RESILIENCE STRATEGIES FOR WILDFIRE

CENTER FOR CLIMATE AND ENERGY SOLUTIONS

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The risk of wildfire is expected to grow across the United States due to reduced precipitation in some regions, and higher temperatures caused by climate change. Wildfire has far-reaching impacts that can ripple through communities, regions, watersheds, and ecosystems. This paper overviews a number of adaptation strategies for areas with a projected increase in wildfire conditions. For each strategy, it will discuss design and operation costs, and primary and co-benefits. The paper includes a community case study of Austin, Texas, which has used a number of these strategies, and a list of publications and interactive tools to help communities become more resilient to wildfire.

INTRODUCTION: FUTURE WILDFIRE RANGE, FREQUENCY AND SEVERITY

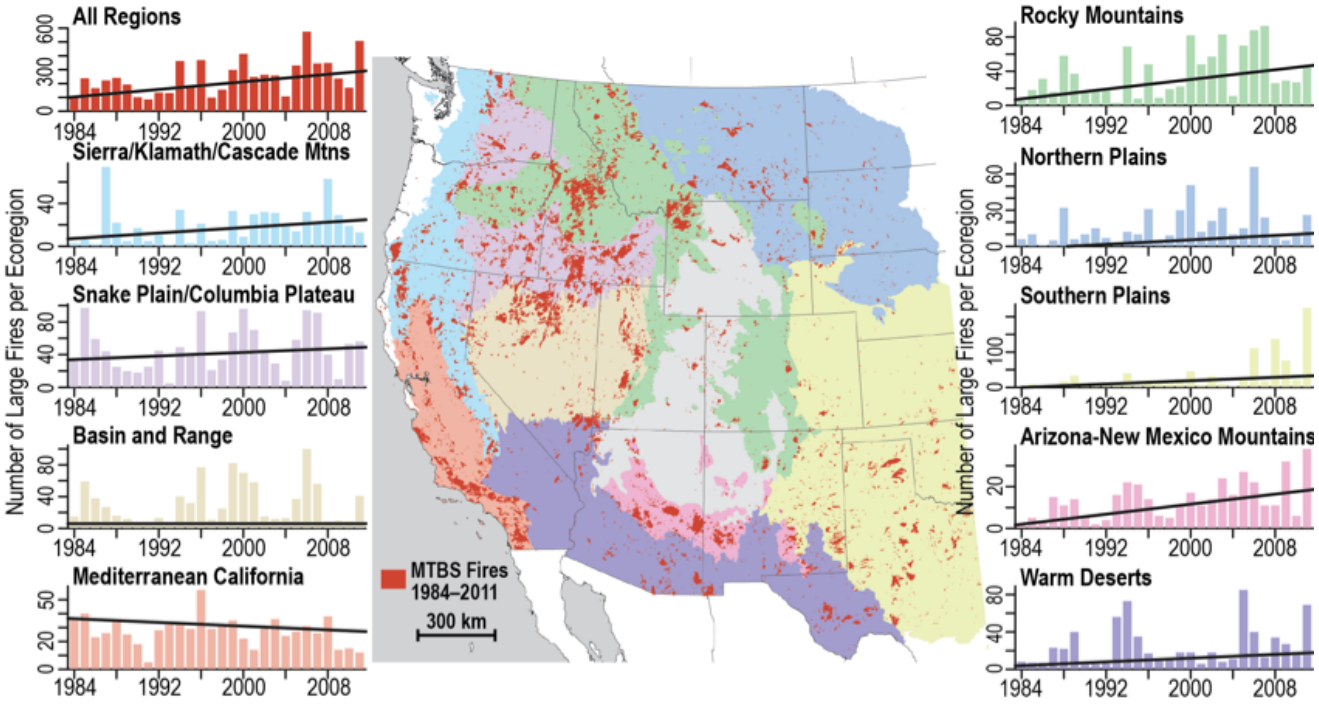
Climate change is expected to cause increased temperatures, drier conditions, and insect outbreaks in the decades to come, all of which will likely increase the risk of wildfires, especially in the western United States.[1] Human-caused climate change can be blamed for more than half the documented increases in fuel aridity (the extent to which dryness can turn trees and other organic matter into fuel for wildfires) since the 1970s. Wildfires are also affecting larger areas, causing a doubling of the cumulative areas of the United States affected by wildfire since 1984.[2] Indirectly, climate change may also increase wildfire risk through warmer temperatures that could increase bark beetle populations. Bark beetles, such as mountain pine beetle, spruce beetle, and southern pine beetle, infest and reproduce in live trees.[3] Bark beetles can affect wildfire risk by killing trees and creating fuel for wildfires, though the relationship between climate change, bark beetles, and wildfire risk is complex and varies geographically.[4]

The number of large fires per year has increased steadily from 1984 to 2011 in much of the West.[5] The most dramatic increase in wildfires has been observed in Alaska. An attribution study found that anthropogenic climate change makes Alaska's severe fire season 33 to 50 percent more likely.[6]

Wildfires have far-reaching adverse effects, including degraded air quality, erosion, and damaged habitat. Degraded air quality can be a particular public health concern for communities. Wildfires near San Diego in 2007, for example, coincided with excess emergency room visits for asthma, respiratory problems, chest pain, and lung disease. During peak fire particulate matter concentrations, it was 50 percent more likely for a person to seek emergency care than in non-fire conditions.[7] After a wildfire, landscapes are also more prone to flash-flooding and erosion, because of vegetation losses and changes to runoff. For instance, in New Mexico, the greatest threat to lives and property after wildfire is the flash flooding that can come in the summer and early fall.[8] Wildfire and the resulting runoff and ash can affect regional water-supply reservoirs, disrupt downstream drinking water supplies,[9] harm lives, destroy infrastructure, and affect energy distribution, with many communities losing or having to shut off their power in fire conditions.

These impacts and efforts to prevent fires result in significant costs for the United States. In California alone during 2017, more than 7,000 wildfires were recorded with a total cost (including fire suppression, insurance and recovery) close to $180 billion. Nationally, the U.S. Forest Service reports an increase in annual budget

FIGURE 1: Wildfire Trends in the Western United States



Trends in the annual number of large fires in the western United States from 1984 to 2011. The areas are divided into ecoregions, seven of which are experiencing a significant increase in large wildfires (greater than 1000 acres) each year.

Source: Philip Dennison et al., "Large wildfire trends in the western United States 1984-2011," Geophys. Res. Lett., 41, 2928-2933, doi: 10.1002/2014GL05957

allocated to wildfire from 16 percent of the 1995 budget to more than 52 percent of the 2015 budget.[10] These growing suppression costs force the Forest Service to divert funds from fire prevention to suppression efforts, or "fire borrowing." While climate change has increased the risk of wildfires, these risks are compounded by forest management and fire suppression practices that allow the accumulation of easily burned wood (fuel) as well as continued housing development in forested areas.

This paper reviews a number of strategies that can be part of a comprehensive approach to managing climate risks related to wildfire. These community-wide resilience strategies and the associated co-benefits can inform decision makers about how local, county, and state governments and property owners can apply the most effective strategies. The paper also includes estimates of the cost to develop or implement these strategies, though project costs will vary based on the location and project design. Identification of co-benefits creates more opportunities for financing and can inform additional design objectives that can increase the viability of a resilience project. This paper also includes tools that local officials and planners can use in assessing local project co-benefits and a case study of Austin, Texas where a number of these strategies have been implemented.

ZONING, BUILDING CODES, AND LANDSCAPE MANAGEMENT

While wildfire risk is exacerbated by climate change, development patterns have also played a role in increasing risk. The number of houses in the wildland-urban interface (WUI), or areas where structures or human development intermingle with undeveloped wildland, grew dramatically from 31 million housing

units in 1990 to 43 million in 2010 in the United States, a more than 30 percent increase in a 20-year span.[11] Due to growing damages from fires and the greater populations living in areas with wildfire risk, there is opportunity to reduce fire risk by managing the number of people living in harm's way, and make individual structures less vulnerable to fire. WUI Code and community wildfire protection plans encourage land conservation in the WUI and dense development in areas with less risk. Zoning and building code policies can also space homes to create barriers to stop wildfire from spreading and encourage use of fire-resistant building materials.

ZONING AND DEVELOPMENT CODES

Communities can limit the development in the WUI using smart growth (a development strategy that includes compact design to create walkable neighborhoods and preserve open space) and land conservation. The strategy can also be used to incentivize dense development in lower wildfire risk areas. Communities should assess wildfire risk to determine where it is elevated and what should be designated as WUI to inform these decisions.[12] Within an area designated as WUI, new development should be minimized as a lower density of structures can prevent rapid movement of wildfire. Communities can incentivize developers within WUI areas to plan open space and recreational trails to create fuel breaks to limit the spread of fires while also offering community benefits.[13]

LANDSCAPING REGULATIONS

Community development standards combined with permit review can ensure building owners or developers are taking steps to reduce fire risk surrounding buildings. Reducing flammable vegetation around a structure and creating a low-fuel buffer creates a "defensible space" around buildings. Individuals and homeowners can create defensible space by removing vegetation within 3-5 feet of their home, removing dead plant materials, thinning trees, pruning lower tree branches, and keeping grass mowed.[14] Fire-resistant plants and landscaping materials can also help protect the home and as an added bonus are often drought tolerant, making them more likely to thrive in dry, fire-prone areas. In addition, high-moisture plants that grow close to the ground or have low sap or resin content are less flammable.[15] Local government officials can review site plans for wildfire mitigation measures like defensible spaces and having access to an adequate water supply before issuing building permits. Communities can require existing homes to maintain defensible space, as in San Diego, where the Fire Rescue Department requires 100 feet of vegetation management from structures and regularly inspects properties for compliance.[16]

If regulations on building design or development are not locally politically feasible, effective community outreach can play an important role in preparing individuals for wildfire. For instance, communities or local non-profits can offer free consultations about fire risk to residents, or services where cleared fuels can be chipped or collected from property.

FIRE-RESISTANT CONSTRUCTION AND RETROFITS

Choosing fire-resistant building materials and design can reduce risk for individual buildings and the community when widely implemented. California's Department of Forestry and Fire Protection (CalFire) offers a number of recommendations to fire-proof a building on its website:

- Use composition, metal, or tile instead of wood or shingle roofs.
- Cover vent and chimney openings with metal mesh.
- Use dual-paned windows with one pane of tempered glass to reduce the chance they will break in a fire. Home design should also limit the number of windows that face vegetation.
- Use ignition resistant building materials such as stucco fiber cement, wall siding, fire retardant and treated wood for walls, decks, patios, and fences.
- Have multiple garden hoses that can reach all areas of property.[17]

These measures can be incentivized by waiving application and processing fees or offering even a modest, 5-10 percent rebates on the cost.[18] Fire-proof building design and materials can also be required by plan review procedures and development regulations. The Tools section of this paper includes a number of other guides to fire-resistant construction. In addition to less flammable buildings, construction of new homes or new neighborhoods should require multiple accesses, a minimum road width that allows fire truck access, adequate water supply, and signage to help fire-rescue

workers to aid in fire suppression efforts if wildfires do occur.[19]

COSTS

Zoning, building code, and landscape management to manage fire risk should be elements of WUI code, community ordinances or planning processes, folding the cost into other planning processes. Creating defensible space around buildings is one of the most cost-effective ways to protect a building from wildfire, but estimated costs for treating properties vary based on the terrain and how much vegetation needs to be cleared.[20] Steps to make buildings more fire resistant vary greatly in cost from inexpensive actions such as pruning tree branches near the home to actions that could cost considerably more, like replacing flammable siding with non-flammable materials.[21]

BENEFITS

Savings on Insurance

Fire prevention can reduce community home insurance costs. For example, Angel Fire, New Mexico, formed a community wildfire protection plan in 2009, triggering the thinning of a number of areas recommended for treatment. Thinning has also occurred along highways and evacuation routes, and the addition of a million-gallon water tank, new fire station, and new equipment improved Angel Fire's Insurance Services Office rating. The new rating could save homeowners 10 to 15 percent in insurance premiums.[22] State Farm is developing a market incentive for fire risk mitigation by initiating a pilot program for assessing properties for wildfire risk and rewarding properties participating in Firewise, a federal program that teaches how to adapt to wildfire risk.[23]

Public Health

Health benefits from wildfire risk mitigation are challenging to quantify, but there are potentially significant costs avoided in reducing wildfire-related health impacts including respiratory and heart distress. A California study found a 42 percent increase in emergency department visits for heart attacks and a 22 percent increase in visits for heart disease among individuals 65 and older during wildfires.[24]

Property Values

A study of housing prices in Southern California estimates that house prices drop about 10 percent after a wildfire. In areas that experienced a second wildfire, housing prices dropped by an additional 22 percent. The study also finds that homebuyers underestimate the risk posed to different properties.[25] The lowered property values of buildings left standing highlights the importance of community-scale fire risk mitigation.

The Flagstaff, Arizona, Fire Department found that thinning stands of trees around a home can improve property values because homebuyers prefer a forest with medium canopy closure and moderate tree density. Market value increases an average of $200 or more for each quarter-acre of land that is thinned around a home or property, and a buffer of thinned vegetation around a home can increase the overall market value by $40,000.[26]

IMPLEMENTATION EXAMPLES

- **Flagstaff, Arizona**, adopted a modification of the International Wildland-Urban Interface Code in 2008. The fire department began working with community development staff to require hazard mitigation for wildfires on all properties prior to development. The city's Regional Plan 2030 includes guidance on investments on forest health and watershed protection measures, public awareness of the region's forests, and protection of diverse ecosystems.[27]
- A **Caughlin Ranch, Nevada**, homeowners' association (HOA) enacted a number of changes including: banning bark mulch, increasing the grounds crews' activities to reduce hazardous fuel between parcels, and hosting community fire safety meetings in partnership with an agricultural extension. They also changed the HOA's rules to make it easier to replace flammable vegetation with fire-resistant plants.[28]
- **Colorado Springs, Colorado**, passed a roof ordinance that banned wood shake roofs and required roofing materials and assembly to keep fire from penetrating the roof and igniting the structure below. From 2002 to 2016, more than 69,000 roofs were replaced or upgraded to fire-resistant roofing.[29] The city also has a map of wildfire risk ratings, offers property owners free on-site consultations with the

Wildfire Mitigation office to learn about wildfire risk on a specific property, and runs a neighborhood chipping program to dispose of tree branches and hazardous vegetation. Residents also can receive a tax credit for the costs incurred from wildfire mitigation measures.[30]

VEGETATION MANAGEMENT AND FOREST RESTORATION

Wildfire risk is worsened by climate change but is also a function of the accumulated fuel in an area. Fuel refers to live and dead plant biomass that can be ignited by fire. Fuels can be managed to reduce the risk of severe wildfires by allowing some natural fires to burn, using prescribed fires, thinning forests, removing excessive dead vegetation, and using grazing to limit vegetation.[31] All of these strategies, if used correctly, can help reduce fuel and in many cases restore ecosystem health.[32]

A study in Washington state found that in areas treated with both thinning and prescribed burns, more than 57 percent of trees survived wildfires while only 19 percent of trees survived in areas treated with thinning alone. In the untreated areas, only 14 percent of trees survived wildfire.[33]

COSTS AND BENEFITS

Managing forests and reducing fuels can be expensive, but the benefits can far exceed the costs. A California study modeling fire impacts found a return of $1.90 to $3.30 for every dollar spent. The study considered a number of benefits of fuel-treatment including structures saved and avoided damages, avoided fire clean up, carbon sequestration, timber from treatment, biomass, transmission lines saved, and avoided water quality degradation.[34]

Forest products

In some cases, fuel treatment could result in biomass collected from mechanical treatments that could provide wood products. The cleared biomass could be used for energy production or small diameter forest products. Distance from wood processing facilities and access to a biomass market can limit these benefits. There is potential for a market to develop around increased biomass production, and this is a future benefit to consider.[35]

Ecological Benefits

Reducing fuel for wildfire can have the dual objective of forest restoration. In California, disrupted fire cycles have caused a greater number and density of trees. Removing smaller diameter trees helps old growth forests return to a more natural state while reducing fuel for fires.[36] The ecological benefits of thinning vary based on methods used and the local environment and some studies have found that forest treatments can harm some species.[37]

IMPLEMENTATION EXAMPLES

- **Denver Water** spent more than $27 million in water quality treatments, sediment and debris removal, reclamation, and infrastructure projects after two large fires in 1996 and 2002. Since 2010, Denver Water has helped pay for forest thinning and wildfire fuels reduction projects upstream of the city to reduce potential future wildfire damages.[38]
- **Los Alamos, New Mexico**, worked with Los Alamos County and the U.S. Forest Service to thin forestland around the city and a nuclear weapons lab following the Cerro Grande fire in 2000.[39] A 2011 fire was the largest in state history, but partially due to fuel reduction efforts, no homes in Los Alamos were lost while 63 homes in other communities were destroyed.[40]
- **Flagstaff, Arizona**, issued $10 million in bonds in 2013 to support the U.S. Forest Service's forest thinning beyond the city's limits and counteract funding deficiency. The city's Wildland Fire Management division also did some treatment work in the forests surrounding Flagstaff. In response to public resistance, the department partnered with Northern Arizona University's Ecological Restoration Institute to do public outreach, providing literature and explanations based on scientific studies about why forestry thinning is important.[41]

PUBLIC EDUCATION AND PREPAREDNESS

Greater frequency of wildfire and longer wildfire seasons add to the importance of public safety officials regularly communicating with residents to encourage household- or business-level risk mitigation, build public support for

public wildfire risk management, and to inform residents about being prepared for wildfires.

Public Education

Residents should understand wildfire risk as it affects their neighborhood or property specifically, and the value of implementing risk reduction activities on individual property, like creating defensible space. Preparedness messaging about wildfire risk mitigation is most effective when it's carried out by a number of partners including public policymakers, officials, local community and business leaders.[42] Raising public awareness also can build public support for wildfire management projects in the broader community, like prescribed fire. Increased interactions between wildfire agencies and the community build trust and contribute to support for public wildfire mitigation actions.[43]

Emergency Preparedness

Wildfire emergency preparedness should be part of the hazard mitigation, emergency response, and climate resilience planning processes (if applicable) in areas with wildfire risk. To prepare for wildfire emergencies, communities can develop wildfire education, warning systems, evacuation procedures and routes, and training for homeowners who may choose to remain on well-prepared properties to extinguish embers and spot fires.[44] Residents should also be taught how to create personal wildfire preparedness plans.

Communication continues after wildfires to warn about post-fire hazards like flooding and drinking water contamination and explain relief and recovery actions. Some fire-prone communities include wildfire response and recovery in their hazard mitigation planning or determining the funding available for grant funding and preparedness for post-wildfire floods.[45]

COSTS

Integrating wildfire management and risk reduction in a hazard mitigation plan, comprehensive plan, or other planning activities carries a small additional cost. A community wildfire preparedness plan could have greater costs associated with it depending on the community size, fire risk data available, and resources at hand. Public education campaigns on wildfire can be cost effective. A 2009 study on wildfire prevention education programs in Florida found $35 of benefits for every dollar spent.[46]

BENEFITS

Increased Awareness and Public Trust

While educating residents about fire risk, agencies can build trust with the community through outreach programs. Trust is built by both individual practitioners and agencies as a whole, through effective outreach, sincere engagement with stakeholders, transparent decision making, and cooperation with other agencies.[47]

Public Health and Safety

Clear communication about wildfire risk and how residents should act in emergencies can reduce life loss and health impacts from wildfire. There are not studies quantifying this benefit, but news reports following California's 2017 and 2018 fires blamed local and state governments for not using available alert systems to communicate with residents and called for improved warning systems.[48]

IMPLEMENTATION EXAMPLES

- **Colorado Springs** developed a local Firewise program and a strong community education effort in the Colorado Springs Fire Department Mitigation Section. The city's outreach included a "Sharing the Responsibility" campaign to involve residents in mitigation activities. Fire Adapted Communities estimates that the mitigation efforts resulted in $517 in benefits for every $1 spent in the three neighborhoods with the greatest impacts.[49]
- A 2006 wildfire in Oregon forced a neighborhood near Deschutes National Forest to evacuate. The community had developed an evacuation plan and had built a strong relationship with Forest Service personnel through its preparedness activities. This set the stage for strong communication between the community and Forest Service during the fire, and residents received updated, thorough information about the firefight at twice-daily meetings.[50]

TABLE 1: Costs and Benefits of Wildfire Resilience Strategies

		BENEFITS					
		Insurance Savings	Public Health	Property Values	Relationship Building	Public Safety	Ecological
STRATEGIES	*Zoning and Building Code*	▲	▲	▲		▲	●
	Wildfire-Resilient Landscapes	▲	●	▲		▲	▲
	Fire-Resistant Construction	▲	●	●		▲	
	Vegetation Management	▲	▲	▲		▲	▲
	Public Education	▲	▲	▲	●	●	
	Emergency Preparedness	▲	▲		●	●	

Table 1. The table above demonstrates the benefits (in columns) of the strategies overviewed in the factsheet (in rows). Green circles indicate a benefit that could be expected from each of the strategies. Yellow triangles indicate benefits that could apply in certain areas or circumstances, especially if the strategy was designed or implemented to that purpose. When weighing different strategies for use in a community, consider the greatest local vulnerabilities, which benefits would address them and choose strategies that offer these benefits. Be aware of gaps in benefits offered by the strategies prioritized.

CASE STUDY: AUSTIN AND TRAVIS COUNTY, TEXAS

An estimated 45 percent of Austin's residents live in the WUI. Following especially devastating fires in 2011, Austin and Travis County formed a Joint Wildfire Task Force.[51] The task force's goal was to make sure communities in the region were more fire adapted. The city developed a comprehensive joint city-county Community Wildfire Protection Plan (CWPP),[52] a non-regulatory document that aims to restore and maintain landscapes, create and support fire-adapted communities, and implement a risk-based management response to wildfires across municipality lines. To ensure implementation and administrative support, the CWPP was added as an appendix to the Hazard Mitigation Plan.[53]

A Wildland Fire Division formed within the Austin Fire Department to collaborate with other departments and manage wildfire risk, mainly by constructing fire buffers by clearing or thinning vegetation[54] and prescribed fires in wildlands.[55] The Wildland Fire Division also partnered with the Austin Energy Green Building Program to incorporate best practices for wildfire safety into the green building rating system with the goal of future affordable housing construction complying with best practices for wildfire and to also demonstrate that wildfire safety can be a marketing strategy for developers.[56]

Austin has designated nearly 30 percent of city land as conservation lands which limits the number of future structures at risk within high hazard areas. Integrating international WUI code is a priority of revising the city's land development code, thought that process was stalled in 2018.[57] The Austin Community Climate Plan, approved in 2015, contains wildfire resilience strategies including establishing and updating emergency evacuation routes for flooding and wildfire.[58]

The City of Austin distributed wildfire risk information to its residents through the "Ready, Set, Go!" guide and the city government's website. Residents can request a fire assessment of their property, view maps of wildfire risk in Austin and surrounding Travis County. They can also learn about how to limit wildfire risk on their property and prepare for wildfire.[59]

KEY INSIGHTS

Wildfires are becoming more severe, common and expensive due to increased temperatures, decreased soil moisture, and insect outbreaks related to climate change. Additionally, increased development in the WUI has put more structures at risk. Wildfire impacts public health, public safety, the environment, and drinking water access during and after the fire.

Wildfire resilience is more than a matter of adapting to changing conditions: It also requires reducing exposure to the risk, or limiting development in the

WUI. Wildfire resilience strategies can be costly up front, although many have a high benefit-cost ratio over their lifetimes. Communities are seeing returns on their investments with lower wildfire insurance rates, lesser impacts on public health during fires and improved property values. Table 1 shows the benefits offered by each strategy. When choosing which strategies to prioritize, consider which benefits are most aligned with other community priorities, and which combination of strategies may yield them. Because wildfire risk is tied to higher temperatures, drought, and flooding, comprehensive resilience planning for multiple impacts is critical for communities.

TOOLS

FIRE ADAPTED COMMUNITIES

The Fire Adapted Communities Learning Network, an effort supported by U.S. Department of Agriculture, Department of the Interior and The Nature Conservancy, engages residents and other actors including fire departments, business owners, and land managers. The network shares best practices and exchanges information about strategies like evacuation planning, wildfire protection plans and WUI codes. A Fire Adapted Communities Self-Assessment tool is also available on the website which helps communities evaluate their progress in wildfire adaptation and identify priorities and potential actions. The tool is for non-profits, fire departments, state governments, and emergency management offices.

www.fireadaptednetwork.org

FIREWISE

Firewise is a program of the National Fire Protection Agency that encourages local solutions for wildfire safety by involving homeowners, community leaders, planners, developers, firefighters, and others in creating fire-adapted communities. The recognition program provides instructional resources to guide how individuals can work together to reduce wildfire risk. To participate, communities must form a Firewise board, complete a wildfire risk assessment, create an action plan, and meet a required minimum for hosting events and investing in Firewise actions for a year.

https://www.nfpa.org/Public-Education/By-topic/Wildfire/Firewise-USA

HOME BUILDER'S GUIDE TO CONSTRUCTION IN WILDFIRE ZONES

This series of technical factsheets published by the Federal Emergency Management Agency (FEMA) provides recommendations for building design and construction methods in wildland-urban interface.

https://www.fema.gov/media-library-data/20130726-1652-20490-4085/fema_p_737.pdf

INSURANCE INSTITUTE FOR BUSINESS & HOME SAFETY

IBHS provides a series of regional wildfire retrofit guides which include a risk assessment checklist and cost estimator to help home and business owners choose retrofit projects. There is a separate guide available for each region with fire risk.

https://disastersafety.org/ibhs/ibhs-regional-wildfire-guides/

WILDLAND URBAN INTERFACE TOOLKIT

This U.S. Fire Administration website is a compendium of tools and other information that can be used to assess wildfire risk, develop codes and standards, develop outreach, create wildfire protection plans and training materials.

https://www.usfa.fema.gov/wui_toolkit/

WILDFIRE SAFETY SOCIAL MEDIA TOOLKIT

The Wildfire Safety Social Media Toolkit has safety and preparedness messages that local governments and others can use to promote wildfire resilience. These messages are provided for public use by the Department of Homeland Security and can be used directly or customized.

https://www.ready.gov/wildfire-toolkit

C2ES thanks Bank of America for its support of this work. As a fully independent organization, C2ES is solely responsible for its positions, programs, and publications.

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