Missing the Mark: Effectiveness and Funding in Community Wildfire Risk Reduction

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Executive Summary

Wildfire risk has many dimensions – for example, fires can impact ecosystems and wildlife, and smoke increases greenhouse gas emissions. However, this research report is narrowly focused on the effectiveness of specific governmental policies to reduce risk to *communities*—the residents and neighborhoods impacted by wildfire.

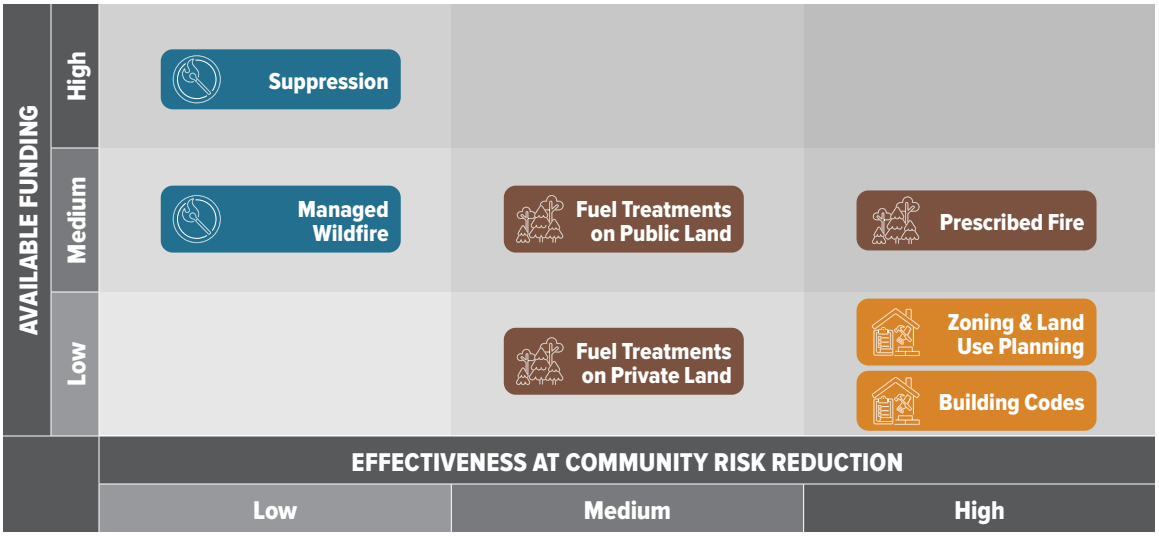
This research has two objectives:

1) identify which policies are most effective for reducing wildfire risk to communities, and

2) of those, determine which are attracting consistent funding over time.

The authors conducted a rigorous review of both the scholarly and technical literature, including congressional reports and budget documents. They conducted 38 expert interviews with land managers, local officials, scientists, and firefighters. Based on these resources, policies were sorted into three categories, based on which leverage point each one was attempting to modify: managing fire, managing fuels, or managing the built environment. These categories mirror the federal National Wildland Fire Management Cohesive Strategy's three goals: executing safe and effective wildfire response, building resilient landscapes, and creating fire-adapted communities.

This analysis concludes that the most effective policies for reducing community wildfire risk tend to be those that manage the built environment, including mandated building codes and home hardening. Those policies are also among the least funded or supported. Managing fuels, especially on private lands near homes, was also found to be effective, as it can reduce risks to communities, but is similarly underfunded. Meanwhile, policies such as broad wildfire suppression are regularly funded but do little to reduce risk to communities and actually contribute to increasing risk over time.



Several recommendations come directly from this analysis, including:

- *Congress* should create and fund home-hardening programs. These efforts should complement and support existing programs for communities in agency budgets.
- *Federal agencies* should modify protocols regarding wildfire suppression to facilitate treating more acres with managed and prescribed fire, including exploring innovations in the application of National Environmental Policy Act NEPA requirements.
- *State governments* should encourage mandatory building codes in wildfire-prone areas, and support market strategies for timber including development of biomass energy.

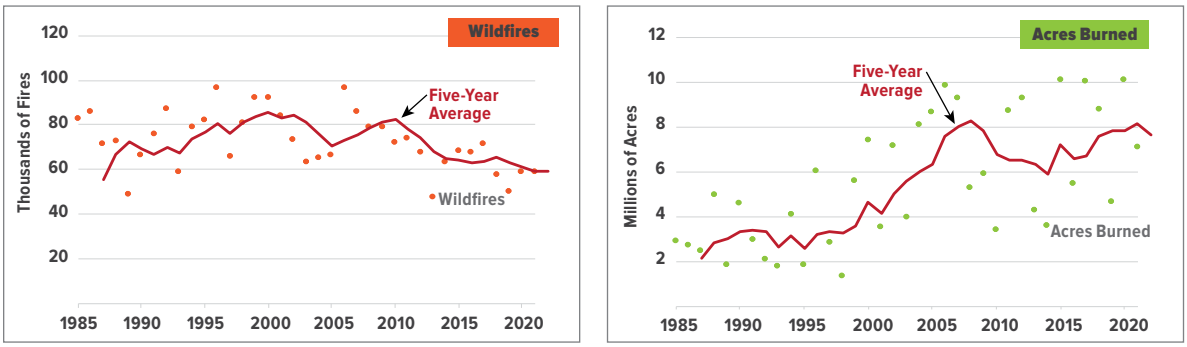
As the wildfire crisis grows in step with escalating impacts from climate change, all levels of society will need to work together to keep communities safe. This analysis demonstrates that we have multiple opportunities to reduce wildfire risk to communities if we strategically target funding to the most efficacious policies and programs.

1. Introduction

Well before human settlements defined the landscape, wildfires in the American West played an essential role in maintaining natural forest ecosystems. Native people lived with the frequent disturbance of wildfire, modifying their living arrangements to avoid seasonal risk and utilizing controlled burns to improve wildlife habitat and crop yields.[1] But the arrival of European settlers brought expansive development to those same landscapes. Homes, roads, utilities, and industrial facilities were built within or adjacent to those naturally burning forests, and soon fire was a primary threat to their lives and property. As the population grew, and particularly after the Great Fires of 1910, this context formed the foundation of wildfire policy that prioritized aggressive suppression.[2]

But since wildfires are both natural and essential for forest health, the suppression mindset didn't eradicate the problem. Instead, fueled in part by climate change, wildfires in the American West have grown in size, duration, intensity, and frequency (Figure 1).[3,4,5] Simultaneously, population has dramatically expanded with private homes, neighborhoods, towns, and even cities now located within and adjacent to public forest lands, a geographic zone called the Wildland-Urban Interface (WUI). In the West, there was more than a 47% increase in the number of housing units from 1990 to 2020 in the WUI.[6] When wildfires encounter human communities, the result is too often loss of life and destroyed structures. Since 2005, more than 97,000 structures have been lost to wildfire.[7] Predictions suggest these losses will increase, with an estimated 100 million acres at high risk for unwanted wildfire.[8] Federal agencies, local communities, and others have long recognized the challenge of managing wildfire risk, and over several decades have implemented a complex set of policies designed to address it.

Figure 1. Number of wildfires and acres burned in the United States from 1985 – 2022.



This research has two objectives: 1) identify which policies are most effective for reducing wildfire risk to communities, and 2) of those, determine which are attracting consistent funding over time. Only when we understand how current policies are performing can we meaningfully explore desired

reforms. There are many dimensions of wildfire risk – for example, fire impacts ecosystems and wildlife, and smoke increases greenhouse gas emissions – but this research is narrowly focused on risk to *communities*—the residents and neighborhoods impacted by wildfire. We define *effectiveness* based on data that reveals whether or not a given tool succeeds in reducing wildfire risk to residents and neighborhoods.

We define "communities" as the residents and neighborhoods impacted by wildfire.

We define "effectiveness" based on data that reveals whether or not a given tool succeeds in reducing wildfire risk to residents and neighborhoods.

We begin with a brief overview of our research methods, and then introduce the policy typology we use to organize our analysis. From there, we proceed through each of the three policy categories in the typology, explaining what each policy is, assessing its relative effectiveness at risk reduction, and describing its funding history. We then offer an analysis of barriers to improved effectiveness and a discussion of opportunities to improve outcomes. Revisiting the policy typology at the end of the report, we summarize our findings and offer recommendations for policymakers.

Research Methods

To answer these research questions, we gathered information from three broad sources. First, we probed the scholarly literature, identifying 210 peer-reviewed articles that offer insight on the relative effectiveness of wildfire risk-reduction efforts. As a part of this literature review, we also consulted more than 100 technical reports, news articles, and policy documents, particularly from federal agencies and nonprofit organizations (NGOs). Secondly, and simultaneously, the lead author conducted 38 expert interviews, speaking at length with wildfire leadership including land managers, local officials, scientists, and firefighters. Those interviews were conducted in person or virtually; for a complete list of experts consulted, please see Appendix B. Lastly, we used funding and appropriations data from congressional reports and budget documents to help us chart funding patterns.

Drawing on these resources, we sort policies into three categories according to which lever they activate: managing fire, managing fuels, or managing the built environment. These categories mirror the federal National Wildland Fire Management Cohesive Strategy's three goals: building resilient landscapes, creating fire-adapted communities, and executing safe and effective wildfire response.[9] Within our three categories, we identify the lead actor for each approach: the federal government, including Congress and the U.S. Forest Service (USFS); state governments; local governments; the private sector; or civil society, including individuals, neighborhood groups, and NGOs. Plotting these variables on a simple matrix gives us a policy typology to guide analysis (Figure 2).

Figure 2: Strategies to Reduce Wildfire Risk and Responsible Entities

	Managing Fire	Managing Fuels	Managing the Built Environment
Federal Government	**Suppressing wildfire** Federal land management agencies and local firefighters suppress 99% of all unwanted wildfires. **Managing wildfire** When homes and communities are not at risk, allowing wildfire to burn in pre-planned locations has important ecological benefits.	**Treating fuels on public lands** Mechanical treatments and prescribed fire are methods used by land management agencies to strategically reduce flammable material on federally managed public land.	**Grant distribution, technical assistance, and resources** Providing funding opportunities to states and communities to mitigate the built environment through structural improvements ("home hardening"), and offering technical assistance for building code adoption and land use planning.
State Government	**Suppressing wildfire** States may contribute funding and support for local firefighting efforts.	**Treating fuels on private lands** States provide financial and technical support for communities to implement mechanical treatments and prescribed fire on private land.	**Adopting Statewide Regulations** States can adopt statewide building codes, zoning, and other regulatory measures requiring local jurisdictions to mitigate wildfire risk, often through construction standards and vegetation management on private and public lands.
Local Government	**Suppressing wildfire** Local governments play an essential role in initial attack for unwanted wildfire. **Developing a workforce** A suite of policy tools is available to local governments to fund, train, and employ firefighters.	**Developing a workforce** A suite of policy tools is available to local governments to fund, train, and employ land managers. **Developing Community Wildfire Protection Plans (CWPPs)** Counties and municipalities play a central role in fostering local collaboration efforts designed to reduce risk from wildfire.	**Adopting Local Regulations** Counties and communities can adopt local building codes, zoning, and other regulatory measures requiring residents to mitigate wildfire risk, applicable to proposed new developments only. However ordinances, subdivision standards, and other regulations can be applied to existing structures and/or significant remodels.
Residents & NGOs	**Developing a workforce** Communities and collaborative groups partner with federal land management agencies to fill workforce gaps in fire management.	**Developing Community Wildfire Protection Plans (CWPPs)** Homeowners and non-profit collaborative groups work together to establish wildfire risk reduction strategies. **Reducing fuels on private land** Homeowners, potentially supported by local non-profit groups and in concert with their neighbors, reduce flammable material on their property.	**Structural improvements** Also known as home hardening, structural improvements includes constructing and designing a home and landscaping using wildfire resistant building materials techniques.
Private Sector	**Developing a workforce** Training, funding, and deploying fire managers builds capacity for more effective risk reduction.	**Reducing fuels on private land** Homeowners often need financial and technical support to reduce fuels on their properties, turning to contractors for help. **Utilizing biomass** Traditional timber products and biomass energy both offer opportunities for private companies to remove marketable flammable material from fire-prone forests.	**Structural improvements** In addition to homeowners, involving the construction industry, including builders, developers, architects, realtors, and landscapers in the wildfire-resistant construction is essential. **Collaborative Partnerships** Including partners in the private sector, including the construction industry, utilities, and insurance companies, offers opportunities to encourage broad implementation and maintenance of risk reduction measures to homes, neighborhoods, infrastructure, and communities.

2. Managing Fire

Wildfire is a natural process that creates dangerous risks for adjacent communities, and addressing that problem by managing fire directly is perhaps an intuitive response for policymakers. An average of 60,000 fires occur each year nationwide, with an estimated 20% occurring on public lands managed by the USFS, the Bureau of Land Management (BLM), or the National Park Service (NPS).[10] These wildfires can be suppressed or, under careful observation, allowed to burn for resource benefit.

A. Wildfire Suppression

The origins of the U.S. wildfire suppression policies are well documented. With newly settled communities in need of timber supplies for building, wildfire was understood as an immediate, economic threat to the viability of the settlement enterprise. The USFS established the 10 a.m. policy in 1935, asserting a new standard that all wildfires should be suppressed by 10 a.m. the next day.[11] To support this policy, the agency began to build its firefighting expertise, including installing fire towers, accumulating equipment, and training crews to battle blazes by land and by air.[12] Soon, the vast majority of wildfires were met by a militaristic array of suppression efforts.

But even as the agency invested resources in a robust suppression response to wildfire, scientists were learning about the essential role played by fire in many forest types. Some, such as high-elevation lodgepole pine, have serotinous cones that require fire to melt the resin-encased seeds for dispersal. Wildfire also stimulates new sprouts in trees and grass, removes dead vegetation, and releases nutrients back to the soil,[13] all essential services for a resilient forest structure.[14] Animals, birds, and insects have also evolved to depend on fire.[15,16,17,18] Similarly, fire greatly impacts hydrological processes, and in some places wildfire is crucial for increased streamflow.[19,20]

These two realities – unplanned wildfire can pose substantial risk to human societies but is also necessary for ecosystem function – form the core of the complex wildfire response today. Suppression remains dominant, but is not the only way to respond to fire. Indeed, efforts to allow unplanned fires to burn for resource benefit in pre-planned locations, and a growing recognition of how planned fires, called controlled or prescribed burns, can be deployed for both resource and community benefit form important pieces of the toolkit. These approaches are critical for forest restoration and resilient landscapes, and are explored in more detail below.

Fire response often begins when local fire crews take the lead in extinguishing blazes they detect, followed by state and federal firefighting resources deployed for larger fires that exceed local capacity.

So effective are these initial attack efforts that more than 99% of fires are suppressed before they exceed one acre in size.[21] The large, damaging, and expensive fires that evade suppression make the news, but they represent a tiny fraction of the total.

Effectiveness for Community Risk Reduction

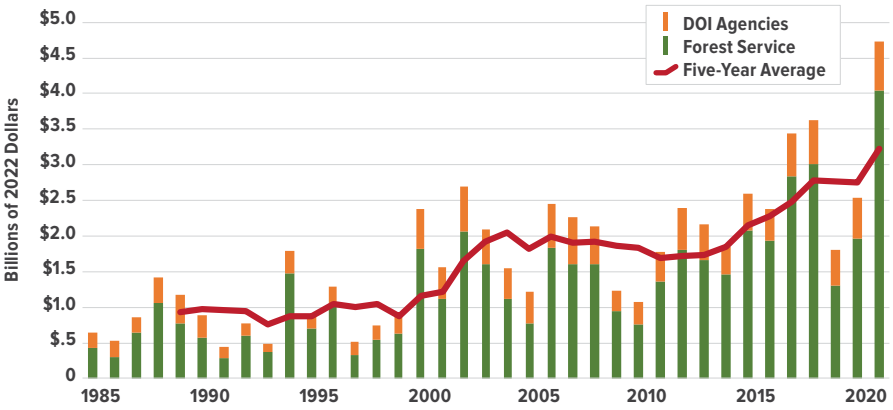
While we may understand suppression to be effective at achieving its immediate goal – putting out unplanned wildfire – it is also implicated as a powerful contributor to longer-term risk for communities.[22] Without regular intervals of fire, many fire-dependent ecosystems become overly dense with woody biomass, creating flammable conditions that then contribute to more intense, larger wildfires when one inevitably escapes initial attack. The feedback loop is commonly referenced as the "wildfire paradox": suppressing a wildfire today contributes to conditions for a more extreme and potentially damaging wildfire in the future.[23] In this way, suppression can be understood to be an effective tool for reducing risk to communities in the short-term, but counter-productive over a longer time frame.

It is worth noting that even in the context of more than a century of fire suppression, so much fire has burned in that time period that fire scars on the landscape now also modify fire behavior. For example, the Arapaho-Roosevelt National Forest in Colorado has been the site of frequent ignitions. Many of those have been suppressed but some have escaped initial attack; the result is an estimated 75% of the cover area having burned in some capacity over the last 20 years.[24] Now when a wildfire is sparked, it will behave differently in that forest than it would have absent those widespread fire scars. Still, extensive fire scars on public lands do not create meaningful risk reduction for communities. The interactions between fire management in the past and future fire behavior is multi-layered and complex, making any assessment of effectiveness for community risk reduction potentially incomplete.

Funding

Fire suppression is expensive and costs are rising. Combined, the USFS and Department of Interior (DOI) spend an average of $2.8 billion each year on suppression, an amount that represents a four-fold increase since 1989[25] (Figure 3). Land management budgets itemize totals for suppression, but a more accurate assessment also tallies the "preparedness" line item, since those funds support firefighting equipment and training, all geared toward future suppression needs. Taken together, more than 80% of the USFS budget goes to fire suppression.[26,27] A large proportion – an estimated 50-95% – of those federal suppression costs are spent protecting private homes and structures located in wildfire risk areas.[28] In principal, this kind of structure protection during a wildfire is a state and local responsibility, but in practice the federal government incurs significant risks and costs defending private property.[29] Federal suppression costs therefore increase in parallel with the rising trends in home development in wildfire-prone areas. As these suppression costs have steadily increased, the agencies have been forced to move funds appropriated for other land management activities to emergency fire response when those accounts run dry. The resulting cascade of project cancellations and reconfiguration is known as the fire borrowing problem, and it has contributed to uncertainty in fuels reduction efforts (see Section 3, Managing Fuels).

Figure 3. Spending on fire suppression by the U.S. Forest Service and Department of Interior from 1985 through 2021 (shown in inflation-adjusted 2022 dollars).



States and local governments are also shouldering more suppression costs than in the past through a network of cooperative agreements and intergovernmental partnerships. Recent data suggest those entities are spending two or three times as much as they were a decade ago.[30] Few states and local governments have dedicated and adequate funding for wildfire mitigation and response and instead rely heavily on reimbursement from the federal government. As wildfire risks continue to rise, state and local governments are increasingly strained to fund wildfire budgets sufficiently and sustainably.

Barriers and Opportunities

The double-edged nature of suppression – reducing proximate risk while simultaneously contributing to longer-term risk – has been understood for many years. Still, there are powerful barriers to modifying the practice. Perhaps most notably, the public expects robust and immediate fire suppression in all circumstances. As development in wildfire-prone areas continues to expand and more assets of value lie in the pathway of future fires, those expectations will persist. Private contractors have profited from these expectations, and thousands of federal jobs are tied to them.

These mutually-reinforcing incentives for suppression are so durable that experts have labeled them the "wildfire industrial complex."[31,32,33] Institutional path dependency traps firefighting agencies in an endless pattern of buying new planes for aerial suppression, deploying those aircraft to fight fire even in unacceptably dangerous conditions,[34] and feeding public expectations for "performative firefighting"[35] that may calm political nerves but ultimately fail to address the long-term threat wildfire poses to communities.

Devoting so much collective energy and funding toward a singular fire response – suppression – also has important opportunity costs. Research shows that funding spent on pre-fire planning and prevention efforts can effectively reduce risk in the future; one study on tribal lands found that each $1 spent on prevention programs was found to avert suppression costs by $5-$38.[36] Yet these pre-fire programs are chronically underfunded, a pattern made worse by the fire borrowing problem, in which the USFS has to borrow funds from other accounts to cover emergency firefighting needs.

For some, this fire policy rut is emblematic of our collective failure to adapt to climate change. Instead of assuming suppression is the default fire response, many leaders would prefer a more flexible fire response that allows them to consider weather, terrain, and ecosystem conditions when making a suppression decision. But to act on this paradigm shift, new discretion for fire response would have to be codified in law, and both homeowners and political leaders would need to modify their expectations.

B. Managed Wildfire

When an unplanned wildfire is naturally ignited, suppression is not the only option. Forest managers seeking to maximize the resource benefits associated with natural fire have established a pathway for allowing those blazes to burn under carefully controlled conditions. The USFS requires substantial pre-planning for the use of managed fire as a tool, and once underway, the fire must be monitored to ensure it doesn't escape the defined boundaries planners mapped out ahead of time. If nearby communities are not hardened and prepared for wildfire (see Section 4, Managing the Built Environment), the risk of the fire escaping can eliminate any opportunity to use natural fire for resource benefit. As a result, managed fire has been implemented mostly in low-density population areas like the Gila National Forest in New Mexico and the Selway-Bitterroot and Bob Marshall wilderness areas in Montana. Far from population centers, these fires can accomplish critically important ecological work. But with only 0.4% of all naturally ignited fires allowed to burn as managed wildfires,[37] this tool is under-utilized.

In 2022, the USFS announced a new 10-year strategy, Confronting the Wildfire Crisis, that emphasizes a new paradigm focused on fuel treatments with the goal of treating millions of acres of federal, state, tribal, and private land.[38] This effort will be funded, in part, by the 2021 Bipartisan Infrastructure Law that provides nearly $1.5 billion to reduce hazardous fuels, invest in fire-adapted communities, and conduct post-fire restoration.[39]

Managed Fire on the Wallowa-Whitman National Forest

In 2019, U.S. Forest Service fire managers allowed the 5,500-acre Granite Gulch Fire in the remote Wallowa-Whitman National Forest of eastern Oregon to burn for resource benefit under careful supervision.[i] The land that was treated by this managed fire now features better conditions for future blazes to burn at a lower intensity, and for firefighters to safely stage suppression efforts if necessary. Estimates suggest the Granite Gulch Fire cost the Forest Service less than $150,000, making managed fire among the most cost-effective treatments available.[ii]

i Bartuska, A., Wibbenmeyer, M., 2022. Managed Fires Can Help Mitigate the Risks Posed by Increasing Frequency of Wildfires. Resources for the Future. https://www.resources.org/common-resources/managed-fires-can-help-mitigate-the-risks-posed-by-increasing-frequency-of-wildfires/?mc_cid=7571d27fce&mc_eid=1c4294893f

ii Urness, Z., 2019. Forest Service keeps wildfires burning in Oregon's Wallowa Mountains for forest health. Statesman Journal. https://www.statesmanjournal.com/story/news/2019/08/26/forest-service-allows-wildfires-burn-wallowa-mountains-granite-gulch-fire/2101464001/

Effectiveness for Community Risk Reduction

Managed wildfire is highly effective as a tool for improving ecosystem health.[40,41,42] And although the planning and implementation of a managed wildfire can be both time consuming and expensive, managed wildfires have lower costs per acre than any other form of treatment.[43,44,45] As a tool for community risk reduction, however, the effectiveness of managed wildfire is mixed. Certainly, allowing fires to burn for resource benefit can treat acres that need attention, thereby reducing woody biomass, modifying future fire behavior and establishing new fire lines for firefighting.[46] Managed wildfires may contribute to backcountry forest health, and those improved conditions likely have important ramifications for landscape-scale flammability.[47,48] But managed wildfire is severely constrained by perceptions of risk and is rarely implemented in areas with homes; even new USFS guidance in 2009, which succeeded in expanding the number of fires managed for resource benefit overall,[49] didn't expand use of the tool to more front-country locations where risk to communities is most proximate.[50] As a result, its overall effectiveness for reducing community risk is low.

Funding

Managed wildfire is legally restricted to public land, and yet there is no dedicated budget line for supporting the practice. Instead, fire managers have the authority to allocate their own limited funds across the range of activities – suppression, planning, and management – that contribute to fire management. Despite this potentially limiting funding shortage, no experts raised lack of funds

as a meaningful barrier to expanded implementation of managed wildfire. Here we may conclude that funding is moderate, but removing other barriers presents much more compelling on-ramps for action.

Barriers and Opportunities

Several barriers prevent managed wildfire from becoming a more commonly applied strategy. First, and most importantly, the risk of exposure for nearby communities means allowing a wildfire to burn is politically perilous. Generations of Americans watched Smokey Bear warn about the dangers of wildfire, and this message has been difficult to change. Even as general awareness of wildfire risk has grown in recent years, social science research has shown persistent concern among residents about the use of wildfire for resource benefit near their homes.[51] Most worrisome for locals is the potential for the fire to escape its defined boundaries, but other concerns include smoke, loss of habitat for wildlife, reduced recreation opportunities, and potential damage to property.[52] These concerns reinforce the current practice of limiting managed wildfire to areas distant from private land.

Secondly, federal policies currently constrain the application of managed wildfire by ignition source and jurisdiction. According to the USFS Handbook, only fires ignited by lightning are eligible for managed wildfire;[53] with only 11% of fires from 2017-2021 naturally ignited,[54] that restriction limits application. The vast majority of wildfires are ignited by humans. Related, only federal fire managers are authorized to use unplanned ignitions for resource benefit, as state and local jurisdictions are nearly always explicitly prohibited from responding to fire in any way other than suppression.[55]

A third barrier arises from the performance metric known as "acres treated" that can drive USFS decision making at the national forest level. Measuring how many acres of hazardous fuels have been treated became central to national accountability in land management in the 1990s; today, achieving treated acres can drive promotion and professional mobility, but the practice creates a web of incentives that don't align with efficiency. Acres burned by a managed wildfire do not count toward a national forest's reportable acres; in other words, even if a managed wildfire could reduce fuels for lower cost, it would make more sense for a fire manager to extinguish the fire and then conduct more expensive fuels reduction through mechanical means, since only those hand-cut acres will "count." These incentives have been critiqued,[56,57] but not updated.

Fourth, questions around liability hinder more intensive application of managed wildfire. Should the wind pick up or conditions change and a community suffer harm, the line officer who opted against suppression could be considered liable for any damage and the agency held to account. Experts urge the USFS to modify and clarify liability laws to decrease professional risk associated with burn decisions for line officers. Combined with a modification of the language in the USFS Handbook to make human-caused ignitions eligible for managed fire use, these reforms could result in expanded application of natural fire to fire-dependent ecosystems. Some experts go even further, proposing a new paradigm in which the default decision would be to let fires burn, and the burden of justification would be imposed for suppression.[58,59] In this scenario, fire managers would be pushed to assess weather conditions, fire dynamics, and possible natural resource benefits in addition to potential damage to private property when they make a decision about how to respond.

One new tool, called PODs, offers a potential pathway through these complexities. Potential Operational Delineations (PODs) is a framework for cross-boundary, collaborative fire planning that brings together local managers, stakeholders, and scientists to plan for future fires. The framework is used to define meaningful projects, plan fuels management, and assess when managed fire might be a successful tool for fuels reduction. PODs have been heralded as a promising new way to engage locals in landscape-scale planning, but experts agree that PODS will be best deployed in concert with other management tools.

3. Managing Fuels

In order to burn, a fire needs three things: fuel, ignition, and oxygen. Both ignition and oxygen are largely outside the control of fire managers, and so a focus on fuels has become the mainstay of wildfire risk-reduction efforts. Intuitively, reducing flammable material may result in lower-intensity fires, modified fire behavior, and safer conditions for firefighters when the inevitable fire does erupt. Even in the absence of fire, reducing fuels may contribute to healthier forests and better habitat for wildlife. But implementing fuels-reduction projects is complex on public lands and often prohibitively expensive on private land. Further complicating the picture, foresters tend to define fuels only as woody biomass in forests; however, when homes ignite, the structures themselves become fuel, with embers and home-to-home ignition imperiling a neighborhood.

A. Mechanical Treatments on Public Land

On public lands managed by the USFS, locations for fuels treatment must align with Forest Plans, which are required of national forests pursuant to the National Forest Management Act (1976). Forest Plans identify which areas will be prioritized for different uses; for example, places on the map with high timber sale potential will be prioritized for extractive use, while places with high recreation value will be largely off-limits for those sales. Individual projects – such as a timber sale – must align with a Forest Plan's priorities, and are then subject to environmental review as mandated by the National Environmental Policy Act (NEPA).

Mechanical treatments may also occur on lands managed by the Bureau of Land Management or the National Park Service, and those projects travel a similar approval pathway. Across all agencies, fuel treatments may be conducted by timber companies, in which case they tend to generate revenue; those treatments are categorized as timber sales. But more commonly, fuels treatments are conducted by the land management agency itself, not to remove valuable timber but to reduce flammable material; those treatments are funded through service contracts and generate little or no revenue.

For the decade 2009-2018, the USFS treated an average of 1.4 million acres of fuels reduction projects per year, and the Department of the Interior treated 1.1 million acres per year.[60] These treatments were overwhelmingly intended to reduce the risk from wildfire. In some cases, they were also implemented as a precursor to allowing fire on the landscape, through either managed wildfire or prescribed burning. They may contribute to forest health through modified tree density and can have other benefits for forested ecosystems.

Effectiveness for Community Risk Reduction

Mechanical treatments have been shown to be moderately effective at reducing fire severity, reducing likelihood of crown fire, slowing the rate of spread, and moderating surface fire behavior.[61,62,63,64,65,66,67]

They are less effective for shrinking the size of fire.[68,69] Effectiveness overall increases with the size of treatment area, but researchers find diminishing returns beyond an estimated 30% of the landscape treated.[56] Copious evidence suggests that the benefits of mechanical treatments are more profound when the same parcel is subsequently treated by managed or prescribed fire.[70,71] To underscore the importance of this second step, some studies show thinning alone can actually make severity worse.[72]

The influence of mechanical treatments on fire behavior is almost entirely ecological, short term, and localized. Recall that out of an estimated 100 million acres at high risk for wildfire, the USFS treats an estimated 1.4 million acres per year[73]; this rate of progress simply doesn't have measurable impacts relative to the scale of the wildfire problem in the West. For meaningful contributions to community risk reduction, backcountry thinning needs to be focused on public lands near communities and matched by homeowner modification of their property (see Mechanical Treatments on Private Land, below).[74] Fuels-reduction projects can contribute to risk reduction in small, localized settings but they do not offer a path to resolution of wildfire risk across the West.

Funding

Combined, the USFS and Department of Interior were appropriated more than $5 billion for fuels reduction from 2009-2018.[75] Those funds were then allocated across the country to individual national forests and BLM units to support projects that have gone through a NEPA environmental analysis process. Tribes face additional hurdles accessing this federal support, navigating a complex funding route that moves money from USFS through the State & Private Forestry program to the Bureau of Indian Affairs and eventually to individual reservations. In all cases, fire borrowing can render the flow of financial support inconsistent, with experts everywhere reporting frustration with planning in uncertain financial times.

Barriers and Opportunities

Ownership Boundaries

With some limited exceptions, the USFS has authority only over its own public forestland and not the adjacent private land, making landscape-scale fuels treatments often impossible. Good Neighbor Authority, a 2018 provision that allows federal foresters to enter into agreements with state forestry agencies to treat across ownership boundaries, has been a welcome step but hasn't resolved the essential jurisdictional challenge. Given those geographic limitations and the mandate to achieve "acres treated," (see Barriers and Opportunities for Managed Wildfire, above) the agency may be driven to conduct fuels removal in the backcountry. This practice may succeed in reducing fuels on public land, potentially with benefits for ecosystems, but does very little to modify risk in nearby communities. Still, as project leaders navigate NEPA environmental analysis requirements, they likely avoid parsing those details in the "purpose and need" section. Put another way, the agency is often stuck treating acres far from communities, and to justify those treatments it may proceed through the NEPA process with a grab-bag of project goals that conflate ecosystem protection with risk reduction. Experts explain that the result is too often a set of muddy prescriptions for treatment that fail to prioritize risk reduction, and instead lead to scientific disagreement.

NEPA

The NEPA process raises a host of related barriers that interfere with using mechanical fuels reduction for risk modification. Most prominently, the legal requirements for analysis can be time consuming and onerous. Fear of litigation – from timber companies[76] or environmental groups[77] – drives ballooning analyses[78] and contributes to even longer timeframes for completion. Litigation itself can derail projects, adding additional delays to implementation or blocking them entirely. Instead of hiring foresters to treat fuels, land management agencies are forced to hire lawyers and analysts to navigate NEPA. Experts report NEPA's mandatory "no action" alternative is routinely under-analyzed, resulting in environmental reviews that fail to document the costs of doing nothing. Possible NEPA reforms are described in more detail in Section 3C.

Workforce

Workforce weakness also contributes to delays in fuels treatment. In part, the shortage of trained foresters is not new, but rather a result of long-term societal shifts. For example, many universities have re-configured their traditional forestry programs to better meet academic demand for popular but less forestry-focused environmental studies programs. Workforce shortages are also a reflection of a post-pandemic national labor shortage, the low pay most entry-level forestry positions offer, and the geographic remoteness of where many such positions are located. Tribal reservations have been particularly hard hit by these trends; some report having lost up to one-third of their staff during the worst of the pandemic, an institutional loss that they estimate will take 15 years to rebuild.[79] Experts point to missed opportunities that could potentially link rural areas struggling with high unemployment with entry-level work opportunities as land managers. Improving training opportunities, particularly in community colleges across rural America, could potentially resolve the gap in trained foresters.[80]

Funding

A final piece of the puzzle is financial. When the local timber industry can secure USFS contracts to remove woody biomass, has reliable access to a mill, and can generate revenue from the sale of forest products, mechanical treatments are not only affordable, it can create profit. But across much of the Intermountain West, timber jobs have hollowed out after years of unreliable supply and the advent of technological automation in production.[81] Biomass energy facilities are still nascent and do not exert sufficient pull to make timber markets more active. Even tax credits, used to incentivize other forms of renewable energy like solar and wind, are not well deployed for biomass energy.[82] The result is that many forests across the West remove only very low-value material when they conduct fuels-reduction projects; rather than contribute revenue to the agency's bottom line as timber sales do, those same projects come out of the agency's service budget. Fuels reduction on public lands is thus profoundly limited by financial capacity. Some existing tools and programs – like Stewardship Contracting, Fuels for Schools, and the use of portable co-generation mills – could be expanded to make fuels reduction more affordable. But those reforms are politically complex and don't offer the radical restructuring necessary to make mechanical fuels treatment a viable strategy for risk reduction.

B. Mechanical Treatments on Private Land

As described, mechanical treatments on public land are limited by funding, workforce, and jurisdiction. But private land offers a vastly different administrative setting with its own challenges and opportunities. Just as mechanical treatments on public lands can achieve ecosystem objectives, reducing hazardous fuels on private land can modify fire intensity and severity, thereby contributing to healthier forests. Importantly, a majority of wildfires originate on private lands and spread into housing developments and communities.[83] For this reason, addressing the massive accumulation of fuels on the more than 300 million acres of private land in the western United States is a substantial legal and administrative challenge.

Research suggests a home's characteristics in relation to its immediate surroundings principally determine home ignition potential during extreme wildfires.[84] Therefore, reducing vegetation within 100 feet of the home in combination with consideration for the building materials, design, and layout of the home itself is essential in reducing structure ignition potential and might be wisely considered a priority for mechanical treatments on private land.

Effectiveness for Community Risk Reduction

Reducing fuels in the home ignition zone (HIZ) has been shown to reduce structure ignition probabilities.[85,86] But those gains are small and easily undermined by a host of variables. Leaving dead wood – called slash – on site, for example, reduces overall effectiveness significantly.[87] Treating private land when adjacent public forests (see above) are not thinned also reduces overall effectiveness.[88] And fuels-reduction efforts undertaken by individual homeowners are highly

dependent on whether or not neighbors have also done work on their own land, creating a classic collective problem.

But reducing woody fuels is only part of the equation, and taken alone, effectiveness is low. The key to unlocking the potential for private land risk reduction is to understand that the home itself is flammable, potentially risking other homes nearby with flying embers and radiant heat. Indeed, up to 90% of structure loss has been attributed to embers.[89,90,91] Once a single home starts to burn and depending on the proximity of adjacent buildings, structure-to-structure ignition can quickly spread, overwhelming firefighting defense efforts and leading to a large urban conflagration. (For more detailed information on home hardening, see Section 4.)

Funding

Private landowners who want to reduce their wildfire risk by modifying their home and property routinely find very little financial support available. Mechanical treatments on private land average $127/acre and can be prohibitive for large properties.[92] One recent study found 68% of landowners living in wildfire risk zones were concerned about fire, but only 45% pursued fuels reduction.[93] The most-cited reasons why homeowners do not maintain defensible space are cost and effort.[94] More importantly, treating fuels around the home is only a small part of the challenge, as homeowners face an array of modifications to the structure itself for maximum benefits (see Section 4). Any work done to reduce woody biomass in the vicinity also needs regular maintenance, so costs are ongoing.

Barriers and Opportunities

Improving access to financial and technical support for all private landowners, but particularly those who face income limitations and political marginalization, is essential. Since the USFS does not have jurisdiction, funding, or expertise to be an effective conduit for private landowners, this issue must be addressed largely outside of the federal public land management system.

Researchers found an estimated 53% of western communities are considered low capacity, including lack of access to training, resources, and expertise.[95] Existing grant programs – administered through Federal Emergency Management Agency (FEMA), individual states, and NGOs – too often fail to reach those communities most in need. One way those programs remain inaccessible is through the requirement for matching funds from the applicant, which can serve to reinforce wealth differences; lower-income communities can only provide minimum cost-share funds, a reality that paradoxically makes them eligible for less grant funding than their wealthier neighbors. Dropping matching requirements, stratifying grants to guarantee support for underserved communities, providing technical assistance, and creating regional capacity centers to help homeowners develop competitive applications are all reforms that could improve outcomes.

Homeowners in some areas have become creative with tapping into private and nonprofit sources of funding. Community Wildfire Protection Plans (CWPP), initially promoted through the 2003 Healthy Forests Restoration Act, offer a tool for bringing neighbors together to assess their relative risk and commit to reducing it; many CWPPs focus on the importance of individual action to create collective gains. Some CWPPs have been proven valuable, and experts point especially to those created bottom-up at a county or localized scale with a collaborative group involved. These efforts, newly bolstered by financial incentives in the Infrastructure Investment and Job Act's Community Wildfire Defense Grants program (see Section 4), have built some support for front-country thinning on private land. Collaborative groups are very important here, providing funding, education, and support for communities that want to implement the plans in their CWPPs.

But even if landowners are able to come up with funding for work on their property, they may encounter unexpected local barriers. For example, across the country, homeowner associations (HOAs) regulate building materials, landscaping requirements, and aesthetics; some of those covenants are decades old, created before wildfire risk reduction was well understood. To remedy this unintentional barrier, HOAs should revisit their requirements with an eye to reducing wildfire risk. More productive

solutions may come through state regulatory authority. For example, Colorado's Common Interest Ownership Act made it illegal for HOAs to block defensible space or HIZ work.

C. Prescribed Fire

The intentional use of fire for both resource benefit and reduced risk has a long history. Indigenous groups across the American West used fire to clear land for agriculture and European settlers continued the practice. In recent years, prescribed fire has been implemented haltingly as rising temperatures associated with climate change create challenging conditions. Expanding drought, concern about risk to nearby communities and infrastructure, and limited public acceptance have limited its application.[96] Today, 70% of the prescribed fire occurring nationwide takes place in the wetter southeast part of the country by nonfederal entities, a reality that underscores how important land ownership, terrain, and precipitation patterns are in driving outcomes.[97]

Prescribed fire could reasonably be analyzed under the "managing fire" section of this report. We include it here instead to underscore its use as a strategy for modifying fuels through burning woody biomass. Unlike mechanical treatments, prescribed fire offers the full range of ecosystem benefits that only fire can deliver (see Managed Wildfire above for more details). To be clear, not all forest types stand to benefit the same way from fire. Cheatgrass, chapparal, and pinion-juniper forests, common across much of the Southwest, do not respond well to surgically applied fire.[98,99] But some ecosystems thrive, and restoring some measure of a natural fire cycle to unhealthy, overly dense areas offers a potentially transformative approach to forest management.

Effectiveness for Community Risk Reduction

As a tool for improving ecosystem health, prescribed fire is highly effective.[100] It effectively modifies forest structure and fire behavior, creating safer access for firefighters and contributing to lowering future fire intensity by up to 72%.[101,102] But here we are more interested in whether prescribed fire is an effective strategy for reducing risk to communities, a more complicated question to answer.

Researchers find prescribed fire effective for risk reduction, but these outcomes are highly dependent on the size and frequency of burning. Most burns offer only localized and time-limited risk reduction, since landscape-scale risk reduction can be achieved only through large-scale and repeated burns.[103] To underscore the necessity of proximity, one researcher found 15% fewer homes were lost in a wildfire if prescribed burning had occurred in the most recent five years and within 0.5 km from the home.[104] Since perceived risk is likely highest in the areas closest to homes, prescribed burns in those areas may not find the necessary community support. The full promise of prescribed fire for community risk reduction therefore remains largely untested because complex limitations have hampered its more widespread application.[105] Under current conditions, prescribed fire is highly effective for achieving ecological goals, but much less effective for community risk reduction.

Funding

On federal lands, prescribed fire funding is budgeted through the broader hazardous fuels line item. Estimates for cost vary from $100- $700 per acre,[106,107] with larger burns generally on the lower end. Overall, prescribed burning is significantly cheaper than mechanical treatments, and it would seem the incentives are aligned for managers to stretch their respective budgets by treating as many acres as possible with fire. While it is always true that more funding would help fire managers implement the tool at scale, lack of money is not a meaningful barrier to expanded use of prescribed fire. Funding levels are moderate but relatively stable.

Barriers & Opportunities

Liability

The most powerful barrier to expanded implementation of prescribed fire is risk, both real and perceived. Risk of escape – and consequent damage to property or lives – is one of the most

commonly cited reasons more line officers don't go through with planned burns.[108] But the data actually show very low rates of escape – from 0.8%[109] to 1.6%[110] – and correspondingly low fatalities. Indeed, in the last 50 years, fatalities resulting from unplanned wildfire substantially exceeded those from prescribed fire by 3,350%.[111]

Fear of escape invariably raises liability concerns. Individual line officers – the ones who make the famed go/no-go decision – may carry USFS liability insurance, but if they are found to have acted "outside the scope" of their duties, that insurance may not protect them.[112] Experts are quick to point out that nobody has ever been fired from the USFS for an escaped burn; recent headlines that a USFS employee was arrested in Oregon for a prescribed burn that spread onto private lands made national news[113] precisely because it was highly unusual.

Still, perception matters more than any quantification of actual risk, since it is the perception of risk that drives decision-making. Clarifying liability laws and coverage at the agency scale could help, but having the agency be the primary insurance carrier – not individual fire staff – would go a long way too. Experts also urge a broader reconfiguration in the way we calculate risk from prescribed fire. They point out that some level of acceptable risk is taken in other sectors of government – building infrastructure and adding roadways, for example – as it is impossible to protect everyone. Perhaps reimagining how we understand risk in the context of fire would help.

NEPA

Even when risk of escape is low and fire experts are keen to burn, they face many layers of planning and permitting. Federal prescribed burns go through NEPA, a process that can take many years. Preparing an Environmental Impact Statement requires a team of up to 30 experts and takes an average of 7.2 years to complete.[114] Anecdotes of even more drawn-out timelines abound: one fire in Colorado took fully 18 years to plan and implement.[115] Many prescribed burns can only occur safely when mechanical treatments have already occurred, making the layers of planning even more complex. Federal experts note that cultural surveys, a required part of the NEPA process, can be particularly confounding. Joint planning between two federal agencies – usually the BLM and the USFS – also adds difficulty. So does taking endangered species habitat into account. For example, tribal fire leaders in Montana find protected grizzly bear habitat overlaps tightly with the highest-risk areas on their local forests, rendering them unable to apply fire to that landscape.[116] Seasonal restrictions for owl habitats in the Pacific Northwest function similarly. Frustrated, fire leaders suggest the planning process is backward. Having to justify using fire in a fire-dependent ecosystem, they argue, is akin to having to justify leaving a tree standing when the default action would be to cut it down.

One promising tool has emerged in the USFS as a possible way to break the NEPA logjam for both prescribed burning and mechanical treatment. Conditions-based management (CBM) begins from the premise that ecosystem types function similarly across geographies. That is, if conducting a prescribed burn in a ponderosa pine forest can succeed under specific conditions – for example, on a day that isn't too windy, in a forest not stricken by drought, and conducted using clearly delineated techniques – then perhaps those conditions can be standardized and agency staff can avoid re-writing the same analysis each time they want to conduct a similar burn in a ponderosa pine forest. Pilot efforts to use CBM are underway in Mendocino National Forest in California, the Tongass National Forest in Alaska, and other locations. Similarly, the National Park Service has a programmatic EIS – a tool that covers many projects within the same resource management issue area – for its entire prescribed burn fire program and they are able to do a lot more burning. Perhaps these pilot projects will create opportunities for the USFS to apply CBM more commonly across its forested lands.

NEPA reform advocates have also long sought to deploy new criteria for Categorical Exclusions (CEs) as a way to exempt prescribed burns and/or mechanical treatments from time-consuming environmental analysis. For example, the 2018 Fire Funding Fix extended categorical exclusions to cover smaller projects,[117] the 2022 Infrastructure Investment and Jobs Act imposed limitations on the timing and length for required analyses, and the proposed Save our Sequoias Act (2022) included language that would characterize fuels removal as an emergency action and thereby qualify for a CE.

These measures often run into staunch public opposition and lawsuits. The draft Save our Sequoias Act was met with more than 100 environmental groups jointly expressing disapproval.[118] Distrust of the federal agencies has members of the public reluctant to give up transparency, site-specific analysis, and opportunities for public comment, all guaranteed through a traditional NEPA process. Reforming NEPA has always been politically challenging.

Smoke

In addition to NEPA, prescribed burns must also navigate state permitting requirements, particularly for smoke. Compliance with Clean Air Act rules has historically led many state air quality officers to deny permits to would-be burners. Frustrated fire managers point to research that finds the smoke impacts from unplanned wildfire to be much more severe than from planned burns, in part due to the length of time of exposure and proximity to the burn.[119,120] If prescribed burns today reduce the likelihood of severe unplanned fire in the future, smoke permitting should be reconfigured to better recognize these delayed benefits.

Standardizing permitting at the state level could also facilitate implementation. To illustrate the potential of this administrative adjustment, California's Department of Forestry and Fire Protection (CAL FIRE) has a new automated system for permitting across 21 units in the state. Integrating smoke and air permitting, the new system has succeeded in cutting permitting time dramatically.[121]

Workforce

Just as workforce weakness limits the use of mechanical treatment, so too does a shortage of expertise in burning limit agencies' ability to use prescribed fire.[122,123] Burn boss qualifications – with gradations from 1 to 3, the highest level of expertise, and a requirement for authorizing any prescribed burn – are particularly difficult to achieve, with many years of training required. Private burn teams have established Cooperative Burn Partnerships[124] with the USFS to alleviate workforce shortages in some locations; for example, The Nature Conservancy has taken on a prominent role in certifying experts to conduct burns. More partnerships and improved access to training would contribute to building a more robust workforce to support prescribed fire opportunities.

Climate change

Amid the layers of permitting and approvals lies another foundational barrier to increasing prescribed burning: the warming climate. Snowpack, often used as a holding feature to create natural boundaries for a planned burn, now melts sooner.[125] Experts across the Intermountain West describe a variety of factors that contribute to shrinking windows for burning:[126] each day is either too windy, too wet, or too dry. In 2022 for example, tribal managers in northern Montana reported that in the normally burn-heavy months between March and July, the year offered only 10 burn days. The tribe used them all, but other planned burns sit on the shelf. This is common, and many detailed plans are approved but never implemented.[127]

CSK Tribes Well Prepared to Use Prescribed Fire

When a lightning-ignited fire broke out in July 2019 on the Confederated Salish and Kootenai Tribes (CSKT) trust lands in rural Montana, the tribe quickly assembled an Incident Management Team (IMT) to take action. Tribal land managers had previously completed the NEPA process and had an approved land management plan in place for a parcel nearby. This pre-approval allowed fire managers to proactively deploy prescribed fire ahead of the encroaching wildfire in an effort to reduce the fuel load. The benefits from this event that featured both prescribed and managed fire included improved firefighter safety, reduced costs for suppression, reduction in invasive species such as juniper, and nutrient renewal of the soil.[i]

i Confederated Salish and Kootenai Tribes Make Strides in Managing Wildfires on Flathead Indian Reservation. 2019. Bureau of Indian Affairs. https://www.bia.gov/sites/default/files/dup/assets/bia/ots/dfwfm/image-stories/files/FINAL_CSKT_Make_StridesIn_Managing_the_MossRanchFireOn_FlatheadIndian_Reservation_508.pdf

4. Managing the Built Environment

As growth in wildfire-prone areas continues,[128] new homes, roads, infrastructure, and commercial buildings dot the landscape, fragmenting forests and adding new risk. In many housing settings, individual homeowners are left to their own devices to make decisions about whether or not to implement home hardening actions on their properties. But state and municipal governments, long excluded from most wildfire decision-making, have an essential role to play in mandating, guiding, and supporting such activities on private land.

One way to think about this approach to wildfire risk reduction is to consider the way we, as a society, manage flood, seismic, and tornado zones. We don't forbid residential development in these places. Instead, we impose layered rules, including construction guidance and insurance requirements. Remember, embers and radiant heat from other burning structures (not burning forests) are the main threat to structures, rendering homes themselves as fuel. Applying rules to wildfire risk zones, including where and how people can build, offers a potentially powerful leverage point for moving the needle toward reduced risk.

Figure 4. Sources of ignition exposure during a wildfire.

Definitions

There are three types of ignition exposure to buildings during a wildfire:

Wind-blown embers.
The most common cause of building ignitions during a wildfire. Traveling far ahead of a wildfire front, embers can directly threaten a home by landing on a combustible material or vulnerable component, such as the roof or open window. Indirect ember exposure occurs when embers ignite spot fires on nearby combustible material.

Radiant Heat.
Exposure from radiant heat occurs when nearby combustible materials and fuels ignite. Influenced by duration and intensity, radiant heat can ignite a combustible material or break the glass of windows and doors.

Direct Flame Contact.
When flames touch a building or combustible material.

(Source: Valachovic, Quarles and Swain. 2021. Reducing the Vulnerabilities of Buildings to Wildfire: Vegetation and Landscape Guidance. UC ANR 8695.)

A. Zoning and Land Use Planning

Zoning has long served as one of local governments' most powerful tools. It can dictate where new houses are built, how densely they are organized, and where industrial facilities can be located. When done well, zoning can amount to thoughtful and intentional community design. When those strategies are implemented with hazards in mind, including flood and wildfire risk, they can exert significant influence over exposure to hazard for new residential developments.[129,130] Additional regulatory tools like landscaping regulations, subdivision design standards, and other ordinances have expanded the reach of land use planning to reduce wildfire risk across the West.

Effectiveness for Community Risk Reduction

Given the paucity of municipalities with complete zoning in wildfire-risk areas, it is difficult to assess the effectiveness of risk-informed municipal planning. Compared with dispersed housing, clustered housing that conforms to zoning for wildfire mitigation has been shown to reduce both localized wildfire risk and the costs of suppression, but only when those homes have been constructed with wildfire-resistant materials and design.[131] In most locations where this kind of zoning effort has been tried, public resistance has prevented it from being mandated through local or state regulation. Not surprisingly, voluntary uptake rates have been low. Zoning and regulations only succeed in a community when they are widely adopted.

Funding

In general, costs associated with zoning and most regulatory measures are already allocated in many local government budgets. Similarly, zoning boards and other institutional frameworks are likely already in place. Still, reconfiguring municipal planning around reducing wildfire risk would require most local governments to find both expertise and funding. To that end, the 2021 Infrastructure

Investment and Jobs Act (IIJA) includes financial support for land use planning through Building Resilient Infrastructure for Communities (BRIC) and Community Wildfire Defense (CWDG) grants. While CWDG offered much needed funding to communities to reduce wildfire risk, eligible projects largely focused on hazardous fuels reduction and did not include home hardening. Additionally, in the initial round of funding in 2023, the number of community applications far exceeded the amount of funding appropriated to the program, demonstrating that the need for community assistance outpaces the money and resources currently available.

Barriers and Opportunities

Politics

Regulating wildfire-prone areas to reduce risk is complicated by the political and geographic context of communities. Lack of political will is perhaps the most glaring barrier to more widespread use of mandatory zoning regulations that could reduce risk. Across the West, where "local control" appears in many state constitutions as both a governance principle and legal foothold, opposition to regulation runs deep.

Still, many states require water rights analysis before new residential buildings can be approved, suggesting a parallel process that would focus on wildfire could gain support. Part of the reason it hasn't yet taken hold is that local governments rely heavily on property tax revenue, incentivizing them to approve new development without adding more layers of analysis. Those incentives are also influenced by the way wildfire costs tend to be covered; when the federal government reimburses local fire suppression costs, as happens in locations with significant public lands, there is again little financial incentive for local governments to limit development in areas of wildfire risk. This is a perfect example of moral hazard: the entity paying the costs (in this case, the federal government) shifts the risk away from the entity suffering harm (in this case, local residents).

Risk Maps

Shortcomings associated with risk maps are another important barrier to adopting regulatory measures. Since many wildfire zoning strategies begin with a map that helps planners identify where risk is highest, the maps themselves become sources of controversy. Mapped high-risk areas are potentially subject to a range of possible restrictions, fees, and other regulations that might be part of comprehensive wildfire zoning. But those maps require frequent updating and therefore often fail to account for fuels reduction work that may have occurred, recent fires that can have profound effects on the behavior of future fires, the complex influences associated with climate change, and other elements that define risk at a local level. Despite decades of investment and technological advancement, scientists are still unable to produce reliable parcel-scale risk data. Experts interviewed for this research report that risk maps are functionally out of date the instant they are published. Recent fires in Louisville, CO, and Santa Rosa, CA, showcased the shortcomings of risk maps, as the areas that burned were far outside what maps had flagged as highest risk.[132]

To better empower homeowners to take personal responsibility for their risk, some have urged states to require wildfire risk disclosure in real estate transactions. However, to date only Oregon and California rely on risk maps to trigger mandatory disclosure for new home buyers;[133] for comparison, 29 states require flood disclosure information to potential buyers. A related idea – imposing fees on households in high-risk areas to cover costs associated with fire protection – has also not gotten traction. For example, in 2014, California began requiring homeowners in the CAL FIRE protection area to pay an annual fee of about $150 per year. The fee proved unpopular among homeowners and was suspended in 2017.[134] Politically controversial, the notion of imposing new costs on vulnerable residents does not sit well with developers, the real estate industry, advocates for social justice, and others. Lack of confidence in the accuracy of risk maps contributes to this opposition.

Still, risk maps proliferate. States use risk maps to prioritize resource allocation. Insurance companies use their own maps to help delineate premium rates. Tribes use maps to highlight ecosystems and other cultural values. Federal land management agencies use their own maps to

prioritize fuels treatments. The result is the prevalence of multiple, competing risk maps, creating policy confusion and public concern. For example, in 2022 and shortly after their publication, Oregon rescinded statewide maps after public outcry.[135]

B. Building Codes

Building codes are regulations that govern the design, construction, and maintenance of structures to protect public health, safety, and general welfare as they relate to the construction and occupancy of buildings and structures. Codes also usually include attention to evacuation routes, an expensive element to consider when new roads must be built. Codes can be adopted on a statewide level, often modeled off the International Code Council's standards.[136] Some allow local jurisdictions to adopt more stringent requirements than those required by the state. But with only a couple of important exceptions, most codes adopted by states, HOAs, municipalities, and counties remain voluntary.

Communities that adopt these codes and conduct additional risk-reduction activities on private land may qualify as a Firewise community – a program sponsored by the National Fire Protection Association that encourages property owners to take proactive risk mitigation steps. To date, nearly 2,000 such communities have been celebrated across the West by the nonprofit Firewise group, with more than 600 of them in California.[137] But these are again voluntary actions, and although the Firewise program has some funding support available for participating communities, Firewise activities tend to be adopted in high-capacity areas, raising equity questions.

Only three western states have a statewide mandatory building code specific to wildfire risk: California, Nevada, and Utah.[138] California's Building Code Chapter 7A (Ch7A) is by far the most developed, applying to all buildings constructed after 2008 that are mapped in the state's Fire Hazard Severity Zones. Ch7A is also coupled with state regulations[139] that authorize CAL FIRE to update the wildfire severity maps regularly. Provisions within Ch7A require wildfire-resistant construction materials and structural design standards intended to reduce ignition vulnerabilities to the building. Landscaping, vegetation management requirements, and other fire safety regulations are addressed in separate public resource codes.[140]

Effectiveness for Community Risk Reduction

The literature supporting the effectiveness of wildfire resistant construction and applicable building codes is well established.[141,142] In California, CAL FIRE inspected 1,300 homes and found those compliant with Ch7A were five times more likely to survive fire.[143] Other researchers have found similarly high effectiveness, with one study showing compliant homes 40% more likely to survive a fire than older, noncompliant ones.[144] When neighboring homes are also up to code, results are even more striking, underscoring the importance of collective action and neighborhood cohesion.

Building homes with fire-resistant materials is also relatively affordable, with evidence showing costs are not substantially higher than building with traditional, more flammable materials.[145,146] Importantly, voluntary codes

Building Codes Helped Save Homes

In 2003, Colorado Springs passed a new ordinance to replace cedar-shake roofs for all new construction, re-roofing, and significant repairs. This new building code prompted the replacement of more than 55,000 cedar-shake roofs in subsequent years. With FEMA grant support, the city also deployed fuels treatment across roughly 900 acres annually in nearby parks and on private property. In June 2012, the Waldo Canyon Fire broke out, destroying 346 homes across the city and testing the effectiveness of earlier risk-reduction efforts. Estimates suggest they were most successful in three neighborhoods that were directly threatened by the fire. One of those neighborhoods, Cedar Heights, suffered some damage but avoided losing any homes during the fire; analysts concluded that the city saved an estimated $77,248,301 in losses from $300,000 of mitigation spending.[i]

i Quarles, S., Leschak, P., Cowger, R., Worley, K., Brown, R., Iskowitz, C., Lessons Learned from Waldo Canyon. Insurance Institute for Business and Home Safety. https://epcso-main.s3.us-east-2.amazonaws.com/s3fs-public/resources/resources/9.%20Lessons%20Learned%20from%20Waldo%20Canyon_Full%20Report%20%26%20Findings.pdf

have been found to underperform for the many reasons described here; mandatory is better.[147] While even mandatory building codes cannot guarantee home survivability, incorporating wildfire-resistant construction materials and mitigation techniques into new home development can improve resiliency against increasing wildfire risks.

Funding

Despite the scientific consensus on the importance of wildfire-resistant building materials and techniques, also known as "home hardening," evidence shows that many homeowners lack awareness of their risk or what they can do to reduce it.[148,149] Survey research suggests that even when people are aware, the most powerful barrier to more aggressive actions on private land is the expense.[150,151] Since these high costs will ultimately be returned through reduced damage to society – for example, the National Institute of Building Sciences found that the cost-benefit ratio for adoption of a robust wildland-urban interface (WUI) code is approximately 4:1[152] – communities might reasonably expect public financial support. In other words, for every $1 invested in WUI code mitigation measures to buildings and properties, $4 is returned in long-term savings.

This funding gap represents perhaps the most important lapse in mounting an effective strategy for minimizing wildfire risk to homes and communities. Home hardening is potentially the most effective tool for reducing wildfire risk to communities, but funding for work on private land is not generally seen as the purview of the government. USFS experts were unanimous in their insistence that structural improvements for private homes fall outside their zone of authority. Tribes face even more daunting circumstances, as private parcels dot federally administered reservations and jurisdictions are often cloudy.

A few federal programs ostensibly fill this gap in support for private landowners. The Bureau of Land Management's (BLM) Community Assistance Program offers five-year grants and technical risk mitigation support for awardees. FEMA has also tried to expand its funding beyond flood risk to include wildfire risk. The Building Resilient Infrastructure and Communities (BRIC) program, established through the Stafford Act (2018), offers funding for defensible space, ignition-resistant construction, and other elements of private risk reduction work. In FY21, BRIC received 788 applications; the agency ultimately awarded $1 billion across 369 projects. These awards seem to have done little to affect the wildfire challenge, as the vast majority of BRIC funds went to coastal projects managing flood risks.[153]

Two recent large federal spending bills – the Infrastructure Investment and Jobs Act (2021) and the Inflation Reduction Act (2022) – prominently include funding to ameliorate wildfire risk, but not all of those funds are available for use in the highest-risk areas. For example, the Inflation Reduction Act includes $1.8 billion for "federal land in the WUI," a restriction that would seem to limit its use on private land. More promisingly, the Infrastructure Act includes $1 billion over five years for wildfire infrastructure and resilience projects under the Community Wildfire Defense Grant program. These funds can be used on private land and for building code adoption, but so far they cannot be used for individual

Grant Helps the Karuk Tribe Reduce Community Risk

In 2021, FEMA announced $3.46 billion in available Hazard Mitigation Grant Program (HMGP) funding.[i] Intended to make infrastructure more resilient, these funds are awarded competitively. In April 2022, the Karuk Tribe of Northern California was awarded a $3 million HMGP grant, which they have used to create defensible space around structures, retrofit homes with ignition-resistant materials, and reduce hazardous fuels along roadsides and other areas where wildfire could threaten life or property. Funding is expected to improve wildfire resilience for 400 community members and 146 housing units.[ii]

i Horn, D., 2022. Recent Funding Increases for FEMA Hazard Mitigation Assistance. Congressional Research Service. https://crsreports.congress.gov/product/pdf/IN/IN11733

ii Karuk Tribe Receives $4M Grant to Reduce Wildfire Risk, 2022. FEMA. https://www.fema.gov/press-release/20220414/karuk-tribe-receives-4m-grant-reduce-wildfire-risk

home hardening.

States also have a critical role to play. To date, however, only a few have accepted that responsibility. California is perhaps the most ambitious with a pilot program in rural San Diego, Lake, and Shasta counties. Partnering with FEMA and managed by CAL FIRE and its Office of Emergency Services (OES), the state program offers competitive grants up to $40,000 for homeowners to retrofit their property in wildfire risk zones. Notably, the pilot effort explicitly targets low-income neighborhoods through a sliding scale model.[154]

Other states, including Colorado, and local governments such as Missoula, MT, Marin County, CA, Jefferson County, OR, and Summit, UT, offer small-scale grant programs to support landowners in their home-hardening efforts. Some, including Boulder County, CO, Ashland, OR, and Rolling Hills, CA, have partnered with FEMA's Disaster Mitigation Program to offer financial support for hardening efforts. But these state efforts are all small-scale, localized, and funded only on a trial basis. Scaling up and expanding the reach of financial support will be essential to foster broader adoption of building codes.

Barriers and Opportunities

Mandatory building codes are not popular. Especially in the West, homeowners prefer to manage their own private property without interference from government. "Home rule" and "local control" are governing principles that may underlie this hostility to regulation, with several state constitutions explicitly limiting state authority over local governments. Even when codes overcome public opposition and are enacted, enforcement by local governments can be inconsistent. Without a robust tax base to train support staff in building code regulations, local enforcement capacity in rural areas is often weak.[155]

Perhaps the most important barrier to improved outcomes from building codes has to do with the need for retrofits. Building codes do not address existing structures. Even California's groundbreaking Ch7A requires compliance for buildings that were constructed since 2008. With existing structures making up an estimated 80-90% of the housing stock,[156] this is a significant gap. Identifying stable sources of funding to support homeowners in older homes, and investing in outreach and technical support to bring them into compliance with newer building codes, is an essential first step toward creating neighborhoods that are more comprehensively hardened.

Offering homeowners financial incentives – similar to current efforts encouraging a shift to electric vehicles and renewable energy – would align home-hardening measures with market-based policy structures. Widespread retrofitting in high-wildfire-risk areas will require substantial resources, technical expertise, and funding from the state and federal government. For example, one study indicated that replacing the wood roofs of more than 1 million homes located in high-wildfire-risk areas will require a minimum investment of $6 billion.[157]

Workforce weakness is apparent here too. Builders may not be aware of hardening techniques, developers may not know how to incorporate construction best practices and materials into their plans, and local governments may lack enforcement staff. Communications may be undervalued too, as technical experts are enlisted to draft materials and conduct outreach without having been trained for those tasks. Urgent needs for training programs suggest an opportunity for community colleges and rural institutions, potentially matching pockets of unemployment with demand for local neighborhood protection.

Finally, and contributing to public skepticism, it is worth noting that even though home hardening across neighborhoods has been found to be highly effective, there are no guarantees. In other words, "fire-resistant" does not imply "fire-proof." Intense wildfires have tested even the most robustly hardened homes, and when embers fly in high wind, structures tend to burn. As one expert quipped, if we want guarantees, we should live in igloos.

5. Findings & Discussion

The findings of this research are stark. In the category of managing fire, we find fire suppression consumes the vast majority of public funds devoted to reducing wildfire risk to communities. While the short-term outcomes may align with proximate risk reduction, the practice contributes to vastly increased risk over time. Funding is high, and effectiveness is low. Managed wildfire offers ecological benefits but – at least at the scale currently implemented – the tool does little to reduce risks for communities. Funding is low, and effectiveness is low.

Managing fuels through mechanical treatment on public lands is expensive and routinely underfunded, resulting in scale mismatch and only moderate effectiveness at reducing risk to communities. Managing fuels through mechanical treatment on private land is similarly expensive but much more effective at reducing risks to communities; this tool is even more profoundly underfunded.

Managing the built environment through zoning and other regulatory mechanisms offers a possibly effective and affordable tool, but its use in wildfire risk reduction has not been fully tested. As a result, this research is not conclusive about how well it might fare at scale.

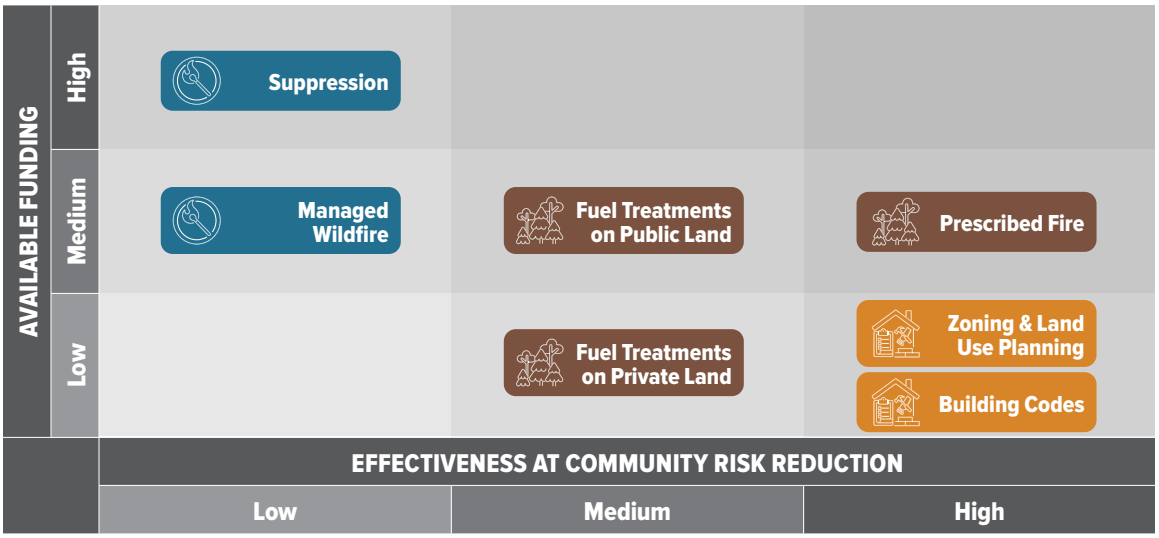
But managing the built environment through home hardening, and requiring those actions through robust and mandatory statewide building codes, emerges here as by far the most effective tool for reducing wildfire risk. Yet funding for those efforts has always been elusive. Federal agencies see private home hardening as outside their jurisdiction, and private landowners are left without many options.

The Resist–Accept–Direct (RAD) framework[158] has emerged in recent years as resource managers face an array of irreversible changes to natural systems, driven in part by anthropogenic climate change. A simple tool, RAD shifts decision-makers' gaze away from a desire to replicate ecological conditions from the past, and instead toward the future. It identifies three pathways for action. First, for changes seen as unacceptable, managers may choose to resist them, pushing conditions back toward what might be considered "baseline." In the wildfire context, we can imagine expanding the use of managed and prescribed fire to better replicate the role natural fire played throughout history in supporting healthy forested ecosystems. Second, for changes that cannot be remediated, managers may simply have to accept them, even when those conditions lead to higher risk or modified ecosystems. Larger, more frequent, and more intense wildfires may well fall into this category. Third, some changes can be anticipated in the future, giving managers an opportunity to direct actions today toward a desired future condition. As development in wildfire-risk areas accelerates, fire-adapted communities that have access to both funding and technical support for home hardening offer potentially the best tool for reducing risk far out into the future.

Using the RAD framework to make management choices more transparent could help. Better

aligning the allocation of scarce resources with effective policy actions is critical. We conclude with an updated policy typology that summarizes these key findings (see Figure 5), and an itemized roster of recommendations.

FIGURE 5: Policies effective at community risk reduction



6. Recommendations

Congress should:

1. **Develop structure improvement (home hardening) programs**. Create new pathways for delivery of both technical and financial support for communities to implement home hardening in high-risk zones. Focus on consistent service to vulnerable households with low capacity and low incomes, including tribal communities, through workforce development and funding support.
2. **Modify annual USFS budget allocations to prioritize fire planning and support for communities in home-hardening efforts.**

Federal agencies should:

1. **Codify expanded discretion for fire managers in the context of response to unplanned wildfire**. This discretion could allow them to consider weather conditions and potential benefits for forest health before a suppression action is ordered.
2. **Campaign for community tolerance of managed fire and prescribed fire**. Work closely with communities – through POD development, CWPP updating, or other avenues for outreach – to enhance public understanding and build awareness of the complexities of wildfire management, including benefits of prescribed fire.
3. **Modify language in USFS Handbook 5100 to make human-caused ignitions eligible for managed fire use.** Expanding the criteria that guide the use of wildfire for resource benefit will open new opportunities for fire management and risk reduction.
4. **Reduce personal liability for fire personnel**. Clarify liability laws and practices to mitigate perceptions of personal risk among line officers charged with making burn/suppress decisions.
5. **Incentivize decisions that lead to increased use of unplanned wildfire for natural resource benefit.** Incentives could include professional recognition, guarantees of liability coverage, and contribution of acres treated during burns toward performance targets.
6. **Streamline funding pathways to tribes for prescribed fire and forest treatments**. Consider eliminating some signature requirements, or mandating shorter timelines for delivery of federal funds.
7. **Reform NEPA to offer more flexibility for fire managers.** Extend Categorical Exclusions to landscape-scale prescribed burns when appropriate. Pilot conditions-based NEPA to foster more timely environmental reviews. Monitor early efforts to develop best practices and move toward agencywide opportunities.

State governments should:

1. **Implement statewide building codes in areas of wildfire risk**, such as a version of California's Chapter 7A. Include attention to underserved communities and retrofit needs through grant programs that also offer capacity building, technical assistance, and support for long-term maintenance.
2. **Classify biomass energy as renewable in statewide Renewable Portfolio Standards.**
3. **Support the local timber industry**, including exploring opportunities to subsidize or underwrite new mills for forest products.

There is no panacea for the wildfire crisis, and no single level of government can fix this alone. Indeed, as the wildfire crisis grows with climate change and accelerated development in wildfire-prone areas, we will need to work together to keep communities safe. This research and analysis demonstrates that we have multiple opportunities to reduce wildfire risk to communities if we strategically target funding to the most efficacious policies and programs. We can adapt to increasing wildfires by thoughtfully balancing management of fire, fuels, and the built environment.

Appendix A: Acronym Guide

BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BRIC	Building Resilient Infrastructure and Communities
CAL FIRE	California Department of Forestry and Fire Protection
CBM	Conditions-Based Management
CE	Categorical Exclusion
Ch7a	California Chapter 7a Building Code
CSKT	Confederated Salish and Kootenai Tribes
CWDG	Community Wildfire Defense Grants
CWPP	Community Wildfire Protection Plan
DOI	Department of Interior
EA	Environmental Assessment
FEMA	Federal Emergency Management Agency
HIZ	Home Ignition Zone
HOA	Homeowners Association
HMGP	Hazard Mitigation Grant Program
IMT	Incident Management Team
IRA	Inflation Reduction Act
IIJA	Infrastructure Investment Jobs Act
NEPA	National Environmental Policy Act
NF	National Forest
NGO	Non-Governmental Organization
NPS	National Park Service
OES	Office of Emergency Services
POD	Potential Operational Delineations
RAD	Resist, Accept, Direct Program
USFS	U.S. Forest Service
WUI	Wildland-Urban Interface

Appendix B: Experts Consulted

Greg Aplet, The Wilderness Society
Faith Berry, Federal Emergency Management Agency
Aitor Bidaburu, Federal Emergency Management Agency
Dale Bosworth, U.S. Forest Service
Madalyn Bryant, Pew Charitable Trusts
Rick Cables, U.S. Forest Service, DNR, Vail Resorts
Tony Cheng, Colorado Forest Restoration Institute
Darrell Clairmont, Confederated Salish and Kootenai Tribes
Jack Cohen, U.S. Forest Service, Missoula Fire Lab
Ron Cousineau, Colorado State Forest Service
Greg Dillon, U.S. Forest Service, Rocky Mtn Research Station, Missoula Fire Lab
Mark Finney, U.S. Forest Service, Rocky Mtn Research Station, Missoula Fire Lab
Colin Foard, Pew Charitable Trusts
Steven Hawks, CAL FIRE
Meghan Housewright, National Fire Protection Association
Tony Incashola, Confederated Salish and Kootenai Tribes
Tim Ingalsbee, Firefighters United for Safety, Ethics, and Ecology
Lathan Johnson, Bureau of Land Management
Peter Lahm, U.S. Forest Service
Nicole LaRosa, Federal Emergency Management Agency
Katie Lighthall, Wildland Fire Leadership Council
Jim Menakis, U.S. Department of Agriculture, Forest Service
Adam Mendonca, United States Forest Service
Peter Muller, Pew Charitable Trusts
Schelly Olson, Grand Lake
Casey Ryan, Confederated Salish and Kootenai Tribes
Rebecca Samulski, Fire Adapted Colorado
Michelle Steinberg, National Fire Protection Association
Ron Swaney, Confederated Salish and Kootenai Tribes
John Twitchell, Colorado State Forest Service
Brad White, Grand County Fire Department
Jerry Williams, U.S. Forest Service
Brendan Witt, Western Resource Advocates
Scott Woods, Colorado State Forest Service

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