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SCOPING THE PUBLIC HEALTH IMPACTS *of Wildfire*

A Primer for Stakeholders

MAY 2024
Scoping Report

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MAY 2024 | SCOPING REPORT

SCOPING THE PUBLIC HEALTH IMPACTS OF WILDFIRE

A Primer for Stakeholders

AUTHOR

KASIA DAHLBECK, Climate Research Fellow, Center for Law, Energy & the Environment

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ABOUT THIS REPORT

The Center for Law, Energy, and Environment (CLEE) developed this scoping report as a primer for stakeholders interested in the intersections of wildland fire and public health. The report investigates current research on the health impacts of wildfire to review key issues, provide an overview of the current policy landscape, and identify recommendations for future resilience. It combines an academic and policy literature review with 10 expert interviews, synthesizing disparate multi-disciplinary research in order to identify remaining questions and inform future efforts at integration. Research has been conducted primarily within California and U.S. federal contexts with a view toward transferability to other Mediterranean climates. The report is intended to serve as a starting point for future research, policy development, and public engagement in building greater health resilience to wildfire.

PROJECT PARTNERS

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The Center for Law, Energy and the Environment (CLEE) channels the expertise and creativity of the Berkeley Law community into pragmatic policy solutions to environmental and energy challenges. CLEE works with government, business, and the nonprofit sector to help solve urgent problems requiring innovative, often interdisciplinary approaches. Drawing on the combined expertise of faculty, staff, and students across the University of California, Berkeley, CLEE strives to translate empirical findings into smart public policy solutions to better environmental and energy governance systems.

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ASSOCIATE PROFESSOR, SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNIVERSITY OF CALIFORNIA, SAN DIEGO

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ASSISTANT PROFESSOR, ENVIRONMENTAL AND OCCUPATIONAL HEALTH SCIENCES, UNIVERSITY OF WASHINGTON

Dr. Sam Heft-Neal
SENIOR RESEARCH SCHOLAR, ENVIRONMENTAL CHANGE AND HUMAN OUTCOMES LAB, STANFORD UNIVERSITY

Dr. Amy Padula
ASSOCIATE PROFESSOR, OBSTETRICS, GYNECOLOGY & REPRODUCTIVE SCIENCES, UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

Dr. Minghao Qiu
POSTDOCTORAL SCHOLAR, ENVIRONMENTAL CHANGE AND HUMAN OUTCOMES LAB, STANFORD UNIVERSITY

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ASSOCIATE DIRECTOR, CLEE

Shivani Shukla
CLIMATE RESEARCH FELLOW, CLEE

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GLOSSARY OF KEY FIRE TERMINOLOGY

- **Wildfire:** Unplanned, uncontrolled fire in the natural environment.
- **Wildland fire:** Both planned and unplanned fire that burns in the natural environment.[1]
- **Beneficial fire:** A term collectively referring to prescribed fire, cultural fire, and fire for resource benefit.[2]
- **Intentional fire:** A term collectively referring to prescribed and cultural fire.[3]
- **Prescribed fire:** Intentional burning on wildland for land and ecosystem management goals.
- **Cultural fire:** Intentional burning by Native American Tribes or cultural fire practitioners for subsistence, ceremony, biodiversity, or other cultural intentions.
- **Fire for ecological benefit / ecologically beneficial fire:** Descriptive terms referring to fire that benefits the ecological environment.
- **Fire regime:** The spatial and temporal pattern by which fires naturally occur in a particular ecosystem over a period of time.[4]

EXECUTIVE SUMMARY

Wildfire and resulting smoke have become a constant presence in American life. Catastrophic wildfires are fueling a complex and extensive public health crisis, including air pollution, harm to social systems, and a growing toll on mental health. Public health has historically been siloed from land management, posing challenges for the current wildland fire policy landscape. Research into the varied health burdens of wildfire is nascent, while wildfire incidence is increasing sharply: climate models predict wildfires will further triple in frequency and severity by 2050.[5]

Over 99% of California's population has lived in a county exposed to chronic smoke pollution.[6] Wildfire smoke contains particulate matter (PM), carbon monoxide, nitrogen oxides, complex hydrocarbons, carbon dioxide, and other irritants associated with a multitude of adverse physiological effects and increased mortality.[7] Smoke exposure is responsible for heightened rates of mental health outcomes including anxiety, depression,[8] and PTSD.[9] The compound impacts of wildfire-induced air pollution result in hundreds of millions of dollars of earnings losses every year.[10]

The health burdens of wildfire also have stark environmental justice implications. Low-income communities without access to adequate air filtration, outdoor workers, and populations with existing health conditions are some of the demographics most disproportionately affected by a more wildfire-prone climate.[11] Children, the elderly, and pregnant people are particularly vulnerable to the irritant compounds in wildfire smoke.[12] As with other natural disasters, the loss of life, property, and employment in catastrophic wildfires is most prevalent among already marginalized populations.[13]

Perhaps counterintuitively, a foundational wildfire mitigation strategy involves more burning. There is widespread scientific consensus that the application of regular and controlled wildland fire to fire-adapted landscapes thins combustible organic matter buildup and lowers the risk of severe wildfire.[14] While Indigenous communities historically engaged in regular burns across the landscape, colonization and ensuing policies of fire suppression have resulted in millions of acres of U.S. forest and grassland left untreated.[15] Warmer climatic conditions and expanding human development in vegetated areas further exacerbate high wildfire risk[16] and the associated need for scaling ecologically beneficial fire.[17]

Fire for ecological benefit comes with its own tradeoffs regarding public health. As a pollution source itself,[18] beneficial fire requires responsible governance to ensure communities are protected and burns are carried out in the safest possible conditions. The management, implementation, and public communication around scaling beneficial fire remain a key area for future research and policy development.[19]

The complexity and rapidly evolving nature of the issue poses challenges for policy development and implementation. Integration between land management and public health considerations in policy development is yet emerging. Siloed agency remits create myriad barriers to coordinated policy development in California and federal contexts. Where collaborative initiatives exist, challenges remain in streamlining the effective implementation of health protections across a bureaucratic landscape. These barriers are amplified by the ambitious pace of implementation needed to address wildfire risks at scale.

A multi-pronged approach is necessary in building greater health resilience in wildland fire management including:

- **Utilizing existing policy channels to build capacity in the near term,** through expanding the wildland fire sector workforce, research capabilities, data collection and monitoring, wildfire smoke protection resources, emergency response, and wildfire preparedness.
- **Integrating broad and siloed policy remits with wildland fire management,** including air quality regulation, public health policy, fire-safe housing stock, employment and labor protections for wildfire events, and climate change mitigation, among others**.**
- **Building toward systems-level governance in the long term,** by fostering innovative policymaking processes across interagency and intersectoral silos, as well as supporting multilevel decision-making centering frontline communities**.**

Coordination channels such as the California Wildfire and Forest Resilience Task Force and the federal Wildland Fire Leadership Council are well positioned to facilitate a stronger integration of public health considerations in wildland fire policy development. The Task Force's Fire Adapted Communities Roadmap[20] and the Wildland Fire Mitigation and Management Commission's 2023 Report[21] provide valuable recommendations for burgeoning intersectoral coordination in wildland fire policy. These and similar collaborative initiatives can be supplemented by commissioning further research into the health burdens of wildfire and integrating existing research in siloed academic and policy contexts. Policy efforts would also be benefited by expanding ongoing efforts to minimize bureaucratic barriers to streamlined policy action.

Building lasting public health resilience to wildfire is notably underpinned by restoring a balanced societal relationship to wildland fire. Fire as a natural process in healthy fire-adapted ecosystems has been largely removed from land management practice, with high-risk results and detrimental effects on public health.[22] Restoring fire-resilient communities and landscapes will require the responsible scaling of fire for ecological benefit, the integration of silos in wildland fire management, and streamlined avenues for effective implementation. As the impacts of wildfire are only expected to worsen under current climate scenarios, building public health protections into state and federal wildland fire policy presents a challenging yet necessary cornerstone of wildfire resilience.

PROJECT FINDINGS

The public health impacts of wildfire are widespread across both the physical impacts of wildfire smoke and the psychosocial impacts of destructive wildfire. These include the physical risks of PM 2.5 exposure, the toxicity of wildfire-specific PM 2.5, the combustion of chemical fire retardants, smoke dispersion, the mental health effects of smoke exposure, and the social harm of catastrophic wildfires, among others. The public health impacts of prescribed fire are an evolving area of research and debate, although studies show these to be significantly less severe.

Integral coordination bodies such as the California Wildfire and Forest Resilience Task Force and the federal Wildland Fire Leadership Council are well placed as vital channels for integrating multisectoral collaboration in wildland fire. However, public health is still siloed from these bodies and other aspects of wildland fire management, especially in federal and international policy contexts.

Recommendations for policymakers: This report identifies the following key areas for future resilience, with consideration and prioritization throughout of affected communities most vulnerable. Responsible for the implementation of these recommendations we expect to be state and federal legislators, air quality regulators, land managers, local air districts, non-governmental organizations, private landowners, and fire practitioners, among other stakeholders. Future policy research and stakeholder convenings are urged to further develop best-placed avenues and mechanisms for implementation, facilitated by coordinating entities. Recommendations for policymakers include:

1. **Enhancing proactive capacity-building to address wildfire risk in the near term**, through expansions in the wildland fire sector workforce, research capabilities, data collection and monitoring, wildfire smoke protection resources, emergency response, and wildfire preparedness.

1. **Facilitating responsible implementation of ecologically beneficial fire,** through establishing integrated, community-led governance principles, multi-pronged policy development, public education and outreach, and a considerable expansion of research into the effects of prescribed fire.

2. **Building systems-level resilience in wildland fire and public health**, through facilitating coordinated, streamlined governance structures, developing integrated air quality regulation frameworks, mitigating climate change, and incorporating wildland fire safety into broader policy areas such as housing and occupational protections.

I. INTRODUCTION

Increasing wildfire severity has created a new and complex public health crisis. Wildfire smoke is now a primary contributor to U.S. air pollution and associated mortality.[23] The health burdens of wildfire nevertheless extend far beyond air pollution: the social impacts of catastrophic wildfire, the toll on mental health, and the potential risks of wildfire mitigation also present adverse health impacts with lasting effects. These risks have historically been concentrated in particularly wildfire-prone areas; now, as climate change fuels longer and more severe wildfire seasons, they are increasingly experienced population-wide.[24]

However, the public health impacts of wildfire have so far resulted in limited policy integration. Research into the varied public health burdens of wildfire is nascent, and the complexity of wildland fire-specific health risks poses challenges for the existing policy landscape. This scoping exercise investigates the latest research on the public health impacts of wildfire in order to review key issues, identify remaining gaps, and propose recommendations for future resilience.

1.1. SEVERE AND GROWING WILDFIRE RISK

Wildfires are becoming increasingly destructive due to more frequent wildfire incidence, as well as consistent growth in wildfire severity, size, and duration over the last 20 years.[25] This is driven by three primary factors: climate change, historical fire suppression in U.S. forest management, and the expansion of the wildland-urban interface (WUI),[26] or "the zone of transition between unoccupied land and human development".[27] As a result, eight of California's ten largest wildfires have burned within the last decade.[28] Similarly beyond a U.S. context, wildfires in the European Union burned nearly 2 million acres in 2022, about 2.5 times the annual average from 2006-2021.[29]

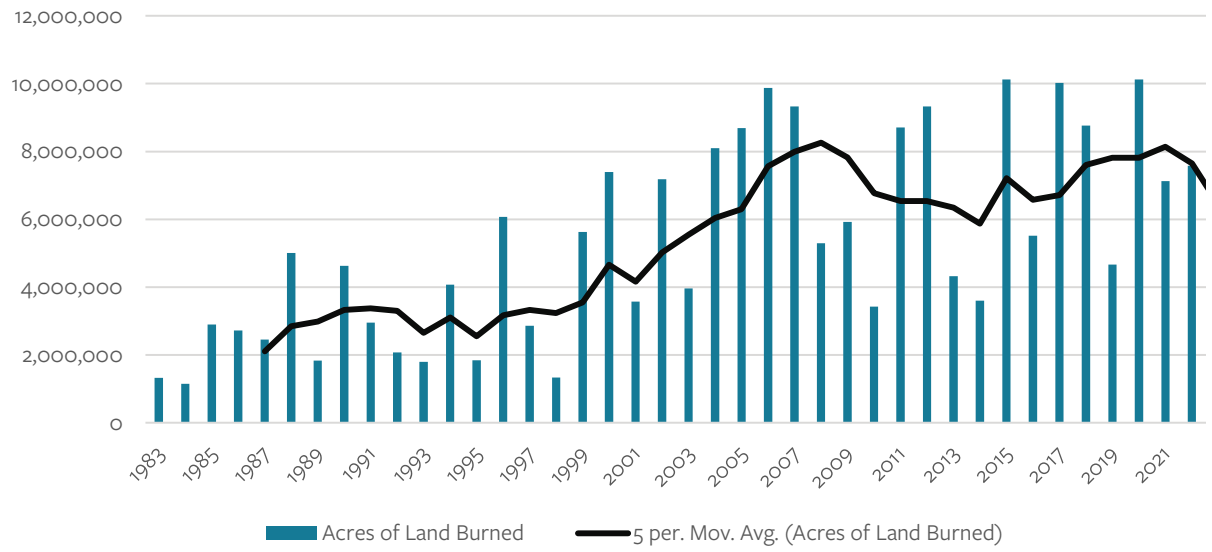

Figure 1 (OECD data). Wildfire incidence in the U.S. in thousands of acres, 1983-2022[30]

Current wildfire risk

Severe wildfires incur well-documented ecological and economic costs. High-severity wildfire events cause long-term species and even ecosystem loss[31] as well as contribute sharply to greenhouse gas emissions.[32] The 2018 California Camp Fire killed 85 people, destroyed over 18,000 structures,[33] and created $19 billion (inflation-adjusted) in damages.[34] Today, federal fire suppression costs total over $2.5 billion a year, in addition to costs borne by state, local, and Tribal governments.[35] The total economic cost of wildfire damages nationwide is estimated at "tens to hundreds of billions of dollars" annually.[36]

Increased attention is now being brought to the social costs of wildfire to human health. Between 2007 and 2018, 99.5% of California's population lived in a county with at minimum one smoke wave, or chronic smoke event.[37] Today, according to a Stanford University study, wildfire-specific PM2.5 pollution has increased to the extent that it has reversed multi-decadal progress in U.S. air quality made under the Clean Air Act.[38] The health costs of wildfire also notably exacerbate social inequalities by most severely impacting populations least able to protect themselves from wildfire and resulting smoke.

Projected future risk under current climate scenarios

While fire is natural and healthy in fire-adapted landscapes, research shows that anthropogenic climate change contributed to a +172% increase in the area burned in California between 1971 and 2021, and a +320% increase between 1996 and 2021.[39] A warming climate lengthens the wildfire season, increases temperatures, and decreases soil and plant moisture, leading to increased fuel, or dry organic matter buildup.[40] Warmer climatic conditions such as high temperatures and high winds also often

increase wildfire severity and area burned.[41] Periods with the largest area burned have coincided with the warmest years on record in the U.S.,[42] and these trends are expected to continue.

Modeling shows that an average annual temperature increase of 1°C (1.8°F) will increase the median area burned by wildfire annually by up to 600%.[43]The Fourth U.S. National Climate Assessment predicts that climate change will result in a tripling in the amount of large wildfires by 2050,[44] and research accordingly projects that over 82 million people will be impacted by smoke waves by mid-century.[45]

Building public health resilience to wildfire

The California Climate Adaptation Strategy defines resilience as "a state of readiness to face climate risks".[46] Various efforts have been made to build public resilience to wildfire, most notably including public information about smoke and fuel management strategies to decrease wildfire risk. The California Air Resources Board engages in extensive communication campaigns sharing smoke precaution mechanisms with wildland fire-affected communities.[47] Land management strategies to mitigate wildfire risk have also been significantly increased on state and federal levels.

Efforts are notably underway to coordinate siloed stakeholders in wildland fire management and public health. The California Wildfire and Forest Resilience Task Force integrates multi-stakeholder efforts at the state level,[48] and multiple coordinating entities have issued meaningful recommendations for interagency wildfire resilience on the federal level.[49]

However, the complexity of public health impacts poses significant challenges for the policy landscape, and many effects are yet unknown. This scoping exercise investigates the latest research on the public health impacts of wildland fire in order to identify remaining gaps and propose recommendations for greater health resilience.

1.2. SCOPING REPORT DESIGN

The report investigates the following research questions:

1. What are the key public health impacts of wildfire?

2. How does the current policy landscape in California and the United States address the public health impacts of wildfire?

3. How could wildland fire policy and management more effectively and equitably build health resilience to wildfire?

Scope of project

This scoping report was informed by a literature review of academic and policy work across the intersections of wildland fire and public health, as well as 10 interviews with scientists and policymakers in the U.S. It also builds on a Climate and Wildfire Institute brief detailing a stakeholder convening in October 2023.[50] While the bulk of this exercise focuses on the California and U.S. context, some international examples are included. We hope this initial primer will serve as a starting point for further research, discussion, and policy development in wildfire management from the perspective of public health.

This project is an introductory scoping exercise, serving as a synthesizing overview of relevant disciplinary research and policy action. The report is neither prescriptive nor comprehensive, but is intended to facilitate further research and support collaboration in a multidisciplinary space. Examples presented are representative of fields addressed, while not exhaustive. Recommendations presented are primarily synthesized from interview findings and supplemented with policy-facing literature.

II. PUBLIC HEALTH IMPACTS OF WILDLAND FIRE

Severe wildfires generate significant acute and chronic harm to both physical and psychosocial determinants of health. These impacts are both concentrated in wildfire-affected communities and increasingly dispersed across the U.S. population. While the impacts of wildfire smoke feature throughout this section, we focus first on the physical impacts of smoke pollution, followed by the psychosocial impacts of catastrophic wildfire.

2.1. PUBLIC HEALTH IMPACTS OF WILDFIRE

2.1.1. Physical impacts of wildfire smoke-induced air pollution

The primary physical health risk from wildfire is smoke-induced air pollution. Wildfire smoke contains thousands of compounds, including particulate matter (PM), carbon dioxide, carbon monoxide, nitrogen oxides, complex hydrocarbons, and irritant gases.[51] These compounds cause varying levels of damage to human health depending on the material burned and its interaction with chemical compounds in the atmosphere.[52]

PM2.5 exposure

The majority of epidemiological research on wildfire smoke has concentrated on its emission of PM2.5, or particulate matter smaller than 2.5 micrometers in diameter, which can easily lodge in the lungs and enter the bloodstream.[53] **Even brief PM2.5 exposure has been shown to cause spikes in asthma, respiratory symptoms, allergic reactions, strokes, heart attacks, and general hospitalization.**[54] Its health effects are not limited to acute wildfire events, however: PM2.5 exposure has been linked to lasting damage to the heart, lungs, liver, kidneys, and the immune system.[55] A Harvard University study showed that a minor increase in PM2.5 exposure correlated to an 8% increase in Covid-19 related mortality,[56] while other recent research has shown a correlation between wildfire-associated PM2.5 exposure and the incidence of tuberculosis.[57] Smoke pollution exposure is associated with preterm birth and elevated measures of risk if experienced at any point of pregnancy.[58]

Over the long term, PM2.5 exposure has been linked to the exacerbation of Alzheimer's disease and related dementias,[59] as well as increases in average mortality.[60] **The World Health Organization (WHO) estimates that PM2.5 exposure results in 7 million premature deaths globally per year.**[61]

Spikes in PM2.5 exposure from wildfire smoke are becoming increasingly chronic. Research has quantified the contribution of wildfire smoke to ambient PM2.5 exposure in the U.S., showing a 25% average erosion in air quality progress due to increasing wildfire pollution, rising to over 50% across most of the western U.S.[62]

Toxicity of wildfire-specific PM2.5

New research is showing that wildland fire-specific PM2.5 interacts differently with the human body than other types of PM2.5 from pollution sources such as vehicular and industrial emissions.[63] **A UC San Diego study found wildfire-specific PM2.5 to be about 10 times more harmful to children's respiratory health than ambient PM2.5 pollution.**[64] These impacts are attributed to smoke composition: organic matter (such as the wood and forest biomass combusted in wildfires) has high oxidative potential, which is linked to higher levels of inflammation in the body than that caused by other air pollutants.[65] Higher levels of inflammation exacerbate the existing respiratory and immunological effects of PM2.5 exposure.[66] Research is continuing into the differential impacts of wildland fire-specific PM2.5 on human health.[67]

Residential and industrial combustion

As wildfires increasingly affect the wildland-urban interface (WUI), the organic composition of combusted material is often accompanied by burning residential or industrial infrastructure.[68] The combustion of residential insulation, appliances, electronics, cars, paints, pesticides, and other materials can release asbestos, heavy metals, and other chemically hazardous substances into wildfire smoke and the water supply.[69] While this chemical pollution is usually more localized to the area burned, its adverse health impacts on firefighters and local communities is of concern.[70] Research into the specific health effects of burning infrastructure on wildfire-affected populations is currently underway.[71]

Chemical fire retardants

In order to meet state flammability standards, many household and consumer products such as mattresses, car interiors, electronics, and carpets are coated in flame retardant chemicals.[72] **Despite their success in slowing point-source ignition, fire retardants' chemical composition has been shown to significantly increase smoke toxicity upon combustion.** Polybrominated diphenyl ethers (PBDEs), a common group of fire retardants, have been linked to neurological, reproductive, and cognitive harm, as well as cancer incidence in multiple studies.[73] **Halogenated fire retardants increase the emission of carbon monoxide, hydrogen chloride, and other toxic gases, which are responsible for more fire deaths than combustion itself.** The detrimental health effects of fire retardants have been most documented among firefighters, who experience elevated rates of chemical exposure-related cancers — up to six times the national average.[74] Fire retardant chemicals can also adversely impact public health outside of fire events: PBDE blood levels in Californians have been found

to be twice the U.S. average, and PBDE levels in California household dust were 200 times higher than those in the European Union.[75]

Smoke dispersion

The dry, windy, and hot weather conditions that drive wildfires also facilitate smoke dispersion high into the atmosphere and over large geographic distances. **The interaction of smoke particles with atmospheric conditions can alter their chemical composition, exacerbating health impacts on downwind populations.**[76] Increases in smoke particle toxicity through oxidation in the atmosphere is a key area for future research.[77] The National Oceanic and Atmospheric Association has cataloged wildfire smoke's outsized contribution to the creation of ozone pollution, and is continuing research into the complex properties of smoke dispersion and their cross-populational impact.[78]

Distributional impacts of wildfire smoke

The health risks of wildfire smoke-induced air pollution follow different distributional patterns than those from other sources of ambient air pollution.[79] Contrary to other sources of PM2.5 typically concentrated around industrial or vehicular emissions corridors, wildfire smoke disperses widely and affects a much higher proportion of the U.S. population.[80] **When analyzed on a census tract level, the highest increases in PM2.5 exposure between 2006 and 2020 have been observed in higher-income and Hispanic populations.**[81] Exposure among Black populations has decreased over time,[82] but exposure in Tribal populations has remained by far the highest of all demographic groups.[83]

Beyond broader demographic distribution patterns, wildfire smoke exposure exacerbates structural determinants of health by most harming already-marginalized populations. **Those most vulnerable to increases in air pollution include children, the elderly, the disabled, pregnant people, those with chronic health conditions, outdoor workers, firefighters, Indigenous populations, undocumented populations,84 incarcerated populations, and unhoused populations.**[85]

Mediating effects of behavioral responses to wildfire smoke exposure

It is important to note that the physical health impacts of wildfire smoke are differentially experienced depending on the ability to afford private measures of protection. **Access to protective measures such as air filtration, adequate insulation, and ventilated spaces has the potential to mediate the distributional impacts outlined above.** Research by a team at Stanford University found that behavioral responses to smoke exposure, such as Google searches for air filters, were effectively predicted by higher socioeconomic status.[86]

Another study found that medical care-seeking behavior was also impacted by smoke concentration.[87] Emergency department visits during low and moderate smoke days in the study were higher than normal, but declined significantly during extreme smoke days. The starkest declines in seeking medical care were observed for non-respirato-

ry symptoms and injuries, as well as for less-insured populations. This mediation of behavioral responses on the health effects of wildfire adds an element of complexity in epidemiological research on smoke, which often measures emergency department visits as a metric of exposure severity.

Economic costs of wildfire smoke exposure

These health impacts translate to direct economic costs of wildfire smoke exposure. Wildfire smoke reduced earnings in the U.S. by $125 billion a year (in 2018 dollars) on average between 2007 and 2019.[88] Earnings reductions were seen across manufacturing, utilities, crop production, health care, and transportation sectors, and were primarily linked to declines in labor force participation.

2.1.2. Psychosocial health impacts of wildfire

In addition to the physical health impacts of smoke-induced air pollution, wildfires generate considerable adverse psychosocial effects. Similarly to smoke exposure, these are experienced acutely during catastrophic wildfires, over the long term, and increasingly by populations not directly affected by the wildfire itself. The dispersed and concentrated impacts of wildfires on wellbeing and mental health are detailed in the following sections. Societal impacts such as housing loss and displacement are included due to direct links to negative mental health impacts of catastrophic wildfire.

Dispersed societal health impacts

Wildfires generate dispersed adverse societal impacts in two primary categories besides smoke exposure: exacerbating climate change and disrupting power availability. **Wildfires are a significant source of greenhouse gas emissions even as they are driven in large part by climate change.**[89] Severe fire events produce large amounts of carbon dioxide as well as ozone, the third most potent greenhouse gas.[90] Higher greenhouse gas emissions fuel future wildfire incidence and exacerbate the broader societal impacts of climate change, such as further air quality deterioration and disease incidence.[91]

Wildfires are also notable for disrupting regional power availability. As electric power lines have sparked multiple of California's most destructive fires, preemptive power shutoffs are often employed as a wildfire mitigation measure during high-risk weather events.[92] In 2019, power shutoffs were implemented by California utilities on 27 separate days, some lasting over five days in duration.[93] **While they successfully mitigate wildfire incidence, protective power shutoffs also result in a range of public health risks**, most notably on populations relying on electricity to power at-home medical equipment.[94] Other impacts include the loss of refrigeration of medicines, food, and other essential supplies, the loss of electric waste disposal and clean water supply mechanisms, as well as the loss of lighting, especially for populations with disabilities and the elderly.[95] Public safety power shutoffs also impact communication infrastructure, limiting residents' ability to go about their daily lives, call for emergency services, or receive evacuation notifications if needed.

Dispersed mental health impacts

While the links between severe wildfire incidence and population-wide harm to mental health are still an emerging area of academic research, **physicians have noted links between increasing rates of natural disasters and climate distress**.[96] These experiences can be exacerbated during wildfire events by media coverage fueling ongoing anxiety and vigilance,[97] as well as by the destruction of meaningful natural landscapes or towns.[98]

Dispersed mental health impacts worsen with proximity to wildfires. A study of Australian residents from the 2019-2020 bushfire season found that 45.3% of survey respondents reported anxiety with smoke exposure, while 21.4% reported depressive symptoms from smoke exposure.[99] Children and adolescents exposed to chronic smoke scored considerably higher on an Australian mental health screening predicting psychiatric diagnoses.[100] Another study found negative smoke-associated mental health impacts in Washington state, including heightened depression, anxiety, and isolating behavior, increasing with lower income levels and pre-existing health conditions.[101] Air pollution from wildfire smoke has also been linked to higher rates of suicide, disproportionately experienced among rural populations.[102] **Mental health impacts of severe wildfire are a key area for future research given the well-documented links between air pollution and adverse outcomes including anxiety, depression, suicide, and psychological distress.**[103]

For those who had previously experienced wildfire-associated harm, repeated smoke exposure was associated with heightened anxiety and the resurgence of PTSD.[104]

Concentrated societal health impacts

Catastrophic societal impacts are most strongly observed in the area burned, most notably through the destruction of essential infrastructure and the displacement of people from their homes. **Wildfires can directly cause the loss of power infrastructure in two primary ways: by burning power lines and other electrical infrastructure, and by resulting in soaring emergency electricity use, overloading the electrical grid.**[105]

The starkest concentrated losses and lasting psychological effects in wildfire-affected communities are due to the loss of housing and health infrastructure.[106] **Displacement due to the lack of safe and consistent shelter is responsible for high emotional stress, including causing deaths post-fire.**[107] The destruction of communities results in property loss, employment loss, and the increased incidence of poverty and homelessness.[108] In line with literature on the effects of other natural disasters such as hurricanes, floods, or tornadoes, these impacts disproportionately harm those most vulnerable.

Concentrated mental health impacts

The direct societal impacts of wildfires cause extensive detrimental mental health risks similar to other disasters. These include high rates of anxiety, depression, PTSD, and higher rates of suicide.[109] The Camp Fire in 2018, California's deadliest wildfire on record, left thousands of Paradise residents houseless and forced the closure of a community

hospital, generating "community-wide posttraumatic stress".[110] Those who survived reported widespread distress, grief, and trauma lasting well after wildfire subsided.

People forced to evacuate due to catastrophic fire report multiple types of mental health issues, including anxiety, depression, changes to appetite, and post-traumatic stress.[111] Unemployment from wildfire destruction and its resulting economic instability is responsible for increased levels of depression and anxiety.[112] The links between poverty and adverse mental health are well established.

Severe wildfires leave lasting mental health impacts on affected communities for years into the future. **Mental health conditions such as depression and PTSD often do not set in until six to 18 months after the disaster, when emergency services usually no longer provide community care.**[113] Rates of intercommunity violence and abuse have also been shown to rise after the incidence of fire disasters, linked to the increased societal stress of housing loss and unemployment. These include higher rates of domestic violence, sexual abuse, child abuse, and substance abuse.

Conclusions on the public health impacts of wildfire

Wildfires generate different variations of adverse health impacts in cases of acute, chronic, dispersed, and concentrated exposure. **The public health crisis associated with severe wildfire creates two primary dimensions of public health burdens: the population-wide impacts of chronic smoke exposure and the unequal distributional effects of wildfires on public health. These are both projected to increase with the growing severity, frequency, and size of catastrophic wildfires in the coming decades.**

Smoke exposure and wildfire preparation have become constant aspects of life in the western U.S., with harmful physical and psychosocial effects on population-wide public health. Toxic and pervasive air pollution, exacerbated climate change, power shutoffs, and the mental health effects of a burning environment present dispersed public health burdens across jurisdictional boundaries and societal demographics.

However, social protections from wildfires are slim and primarily dependent on the private provision of protective measures such as indoor filtration, creating distributional effects that exacerbate existing social inequalities. Low-income communities, outdoor workers, and other marginalized populations are disproportionately impacted both by smoke exposure and by the destruction of communities to catastrophic wildfire. Children, the elderly, and pregnant people in all populations are notably vulnerable to wildfire harm.

Historical land management and fire suppression leading to fuel buildup, development in the WUI, and climate change are driving increasingly destructive wildfires in U.S. forests and grasslands. The physical and psychosocial health impacts of severe wildfire are stark, including the long-lasting toll of air pollution, the destruction of infrastructure, displacement, and mental and emotional trauma.

There is a suite of available actions taken currently and recommended in the future to build health resilience to wildfire, detailed in later sections. However, a primary wildfire mitigation strategy involves deploying ecologically beneficial fire to reduce

organic matter buildup (combustible fuel) and lower the risk of severe wildfire. **Intentional fire (prescribed and cultural burning) introduces complexity to the existing wildland fire policy landscape, deliberately increasing emissions and pollution metrics in order to decrease the risk of severe emissions and harm in the future.** As beneficial burning can also generate public health impacts, emerging research and the management of these are discussed below.

2.2 PUBLIC HEALTH IMPACTS OF FIRE FOR ECOLOGICAL BENEFIT

2.2.1 Fire for ecological benefit

A significant contributing factor in the proliferation of severe wildfires has been a historical paradigm of fire suppression. **Fire-adapted ecosystems, of which California forests are a key example, require periodic fire intervals to maintain healthy ecosystem function.**[114] This includes thinning the dry organic material that serves as fire fuel. As a result, an essential wildfire mitigation strategy involves the application of fire for ecological benefit in line with local fire regimes.[115] There is widespread scientific consensus that the application of ecologically beneficial fire over time decreases the risk of catastrophic wildfire.[116]

Before colonization in the Americas, Indigenous communities regularly engaged in cultural fire for purposes of ceremony, environmental health, cultural foods, and spiritual connection.[117] However, the forcible removal of Native Americans from their ancestral lands, and laws prohibiting cultural fire by settler populations, began a land management era of fire elimination that continues to this day.[118] Restoring natural wildland fire patterns following centuries' worth of fire suppression in the U.S. poses a foundational challenge in present-day land management.

Land managers have increasingly rallied around returning "good fire" to American forests.[119] The California Department of Forestry and Fire Protection (CAL FIRE) and the U.S Forest Service (USFS) have both committed to burning 500,000 acres a year by 2025, or up to one million acres annually.[120] However, ecologically beneficial fire does not come without its own public health risks. It is also a source of smoke, increasing greenhouse gas emissions and air pollution levels in surrounding communities. This generates necessary tradeoffs for air quality regulatory agencies in the realm of wildland fire management. **Experts interviewed in this project agreed that scaling fire for ecological benefit is an urgent priority; however, specific management questions around the amount burned, optimal fuel conditions, and the timing of ecologically beneficial burns remain an evolving area of policy and research.**

The state of California identifies three primary types of beneficial fire: prescribed fire, cultural fire, and fire for resource benefit. This scoping exercise primarily focuses on considerations around prescribed fire.

2.2.2 Prescribed fire

While a source of smoke-induced air pollution, prescribed fire is highly controlled and therefore generates a different landscape of public health impacts

from wildfire. Prescribed fire smoke emits lower levels of PM2.5 to comply with air quality standards; however, prescribed burns occur chronically over longer periods of time. Prescribed fire smoke also does not include the toxic additives of industrial or residential combustion or the high levels of smoke dispersion associated with wildfires.

Decreased health risk landscape compared to wildfire

The U.S. Environmental Protection Agency (EPA), in collaboration with the U.S. Forest Service, the Department of the Interior (DOI), and the National Institute of Standards and Technology (NIST), were tasked by the Wildland Fire Leadership Council to compare the public health impacts of wildfire and prescribed fire smoke in 2021.[121] The resulting report found, based on two case studies, that prescribed fire is associated with strongly decreased health risks compared to wildfire smoke. Other recent research has also found that when controlled for compliance with air quality standards, prescribed fires do not cause significant changes in ambient air pollution levels.[122] The California Air Resources Board (CARB) has found that prescribed fire smoke carries less toxins, such as chrome, lead, and other heavy metals, than wildfire.[123]

Presence of notable health concerns

However, multiple studies have measured concerning increases in PM2.5 concentrations during prescribed burns of varying severity.[124] One study found that areas with high current and expected levels of prescribed fire are in communities that experience 25% higher social vulnerability than the state average.[125] The researchers identified that prescribed burning in the state of Georgia was associated with a number of mortality cases related to smoke pollution, and that its health impacts were primarily experienced in areas with lower socioeconomic status. Detrimental health impacts have also been identified from prescribed burns with PM concentrations well within air quality standards: Halkerwal et al. note that "there is no known safe level of pollutant exposure below which adverse health impacts are not observed."[126]

Smoke monitoring and management

Smoke management data capabilities are currently under expansion in multiple countries to minimize the public health impacts of prescribed fire.[127] These include air quality assessment tools such as the Base Line Air Network (BLANkET), used widely in Australia, which contains 19 monitors that measure real-time PM2.5 concentrations during prescribed burns.[128] They also include the Interagency Real Time Smoke Monitoring program (AIRSIS), used by the U.S. Forest Service to monitor smoke concentrations from portable smoke monitors. Remote sensing tools and air quality models offer other alternatives, although the health impacts of prescribed burns are challenging to monitor as they often take place in rural areas without robust monitoring infrastructure and lower population density.

Ongoing research

The California Air Resources Board (CARB) is investigating the differential air quality impacts from wildfires and prescribed fires on urban population centers in California to inform state policy analysis on tradeoffs surrounding increasing the scope of prescribed fire.[129] The California Department of Public Health (CDPH) is also researching the expected health impacts of scaling prescribed fire.[130]

Academic research is underway at the Stanford Law and Policy Lab evaluating the costs and benefits of California's rapid scaleup of prescribed fire by modeling the health impacts of prescribed burns.[131] Initial results show differential impacts of prescribed fire depending on fuel conditions, location, intensity, and timing of the fire, identifying a need for future research and effective governance in prescribed fire. Other **academic and policy research is continuing into the comparative health effects of wildfire and prescribed fire smoke.**[132] Robust cost-benefit and health impacts analyses of wildfire under different prescribed burning scenarios were identified as key areas for future work by multiple interviewees.[133]

The role of public education

The California Department of Forestry and Fire Prevention (CAL FIRE)'s Forest Health Research Program organized listening sessions with communities affected by prescribed fire in El Dorado and Nevada Counties in order to better understand community impacts of prescribed burns.[134] Participants expressed strong support for the expansion of prescribed fire efforts as a key mechanism in mitigating the risk of catastrophic wildfire. However, residents emphasized that prescribed burns must be managed safely and with adequate community education.

Public education is a key component in scaling prescribed fire efforts, as many communities impacted by prescribed fire smoke have also been harmed by wildfire.[135] Especially as the rates of ecologically beneficial fire increase, providing real-time information to local air districts and communities about whether smoke is issuing from wildfires or beneficial burns is crucial.[136] Effective and consistent communication about burn planning, community protection initiatives, and mechanisms for ensuring public safety have been identified as priorities for stakeholders planning prescribed burns.

Conclusions on the public health impacts of beneficial fire

There are complex tradeoffs involved with a primary wildfire mitigation strategy comprising more burning, in terms of effective policy implementation, equity, and societal acceptance. However, fire patterns are natural and necessary to healthy forest ecosystems. Over a century of fire suppression, growing development in the WUI, and increasing climate change have created a particularly high-risk landscape for wildfire and a strong associated need for ecologically beneficial burns.[137] A leading challenge for wildland fire policy and management today involves restoring a balanced and resilient societal relationship with fire that centers the protection of frontline communities. Community engagement, public education, expansions in research and monitoring capabilities, and effective, equity-minded governance around ecologically beneficial fire are key recommendations for next steps detailed in later sections. An overview of the current policy landscape in wildland fire and public health is provided below.

III. CURRENT POLICY LANDSCAPE IN WILDLAND FIRE AND PUBLIC HEALTH

Policy measures addressing the public health impacts of wildland fire have historically been siloed among different agencies on state and federal levels. The increasing severity of wildfire-induced air pollution, as well as its transdisciplinary and transboundary nature, have highlighted the need for policy integration. Notable efforts are emerging accordingly to strengthen interagency and interjurisdictional collaboration on state, federal, and international levels. However, integration between wildland fire management and the field of public health specifically is yet nascent; and, where collaborative mechanisms are strong, challenges remain in streamlining effective public health protections across a bureaucratic landscape.

The rapidly evolving nature of this issue has also raised new policy questions. There is now policy consensus on the need to facilitate higher rates of beneficial fire.[138] However, research into the optimal conditions for carrying out prescribed burns with the lowest public health impact is still underway.[139] Furthermore, **air quality regulation has historically classified wildfires as a natural source of particulate matter outside the scope of regulatory processes. Ecologically beneficial fire, on the other hand, is usually treated as an anthropogenic emission source and regulated accordingly, posing barriers to its deployment at scale.**

Wildfires' impact on public health presents a unique combination of acute and chronic policy challenges. This requires efficient utilization of the existing policy landscape to protect public health in the short term, while also facilitating dialogue about building systems-level resilience as wildfire incidence increases over the long-term. A representative, but not exhaustive, list of stakeholders and initiatives active in the current policy landscape is described in the following sections.

3.1. CALIFORNIA POLICY LANDSCAPE

The California policy landscape is characterized by many disparate efforts to address the intersection of wildland fire and public health, but "no clear lead" on this issue at the state level.[140]

Agency landscape

The primary state agencies working across wildland fire and public health policy include the following:

- **The California Department of Forestry and Fire Protection (CAL FIRE), within the Natural Resources Agency (CNRA)**
- **The California Air Resources Board (CARB)**
- **The California Department of Public Health (CDPH), within the Health and Human Services Agency (CalHHS), and**
- **The California Environmental Protection Agency (CalEPA).**

The policy landscape also importantly includes the 35 local air districts responsible for "regional air quality planning, monitoring, and stationary source and facility permitting."[141] The air districts are key stakeholders in permitting prescribed burns alongside other land management strategies. In order to conduct a prescribed burn, a burner must register a smoke management plan with the air district, obtain a burn permit, and secure the air district's approval, including an assessment of the air quality and fuel conditions of the burn.[142]

California Air Resources Board initiatives

The California Air Resources Board (CARB) engages in close coordination with CAL FIRE, the U.S. Forest Service, and local air districts on smoke management for prescribed fire events.[143] Agency priorities for building health resilience to wildfire include the following:

- **Mitigating climate change[a], with an updated path to net zero emissions laid out in the 2022 Scoping Plan.[144]**
- **Working with land managers to increase the scale of prescribed fire treatments up to the 400,000 acre target by 2045.[145]**
- **Streamlining the bureaucratic process associated with scaling prescribed fire, including streamlining the permitting process and aligning incentives for agencies to engage in more prescribed burning.[146]**
- **Public protection and resilience initiatives for smoke-induced air pollution from both wildfire and prescribed fire smoke.[147]**

Considerable attention is being brought to investigating the differential impacts of smoke pollution from wildfire and prescribed fire events under different fuel conditions.[148] Interviewees emphasized the importance of further research in order to scale prescribed fire in the safest manner possible.

a CARB's 2022 Scoping Plan lays out a path toward net zero emissions that does not include wildfire, although climate change mitigation is a key pathway to decreasing severe wildfire risk.

Notably, smoke protection initiatives have the dual benefit of building community resilience to air pollution from both wildfire and prescribed fire smoke.[149] These include upgrades to HVAC systems in schools and other public buildings, the California Smoke Spotter app, and a soon incoming map of Clean Air Centers across the state on the CARB website.

California Governor's Wildfire and Forest Resilience Task Force

In line with sweeping investments in climate resilience in the 2020 and 2021 state budgets, the California Wildfire and Forest Resilience Task Force was created by Governor Gavin Newsom in 2021.[150] The Task Force collaborates across land managers, policymakers, air quality specialists, Tribal governments, private stakeholders, non-governmental organizations, and local communities to integrate wildfire resilience efforts across the state.

Key Task Force workflows include:

- **Convening interagency teams on wildfire resilience strategy development and implementation.[151]**
- **Coordinating enhanced data capabilities, developing metrics and systems to support strategic priorities.[152]**

Through these mechanisms, the Task Force has published influential work coordinating and streamlining wildland fire resilience strategy at the state level. This includes the 2021 Resilience Action Plan, creating a comprehensive framework for scaling up forest management,[153] the Strategic Plan for Expanding the Use of Beneficial Fire, supporting ambitious beneficial burning targets of up to 400,000 acres annually by 2025,[154] and the upcoming Fire-Adapted Communities Roadmap, providing a strategy for building community resilience.[155]

The Task Force has not yet done specific work on smoke and public health impacts, although it is interested in integrating public health into both proactive priority setting activities and retroactive reporting mechanisms.[156] The Fire-Adapted Communities roadmap addresses public health through issuing valuable recommendations referred to in the following section.[157] **As the Task Force is the primary interagency collaboration channel in the state policy landscape,[158] it is well-placed to further facilitate and lead efforts integrating public health considerations into wildland fire management.**

Other coordinating channels

Other coordinating bodies also present potential avenues for further stakeholder collaboration. The Interagency Air and Smoke Council, convened by CARB, brings together air and land managers addressing issues at the intersection of wildland fire and public health.[159] The Interagency Smoke Communications Working Group grew out of the Air and Smoke Council to specifically coordinate outreach and public engagement around smoke pollution from wildfire and prescribed fire.[160] While not a state entity,

the California Council on Science and Technology plays a leading role in conducting research and facilitating policymaker convenings on the health impacts of wildfire.[161]

State legislation

State legislation has also increasingly addressed the risk of severe wildfires and regulatory barriers to scaling prescribed fire. A representative, but not exhaustive, list of relevant legislation includes the following:

- SB 945 (Alvarado-Gil, 2024), requiring CDPH, CAL FIRE, CARB, and the Wildfire and Forest Resilience Task Force to create and maintain an integrated wildfire smoke and health data platform;[162]
- SB 926 (Dodd, 2022), providing state liability protection for potential losses from prescribed fire; [163]
- AB 642 (Friedman, 2021), facilitating greater support and training for prescribed and cultural fire;[164] and
- SB 901 (Dodd, 2018), allocating an additional $1 billion from the Greenhouse Gas Reduction Fund to fire prevention and recovery.[165]

Collaboration with federal stakeholders

As a large part of land in California is federally owned, state stakeholders collaborate extensively with federal stakeholders on wildland fire management. The Good Neighbor Authority[166] enabled the U.S. Forest Service to enter into collaborations of up to 10 years with state forestry agencies to strengthen forest restoration and management capabilities,[167] and the Agreement for the Shared Stewardship of California's Forests and Rangelands called for proactive and coordinated vegetation management of 1 million acres annually by 2025.[168]

Collaborative efforts are underway to streamline utilization of the U.S. Environmental Protection Agency's Exceptional Events process, described in the next section, to scale prescribed burning.[169] ARB is notably working with local air districts on guidance and tools to minimize the "bureaucratic friction" associated with federal air quality regulation of prescribed fire smoke.[170]

3.2. FEDERAL POLICY LANDSCAPE

The federal policy landscape is still characterized by silos between disparate agency remits on wildland fire and public health, although notable efforts at coordination have emerged due to the severity of the crisis. Similarly to the California context, no clear lead has been identified on the issue.

Agency landscape

The primary federal agencies and entities working on wildland fire policy and management are listed in the table below, alongside their temporal roles in wildland fire governance. These also include the U.S. Environmental Protection Agency (EPA), responsible for air quality regulation and standards.

AGENCY	RISK ASSESSMENT & COMMUNICATIONS	PREVENTION	PREPAREDNESS & RESPONSE	POST-FRE RECOVERY
Department of Agriculture & US Forest Service	X	X	X	X
Department of Defense	X		X	X
Department of the Interior	X	X	X	X
Federal Emergency Management Agency	X		X	X
US Fire Administration	X	X		
National Interagency Fire Center	X	X	X	X
National Oceanographic And Atmospheric Administration	X	X	X	

Figure 2. Key federal entities and agencies' roles in wildfire policy and management (OECD data)[171]

U.S. Forest Service (USFS) Strategy: Confronting the Wildfire Crisis

In 2022, the U.S. Forest Service announced a 10-year strategy called "Confronting the Wildfire Crisis: A Strategy for Protecting Communities and Improving Resilience in America's Forests".[172] The Strategy works across states, Tribal governments, and a wide range of other stakeholders to rapidly scale up forest management, protect communities, and facilitate greater wildfire resilience.[173] National targets include treating up to 20 million additional acres on National Forest System land and 30 million acres of other federal, Tribal, state, and private land.[174] The Strategy has generated historic investments in fire resilience, expected to generate 300,000 to 575,000 jobs. The U.S. Forest Service has also used Strategy funding to conduct publicly available research on the highest-risk firesheds across the country, seen below.

At the time of writing, public health was not notably addressed by the Strategy. However, the U.S. Forest Service collaborates with EPA on the AirNow Fire and Smoke Map, providing public information on health protection from wildfire smoke.[175]

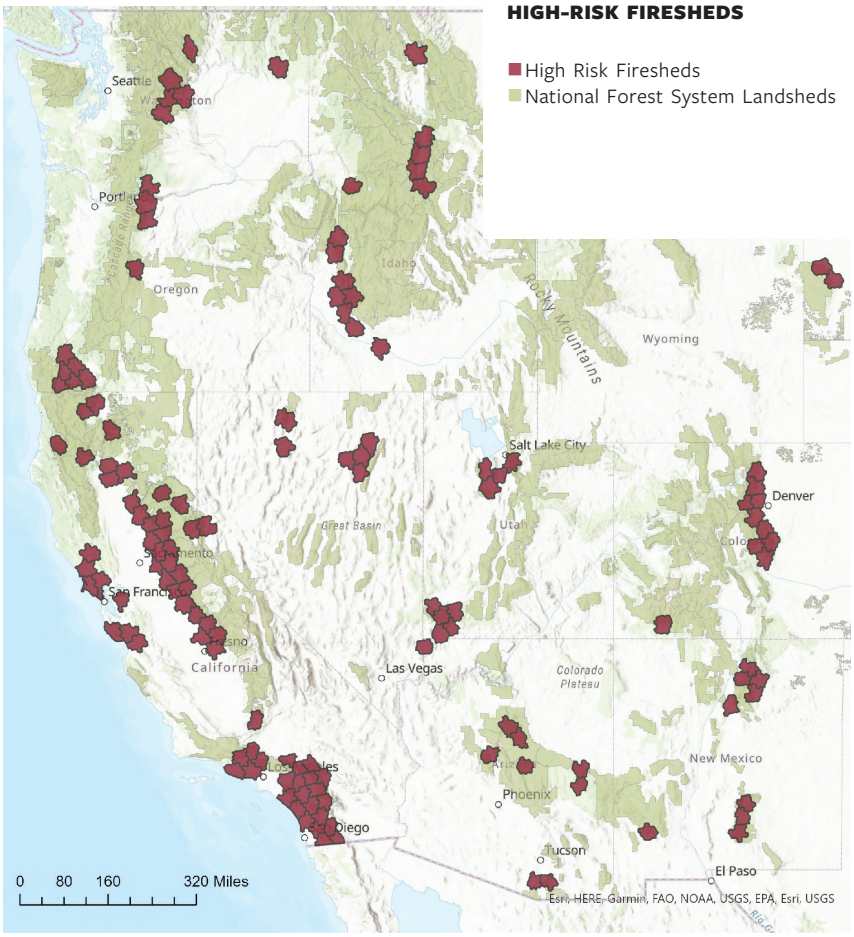

Figure 3. High-risk firesheds identified by the U.S. Forest Service[176]

Environmental Protection Agency (EPA)'s air quality regulation and wildland fire

Although there is no wildland fire program at EPA, the agency is becoming increasingly active in research, communications, and policy development on the public health impacts of wildland fire.[177]

PM2.5 from wildfire pollution is not regulated by EPA's air quality standards, as it is categorized by states as an Exceptional Event alongside volcanic activity, high wind dust storms, and other natural pollution sources.[178] However, the effective contribution of wildfire to ambient PM2.5 levels in the U.S. has been recently quantified to be between 25% to over 50% in much of the western U.S., and increasing under current climate change scenarios.[179]

Notably, prescribed fire smoke can also be categorized by EPA as an Exceptional Event outside of the scope of ambient air quality regulation.[180] However, the approval process for EPA categorization of prescribed burns as Exceptional Events poses bureaucratic barriers to states classifying it as such in practice.[181] This has been exacerbated by

the release of EPA's new National Ambient Air Quality Standards (NAAQS) decreasing from 12.0PM to 9.0 PM in February 2024.[182]

EPA has issued guidance and held workshops for stakeholders engaging in prescribed burns in navigating the approval process,[183] as well as engaged in considerable effort to streamline the process to make approvals more efficient.[184] **Technical tools such as AI assistance in categorizing smoke plumes have been identified as potential solutions to quicker progression and approval through the process.**[185] Utilization of the Exceptional Events process to permit prescribed fire at scale is a key area for future research, stakeholder collaboration and policy development.[186]

Wildland Fire Mitigation and Management Commission

In an effort to coordinate federal efforts in wildland fire management, the Biden Administration created the Wildland Fire Mitigation and Management Commission in 2021.[187] The Commission was tasked with making recommendations to Congress regarding improving the federal policy landscape on wildland fire management in the U.S., and is co-chaired by the Department of the Interior (DOI), the Department of Agriculture (USDA), and the Federal Emergency Management Agency (FEMA). Commission members represent a broad range of scientific expertise, including in prescribed fire, firefighting, cultural burning, public health, and post-fire recovery, among others. The Commission's recommendations report released in 2023 called for an influential shift in federal fire governance to facilitate greater interdisciplinary action, transboundary collaboration, and proactive fire management across the U.S.[188] The full list of recommendations made by the Commission is a valuable resource and informs some of the recommendations made by this report.

Memorandum of Understanding (MOU) on wildfire smoke risk and management

In response to the Commission's recommendations, EPA, the U.S. Department of Agriculture (USDA), the U.S. Department of the Interior (DOI), and the Centers for Disease Control and Prevention (CDC) signed an MOU in November 2023 announcing their collaboration on protecting communities from smoke risk.[189] The resulting joint work plan outlines areas of collaboration on smoke management in the fiscal years 2024 and 2025.

Wildland Fire Leadership Council

The primary coordination channel for federal wildfire resilience has historically been the Wildland Fire Leadership Council (WFLC), founded in 2002 by the USDA and the DOI to coordinate and implement federal fire management policy. The Council is an intergovernmental committee of federal, state, Tribal, and local government officials similarly providing recommendations for federal policy coordination, forest management, and effective wildfire resilience.

The Council is required by the 2010 Appropriations Act to submit a strategy to Congress on fire management, to be revised at least once every five year period.[190] The

National Cohesive Wildland Fire Management Strategy's Addendum Update in 2023 highlights four critical areas not addressed in depth in the 2014 Strategy:

- Climate change
- Workforce capacity, health and well-being
- Community resilience (preparation, response and recovery)
- Diversity, equity, inclusion, and environmental justice[191]

The 2023 Strategy Update also identifies key remaining implementation challenges in the areas of scaling prescribed fire, data-driven decision making, and public education.[192]

As a coordinating and agenda-setting body, the Wildland Fire Leadership Council is well-positioned to facilitate greater integration of public health in wildland fire policy on a federal level, among other coordinating entities.

Further channels addressing policy integration on federal fire resilience include the White House Wildfire Resilience Interagency Working Group, the Joint Chiefs' Landscape Restoration Partnership, and the Joint Fire Science Program.

Federal grant programs for wildfire resilience

The U.S. Forest Service and FEMA also provide grant funding to high-risk communities seeking to build wildfire resilience. Notable grants are listed below:

- The USFS *Community Wildfire Defense Grant Program* funds the implementation of Community Wildfire Protection Plans in communities and Tribes experiencing high wildfire risk.[193]
- The USFS *Wildland Urban Interface Grant Program* funds activities reducing wildfire risk in WUI areas, including community education, risk assessment, planning, and monitoring initiatives.[194]
- FEMA's *Building Resilient Infrastructure and Communities Program* funds state and local projects reducing catastrophic wildfire risk.[195]
- FEMA's *Hazard Mitigation Grant Program* supports post-fire recovery during severe wildfire events declared by the White House as "major disasters".[196]

3.3. INTERNATIONAL GOVERNANCE LANDSCAPE

Challenges in wildland fire governance are shared with other Mediterranean climates and beyond. Furthermore, wildfire smoke exposure is not jurisdictionally bound, generating notable transboundary health impacts and a need for cross-jurisdictional collaboration.

Coordinated governance initiatives

Responding to increases in severe wildfire incidence globally, international efforts have emerged to facilitate information-sharing and governance principles in effective wildfire management. Most notable among these is the Landscape Fire Governance Framework, inaugurated at the 8th International Wildland Fire Conference in 2023.[197] The Framework introduced a set of international guiding principles for fire policy and management, bringing together governments, academia, businesses, and civil society representatives in addressing growing wildfire risk. The resulting principles focus significantly on moving past siloed approaches to facilitate coordinated and interdisciplinary action,[198] and do not yet address public health.

The United Nations and the Food and Agriculture Organization (FAO) have published a series of reports encouraging governments worldwide to shift fire management strategies from suppression to prevention.[199] Portugal has since established an Integrated Fire Agency, drawing international attention for working across the conservation sector, the private sector, and the armed forces to institutionalize fire prevention and resilience.[200]

Bilateral Memorandums of Understanding between national governments enable more efficient sharing of wildland fire research, firefighting training, and post-fire restoration strategies. The U.S. and Portugal most recently signed an MOU on wildfire management in 2023, building on the U.S.'s similar agreements with Canada, Australia, New Zealand, and Mexico.[201]

Data and monitoring

High need for increased research and information sharing in wildfire management has spurred the development of advanced regional and global monitoring systems. The European Forest Fire Information System (EFFIS) collects wildfire data across Europe and provides information to the European Commission and the European Parliament on fire management, supported by a group of fire experts from 43 countries in Europe, the Middle East, and North Africa.[202] The Global Fire Monitoring Center (GFMC) similarly advises the UN and other international organizations on capacity building for wildfire management and disaster risk reduction.[203]

CONCLUSIONS ON THE CURRENT POLICY LANDSCAPE

Across state, federal, and international contexts, notable coordination efforts have emerged across a siloed landscape of wildland fire and public health policy. The California Governor's Wildfire and Forest Resilience Task Force and the Wildland Fire Leadership Council, respectively, are well placed in the California and federal contexts to further integrate public health considerations into the wildland fire policy landscape.

Where integrated policy efforts have been established, the policy landscape could further benefit from more streamlined processes to support effective implementation. Limiting legislative and permitting barriers to scaling responsible prescribed fire, especially through EPA's Exceptional Events process, forms a key area for future research, innovation, and stakeholder collaboration.

Nationally and internationally, there are abundant opportunities for intersectoral and interjurisdictional collaboration on wildfire resilience. Recommendations for facilitating these and streamlining effective implementation of health protections in wildland fire policy are explored in the following section.

IV. RECOMMENDATIONS FOR FUTURE RESILIENCE

This report identifies the following key areas for future resilience, with consideration and prioritization throughout of affected communities most vulnerable. Responsible for the implementation of these recommendations we expect to be state and federal legislators, air quality regulators, land managers, local air districts, non-governmental organizations, private landowners, and fire practitioners, among other stakeholders.

Key recommendations for policymakers include:

Future policy research and stakeholder convenings are urged to further develop best-placed avenues and mechanisms for implementation, facilitated by coordinating bodies such as the Wildfire and Forest Resilience Task Force or the Wildland Fire Leadership Council.

- **Enhancing proactive capacity-building to address wildfire risk in the near term,** through expansions in the wildland fire sector workforce, research capabilities, data collection and monitoring, wildfire smoke protection resources, emergency response, and wildfire preparedness.

- **Facilitating responsible implementation of ecologically beneficial fire**, through establishing integrated, community-led governance principles, multi-pronged policy development, public education and outreach, and a considerable expansion of research into the effects of prescribed fire.

- **Building systems-level resilience in wildland fire and public health**. Facilitating coordinated, streamlined governance structures, developing integrated air quality regulation frameworks, mitigating climate change, and incorporating wildland fire safety into broader policy areas such as housing and occupational protections remain key areas for future research and policy development.

4.1. ENHANCING PROACTIVE CAPACITY-BUILDING TO ADDRESS WILDFIRE RISK IN THE NEAR TERM

Building health resilience to wildfire risk encompasses both strategic utilization of existing policy mechanisms and facilitating systems-level resilience in wildland fire governance over the long term.[204] State and federal legislators should utilize the existing policy landscape to enhance proactive capacity-building to wildfire risk in the following areas.

Wildland fire sector workforce

The wildland fire sector workforce must expand multifold to meet current and future land management targets, without depending on the fire suppression and emergency response workforce to also bear the burden of completing fuels management work at scale during the offseason. Prescribed fire certifications can also be expanded to better support and respect the qualifications of Indigenous cultural fire practitioners.[205]

Research capabilities

Further academic and policy research is needed into many aspects of the public health impacts of wildfire. This includes research into the acute and cumulative health effects of smoke pollution, the risks of smoke dispersion, the toxicity levels of PM2.5 from the combustion of organic material and industrial materials, the financial costs of smoke pollution, and the health tradeoffs associated with scaling prescribed fire, among others.

Data collection and monitoring

Increasing air quality monitoring capacity is an essential component to expanding research and policy capabilities. Monitor spacing should crucially be evenly distributed throughout areas exposed to wildfire pollution, as current private monitor adoption is unevenly concentrated in affluent and already-monitored areas.[206] Air quality monitoring infrastructure in wildfire-prone areas should have backup access to distributed energy sources[b] in order to protect data from wildfire-induced power outages.[207]

Wildfire smoke protection resources

Public protection in the form of information-sharing to notify communities of smoke risk is well-established in both California and federal contexts. However, material resources can be better deployed to facilitate more effective and equitable smoke protection. As private provision of smoke protection tends to only be accessible to higher-income

b Distributed energy resources are an important protective mechanism from wildfire-induced power outages. Expansions in clean energy storage can help support critical services during wildfires without contributing to fossil fuel emissions.

residents, community protection resources are a necessary equity measure for health resilience. These include the expansion of Clean Air Centers, subsidizing accessible home filtration, subsidizing mask provision, and financing capacity-building for community organizations.[208]

Emergency response

Local and regional emergency response services remain under-resourced in their ability to comprehensively respond to catastrophic wildfire. **Sustained funding for emergency care is critical, as well as expansions to effectively address and treat community mental health.**

Wildfire preparedness

The California Wildfire Task Force, in collaboration with CAL FIRE, CDPH, and CARB, is required by statute to plan an integrated wildfire smoke data platform tracking smoke exposure and health data statewide.[209] CDPH, CARB, and air districts are also working on developing best practices on public communication surrounding wildfire smoke events.[210] Nevertheless, public and community engagement should be further expanded in languages other than English, through trusted community information sources, and through communications infrastructure that is not compromised by power disruption.[c] Public engagement is additionally central in understanding and preventing human ignition during times of high wildfire risk.[211] Promoting the widespread adoption of the California Smoke Spotter app and similar platforms can also facilitate more effective dissemination of smoke information for community preparedness.[212]

4.2. FACILITATING RESPONSIBLE IMPLEMENTATION OF ECOLOGICALLY BENEFICIAL FIRE

This report emphasizes the importance of prescribed fire, although further research, collaboration, and emphasis is needed into strategies for facilitating more beneficial fire as a whole, and cultural fire in particular. Beneficial fire is a key area for future work in streamlining policy implementation, as managing associated public health tradeoffs poses regulatory, interdisciplinary, and public engagement considerations. This report recommends the following to help facilitate the paradigm shift toward responsible beneficial fire, in the context of research conducted on the prescribed fire landscape.

Integrated, community-led governance principles

In order to facilitate the responsible management of beneficial fire that incorporates maximum protections for affected communities, multisectoral stakeholders should develop

c Various mechanisms are recommended to protect power lines from high wildfire risk, ranging from burying power lines, vegetation management, and installing rapid earth fault current limiters. Ground fault neutralizers present an especially cost-effective option to protecting power lines with lower associated labor costs.

integrated principles for beneficial fire governance, incorporating equity-based public health considerations in all temporal stages of the planning process. **Incorporating and centering local and place-based knowledge is key to effectively scaling beneficial fire, especially Indigenous knowledge around cultural fire.**[213]

Policy development

Streamlining the approval process for prescribed burns to address the "bureaucratic friction"[214] **inhibiting their deployment at scale is an essential area for future policy development.**[215] Other key policy actions include enhancing monitoring capabilities to enable effective smoke management and expanding air quality protections for affected communities from prescribed fire smoke.

Public education and outreach

Community engagement and social research into strategies that facilitate support for ecologically beneficial fire will be crucial to prescribed fire uptake.[216] Public outreach should include place-based resilience measures for the public health impacts of prescribed fire. Affected communities should be consistently and effectively involved in informational processes about what to expect during prescribed burns, including precautionary measures and air quality protection.

Further research into beneficial fire

Beneficial fire, and especially prescribed fire as focused on in this report, is a central area for future research. Further work is needed comparing the public health impacts of smoke pollution from wildfire and prescribed fire under varying conditions. This could include expanding technical modeling for smoke plume analysis as well as social research into community perspectives and public acceptance of beneficial fire.[217] A research synthesis bringing together work on the public health impacts of different types of fire would be an especially valuable contribution.[218]

4.3. STRENGTHENING SYSTEMS-LEVEL RESILIENCE IN WILDLAND FIRE AND PUBLIC HEALTH

In parallel to capacity-building initiatives utilizing existing policy avenues, stakeholders are urged to explore intersectoral and innovative solutions to building systems-level, long-term health resilience to wildfire. Guiding recommendations are below.

Mitigating climate change

As climate change is responsible for "at least half" of severe wildfire incidence,[219] phasing out the burning of fossil fuels in favor of a clean energy transition is a central recommendation for addressing catastrophic wildfires at their source.[220]

Coordinated and streamlined governance

Innovative policymaking processes facilitating the coordination of wildland fire management efforts will be a cornerstone of long-term health resilience. This includes interagency and intersectoral collaboration across silos, integrating the temporal aspects of wildland fire management, and facilitating multilevel governance structures centering frontline communities at the center.[221]

At the same time, identifying mechanisms for streamlining coordinative governance processes will facilitate effective implementation. This should involve advances in technological tools assisting the policymaking process and facilitating the development of regulatory systems designed to better address the complexities of wildfire and public health.

Integrated air quality regulation

Integrated air quality regulation that accounts for the changing wildfire landscape, with appropriate considerations for beneficial fire emissions, will become a foundational component in developing wildfire resilience over the long term. Adapting the federal air quality policy landscape to comprehensively and efficiently address the public health impacts of wildfire, with their respective tradeoffs and challenges, remains a central area for future work.

Resilient homes and workplaces

Building community resilience to wildfire and fire smoke is closely interlinked with ensuring housing stock and other buildings are fire-safe and compliant with indoor air quality standards.[222] Relying on private provision of smoke protection has been shown to have "modest and unequal benefits" in limiting pollution exposure if fire-safe housing is not widely accessible.[223]

Occupational protections are also needed for workers highly impacted by wildfire smoke and catastrophic wildfire. This includes physical and mental health protections for firefighters, outdoor workers in sectors such as agriculture and construction, and healthcare workers, among others.[224]

The environmental justice dimension of public health resilience to wildfire necessitates addressing the social determinants of health that exacerbate the risks borne by marginalized populations.


Pet City

V. CONCLUSION

5.1. PROJECT FINDINGS

Public health impacts

The health impacts of wildfire cause population-wide harm, have environmental justice implications, and are extremely costly, increasing year on year. The physical impacts of wildfire smoke-induced air pollution include the risks of PM2.5 exposure, the toxicity of wildfire-specific PM2.5, the risks of residential and industrial combustion, especially due to fire retardants, and the increased risk associated with smoke dispersion. The psychosocial impacts of wildfire include societal health impacts from worsened climate change and increased power safety measures, societal mental health effects, the destruction of communities and infrastructure, and the community trauma of catastrophic wildfire. While beneficial fire is a primary mitigation strategy, it also presents public health tradeoffs and policy complexities in responsible deployment.

Current policy landscape

Across state, federal, and international contexts, notable coordination efforts have emerged across a siloed landscape of wildland fire and public health policy. The California Governor's Wildfire and Forest Resilience Task Force and the Wildland Fire Leadership Council, respectively, are well placed in the California and federal contexts to further integrate public health considerations into the wildland fire policy landscape. Where integrated policy efforts have been established, the policy landscape could further benefit from more streamlined processes to support effective implementation. Limiting legislative and permitting barriers to scaling responsible prescribed fire, especially

through EPA's Exceptional Events process, forms a key area for future research and collaboration. International initiatives on fire resilience thus far do not notably include public health, creating ample space for collaboration given the transboundary nature of wildland fire pollution.

Recommendations for future resilience

Integration between wildland fire management and public health is yet nascent. Where collaborative mechanisms are strong, challenges remain in streamlining the effective implementation of public health protections. This report identifies the following key areas for future resilience:

- **Enhancing proactive capacity-building to address wildfire risk in the short term,**
- **Facilitating responsible implementation of ecologically beneficial fire, and**
- **Building systems-level resilience in wildland fire and public health.**

Key areas for future research include the public health impacts of wildfire across different temporal and geographical scales, the health impacts of prescribed fire under different conditions, policy processes facilitating coordinated and streamlined health protections, cross-sectoral coalition-building, and public and community engagement on health resilience.

REFERENCES

1 *On Fire: The Report of the Wildland Fire Mitigation and Management Commission*, Wildland Fire Mitigation and Management Commission (2023), available at: https://www.usda.gov/sites/default/files/documents/wfmmc-final-report-09-2023.pdf.

2 *California's Strategic Plan for Expanding the Use of Beneficial Fire*, California Wildfire and Forest Resilience Task Force (2022), available at: https://wildfiretaskforce.org/wp-content/uploads/2022/05/californias-strategic-plan-for-expanding-the-use-of-beneficial-fire.pdf.

3 Shivani Shukla et al., *Intentional Fire* (2023), available at: https://mcusercontent.com/6cc26fde390849a7ab2bc14b4/files/dd90448e-77d7-d062-acd3-b31cd1c96cd7/cwi_convening_report_final.01.pdf.

4 Science Direct, "Fire Regime" (webpage), available at: https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/fire-regime.

5 "Wildfires: A Growing Public Health Crisis," American Journal of Nursing (December 2020), available at: https://journals.lww.com/ajnonline/fulltext/2020/12000/wildfires_a_growing_public_health_crisis.10.aspx.

6 Patricia Koman et al., "Using wildland fire smoke modeling data in gerontological health research (California, 2007-2018)," *Science of the Total Environment* (May 31, 2022), available at: https://pubmed.ncbi.nlm.nih.gov/35660427/.

7 John Balmes and Stephanie Holm, "Increasing wildfire smoke from the climate crisis: Impacts on asthma and allergies," *The Journal of Allergy and Clinical Immunology* (September 20, 2023), available at: https://pubmed.ncbi.nlm.nih.gov/37739070/.

8 David Eisenman and Lindsay Galway, "The mental health and well-being effects of wildfire smoke: A scoping review," *BMC Public Health* (December 5, 2022), available at: https://link.springer.com/article/10.1186/s12889-022-14662-z.

9 *Public Health Impact of Prescribed Fire: Report on Listening Sessions with Community Members, El Dorado and Nevada Counties, California*, California Department of Public Health (November 8, 2021), available at: https://www.cdph.ca.gov/Programs/CCDPHP/DEODC/EHIB/EES/CDPH%20Document%20Library/PrescribedFire_ListeningSessionsFullReport_ADA.pdf.

10 Mark Borgschulte et al., "Wildfires reveal the large toll of air pollution on labor market outcomes," Stanford Institute for Economic Policy Research (December 2022), available at: https://drive.google.com/file/d/1lR9WfUoWG5rjbdThASG5LfQKdLykaDuw/view.

11 U.S. Environmental Protection Agency, "Which Populations Experience Greater Risks of Adverse Health Effects Resulting from Wildfire Smoke Exposure?" (webpage), available at: https://www.epa.gov/wildfire-smoke-course/which-populations-experience-greater-risks-adverse-health-effects-resulting.

12 U.S. Environmental Protection Agency (EPA), "Wildland Fire Research: Health Effects Research," (webpage), available at: https://www.epa.gov/air-research/wildland-fire-research-health-effects-research.

13 Annie Rosenthal et al., "Health and social impacts of California wildfires and the deficiencies in current recovery resources: An exploratory qualitative study of systems-level issues," *PLOS ONE* (March 26, 2021), available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7997008/.

14 Anjali Haikerwal et al., "Impact of smoke from prescribed burning: Is it a public health concern?" *Journal of the Air and Waste Management Association* (April 14, 2015), available at: https://www.tandfonline.com/doi/full/10.1080/10962247.2015.1032445.

15 Craig Thomas interview.

16 Center for Climate and Energy Solutions, "Wildfires and Climate Change" (webpage), available at: https://www.c2es.org/content/wildfires-and-climate-change/.

17 *California's Strategic Plan for Expanding the Use of Beneficial Fire*, California Wildfire and Forest Resilience Task Force (2022), available at: https://wildfiretaskforce.org/wp-content/uploads/2022/05/californias-strategic-plan-for-expanding-the-use-of-beneficial-fire.pdf.

18 Anjali Haikerwal et al., "Impact of smoke from prescribed burning: Is it a public health concern?" *Journal of the Air and Waste Management Association* (April 14, 2015), available at: https://www.tandfonline.com/doi/full/10.1080/10962247.2015.1032445.

19 Minghao Qiu interview.

20 *Fire-Adapted Communities Roadmap* [*Administrative Draft*], California Wildfire and Forest Resilience Task Force (March 2024).

21 *On Fire*, Wildland Fire Mitigation and Management Commission (2023), available at: https://www.usda.gov/sites/default/files/documents/wfmmc-final-report-09-2023.pdf.

22 Craig Thomas interview.

23 Marshall Burke et al., "The contribution of wildfire to PM2.5 trends in the USA," *Nature* (September 20, 2023), available at: https://www.nature.com/articles/s41586-023-06522-6.

24 Id.

25 *Confronting the Wildfire Crisis: A Strategy for Protecting Communities and Improving Resilience in America's Forests*, U.S. Forest Service (January 2022), available at: https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/Confronting-the-Wildfire-Crisis.pdf.

26 Id.

27 California Air Resources Board, "Understanding the Air Quality Impacts of Wildfires and Prescribed Burns in Urban Environments of California," (webpage), available at: https://ww2.arb.ca.gov/resources/documents/understanding-air-quality-impacts-wildfires-and-prescribed-burns-urban.

28 Western Fire Chiefs Association, "History of California Wildfires" (webpage), available at: https://wfca.com/wildfire-articles/history-of-california-wildfires/.

29 European Forest Fire Information System (webpage), available at: https://effis.jrc.ec.europa.eu/.

30 Emily Orzechowski et al., *Taming Wildfires in the Context of Climate Change: The Case of the United States*, OECD Environment Policy Paper No. 40, available at: https://www.oecd-ilibrary.org/deliver/ef69cc94-en.pdf?itemId=/content/paper/ef69cc94-en&mimeType=pdf.

31 California Department of Fish and Wildlife, "Science: Wildfire Impacts" (webpage), available at: https://wildlife.ca.gov/Science-Institute/Wildfire-Impacts.

32 Michael Jerrett et al., "Up in smoke: California's greenhouse gas reductions could be wiped out by 2020 wildfires," *Environmental Pollution* (October 1, 2022), available at: https://www.sciencedirect.com/science/article/pii/S0269749122011022#.

33 California Department of Forestry and Fire Protection (CAL FIRE), "Remembering the Camp Fire" (webpage), available at: https://www.fire.ca.gov/our-impact/remembering-the-camp-fire.

34 Emily Orzechowski et al., *Taming Wildfires in the Context of Climate Change*, OECD Environment Policy Paper No. 40, available at: https://www.oecd-ilibrary.org/deliver/ef69cc94-en.pdf?itemId=/content/paper/ef69cc94-en&mimeType=pdf.

35 *On Fire*, Wildland Fire Mitigation and Management Commission (2023), available at: https://www.usda.gov/sites/default/files/documents/wfmmc-final-report-09-2023.pdf.

36 Christian Crowley et al., *Increasing damages from wildfires warrant investment in wildland fire management*, U.S. Department of the Interior, Office of Policy Analysis (2023), available at: https://www.doi.gov/sites/doi.gov/files/ppa-report-wildland-fire-econ-review-2023-05-25.pdf.

37 Patricia Koman et al., "Using wildland fire smoke modeling data in gerontological health research," Science of the Total Environment (May 31, 2022), available at: https://pubmed.ncbi.nlm.nih.gov/35660427/.

38 Marshall Burke et al., "The contribution of wildfire to PM2.5 trends in the USA," *Nature* (September 20, 2023), available at: https://www.nature.com/articles/s41586-023-06522-6.

39 Marco Turco et al., "Anthropogenic climate change impacts exacerbate summer forest fires in California," *Earth, Atmospheric, and Planetary Sciences* (June 12, 2023), available at: https://www.pnas.org/doi/abs/10.1073/pnas.2213815120.

40 Center for Climate and Energy Solutions, "Wildfires and Climate Change" (webpage), available at: https://www.c2es.org/content/wildfires-and-climate-change/.

41 Id.

42 U.S. EPA, "Climate Change Indicators: Wildfires" (webpage), available at: https://www.epa.gov/climate-indicators/climate-change-indicators-wildfires#ref25.

43 Center for Climate and Energy Solutions, "Wildfires and Climate Change" (webpage), available at: https://www.c2es.org/content/wildfires-and-climate-change/.

44 "Wildfires: A Growing Public Health Crisis," *American Journal of Nursing* (December 2020), available at: https://journals.lww.com/ajnonline/fulltext/2020/12000/wildfires_a_growing_public_health_crisis.10.aspx.

45 Jia Liu et al., "Particulate air pollution from wildfires in the Western US under climate change," *Climatic Change* (July 30, 2016), available at: https://link.springer.com/article/10.1007/s10584-016-1762-6.

46 California Climate Adaptation Strategy (webpage), available at: https://climateresilience.ca.gov/overview/index.html.

47 California Air Resources Board (CARB) interview.

48 California Wildfire and Forest Resilience Task Force (webpage), available at: https://wildfiretaskforce.org/about/.

49 *On Fire*, Wildland Fire Mitigation and Management Commission (2023), available at: https://www.usda.gov/sites/default/files/documents/wfmmc-final-report-09-2023.pdf.

50 Shivani Shukla et al., *Intentional Fire* (2023), available at: https://mcusercontent.com/6cc26fde390849a7ab2bc14b4/files/dd90448e-77d7-d062-acd3-b31cd1c96cd7/cwi_convening_report_final.01.pdf.

51 John Balmes and Stephanie Holm, "Increasing wildfire smoke from the climate crisis" *The Journal of Allergy and Clinical Immunology* (September 20, 2023), available at: https://pubmed.ncbi.nlm.nih.gov/37739070/.

52 "Wildfires: A Growing Public Health Crisis," *American Journal of Nursing* (December 2020), available at: https://journals.lww.com/ajnonline/fulltext/2020/12000/wildfires_a_growing_public_health_crisis.10.aspx.

53 Id.

54 Id.

55 Id.

56 Id.

57 Lauren Linde et al., "Tuberculosis Diagnoses Following Wildfire Smoke Exposure in California," *American Journal of Respiratory and Critical Care Medicine* (February 1, 2023), available at: https://pubmed.ncbi.nlm.nih.gov/36103611/.

58 Smoke pollution exposure is associated with preterm birth and elevated measures of risk if experienced at any point of pregnancy.

59 Joan Casey interview.

60 "Wildfires: A Growing Public Health Crisis," *American Journal of Nursing* (December 2020), available at: https://journals.lww.com/ajnonline/fulltext/2020/12000/wildfires_a_growing_public_health_crisis.10.aspx.

61 Anjali Haikerwal et al., "Impact of smoke from prescribed burning" Journal of the Air and Waste Management Association (April 14, 2015), available at: https://www.tandfonline.com/doi/full/10.1080/10962247.2015.1032445.

62 Marshall Burke et al., "The contribution of wildfire to PM2.5 trends in the USA," *Nature* (September 20, 2023), available at: https://www.nature.com/articles/s41586-023-06522-6.

63 Tarik Benmarhnia interview.

64 Rosana Aguilera et al., "Fine Particles in Wildfire Smoke and Pediatric Respiratory Health in California," *Pediatrics* (2021), available at: https://publications.aap.org/pediatrics/article/147/4/e2020027128/180791/Fine-Particles-in-Wildfire-Smoke-and-Pediatric?autologincheck=redirected.

65 Tarik Benmarhnia interview.

66 Id.

67 Sam Heft-Neal interview.

68 Lee Ann Hill et al., *The Public Health Dimensions of California Wildfire and Wildfire Prevention, Mitigation and Suppression*, PSE Healthy Energy (July 2020), available at: https://www.psehealthyenergy.org/wp-content/uploads/2020/07/PSEHealthyEnergy_Wildfire_07302020-1.pdf.

69 Id.

70 Tarik Benmarhnia interview.

71 Irva Hertz-Picciotto [Interview], "Wildfire Smoke and Your Health: When Wildfires Hit Close to Home," available at: https://www.niehs.nih.gov/sites/default/files/research/supported/translational/peph/podcasts/2020/mar5_wildfires/when_wildfires_hit_close_to_hometranscript_508.pdf.

72 Alissa Cordner et al., "Firefighters and Flame Retardant Activism," *New Solutions: A Journal of Environmental and Occupational Health Policy* (January 25, 2017), available at: https://journals.sagepub.com/doi/10.2190/NS.24.4.f.

73 Id.

74 Id.

75 Id.

76 Lee Ann Hill et al., *The Public Health Dimensions of California Wildfire and Wildfire Prevention, Mitigation and Suppression*, PSE Healthy Energy (July 2020), available at: https://www.psehealthyenergy.org/wp-content/uploads/2020/07/PSEHealthyEnergy_Wildfire_07302020-1.pdf.

77 Tarik Benmarhnia interview.

78 National Oceanic and Atmospheric Organization, "Smoke from wildfires influences ozone pollution on a global scale," available at: https://research.noaa.gov/2022/01/10/smoke-from-fires-influences-ozone-pollution-on-a-global-scale/.

79 Minghao Qiu interview.

80 Marshall Burke et al., "The contribution of wildfire to PM2.5 trends in the USA," *Nature* (September 20, 2023), available at: https://www.nature.com/articles/s41586-023-06522-6.

81 Marissa Childs et al., "Daily Local-Level Estimates of Ambient Wildfire Smoke PM2.5 for the Contiguous US," *Environmental Science and Technology* (September 22, 2022), available at: https://pubs.acs.org/doi/10.1021/acs.est.2c02934.

82 Id.

83 Joan Casey interview.

84 Michael Méndez et al., "The (in)visible victims of disaster: Understanding the vulnerability of undocumented Latino/a and indigenous immigrants," *Geoforum* (August 7, 2020), available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7413658/.

85 "Wildfires: A Growing Public Health Crisis," *American Journal of Nursing* (December 2020), available at: https://journals.lww.com/ajnonline/fulltext/2020/12000/wildfires_a_growing_public_health_crisis.10.aspx.

86 Marshall Burke et al., "Exposures and behavioural responses to wildfire smoke," *Nature Human Behaviour* (July 7, 2022), available at: https://www.nature.com/articles/s41562-022-01396-6.

87 Sam Heft-Neal et al., "Emergency department visits respond nonlinearly to wildfire smoke," *Proceedings of the National Academy of Sciences* (2023), available at: https://www.pnas.org/doi/10.1073/pnas.2302409120.

88 Mark Borgschulte et al., "Wildfires reveal the large toll of air pollution on labor market outcomes," Stanford Institute for Economic Policy Research (December 2022), available at: https://drive.google.com/file/d/1lR9WfUoWG5rjbdThASG5LfQKdLykaDuw/view.

89 *Implications of the California Wildfires for Health, Communities, and Preparedness: Proceedings of a Workshop,* National Academies of Sciences, Engineering, and Medicine (2020), available at: https://nap.nationalacademies.org/read/25622.

90 National Oceanic and Atmospheric Organization, "Smoke from wildfires influences ozone pollution on a global scale," available at: https://research.noaa.gov/2022/01/10/smoke-from-fires-influences-ozone-pollution-on-a-global-scale/.

91 U.S. EPA, "Climate Change Impacts on Health," (webpage), available at: https://www.epa.gov/climateimpacts/climate-change-impacts-health.

92 Lee Ann Hill et al., *The Public Health Dimensions of California Wildfire and Wildfire Prevention, Mitigation and Suppression*, PSE Healthy Energy (July 2020), available at: https://www.psehealthyenergy.org/wp-content/uploads/2020/07/PSEHealthyEnergy_Wildfire_07302020-1.pdf.

93 Id.

94 Joan Casey interview.

95 Lee Ann Hill et al., *The Public Health Dimensions of California Wildfire and Wildfire Prevention, Mitigation and Suppression*, PSE Healthy Energy (July 2020), available at: https://www.psehealthyenergy.org/wp-content/uploads/2020/07/PSEHealthyEnergy_Wildfire_07302020-1.pdf.

96 Elissa Epel and Elena Fromer, "Coping with Wildfires and Climate Change Crises," UCSF Weill Institute for Neurosciences and Department of Psychiatry and Behavioral Sciences, available at: https://psychiatry.ucsf.edu/copingresources/wildfires.

97 Id.

98 Joan Casey interview.

99 David Eisenman and Lindsay Galway, "The mental health and well-being effects of wildfire smoke: A scoping review," BMC Public Health (December 5, 2022), available at: https://link.springer.com/article/10.1186/s12889-022-14662-z.

100 Id.

101 Id.

102 David Molitor et al., "Air pollution and suicide in rural areas and urban America: Evidence from wildfire smoke," *Proceedings of the National Academy of Sciences* (2023), available at: https://www.pnas.org/doi/full/10.1073/pnas.2221621120.

103 Id.

104 *Public Health Impact of Prescribed Fire: Report on Listening Sessions with Community Members, El Dorado and Nevada Counties, California*, California Department of Public Health (November 8, 2021), available at: https://www.cdph.ca.gov/Programs/CCDPHP/DEODC/EHIB/EES/CDPH%20Document%20Library/PrescribedFire_ListeningSessionsFullReport_ADA.pdf.

105 Joan Casey interview.

106 Annie Rosenthal et al., "Health and social impacts of California wildfires and the deficiencies in current recovery resources: An exploratory qualitative study of systems-level issues," PLOS One (March 26, 2021), available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7997008/.

107 Id.

108 Id.

109 David Eisenman and Lindsay Galway, "The mental health and well-being effects of wildfire smoke: A scoping review," BMC Public Health (December 5, 2022), available at: https://link.springer.com/article/10.1186/s12889-022-14662-z.

110 "Wildfires: A Growing Public Health Crisis," American Journal of Nursing (December 2020), available at: https://journals.lww.com/ajnonline/fulltext/2020/12000/wildfires_a_growing_public_health_crisis.10.aspx.

111 Irva Hertz-Picciotto [Interview], "Wildfire Smoke and Your Health: When Wildfires Hit Close to Home," available at: https://www.niehs.nih.gov/sites/default/files/research/supported/translational/peph/podcasts/2020/mar5_wildfires/when_wildfires_hit_close_to_hometranscript_508.pdf.

112 Annie Rosenthal et al., "Health and social impacts of California wildfires and the deficiencies in current recovery resources: An exploratory qualitative study of systems-level issues," PLOS One (March 26, 2021), available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7997008/.

113 Id.

114 Moreira et al., "Wildfire management in Mediterranean-type regions: paradigm change needed," Environmental Research Letters (January 7, 2020), available at: https://iopscience.iop.org/article/10.1088/1748-9326/ab541e.

115 Craig Thomas interview.

116 Anjali Haikerwal et al., "Impact of smoke from prescribed burning: Is it a public health concern?" Journal of the Air and Waste Management Association (April 14, 2015), available at: https://www.tandfonline.com/doi/full/10.1080/10962247.2015.1032445.

117 Deniss Martinez interview.

118 Central Sierra Environmental Resource Center, "'Good Fire' could help control catastrophes," (July 30, 2021), available at: https://www.cserc.org/news/good-fire-could-help-control-catastrophes/.

119 Shivani Shukla et al., *Intentional Fire*, Climate and Wildfire Institute (2023), available at: https://mcusercontent.com/6cc26fde390849a7ab2bc14b4/files/dd90448e-77d7-d062-acd3-b31cd1c96cd7/cwi_convening_report_final.01.pdf.

120 *Roadmap to a Million Acres,* California Wildfire and Forest Resilience Task Force (2022), available at: https://wildfiretaskforce.org/wp-content/uploads/2022/04/roadmap-to-million-acres_2022.pdf.

121 *Comparative Assessment of the Impacts of Prescribed Fire Versus Wildfire (CAIF): A Case Study in the Western U.S.*, U.S. EPA (September 30, 2021), available at: https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=352824.

122 Don Schweizer et al., "Using National Ambient Air Quality Standards for fine particulate matter to assess regional wildland fire smoke and air quality management," Journal of Environmental Management (October 2017), available at: https://pubmed.ncbi.nlm.nih.gov/28692834/.

123 CARB interview.

124 Anjali Haikerwal et al., "Impact of smoke from prescribed burning" Journal of the Air and Waste Management Association (April 14, 2015), available at: https://www.tandfonline.com/doi/full/10.1080/10962247.2015.1032445.

125 Sadia Afrin and Fernando Garcia-Menendez, "Potential impacts of prescribed fire smoke on public health and socially vulnerable populations in a Southeastern U.S. state," Science of the Total Environment (November 2021), available at: https://pubmed.ncbi.nlm.nih.gov/34323750/.

126 Anjali Haikerwal et al., "Impact of smoke from prescribed burning" Journal of the Air and Waste Management Association (April 14, 2015), available at: https://www.tandfonline.com/doi/full/10.1080/10962247.2015.1032445.

127 Id.

128 Id.

129 California Air Resources Board, "Understanding the Air Quality Impacts of Wildfires and Prescribed Burns in Urban Environments of California," (webpage), available at: https://ww2.arb.ca.gov/resources/documents/understanding-air-quality-impacts-wildfires-and-prescribed-burns-urban.

130 Joan Casey interview.

131 Jeff Wen et al., "Evaluating the Health Impacts of Prescribed Fire Policy in California," Stanford Law and Policy Lab (2022), available at: https://law.stanford.edu/wp-content/uploads/2021/08/Smoke-AGUabstractfinal.pdf.

132 Amy Padula interview.

133 CARB interview; Sam Heft-Neal interview; Patrick Wright interview.

134 *Public Health Impact of Prescribed Fire: Report on Listening Sessions with Community Members, El Dorado and Nevada Counties, California*, California Department of Public Health (November 8, 2021), available at: https://www.cdph.ca.gov/Programs/CCDPHP/DEODC/EHIB/EES/CDPH%20Document%20Library/PrescribedFire_ListeningSessionsFullReport_ADA.pdf.

135 Id.

136 Id.

137 Craig Thomas interview.

138 CARB interview.

139 Sam Heft-Neal interview; Minghao Qiu interview.

140 Patrick Wright interview.

141 California Air Resources Board (CARB), "California Map for Local Air District Websites" (webpage), available at: https://ww2.arb.ca.gov/california-map-local-air-district-websites.

142 CARB, "Prescribed Burning" (webpage), available at: https://ww2.arb.ca.gov/our-work/programs/prescribed-burning/about.

143 CARB interview.

144 CARB, "AB 32 Climate Change Scoping Plan" (webpage), available at: https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan.

145 CARB interview.

146 Id.

147 Id.

148 Id.

149 Id.

150 California Wildfire and Forest Resilience Task Force (webpage), available at: https://wildfiretaskforce.org/.

151 Patrick Wright interview.

152 Patrick Wright interview.

153 *California's Wildfire and Forest Resilience Action Plan: A Comprehensive Strategy of the Governor's Forest Management Task Force*, Wildfire and Forest Resilience Task Force (2021), available at: https://wildfiretaskforce.org/wp-content/uploads/2022/04/californiawildfireandforestresilienceactionplan.pdf

154 *California's Strategic Plan for Expanding the Use of Beneficial Fire*, California Wildfire and Forest Resilience Task Force (2022), available at: https://wildfiretaskforce.org/wp-content/uploads/2022/05/californias-strategic-plan-for-expanding-the-use-of-beneficial-fire.pdf.

155 *Fire-Adapted Communities Roadmap* [*Administrative Draft*], California Wildfire and Forest Resilience Task Force (March 2024).

156 Patrick Wright interview.

157 *Fire-Adapted Communities Roadmap* [*Administrative Draft*], California Wildfire and Forest Resilience Task Force (March 2024).

158 CARB interview.

159 CARB interview.

160 Id.

161 Jennifer Montgomery et al., *The Human Health Benefits of Improving Forest Health in California*, California Council on Science and Technology (September, 2023), available at: https://ccst.us/new-wildfire-smoke-study-finds-that-improving-health-of-californias-forests-benefits-human-health/.

162 Senate Bill 945 (Alvarado-Gil, Chapter 2, Statutes of 2024), Wildfire Smoke and Health Outcomes Data Act, available at: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202320240SB945.

163 Senate Bill 926 (Dodd, Chapter 606, Statutes of 2022), available at: https://legiscan.com/CA/text/SB926/id/2609473.

164 Assembly Bill 642 (Friedman, Chapter 675, Statutes of 2021), available at: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB642.

165 Senate Bill 901 (Dodd, Chapter 626, Statutes of 2018), available at: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB901.

166 "The Good Neighbor Authority on Federal Lands," Congressional Research Service (January 11, 2023), available at: https://crsreports.congress.gov/product/pdf/IF/IF11658.

167 U.S. Department of Agriculture (USDA) Forest Service, "Good Neighbor Authority" (webpage), available at: https://www.fs.usda.gov/managing-land/farm-bill/gna.

168 *Agreement for Shared Stewardship of California's Forest and Rangelands*, State of California and USDA Forest Service, available at: https://www.gov.ca.gov/wp-content/uploads/2020/08/8.12.20-CA-Shared-Stewardship-MOU.pdf.

169 CARB interview.

170 Id.

171 Emily Orzechowski et al., *Taming Wildfires in the Context of Climate Change*, OECD Environment Policy Paper No. 40, available at: https://www.oecd-ilibrary.org/deliver/ef69cc94-en.pdf?itemId=/content/paper/ef69cc94-en&mimeType=pdf.

172 *Confronting the Wildfire Crisis: A Strategy for Protecting Communities and Improving Resilience in America's Forests*, U.S. Forest Service (January 2022), available at: https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/Confronting-the-Wildfire-Crisis.pdf.

173 Id.

174 Id.

175 U.S. EPA and U.S. Forest Service, AirNow Fire and Smoke Map (webpage), available at: https://fire.airnow.gov/.

176 *Confronting the Wildfire Crisis: A Strategy for Protecting Communities and Improving Resilience in America's Forests*, U.S. Forest Service (January 2022), available at: https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/Confronting-the-Wildfire-Crisis.pdf.

177 Susan Stone et al., *Wildfire Smoke: A Guide for Public Health Officials*, U.S. EPA (2019), available at: https://www.airnow.gov/publications/wildfire-smoke-guide/wildfire-smoke-a-guide-for-public-health-officials/.

178 U.S. EPA, "Treatment of Air Quality Monitoring Data Influenced by Exceptional Events" (webpage), available at: https://www.epa.gov/air-quality-analysis/treatment-air-quality-monitoring-data-influenced-exceptional-events.

179 Marshall Burke et al., "The contribution of wildfire to PM2.5 trends in the USA," Nature (September 20, 2023), available at: https://www.nature.com/articles/s41586-023-06522-6.

180 U.S. EPA, "Treatment of Air Quality Monitoring Data Influenced by Exceptional Events" (webpage), available at: https://www.epa.gov/air-quality-analysis/treatment-air-quality-monitoring-data-influenced-exceptional-events.

181 Craig Thomas interview.

182 "Implementing the Final Rule to Strengthen the National Ambient Air Quality Health Standard for Particulate Matter - Clean Air Act Permitting, Air Quality Designations, and State Planning Requirements," U.S. EPA (February 7, 2024), available at: https://www.epa.gov/system/files/documents/2024-02/pm-naaqs-implementation-fact-sheet.pdf.

183 *Exceptional Events Guidance: Prescribed Fire on Wildland that May Influence Ozone and Particulate Matter Concentrations*, U.S. EPA (2019), available at: https://www.epa.gov/air-quality-analysis/exceptional-events-guidance-prescribed-fire-wildland-may-influence-ozone-and.

184 U.S. EPA, "National Ambient Air Quality Standards (NAAQS) for PM" (webpage), available at: https://www.epa.gov/pm-pollution/national-ambient-air-quality-standards-naaqs-pm.

185 Craig Thomas interview.

186 Id.

187 USDA, "Wildland Mitigation and Management Commission" (webpage), available at: https://www.usda.gov/topics/disaster-resource-center/wildland-fire/commission.

188 *On Fire*, Wildland Fire Mitigation and Management Commission (2023), available at: https://www.usda.gov/sites/default/files/documents/wfmmc-final-report-09-2023.pdf.

189 "Biden-Harris Administration Agencies Sign Interagency Agreement to Address Wildfire Risk and Protect Communities from Smoke," The White House (November 9, 2023), available at: https://www.whitehouse.gov/briefing-room/statements-releases/2023/11/09/biden-harris-administration-agencies-sign-interagency-agreement-to-address-wildfire-risk-and-protect-communities-from-smoke/.

190 USDA Forests and Rangelands, "Wildland Fire Leadership Council" (webpage), available at: https://www.forestsandrangelands.gov/leadership/.

191 *National Cohesive Wildland Fire Management Strategy Addendum Update*, Wildland Fire Leadership Council (January 2023), available at: https://www.forestsandrangelands.gov/documents/strategy/natl-cohesive-wildland-fire-mgmt-strategy-addendum-update-2023.pdf.

192 Id.

193 Emily Orzechowski et al., *Taming Wildfires in the Context of Climate Change: The Case of the United States*, OECD Environment Policy Paper No. 40, available at: https://www.oecd-ilibrary.org/deliver/ef69cc94-en.pdf?itemId=/content/paper/ef69cc94-en&mimeType=pdf.

194 Id.

195 Id.

196 Id.

197 *Landscape Fire Governance Framework: Guiding Principles for Adjusting Strategies, Policies, and Management, to Global Change*, 8th International Wildland Fire Conference (2023), available at: https://www.wildfire2023.pt/conference/framework.

198 Id.

199 *Spreading like Wildfire: The Rising Threat of Extraordinary Landscape Fires*, UN Environment Programme and GRID Arendal (2022), available at: https://www.unep.org/resources/report/spreading-wildfire-rising-threat-extraordinary-landscape-fires.

200 Joanna Gill, "Portugal fights wildfires with new tactics as heatwaves raise risk," Thomson Reuters Foundation, available at: https://www.reuters.com/article/idUSL5N2X22BT/.

201 "United States and Portugal signed a Memorandum of Understanding on the prevention and mitigation of forest fires," U.S. Embassy & Consulate in Portugal (May 3, 2023), available at: https://pt.usembassy.gov/united-states-and-portugal-signed-a-memorandum-of-understanding-on-the-prevention-and-mitigation-of-forest-fires/.

202 European Forest Fire Information System (webpage), available at: https://effis.jrc.ec.europa.eu/.

203 *Vegetation Fires and Global Change*, Global Fire Monitoring Center (2013), available at: https://eecentre.org/resources/gfmc-vegetation-fires-and-global-change/.

204 Amy Padula interview.

205 Deniss Martinez interview.

206 Include this reference at end of sentence, for footnotes: Joshua Zivin et al., "Private Adoption of Public Good Technologies: The Case of PurpleAir," *National Bureau of Economic Research* (2024), available at: https://www.nber.org/papers/w32356?utm_campaign=ntwh&utm_medium=email&utm_source=ntwg20.

207 Lee Ann Hill et al., *The Public Health Dimensions of California Wildfire and Wildfire Prevention, Mitigation and Suppression*, PSE Healthy Energy (July 2020), available at: https://www.psehealthyenergy.org/wp-content/uploads/2020/07/PSEHealthyEnergy_Wildfire_07302020-1.pdf.

208 Id.

209 Senate Bill 945 (Alvarado-Gil, Chapter 2, Statutes of 2024), Wildfire Smoke and Health Outcomes Data Act, available at: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202320240SB945.

210 Id.

211 Craig Thomas interview.

212 *Fire-Adapted Communities Roadmap* [*Administrative Draft*], California Wildfire and Forest Resilience Task Force (March 2024).

213 Shivani Shukla et al., *Intentional Fire* (2023), available at: https://mcusercontent.com/6cc26fde390849a7ab2bc14b4/files/dd90448e-77d7-d062-acd3-b31cd1c96cd7/cwi_convening_report_final.01.pdf.

214 CARB interview.

215 CARB interview.

216 CARB interview; Craig Thomas interview.

217 CARB interview.

218 Patrick Wright interview.

219 *Implications of the California Wildfires for Health, Communities, and Preparedness: Proceedings of a Workshop,* National Academies of Sciences, Engineering, and Medicine (2020), available at: https://nap.nationalacademies.org/read/25622.

220 Joan Casey interview.

221 *On Fire*, Wildland Fire Mitigation and Management Commission (2023), available at: https://www.usda.gov/sites/default/files/documents/wfmmc-final-report-09-2023.pdf.

222 Amy Padula interview.

223 Marshall Burke et al., "Exposures and behavioural responses to wildfire smoke," Nature Human Behaviour (July 7, 2022), available at: https://www.nature.com/articles/s41562-022-01396-6.

224 *Fire-Adapted Communities Roadmap* [*Administrative Draft*], California Wildfire and Forest Resilience Task Force (March 2024).

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Center for Law, Energy, & the Environment

Center for Law, Energy & the Environment
University of California
Berkeley School of Law
1995 University Avenue, Suite 460
Berkeley, CA 94704

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