonprofit that provides tools, training and financial incentives to support communities as they pursue sustainability programs. It currently exists in 441 municipalities that make up 88% of the state's population.

The New Jersey Forest Service worked with Sustainable Jersey to provide funding to develop fire plans, create wildfire councils, and identify vulnerable communities. Further, Sustainable Jersey creates incentives for mitigation practices by awarding points toward certification for developing plans and engaging with wildfire prevention organizations.

Many residents, elected leaders, and business owners in the WUI do not realize the extent of their vulnerability. In some instances, communications about wildfire challenges may be more complicated than needed; simple public service announcements and branding similar to the *Smokey Bear* campaigns of past years may be more effective. Creating straightforward messaging that resonate with the public is paramount, as is tailoring messaging to each community audience.

Participants in the Global Resilience Institute-NFPA workshop agreed that reducing the losses due to wildlands fires is everyone's responsibility. Efforts must combine the wise management of wildlands, prudent community standards, codes, sound management policies and pro-active practices for vulnerable communities, and appropriate and adequate resources from all levels of government and the private sector.[166] Managing wildlands alone will not solve the problem.

Several programs already exist that aim to help communities to increase their mitigation efforts, and promote greater community awareness and cooperation. *Firewise; Ready, Set, Go!* and other programs help to prepare communities for wildfires, share resources and knowledge, and work to build the community ties and relationships that can be key during a disaster. Further resources are available to assist communities in building awareness and knowledge of wildfire, including an interactive mapping tool from the Headwaters Economics research group that identifies communities at risk based on an analysis of wildfire from 2000 to 2014.[167] While these programs embrace proven best practices, there remain significant barriers to their being widely adopted. These include lack of consistent, effective education; insufficient political will; competing economic development stresses; and tight local and state budgets.

Building community awareness is necessary not just for mitigation, but also to support adoption of best practices during rebuilding in the aftermath of a fire so that a community can reduce its exposure to damages associated with future fires. Decisions to build back "better and smarter" can be influenced by building codes and by insurance industry guidelines. Unfortunately, this is often the exception to the rule. For example, after the Fort McMurray fire, the most heavily damaged neighborhoods are being built back in the same place.[168] Some believe insurance companies, as well as government regulations, should do more to discourage this behavior.[169] Despite the risks, building back in risky areas remains the only option for some homeowners, whose policies do not pay enough to allow them to move.[170] Insurance does not currently discourage building homes in wildfire-prone areas.[171] Additionally, since the federal government almost always bears much of the cost of large wildfires, state and local governments are not compelled to change the building codes and regulations.[172]

Recommendations:

All levels of government must actively communicate resilience solutions and support educational outreach to businesses and homeowners living in the WUI. Businesses and homeowners must understand the benefits of taking proactive measures to protect their investments from wildfire and be strong advocates for neighborhood and community wildfire mitigation programs.

State and local governments must responsibly manage development in the wildlands-urban interface. This includes using appropriate building codes, zoning ordinances, set-back rules and vegetation management policies to reduce the potential for catastrophic fire ignition and spread.

- Building codes should align with "best-practice" preventative programs and technologies that have had proven success in mitigating damages and financial losses.
- Federal governments can play a role in funding projects that tailor national guidance with unique local circumstances, to include the vegetation, climate, and available resources.

Local governments need to encourage homeowners and businesses to embrace voluntary wildfire management practices such as becoming model *Firewise* neighborhoods and communities.

Private insurers, state insurance commissioners, and government agencies should coordinate to combine the use of special tax districts with insurance incentives for communities that conduct risk mitigation projects.

Forest managers should continue to align investments in fuels treatment to demonstrable risk reduction activities as evidenced by the development of Community Wildfire Protection Plans.

Wildland fires encroach on high power lines during a 2015 fire in the Coconino National Forest (Image Source: Liza Simmons/USFS)

Finding 3

Communities of all sizes, including major urban areas, are at risk of cascading effects as wildfires increasingly encroach on the interdependent regional systems they rely on for critical functions. Interdependencies create vulnerabilities to communities that may not be well understood in advance of a disaster. Stakeholders located both inside and outside of wildfire-prone areas must have the tools necessary to better analyze their interdependencies and the associated risk of cascading failures. This understanding must inform cross-sector collaboration and planning amongst infrastructure owners and operators with the goal of bolstering resilience to wildfires.

Wildfires have the potential to disrupt a vast range of interconnected infrastructures, including power, transportation, water, and supply chains, as well as to generate significant economic consequences that stretch beyond the community immediately affected by the fire. However, there is a pervasive lack of understanding of these systems and their associated interdependencies among key public and private sector decision makers.

The Blue Cut fire demonstrates the potential cascading effects from wildfires. The 2016 wildfire disrupted power distribution to urban areas far from the immediate area of impact. The fire damaged or burned over 300 electric poles[173] and cut power to a total of 957 buildings throughout San Bernardino County.[174] These effects included damage to a major transmission line that carried hydroelectric power to Los Angeles, though the city itself was not in danger from the fire.[175] Natural gas demand rose by 21 percent at Southern California's major natural gas provider, SoCalGas, to compensate for the loss in electric power.[176]

Wildfires can also have drastic economic impacts through business interruption, even where there is no direct damage. The Blue Cut fire caused a 24-hour shutdown of the BNSF Railway, resulting in shipping delays across the national rail network. In conjunction with the closure of Interstate 15, this shutdown backed up shipping at the Ports of Los Angeles and Long Beach, which was estimated by a California Trucking Association spokesperson to potentially costing the trucking industry up to $1 million daily until the congestion could be

resolved.[177] A second powerful example is the 2016 Fort McMurray fire, which shut down the local oil fields despite limited direct risk; the fourteen-day shutdown curtailed oil production by 1 million barrels a day, representing approximately 40 percent of Alberta's production, and an estimated loss of $985 million CAD. The fire caused an overall drop in Canada's Gross Domestic Product in May 2016; GDP declined by 0.6 percent, illustrating the potential for a localized fire to cause national economic impact.[178]

Fort McMurray's water treatment plant serves as another powerful case example for the importance of recognizing interdependent systems and planning for potential cascading failures.[179] During the wildfire, 10 workers stayed behind in spite of the evacuation order to keep the plant running and supply firefighters with water. They continued their efforts for days, only sleeping a few hours, despite the fire approaching within 50 feet of the plant.[180] At one point, a worker went out with a fire extinguisher to combat a hot spot 1.5 meters from the plant's power transformer. As the crew worked to pump as much water as possible in the face of limited manpower and damaged equipment, they were forced to bypass water safety checks; consequently, the entire system required flushing out once the crisis was over.[181]

Disruptions to infrastructure can severely impact the ability of firefighters to operate. The massive Witch Fire outside of San Diego was necessarily fought by helicopters and planes dropping water mixed with fire retardant. However, the damage the fire did to electric lines cut the power to the main water pump station in the city of Ramona. The firefighters kept the station going temporarily with fuel-powered generators but ultimately ran out of the fuel and water that it required to operate. Firefighters began acquiring water by any means necessary, including the local high school's pool, but ultimately could not continue operating.[182]

Water source disruption is not only a problem for firefighting, but also for areas outside the wildfire area that may be dependent on those water systems. In the Global Resilience Institute-NFPA workshop, a participant raised the issue of urban dependence on rural water sources. Much of the City of New York's water supply comes through the Catskill and Delaware Aqueducts whose catchment areas are large forests that are highly vulnerable to wildfire.[183] However, most urban stakeholders are not aware of this dependency. Visibility on such connections is needed not only to maintain day-to-day operations, but also to create an incentive for urban areas to support investments in fire mitigation in the rural areas on which they depend.

These examples illustrate an awareness problem, which served as an important area of concern for the workshop participants. Participants overwhelmingly validated the need for developing greater awareness of infrastructure interdependencies and vulnerabilities.[184] An important realization is that public officials must be aware of their jurisdiction's vulnerability to infrastructure failure from wildfires that may occur significant distances from their communities. This lack of understanding and analysis of vulnerability undermines adequate planning for disruptions and dampens the political will to support mitigation measures. It is difficult for a public official in one location to support costly mitigation measures in another distant jurisdiction without the data and understanding to give credence to that support.

Current mapping of critical infrastructure exists, but is fragmented and not accessible to all stakeholders. Developing more comprehensive maps and models is complicated by the number and diversity of stakeholders who would need to provide data – much of which may be confidential – and the geographic scope; large infrastructures transcend government boundaries and would require inter-state, and in some cases international, coordination.

Recommendations:

State and municipal leaders should establish working committees that include infrastructure owners and operators to create and maintain an accurate understanding of interdependent infrastructure systems. Committees should identify:

- Impediments to data sharing across jurisdictional boundaries;
- Inaccurate assumptions about stakeholders' response and recovery capabilities;
- Priorities for industry investment and public funding of mitigation efforts.

Federal and state officials should engage with local fire management professionals to raise awareness and plan for the protection of critical assets within

Members of the U.S. Forest Service and the Arizona National Guard collaborate on a wildfire response exercise in 2016 (Image Source: Sgt. Wes Parrell/Department of Energy and Military Affairs)

individual jurisdictions that support functions at the regional level. Plans should emphasize the importance of sustaining the operational capacity of critical pieces of infrastructure during a fire, and recovering them quickly following a wildland fire.

Communities located outside of the Wildland-Urban Interface must remain engaged with fire prevention and response planning. These communities have vested interest in ensuring critical assets such as water, transportation, and power infrastructure located outside of their jurisdiction remain operational.

- The federal government and state governments should seek to facilitate this engagement by convening regional working groups with cross-sector representation.

Academic and research institutions should collaborate with emergency managers and first responders to develop tools, including models and maps, that can inform prioritization of response assets when a fire occurs. Tools should be developed with end-user needs and recent wildfire trends in mind.

Finding 4

The complexity of wildland fire management when it involves risk to critical infrastructure poses unique challenges to emergency managers and community leaders responsible for communicating information to residents and between agencies. These stakeholders must ensure that residents and responders are educated before a fire, have the procedures and systems in place to coordinate during a fire, and can leverage community networks to quickly and effectively recover and adapt after a fire.

Infrastructure owners and operators, in addition to community officials, have a mutual interest in protecting vital public infrastructures. Wildfire mitigation and response efforts should therefore be collaborative rather than stove-piped. Communications should flow to and from a variety of stakeholders – public officials, infrastructure owners and operators, fire experts, and urban and rural residents – to coordinate data collection, requirements, resources, and planning.

During the Global Resilience Institute-NFPA workshop, one pop-up innovation addressed a piece of the problem of communication among industry

professionals. (See Appendix B.) In order to combat massive wildfires, firefighters are often brought in from around the country and even from overseas. Often times, however, those from outside the region are not familiar with the local flora and fauna and associated wildfire risks. This challenge could be addressed through a centralized tool to bolster firefighters' understanding once they arrive on scene, of everything from the risk of poison oak to the main fire fuel in a given location.

The importance of efficient, well-planned communication systems between practitioners and residents was on full display during the Gatlinburg wildfire. High winds during the fire brought down phone lines and cell phone towers, leaving authorities to attempt door-to-door notifications, which did not reach everyone in the semi-rural area.[185] Despite TV and radio broadcasts,[186] not all residents who were in the direct path of the fire were aware of the call directing them to evacuate.[187] While the Tennessee Emergency Management Agency (TEMA) has the ability to blast text-message emergency notifications, the character limit led to a decision not to send a message at all, rather than providing incomplete information.[188]

Leveraging the social networks of residents can end up playing an invaluable role in getting the word out. In Alberta, neighboring Slave Lake residents set up Facebook pages for Fort McMurray evacuees that provided timely and important lessons and advice in responding and rebuilding to natural disasters. One such page has over 70,000 members and helped residents in real time during the evacuation and for several months afterwards as they sought answers to their questions that help to guide their efforts to rebuild their community.[189] This organic, informal channel complemented the formal Wisdom Gained report previously published by Slave Lake that documented their lessons learned after their community experienced an earlier major wildfire.[190]

Members of a Firewise community in Oregon take part in fuel management activities in 2015 (Image Source: Oregon Department of Forestry/Flickr)

Finally, communication among insurance agents, homeowners, and fire officials is also key. Often, homeowners only realize after a disaster what is in their insurance policies. Inevitably, they discover gaps in what they thought would be covered and face sticker shock when they realize the cost of replacing the things that they need.[191] There is a pervasive problem with households underinsuring themselves[192] After the Gatlinburg wildfire, FEMA paid over $3 million, divided into about 390 grants, to residents who were uninsured or underinsured.[193] The insurance experts who attended the workshop emphasized the importance of communicating with policyholders prior to disasters about what their insurance covers, and what they need to do in advance to be prepared to submit a claim to bolster the likelihood of a speedy insurance settlement. They also discussed communicating with both fire experts and residents about pre-fire mitigation steps that could be taken and the potential to integrate that process with underwriting insurance policies. Such pre-disaster communication could lessen the damage from a fire, and speed the recovery process.[194]

Recommendations:

Federal, state, and local leaders must establish clear communication protocols across jurisdictional boundaries before wildfires occur so that stakeholders can effectively communicate between one another.

Fire management professionals and infrastructure owners and operators must collaborate in developing comprehensive response plans that are informed by risks to communication systems. Plans must include widely distributed contingency options, should primary methods fail. State fire marshals should assist in the coordination of communication across agencies.

Federal and state governments should formalize lessons learned processes that can be used to inform planners, responders, and individuals in communities that are similarly at risk of wildland fires.

State and local governments must use a diverse set of communication tools, including community education, to relay instructions and information to

individuals who may not have access to traditional alert systems.

Insurance companies should be leveraged to communicate mitigation strategies to policy holders.

Emergency managers and recovery agencies should work with civil society to leverage the capacity of community networks to provide guidance at the local level. Networks can include:

- Social media platforms where residents can share advice, provide resources, and clearly discern official guidance from incorrect information
- Local community networks (e.g. religious congregations, neighborhood organizations, volunteer firefighter communities, local unions, among others)
- Family and personal relationships with at-risk populations including the elderly, infirmed, and those lacking access to the communication means typically used to warn of wildfire risks.

POPUP INNOVATION: WILDFIRE CHECKLIST

Leon Konz – Firewise Station Liaison, Tennessee Division of Forestry

Preparing for wildfires is often complicated, and even the most committed city officials in wildfire vulnerable communities are unaware of all useful information and resources that are available.

Minimizing the Potential of Wildland Fire Catastrophes in Cities – A Checklist for City Officials and Planners, prepared by the Tennessee Division of Forestry, is a comprehensive checklist officials can use to evaluate their communities' vulnerabilities and opportunities for mitigation. The list includes information about creating plans, developing a monitoring system, creating post-disaster plans, and more.

Finding 5

Existing strategies to promote "fire-adapted" communities need to be better tailored to the unique circumstances at the local community and individual levels. Local stakeholders need clearer standards of what it means for their communities to be fire-adapted, guidance on how to achieve and maintain that status, and incentives for doing so.

The *National Cohesive Wildland Fire Management Strategy* calls for fire-adapted communities, in which humans can "safely co-exist with wildland fire."[195] However, federal programs tend to focus on wildlands fire management with minimal emphasis on the community aspects of the strategy.[196] Various programs provide guidance and checklists to assist communities in becoming fire-adapted (including *Firewise, the Fire Adapted Communities Coalition, Living With Fire*, and the *Fire Adapted Communities Learning Network*). However, there is a lack of standards or formal recognition for becoming a fire-adapted community, making it difficult to track the actual number of fire-adapted communities and their state of preparedness.[197]

Furthermore, it is important for communities to realize that becoming "fire-adapted" is an ongoing enterprise. Workshop participants observed that as environmental conditions change, communities must continuously adapt to maintain their resilience. Communities therefore should aim to be in a constant state of "fire-adapting", with a focus on continued growth and improvement.[198] A newly refined definition and clearer standards for creating fire-adapted communities may pay significant dividends in achieving national goal to advance greater community resilience.

Community engagement is a necessary component of both wildfire mitigation and suppression. National and state-level efforts to combat increasing wildfire losses must be complemented and enhanced by wildfire-adapted communities who can co-exist with wildland fires, mitigate fire damage, and reduce fire loss. Those who can best influence residents of the wildland-urban interface (WUI) – elected officials, state agencies, local fire services, and community peers – should take meaningful measures to educate and provide appropriate incentives for small business owners and to residents to adopt proven mitigation measures.

Research into wildfire risk-reduction behaviors indicates that most residents in wildfire-prone communities are aware of the risk. [199]. However, there is an inconsistent level of risk-reduction behavior in response to this awareness.[200] Individual homeowners may engage in measures such as raking leaves, cleaning roofs, and trimming vegetation, but these activities may be limited rather than comprehensive and may be geared towards aesthetics rather than safety. Individual homeowners most frequently cite financial costs and time constraints as reasons for not engaging in wildfire risk-reduction efforts.[201]

Risk reduction is also inconsistent at the community level. Although model building codes exist, they are infrequently adopted, especially in the eastern United States, due to less direct recent experience with wildfire than in the west. Only 6,000 communities were estimated to have implemented *Community Wildfire Protection Plans* by 2009 – the most recent statistics available – which represents less than 10% of the more than 70,000 communities identified as at risk from wildfires.[202]

Low adoption of risk-reduction strategies can be driven by economic factors, notably rapid development. Communities at high risk of wildfires are often those that are rapidly expanding into the WUI due to housing or business expansion, or those with a large tourism industry. In the development case, wildfire-inspired building codes may be seen as increasing costs, thereby slowing the pace of development. Furthermore, the *Firewise* designation may actually be unappealing to developers and those in the tourism industry who want to downplay the fact that the area is fire-prone. Landlords who rent out their property to tourists frequently resist any measures that might increase costs or discourage visitors, including visible signage indicating evacuation routes. Yet, increasing awareness of wildfire risks and impacts is important for creating the political will and local inclination to adapt these communities to be more fire resilient.

Whenever possible, risk-reduction strategies should be incentivized by insurance underwriters, realtors, developers, and lenders. For instance, some programs, including an arrangement between USAA and *Firewise*, provide insurance discounts to USAA members residing in recognized *Firewise* USA sites in 7 states. However, such programs are only available in certain states and from a few insurance companies.[203] Further, if only a limited number of homes in a community implement these measures, including reducing risk to wind-driven embers, the effects of the program can be limited. Because homes in proximity to each other can act as conduits for further ignition, a community may only be as resilient as its least-prepared household. The Global Resilience-NFPA workshop participants acknowledged challenges in convincing homeowners to adopt measures that their neighbors were not also adopting.[204]

Many homes in Fort McMurray, as in other wildfire-afflicted communities, are being built back to the same condition and the same location as they were prior to the fire.[205] The Insurance Bureau of Canada is advocating for a "Build Back Better" program to improve resilience, but homeowners may not have access to additional funds to afford more fire-resistant materials without forgoing other features.[206] Consequently, many of the homes are being built back to pre-fire conditions of vulnerability.

Recommendations:

The **federal government** should encourage, facilitate, and sponsor the development of measurable standards for fire-adapted communities that could inform public officials, private businesses and insurance underwriters. The federal government should engage standards and codes organizations like the NFPA and International Code Council to devise effective guidance.

National organizations should work with state and local leaders to successfully implement programs such as Firewise and FireSmart, so that communities can meet existing and future standards of what constitutes a fire-adapted community.

Federal and state governments should provide incentives for "whole community" participation including attracting investor involvement in fire preparedness programs.

Local leaders should leverage existing community networks to educate residents on the risks posed by wildfires and encourage proactive measures to reduce their vulnerability.

Private insurers, with the support of state insurance commissioners, should develop transparent incentives for individuals, developers, and communities that successfully implement projects to increase wildland fire preparedness.

5) Conclusion

At the time of this report's writing in August 2017, firefighters in British Columbia were dealing with over 100 wildfires. The four largest alone had burned over 700,000 acres.[207] Though the fires largely occurred in rural, sparsely populated areas, the smoke from the fires combined with record-breaking temperatures to result in unhealthy air quality as far south as Seattle, Washington.[208] Sea-Tac International Airport experienced average delays of over 45 minutes as the dense smoke reduced visibility.[209] Meanwhile, in the southwestern U.S., flash floods blocked roads, caused 9 deaths,[210] and required over 50 emergency rescues[211] [212] near areas that had been ravaged by wildfires during a drought earlier in the year. The wildfires had destroyed vegetation and altered the soil composition, removing natural defenses that make areas more resilient to floods that impact populated areas and tourist destinations.

Damage, destruction, and costs due to wildfires are increasing across North America and this trend is likely to continue as the climate changes, development in the wildland-urban interface accelerates, and forest management practices continue to be constrained by local environmental, economic, and political conditions. For these reasons, the United States must hasten its efforts to adapt to and live with the reality of wildfire.

Residents of vulnerable communities must understand the nature of wildfire and the factors that can cause damage and loss, and create community plans that reduce the likelihood of catastrophic loss. Communities must educate businesses and homeowners, and adopt appropriate wildfire behaviors including building and wildfire codes and adaptive land-use policies. Forest managers and public and private property owners must continue fuel management practices using the most effective and efficient methods available in their situations. Only by learning to live with the effects of wildfire – good and bad – and adapting our communities to deal with its realities can we reduce future loss of life and property.

Communities large and small will continue to become more interdependent, and rely on interconnected infrastructure systems for water, fuel, power, and communications that sprawl across wider regions. This elevates the risk of cascading failures from hazards and shocks which translates into a growing need for governments, industries, and individuals to step up their efforts to anticipate, mitigate and plan for recovery from major disasters. There are valuable lessons to be learned from the experiences of communities such as Gatlinburg, Fort McMurray, San Bernardino County, and the thousands of other cities and towns affected by wildfires each year. It is imperative that these lessons are shared and that decision-makers from the national to individual levels use them to learn to better plan for and respond to wildfires when they inevitably do occur. Equally important is the imperative to preemptively design systems that mitigate the damages and support rapid recovery and adaptation when disasters occur.

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6) Appendix A: Workshop Agenda & Participants

Northeastern University
Global Resilience Institute

NFPA

Wildfire in the Wildland-Urban Interface: A Changing Landscape

Thursday, June 29, 2017 at the National Fire Protection Association, Quincy, MA
Dress is "Business Casual"

7:30 am	**Breakfast and Check-in** *Coffee and pastries served*
8:00 am	**Welcome and Introductions** *Dr. Stephen Flynn, Northeastern University* *Michele Steinberg, National Fire Protection Association* *Dr. Robin K. White, Meridian Institute*
8:30 am	**Setting the Stage** *Dr. Stephen Flynn, Northeastern University*
8:50 am	**Panel Discussion** *Dr. Stephen Flynn, Northeastern University* *Panelists: Dr. Grissino-Mayer, Ms. Carole Walker, Mr. Gary Wood, Dr. Steve Quarles, Mr. Tom Welle*
10:00 am	**BREAK**
10:15 am	**Pop Up Innovations** *Dr. Robin White and Dr. Stephen Flynn*
11:00 am	**Work Group Topics and Assignments** *Dr. Robin White and Mr. Warren Edwards*
11:30 am	**Work Group Discussion and LUNCH** *Dr. Robin White*
1:20 pm	**Work Group Reports and Discussions** *Dr. Robin White and Dr. Stephen Flynn*
2:50 pm	**Wrap Up and Closing Remarks** *Dr. Stephen Flynn* *Ms. Michele Steinberg*
3:00 pm	**ADJOURN**

Northeastern University
Global Resilience Institute

NFPA

Wildfire: A Changing Landscape
June 29, 2017
NFPA Headquarters - Quincy, MA
Attendees

Aron Anderson
Firewise Data Manager
NFPA

Phil Anderson
Associate Director
Global Resilience Institute

Faith Berry
Associate Project Manager
NFPA

Don Bliss
VP, Field Operations
NFPA

Christine Boynton
Communications and Media Manager
Global Resilience Institute

Lee Breckenridge
Professor of Law
Northeastern University

Maureen Brooks
Co-Chair, NE Cohesive Strategy
US Forest Service

Nelson Bryner
Acting Division Chief of the Fire Research Division
National Institute of Standards and Technology

Jody Butz
Regional Fire Chief
Municipality of Wood Buffalo

Cathleen Deloach
Government Affairs
NFPA

Warren Edwards
Senior Fellow
CARRI/Meridian

Rebekah Fox
Researcher
Texas State University

Stephen Flynn
Director, Global Resilience Institute
Northeastern University
(Co-Host)

Rob Galbraith
Director of Property Underwriting
USAA

Connor Goddard
Global Resilience Institute
Northeastern University

Dan Gorham
Fire Protection Research Foundation
NFPA

Henri Grissino-Mayer
Associate Head, Department of Geography
The University of Tennessee

Hylton Haynes
Data Analysts
NFPA

Northeastern University
Global Resilience Institute

NFPA

Eric Holdeman
Director, Center for Regional Disaster Resilience
PNWER

John Kirksey
Director, Wildfire Department
Tennessee Division of Forestry

Leon Konz
Firewise State Liaison
Tennessee Department of Forestry

Paul Kovacs
Executive Director
Institute for Catastrophic Loss Reduction

Laura Kuhl
Assistant Professor
Northeastern University School of Public Policy

William Lee
Claims Agent
Enservio

Steve Moore
Firewise State Liaison
South Carolina Forestry Commission

Steve Myers
Senior Program Manager
PNWER

Rob Neale
VP Government Relations
International Code Council

Tom Parent
Head of Northeast Compact
NE Forest Fire Protection Commission

Steve Quarles
Leading Researcher
IBHS

Chris Rol
Senior Policy Adviser
Insurance Bureau of Canada

Janet Ruiz
Regional Representative
Insurance Information Institute

Michele Steinberg
Wildfire Division Manager
NFPA

Hannah Thompson-Welch
Firewise State Liaison
North Carolina Forest Service

Carole Walker
Leads Communicator
Rocky Mountain Insurance Information Association

Ann Walker
Director
Ann Walker Consulting

Tony Watson
Fire Chief
Pigeon Forge, Tennessee

Tom Welle
Wildfire Division
NFPA

Gary West
Deputy Commissioner of Fire Prevention
Office of the Tennessee State Fire Marshal

Robin White
Senior Mediator
Meridian Institute

Gary Wood
Southeastern Regional Coordinator
National Cohesive Wildland Fire Strategy

7) Appendix B: Pop-Up Innovations

Building on the workshop themes, several stakeholders presented innovative ideas for addressing the challenge of wildfires in the Wildland-Urban Interface. These innovations are below and include:

1. An application for mobile phones that helps homeowners assess fire vulnerability;
2. Inducing rural firefighters to focus on mitigation as well as suppression;
3. Developing digital maps to facilitate firefighter communication and deployment;
4. Enhancing wildfire knowledge and preparation in New Jersey communities as part of a larger sustainability certification program;
5. Leveraging civil society to encourage volunteer participation in fire mitigation; and
6. A wildfire checklist for city officials and planners.

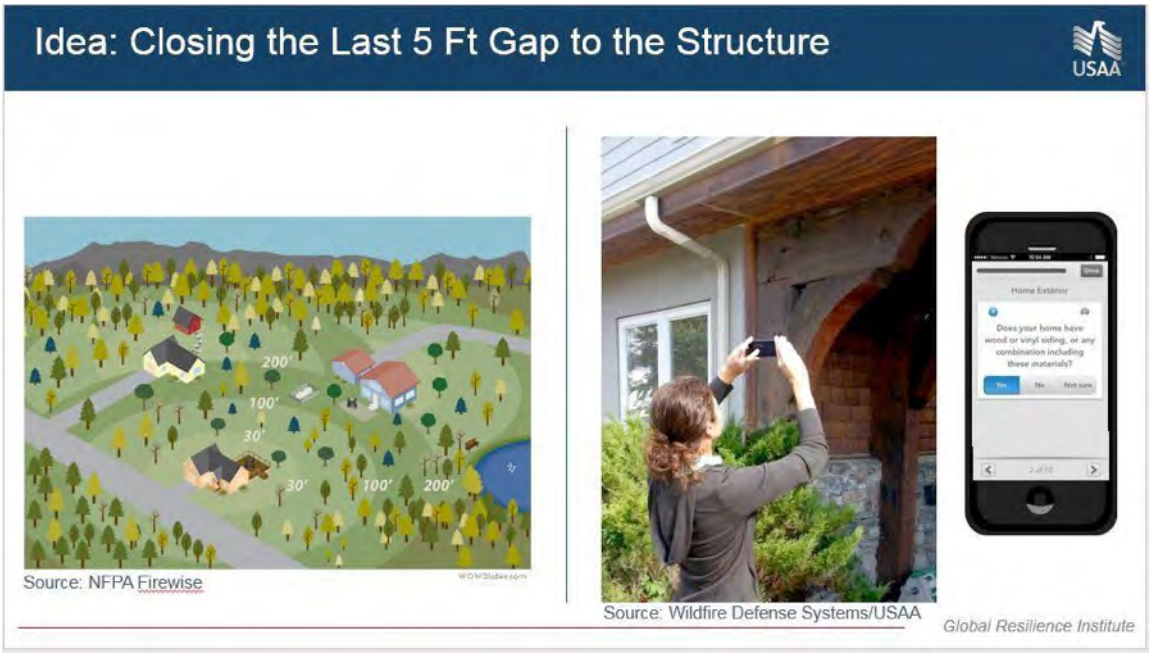
Innovation 1

***Closing the 5-Foot Gap*: Rob Galbraith, Director of Property Underwriting, USAA Insurance Company**

Concentration on the creation of defensible space and vegetation management around homes can sometimes cause homeowners to undervalue the wildfire challenges to the actual home structure. In a wildfire, homes are vulnerable to ignition from many sources, not the least of which are wind-borne embers from adjacent wildfires or from other homes. Homeowners need to understand the effects of all sources of ignition in the last five feet between public space and the home structure. If no ignition occurs in the last 5 feet, no ignition occurs in the home.

In fact, many homeowners do not know nor do they have the means to understand whether their dwelling is in a wildlands-urban interface zone or exactly what risks they face. Getting this foundational information through a thorough evaluation of the home from a trained *Firewise assessor*, insurance home inspection, and/or from the local fire department is often time consuming and comes at a relatively high cost for training, manpower, etc. Yet without this basic knowledge, home owners lack the proper awareness of their most critical vulnerabilities, the knowledge to take effective mitigation actions, and the connections to trained professionals to get expert advice and valuable resources.

USAA developed *Fireshield/WDS*, a mobile application that guides homeowners around the exterior of their homes and allows them to take pictures of this 5-foot gap. These photographs can then be sent to a trained wildland fire expert assessor so that the homeowner gets professional advice on wildfire defense and mitigation measures. As importantly, these pictures allow insurers to assess and track the mitigative measures that homeowners in risky areas have taken and reward pro-active risk management. A similar solution that leverages the use of the latest technology to document vulnerabilities, provides relevant advice and guidance, aggregates data for trending and analysis by local, state, and federal agencies, and provides tracking of progress made could be highly beneficial to allow for scalability of the great work that is currently being done in pockets at the local level by *Firewise* assessors and fire departments.



Innovation 2

***The Rural Firefighter of the Future*: Hylton Haynes, National Fire Protection Association**

Rural, local fire departments make up over 84 percent of fire departments nationwide with over 500,000 firefighters. These departments and firefighters are critical to the wildlands-urban wildfire challenge. In many areas, they are the first line of defense in the wildfire fight keeping small blazes from becoming large and encroaching on urban areas.

Rural, largely volunteer departments, face many challenges – recruitment, training, funding and an aging firefighter population. Traditionally they have focused their training primarily on structural fire suppression. Outside of suppression, the primary tool embraced by local departments is around evacuation – *Ready, Set, Go!* - we need to get this vital national resource of rural firefighters to also embrace mitigation and become community champions, community experts and community resources for home and business owner mitigation efforts in the WUI.

This will require a significant cultural change but the payoff for the nation could be profound. Local departments are the fire experts closest to communities daily. To accomplish this cultural change will require that in addition to their normal training and maintaining activities, local, rural, volunteer departments embrace home ignition zone training, training in mitigation measures and training in engaging the community. Successfully accomplished, however, the nation and local communities gain a powerful, dedicated, knowledgeable cadre of practitioners involved in prevention and mitigation as well as suppression.

Innovation 3

***Firefighter Communication*: Rebekah Fox, Texas State University**

The nation's largest wildland fires are often fought by firefighters who are dispatched and flown in from across the nation. These firefighters rely on learning about local fuels, tactics, and safety concerns once they arrive at their intended location. However, the communication of this information isn't always consistent, occurs often during stressful and time constrained conditions, and happens only after they arrive. For instance, firefighters deployed from the west into the southeast (like those deployed during the 2016 winter fires) had to learn how to cut (or not cut) hardwood trees, how to identify eastern poisonous plants, how to integrate leaf blowers to manage duff, and similar skills not usually used in the west.

When firefighters arrive at a command unit or other local rendezvous point, they must focus their attention on details related to the specific fire, including the changing fire behavior and weather forecasts, etc. We need to find ways to train deploying firefighters more effectively concerning standing regional differences at times and ways that meet their learning needs. One way to do this would be to create a digital map of the deployment area with short, embedded videos that focus on regional specific firefighting tactics and safety information. This digital map with embedded videos could be made available to deploying firefighters via mobile applications and used while in transit. Time spent waiting in airports could be turned into useful, productive training experiences.

Innovation 4

***Sustainable Jersey*: Maureen Brooks, U.S. Forest Service, Northeast Region**

Sustainable Jersey is a nonprofit organization that provides tools, training and financial incentives to support communities as they pursue sustainability programs. By supporting community efforts to reduce waste, cut greenhouse gas emissions, and improve environmental quality, *Sustainable Jersey* is empowering communities to build a better world for future generations. New Jersey communities can become "certified" in a free and completely voluntary program and thereby considered by their peers, by state government and by the experts and civic organizations to be among the leading communities in the state. Begun in 2009, the program now exists in 441 municipalities with 88 percent of the state's population. There are 205 certified communities.

The New Jersey Forest Service worked with *Sustainable Jersey* to include actions that support sustainability in the context of wildfires. They also provided funding to develop fire plans, create wildfire councils, and identify vulnerable communities. Within the Emergency Management and Resiliency category for certification, *Sustainable Jersey* now includes points for creating Community Wildfire Protection Plans, being a *Firewise* Community and having a Wildfire Safety Council.

Organizations and efforts like *Sustainable Jersey* are excellent venues for creating wildfire awareness, providing practical wildfire training and resources and for providing the incentives for communities to take on the challenges of living in the WUI.

Innovation 5

***Creating Innovative Mitigation Resources*: Tony Watson, Fire Chief, Pigeon Forge, Tennessee**

Our effort focuses on creating better incentives for rural and volunteer fire departments to become more involved in mitigation efforts. This will require a difficult balancing act on the part of fire departments who are already stretched with training and operational requirements. This strain on their resources prevents them from achieving their potential to be a rich resource for assisting communities in understanding the ways that the effects of wildfires can be mitigated, as well as a dedicated group to assist in the mitigation efforts.

We also plan to investigate the possibility of using volunteer members of the community who can assist in mitigation and mitigation education efforts and have time to spare. This can range from senior citizens looking for volunteer opportunities, citizens who are working part-time, civic organizations that could also take on mitigation efforts as public service projects. Potential funding mechanisms also include communities, governments or foundations which could compensate those working voluntarily in mitigation programs through grants or reimbursements, to establish a continuity beyond the initial organizers.

Innovation 6

***Wildfire Checklist for City Officials and Planners*: Leon Konz, *Firewise* State Liaison, Tennessee Division of Forestry**

Even the most committed city officials in wildfire vulnerable communities are often unaware of all

the elements that need addressing to prevent or minimize losses during rare, catastrophic wildfire. Consequently, city officials/planners need to know how to prepare for and how to detect when conditions have lined-up to make rare, catastrophic wildfire a high probability. Leon Konz prepared, *Minimizing the Potential of Wildland Fire Catastrophes in Cities – A Checklist for City Officials and Planners* and provided it to workshop planners. The checklist provides a very comprehensive guide for elected and appointed city officials to use in assessing their communities' potential vulnerabilities and charting a path forward. Perhaps it could be disseminated via conferences, association newsletters, incorporated into "community planners' curricula, etc.

Minimizing the Potential of Wildland Fire Catastrophes in Cities –

A Checklist for City Officials and Planners

Are all city officials and city commissioners knowledgeable and supportive of the Fire Adapted Communities (FAC) elements? If not, maybe the local LEPC, or some other entity, can coordinate such training. Large wildfires frequently cross jurisdictional boundaries so at least some FAC elements need countywide or larger planning.

Is there a comprehensive, collaboratively developed Community Wildfire Protection Plan (CWPP) in place? Ensuring that all elements of the FAC concept are at least considered for inclusion into the plan is fundamental. A CWPP provides a golden opportunity to bring coherency to the city wildland fire planning process.

Are the CWPP "Action Plan" items rolled into all relevant short-term and long-term city planning documents? The long term may be up to 30-50+ years to accommodate the economic needs of land developers, builders, etc. to accommodate the adoption of increasingly safer codes and regulations.

Have employees in all city departments (planning, fire, police, public works, tourism, etc.) received training in community wildfire safety? Specifically, do they understand the city's comprehensive strategy for wildland fire safety so that they can implement it in their program and also serve as ambassadors of the strategy to the citizens and homeowners?

As a minimum, is the city promoting voluntary fire safety community design and Firewise practices around homes and businesses while determining to what degree codes and regulations are acceptable to stakeholders and homeowners?

Does the city have access to daily fire danger ratings and current drought conditions to help be prepared for managing a fast-moving, high intensity wildland fire? Has monitoring these two predictors of catastrophic fire been specifically assigned to a city department or office? When conditions are looking bad (extreme fire danger/severe drought) hold meetings to discuss fire response plans. Wildfires do not have to burn hundreds of acres to cause tens of fatalities and burn tens of homes. Also, in many places like Tennessee, fire danger can be completely opposite of what drought conditions are, and vice versa. For example, the ground can be very wet (no drought), but the vegetation can be dry enough to carry high intensity fire under high wind conditions. Conversely, under record-setting drought condition the fire danger could be low-high if there were no winds at all. Certainly, fires under windy, drought conditions are by far the worst. Importantly, the potential for tragedy is present in the vast majority of years. Likely, fire danger ratings and current drought conditions can be easily obtained by cities from the state division of forestry or federal land management agency (US Forest Service or National Park Service).

What are the common wildfire ignition sources within the city and can they be mitigated when there is a high probability of loss of life or multiple structures being lost? For example, if there is a long history of power line caused wildfires within a city and extreme drought conditions exist along with forecast hurricane-like winds and no rain, should the city shut down the electrical system completely before the wind event to almost certainly prevent a catastrophic ignition?

Is there a written evacuation plan in place? Large wildfires typically cross jurisdictional boundaries. Is the evacuation plan coordinated with the county, too?

Is a monitoring system in place to ensure planning and preparedness stay current? Catastrophic fire may not reoccur in the same location for hundreds

of years. Some cities have not yet experienced their first catastrophic fires. As a result, a city must be prepared to monitor its wildland fire strategy over many decades to be prepared for the rare event over the long term. Things such as the following must be monitored:

- Knowledge level of city officials and employees. It changes with changes in individuals. Training will be needed occasionally.
- Currency of planning documents. Plans need to be kept current.
- Vegetation. In just 20 years a completely new brush or forest type can get established potentially altering the flammability and probability of high intensity fire.
- Development.
- Changes in community design, building practices, and materials.
- Topography. Today hills can disappear or be created in a few months changing the topography and the degree of difficulty of suppressing fire.

Is there a post-catastrophe plan in place? Shelters for displaced folks, caterers, utilities, clean-up, etc.

Acknowledgements

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