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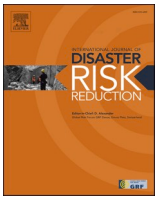

Flashpoints between wildfire recovery & mitigation in northern California

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ABSTRACT

In recent years, wildfires in the western United States have become more challenging to manage, with extreme wildfire behavior, larger fires, and longer fire seasons contributing to rising losses. Community and government leaders are realizing that suppression alone is untenable for future wildfire prevention and seek a wider range of risk reduction strategies from the community to the household levels. Simultaneously, these leaders are faced with the challenge of expeditiously rebuilding communities in the wildland-urban interface (WUI), sometimes after multiple fires that have occurred in quick succession. Although the post-fire recovery period offers opportunities to create safer, more fire-adapted communities, the dual goals of wildfire mitigation and recovery are often at odds. This study investigates changes in the post-fire policy environment across three California counties impacted by recent destructive and repetitive wildfires. Drawing on semi-structured interviews with government officials, wildfire professionals, and informal community leaders, we identify key tensions and synergies, or "flashpoints," participants encountered when addressing risk reduction and recovery simultaneously. These issues emerged across three policy priorities: housing reconstruction, vegetation management, and economic recovery. Despite a largely shared view of wildfire as a chronic hazard, participants identified ways that risk reduction conflicted with the pursuit of housing restoration and economic development. Synergies included alignment between ecological recovery goals and risk reduction and instances of compromise in housing restoration, plan integration, and new partnerships forged in recovery. Based upon our findings, we discuss opportunities for advancing recovery and mitigation together that could translate to post-wildfire learning elsewhere.

1. Introduction

Wildfires are causing rising social and ecological losses across the U.S. due to climate change, expanding human development, and long-term legacies of wildland vegetation and wildfire management [1–3]. In the past decade, average annual area burned reached

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seven million acres per year [4], more than 50,000 homes were lost to wildfire [5], and smoke from wildfires affected air quality across the country, reversing decades of progress after the Clean Air Act [6].

In response, federal strategies increasingly emphasize working with communities and households in wildfire prone areas to 'live with fire', that is, to maintain ecological benefits of wildfire while employing mitigation practices to reduce destructive and extreme wildfires [7,8]. This approach follows a decades-long recognition that long-term exclusion of wildfires on the landscape is neither realistic nor productive: the more wildfire is suppressed, the more vegetation accumulates, making subsequent fires more intense and destructive [2]. In contrast, living with fire involves a range of actions, from the home-to the landscape-level, including using fire-resistant materials in construction, creating defensible space around homes, designing communities to ensure emergency access and egress, enhancing emergency preparedness, and increasing landscape level vegetation management to reduce fuel loads and restore fire regimes [7,9,10]. Transformative change to meaningfully reduce future wildfire losses is challenging, however, given the range of actors and activities that contribute to and mitigate wildfire risks, as well as the current extent and condition of housing development and vegetation [8,9,11].

The time after wildfire events represents a key moment when communities could take stock of and reconsider approaches to living with wildfire, thus reducing the likelihood of loss from future events [12,13]. Such "focusing events" that draw public and policymaker attention may lead to enhanced investments to reduce future hazard risk and severity [12,14–17]. Additionally, households and governments may have access to outside resources during the post-disaster recovery period to invest in vulnerability reduction [18–21]. Resources include federal funding programs administered through the Federal Emergency Management Agency (FEMA) or the U.S. Department of Housing and Urban Development (HUD), state-level programs to assist local governments, utilities, and residents in rebuilding, or resources garnered directly by affected households and property owners, such as insurance payments, legal restitution, or funds drawn from personal savings. However, despite the promises of hazard adaptation and vulnerability reduction through recovery, past events show that people often rebuild places in much the same way as before a disaster [21,22,23].

Studying recovery processes, therefore, offers critical opportunities for learning how to enhance recovery while reducing future vulnerabilities [24,25]. We examine experiences across three counties in California (Butte, Lake, and Sonoma Counties) as they navigated recovery from wildfires from 2015 to 2021, with an emphasis on community-level risk reduction opportunities during recovery. Drawing on semi-structured interviews with government officials, wildfire professionals, and informal community leaders, we identify key tensions and synergies, or "flashpoints," between recovery and risk reduction, focusing on three policy priorities that emerged from our study: housing reconstruction, vegetation management, and economic recovery. Based on our findings, we discuss missed opportunities that could further inform wildfire recovery and risk reduction. This study adds to the limited but growing knowledge of recovery after wildfire [12,13,26,27].

2. Recovery as mitigation or maladaptation?

The post-disaster recovery period is a consequential moment when both the political will and the practical means may exist to rebuild communities that are better adapted and less vulnerable to wildfire and other natural hazards. Successful hazard adaptation entails rethinking aspects of the built and natural environments at a variety of scales [10,28,29]. For example, local governments could champion land use planning efforts that further enhance safety through changes in neighborhood design (i.e. altering open space, fuel breaks, road networks, or housing layouts to reduce risk or enhance egress). Investment in social support structures and community education campaigns could increase residents' knowledge of wildfire risk and further household level preparations [30,31,32]. Public and private utilities could underground power lines to reduce ignitions or improve municipal water supplies for more reliable suppression. Land managers could pursue vegetation management at the landscape level to enhance ecosystem health, reduce wildfire ignitions and fire intensity, and limit potential damage to communities and ecosystem services [27,33–35]. These activities might include the use of prescribed fire, mechanical thinning, livestock for grazing, or in some cases, allowing naturally occurring wildfires to burn on public lands [36]. Finally, at a household level, residents could rebuild with fire resistant materials, install drought resistant landscaping, increase defensible space around structures, and eliminate pathways for flame and ember entry into homes [13,37].

California's extensive state-level requirements already incorporate several of these fire-related risk reduction activities. After the 1991 Oakland Hills Tunnel Fire, the state designated 'Fire Hazard Severity Zones' (FHSZs), and within these zones, begin requiring fire-resistant building materials and defensible space [38]. Over time, these requirements have been strengthened, and local governments may choose to exceed state minimum requirements. These decisions are particularly meaningful for locations outside the rated FHSZs: for example, the city of Santa Rosa (Sonoma County) sustained substantial damages during the 2017 Tubbs Fire, but due to their FHSZ rating and incorporated city status, they do not fall under state standards for fire resistant materials or defensible space. California also has notable standards for roadways and a long history of land use planning that incorporates wildfire concerns (e.g., Safety Element of county-level General Plan, Hazard Mitigation Plans) [39].

Despite the many ways that mitigation measures instituted during the recovery period can reduce wildfire risks, studies from other hazards show it can be challenging for households and policymakers to move these efforts forward for community benefit. At a household level, survivors often mourn what was lost during the disaster and have a strong desire to replicate built forms and natural environments that existed pre-disaster [40–42]. At the same time, policymakers must decide where and how to facilitate reconstruction after disasters. While recovery is a long-term process, significant change is often hampered by pressures to rebuild what was lost at a compressed speed [43,44]. Rapid housing recovery risks recreating and, in some cases, exacerbating many of the same vulnerabilities that led to the disaster [45].

Absent meaningful, inclusive planning efforts before an event, communities often end up recreating existing vulnerabilities or, at the least, missing opportunities to institute meaningful change [44]. For instance, public participation in the planning process is key in

generating buy-in to mitigation plans (e.g., Refs. [46,47]). That participation, however, is often hampered by distrust of government, questions of legitimacy, displacement of survivors, a lack of capacity to participate, and the prioritization of short-term recovery needs, particularly for marginalized residents, at the expense of long-term meaningful risk reduction activities [48,49]. Balancing risk reduction and recovery becomes even more complex against the backdrop of cascading or recurring disasters, such as wildfires preceding mudslides or multiple wildfires in succession [50].

Although the literature on wildfire mitigation emphasizes post-fire recovery as an opportunity to "build back better," it assumes the objectives of recovery and mitigation to be fundamentally synergistic. Extant literature discusses specific challenges therein, for example, the tension between speed and deliberation in post-disaster recovery (cf. [43]), or that between place attachment and risk reduction actions (cf. [51]). However, the existing literature does not explore tensions and synergies between mitigation and recovery from a holistic, systemic perspective. Our paper performs this exploration, grounded in a local context of increasingly recurrent wildfire. We pay particular attention to interactions between housing, ecological, and economic interests, generating new insights that could guide policy formulation by anticipating tensions and seeking synergies.

3. Methods

To better understand how wildfire-affected communities have worked to address their risks, we conducted semi-structured interviews with government officials, wildfire professionals, and informal community leaders in three counties impacted by recent destructive and repetitive wildfires in California. Below, we describe our study communities, data collection, and analysis.

3.1. Study area

California's growing wildfire loss profile, ongoing struggles to provide adequate housing, and the depth of state-level efforts to reduce wildfire risk make the state a singular and worthwhile environment for study. Wildfire recovery is unfolding against a backdrop of worsening state and regional wildfire trends, with record-setting wildfire activity leading to thousands of lost buildings and millions of acres burned. An ongoing housing crisis across the state and climate change are poised to further intensify wildfire challenges in the future [52,53]. California is unique among states in the West; their long-established FHSZs [38] and integration of wildfire prevention and risk reduction into state building codes, land use planning guidance, and vegetation management regulations position California at the forefront of wildfire hazard governance.

Geographic proximity and similarities in fire ecology guided our focus to counties in northern California, while variation across key factors, such as affluence, population density, and housing characteristics, drove the selection of Butte, Lake, and Sonoma Counties (Fig. 1, Table 1). Notably, five of California's ten most destructive wildfires (by structure loss) and five of the state's seven largest wildfires (by acres burned) have occurred in these counties since 2015 [54]. These counties have also experienced smaller wildfires (e.g., the 2021 Cache Fire in Lake County that destroyed two mobile home parks), which did not result in major disaster declarations, thus limiting the availability of post-disaster assistance for residents and local governments. All three counties shared a common wildfire etiology, having recently experienced both wildfires ignited by lightning and fires attributed to human sources (e.g., arson, equipment failure). In all these places, wildfire poses a chronic, highly visible hazard for residents and fire professionals alike. Key differences between locations included population, levels of affluence, proportion of housing located in the wildland-urban interface (WUI), pace of WUI housing growth, and extent of previous wildfire damage (Table 1). Given that any of these contextual factors could influence decisions about and trade-offs between rebuilding and hazard mitigation after wildfire, our study counties were selected with the intent of broadening transferability of our findings.

3.2. Data collection

We conducted 29 semi-structured interviews with 37 participants,[2] including federal and state officials, local officials, and community leaders knowledgeable about ongoing wildfire recovery or risk reduction efforts (Fig. 2; all authors except Balachandran and Greer participated in interviews). We first interviewed university liaisons (UL) and a wildfire consultant (WC) who possessed a birds-eye view of state- and local-level policies, programs, and attitudes about wildfire risk. Next, we used purposive and snowball sampling to recruit state and federal government officials (SG and FG, respectively) to learn more about policy and practice priorities for wildfire recovery and mitigation. We then reached out to local stakeholders who could discuss wildfire recovery or mitigation actions in their county. Local stakeholders included city and county government officials (elected and administrative [LG]) and community leaders (CL) from nonprofit organizations, emergent groups, and citizen councils. With our sample, we captured a range of activities, including recovery operations, construction, land use planning, natural resource management, permitting, budgeting, grants management, code enforcement, and community organizing.

The interview guide included 12 major questions with probes organized into four sections. The semi-structured format enabled flexibility in question order and probe selection based on conversational flow. First, background questions ascertained organizational priorities in wildfire recovery or risk reduction and the participant's role within their organization. Local stakeholders were asked about recent wildfire history, impacts, and housing losses in their communities, while state and federal leaders identified key policies

[2] Some interviews included two or three participants from the same organization.

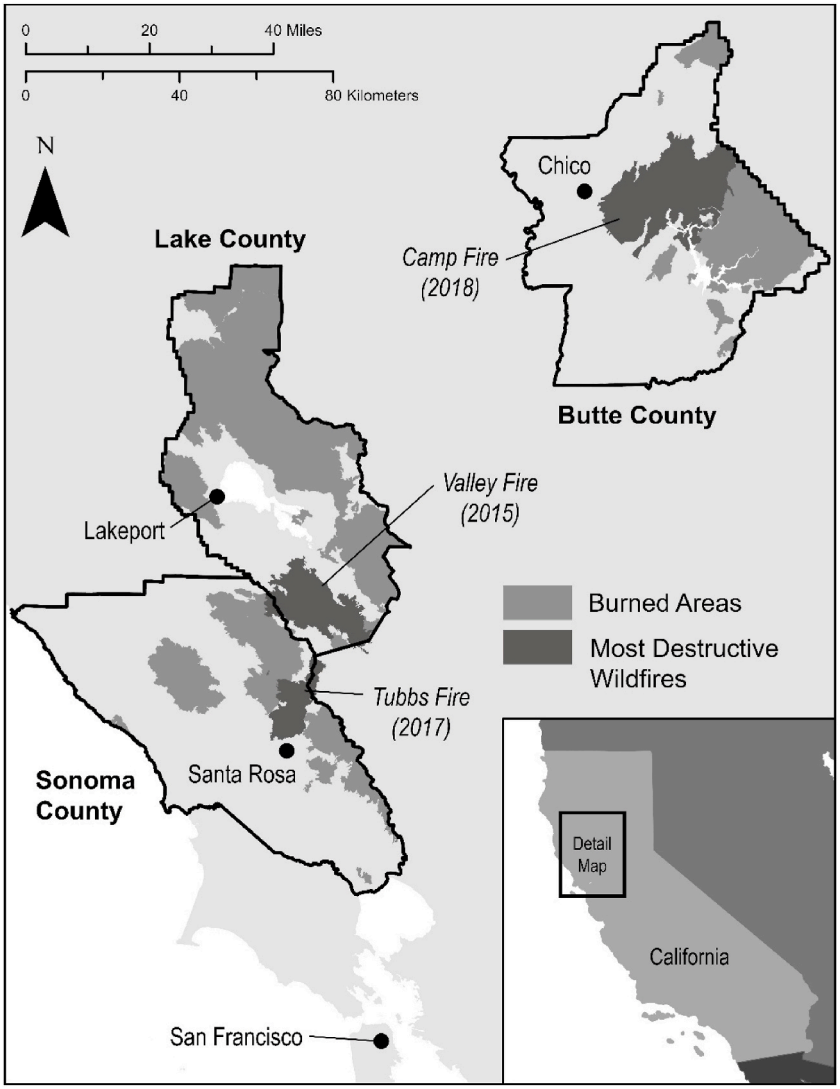

Fig. 1. Map of study area, including primary cities. Within each county, the most destructive wildfire (by building loss) is identified along with other areas burned by wildfire between 2015 and 2021.

Table 1
Contextual factors distinguishing the three study sites.

	Butte County	Lake County	Sonoma County
Population (2011–15)	222,564	64,158	495,078
Median household income (2011-15 inflation adjusted dollars)	$43,444	$35,578	$64,240
Renter-occupied (2011–15, % units)	41.4 %	37.0 %	40.6 %
Manufactured homes (2011–15, % units)	12.6 %	23.8 %	4.9 %
WUI housing (2010, % units)	66 %	96 %	77 %
WUI housing growth, 1990–2010	32 %	25 %	25 %
Cumulative building losses, 2015–2021	21,405 buildings	2,936 buildings	8,055 buildings
Manufactured homes (as % of residential buildings lost)	28 %	22 %	5 %

Note: 2011-15 data are the last available pre-fire dataset.
Sources: [54], [55–58].

governing wildfire mitigation and recovery. The second section on recovery asked participants about post-fire organizational priorities and collaboration in recovery activities. We included probes on housing recovery progress, integration of wildfire concerns in rebuilding, and plans for property acquisition. The third section on mitigation asked participants to broadly characterize the current

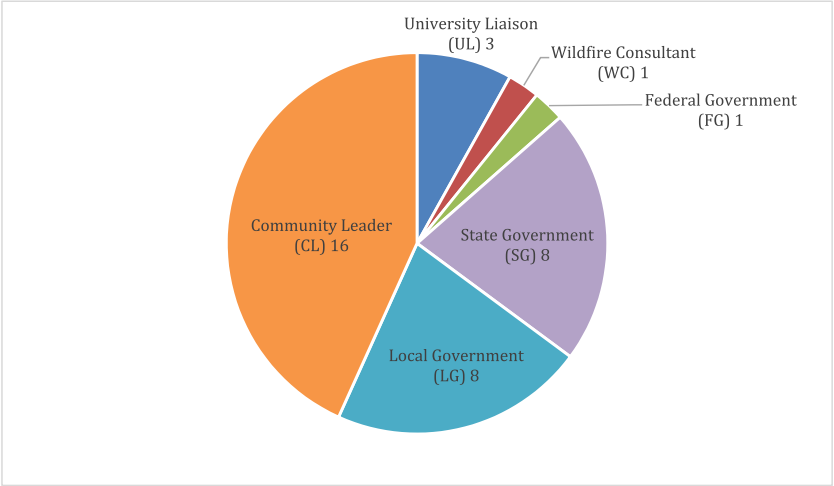

Fig. 2. Number of interview participants by type.

wildfire risk landscape and to describe the status of current efforts to reduce risk. We asked specifically about land use planning, household-level mitigation, and any policies/strategies proposed but not undertaken. Next, we asked directly about challenges in balancing recovery and mitigation. The final section asked about prospects for future wildfire risk. Here participants described their ongoing concerns, opined about future housing and land use in the region, and discussed how community- and household-level mitigation might be further encouraged. A catch-all question (i.e., what have we not asked about?) and a referral question concluded each interview. At both the state- and local-levels, we continued to conduct interviews until we reached thematic saturation.

At the time of data collection, COVID-19 precluded travel. Instead, we conducted interviews via Zoom between July 2020 and October 2021. Establishing entrée virtually, coupled with pandemic-induced scheduling challenges, led to the protracted data collection timeline. Interviews lasted approximately 1 h, were recorded, and transcribed, with personal information redacted before analysis. These procedures were approved by the University of North Texas Institutional Review Board (IRB-19-711). Between September 2022 and November 2023, as analysis was under way and data collection for a subsequent project focusing on homeowners was beginning, research team members visited the study communities. Field visits provided an opportunity to follow-up with participants, view the status of recovery and mitigation activities discussed in the interviews, and familiarize ourselves with each community firsthand, all of which furthered our understanding of the local context.

3.3. Data analysis

All interviews were transcribed verbatim, after which analysis began with an inductive, open coding process performed in two steps by three team members (Balachandran, Mockrin, Schumann). Team members first identified themes from interviews with non-local participants (i.e., state- and federal-level officials, university liaisons, wildfire consultant). We took turns organizing these theme codes hierarchically into umbrella codes until a consensus was reached. Three umbrella codes describing broad policy priorities were identified at this stage: housing reconstruction, vegetation management, and economic recovery. Next, the team repeated the open coding process with only local interviews (i.e., local government officials and informal community leaders) to identify contextual issues unique to each county.

We then performed selective coding [59] on the entire dataset to identify instances where recovery and mitigation activities overlapped or interacted (tensions or synergies). This process was performed by one research team member with results discussed and reviewed by all team members. Group discussion also identified several missed opportunities that transcended tension and synergy

Table 2
Summary of tensions and synergies pertaining to each area. Superscripts denote instances of thematic overlap with a) housing reconstruction, b) vegetation management, or c) economic recovery.

	Tensions	Synergies
a. Housing Reconstruction	Hazard & environmental compliance[c] standards	Fire resistant housing stock[c]
	Streamlined permitting[c]	Integrated planning & programming[c]
	Affordable construction[c]	Community organizing[c]
b. Vegetation Management	Excess dead timber[c]	Ecological recovery as wildfire mitigation
	Fragmented land ownership[a]	
	State environmental policy	
c. Economic Recovery	Incentivizing & managing growth[a]	Accessory dwelling units[a]
		Cannabis revenues[b]

codes, which are considered in the discussion. Throughout these steps, any discrepancies in coding were discussed among the research team until consensus was reached.

4. Results

Promoting recovery and risk reduction after wildfire set the stage for flashpoints, including both tensions and synergies, within three main policy areas: housing reconstruction, vegetation management, and economic recovery (Table 2). We discuss synergies and then tensions for each policy area below, noting instances where tensions and synergies overlapped or connected policy areas.

4.1. Housing reconstruction

Most of the tensions and synergies that emerged were focused on housing reconstruction, ranging from the individual household and parcel site to the community level (Table 2).

4.1.1. Tension: hazard & environmental compliance standards

One of the most direct means by which risk reduction efforts complicated and delayed recovery was through compliance with hazard mitigation or environmental quality-focused policies that had not been in place when homes were originally built but were now required. These standards proved not only difficult and time-consuming for households in our study communities, but they have effectively prevented rebuilding in other instances in California [60].

For instance, those rebuilding in one Lake County neighborhood encountered extensive environmental quality reviews to ensure that septic systems were not polluting a nearby creek. In some cases, residents either had to replace and relocate their septic systems or were forbidden from rebuilding entirely due to the updated riparian setbacks required for these systems. Additionally, residents wanting to rebuild in this neighborhood contended with updated flood zones, which added costly, time-consuming survey and permitting tasks to the housing reconstruction process. Whereas previous dwellings had been small vacation cabins built in the pre-WWII era, long before flood maps had been drawn, some rebuilt houses nearest to the creek are now elevated ten-plus feet above the ground on concrete pillars.

In Sonoma County, interviewees related how some residents had encountered challenges rebuilding due to seismic hazard zones that had been drawn after the construction of their homes. Beyond the financial outlay and time costs of mitigating the seismic hazard (reports and rebuilding could run to six figures), residents were concerned that lots might be deemed unbuildable. Residents' suggestions of non-structural mitigation approaches, like buyouts or the use of new materials for structural mitigation, were either not pursued or were time-intensive processes. For example, one community leader navigating these requirements with their own home indicated they would have preferred a buyout program, but none existed:

> "I wanted them [the county] to buy the property from me, that was the first place I went. […] I was surprised that they wouldn't buy the property from me. So, they would rather I build an unsafe house? So, it was pretty depressing … people will keep saying, oh no, no, the government will buy it and I'm like well nobody's buying it, I don't know who will buy it. So, we tried [to find a buyout program] and two other people [dealing with geohazards] I know have tried that as well, and nobody would ever buy it." – CL09

Ultimately the resident and community leader was able to rebuild, but the process took several years, and required the use of new materials, added inspections, increased costs, and navigating the use of novel materials with contractors and government officials.

Similarly, those rebuilding in more rural areas of Sonoma and Butte Counties found themselves responsible for the cost of upgrading driveways and/or private roads and infrastructure to meet modern standards for emergency access, which could be costly and time-consuming.

> "One of the last things was that the county required them [a household] to pay for […] a certain distance up that driveway to be paved in order to assist with whatever the issues are with the county road. And so, [that] didn't prevent them from rebuilding, but [it] was above and beyond all the things they were already complying with, all the new regulations that we have for building codes and everything else. Something like that could just be too much for somebody to be able to deal with." – CL11

4.1.2. Tension: streamlined permitting

While the examples above are ways in which risk reduction efforts or policies were seen as a barrier to rebuilding, we also found examples of the reverse: instances where regulations and processes had been altered to facilitate recovery, with some respondents questioning whether recovery speed was being traded for risk reduction. For example, to expedite housing recovery, local jurisdictions, including Santa Rosa, Paradise, and Sonoma County, streamlined permitting processes by outsourcing permitting to keep up with post-fire demand or by creating temporary "one-stop-shops" that enabled rebuilding residents to complete all necessary steps at a single location. These efforts were intended to support recovery among affected homeowners, though some questioned if the emphasis on helping homeowners who intended to rebuild a similar home missed opportunities to rethink building or development, and had led to rebuilding in areas destined to burn again:

> "And we allowed rebuilding in some places that I look at, and I'm like, there's just no way this should have been built, no way. There's nothing you could do to save a structure that's built here. That said, politically, how do you go there, in this is expensive

> fancy-pants real estate [market], how do you go to those bazillionaires and say oh, I'm sorry, your really valuable lot is now worthless and we're not gonna let you rebuild there. How do you do that, politically?" – LG07

Compounding these challenges, homes in some areas were not subject to fire-resistant rebuilding standards. Notably, homes rebuilt within the incorporated city of Santa Rosa did not have to meet the state-mandated codes that were required in unincorporated Sonoma County.

> "Building from scratch, new, it is not that uneconomical to [add fire resistant features]. And so, the city council and everybody swore that they were going to enact the Chapter 7A WUI codes, until all the families lined up at the public speaking podiums and cried about, 'Why are you making us do this? This is too onerous. It's too expensive. We can't do it. My contractor says it's going to cost a fortune' […] And they immediately came back down and erased all the requirements. – SG08

In other cases, exceptions or variances were made that enabled homeowners to rebuild with a lower level of mitigation than required by current state and local regulations. According to our interviewees, motivations for granting regulatory exemptions varied. Elected local officials wanted to rapidly recover the tax base and assuage resident outcry about exorbitant rebuilding costs. Simultaneously, residents pulled by memory and trauma wanted to recreate familiar environs. The general effect of streamlined permitting was the replacement of the same houses and neighborhood designs that existed pre-fire, albeit with required upgrades for materials and defensible space, depending on location. Changing land use or open space at the community level was challenging to consider and implement during this time frame.

> "City managers, basically, they had a real hard time grasping that they were going to have to rebuild their entire community. And they had an opportunity there. Also, in this challenge to rebuild it in a different way, and they … That was too far for them." – FG01

4.1.3. Tension: affordable construction

The goal of making housing reconstruction affordable, often inherent in tensions regarding compliance standards and streamlined permitting, emerged explicitly in other circumstances. Local interviewees stressed the right of homeowners to recover their home as their largest financial asset yet maintained that requiring even modest mitigation improvements (e.g., concrete foundation and noncombustible perimeter, water storage and hookups on larger properties) could make reconstruction cost-prohibitive for households with constrained financial resources. Rising insurance rates and expensive building materials, which increased the costs of residential rebuilding, provided justification for local leaders' responses that additional mitigation was too costly. Similar logic applied to limiting mitigation requirements for mobile/manufactured housing (MMH), which had been a prevalent pre-fire housing solution for low-income, working class, renting, elderly, and fixed-income households. Although many of these households lacked adequate insurance, supply chain interruptions and higher prices meant MMHs provided little in cost savings for residents compared to the costs of rebuilding a site-built home. Overall, a heavy emphasis on affordable construction in the present came at the expense of reducing future wildfire housing losses through comprehensive risk reduction measures.

> "Our board has not layered on regulations in addition to the state building code. So, that's not something that they've wanted to do. I mean, honestly … we're kind of pushing against additional measures. I think everybody wants the area to be fire safe, but the flip side, it's this balance, like, you can build housing that's not affordable and it's safer, or you can [just] build housing. So, there's a constant competition between those two pieces. The one thing that the board did do [is they] adopted a requirement that manufactured housing not be older than 10 years … [In] 2008 the state substantially changed the code requirements for manufactured housing and we essentially are now saying that … you can't put a new manufactured unit on your property that's greater than 10 years old, because we're looking for it to have those fire safe components to it." – LG04

> "[There's] the tradeoff between affordability and fire resilience and mitigation. You have to balance those two. Because as soon as you require a perimeter foundation on a manufactured home, you're talking about adding $10,000 to $15,000 to the cost just right off the top, you know, on a single-wide manufactured home. You now push that home [to be] that much less affordable for people who that was their only housing option. So, a tremendous amount of the community said, "You can't do this to us. It's going to make it too expensive," or "We're not going to come back." So, the town council has to balance that …" – CL15

For most homeowners, questions of affordability in rebuilding or in relocating were directly tied to insurance. Throughout the recovery, uncertainty and challenges around homeowners' insurance were common:

> "And right now, it is a major element in being able to buy a home, is whether you can, one, get insurance and two, whether you can afford it. […] And the insurance companies have got to become responsible and realize that this isn't a get rich quick job. Their job is to help people repair their homes in times of emergency and that this isn't a money-making business. We cannot buy a home with a loan without insurance. If the insurance is too high, we cannot buy a home." – CL01

4.1.4. Synergy: fire resistant housing stock

Despite the challenges in achieving risk reduction with residential rebuilding, some informants identified several synergies where the two efforts had combined. Interviewees noted that with rapid rebuilding the exposure of residential property to wildfire may have remained the same (or even increased, if larger houses were rebuilt), the sensitivity of the rebuilt properties to fire was often reduced because of required fire-resistant materials and defensible space. Even in Coffey Park where those rebuilding did not have to meet

FHSZ requirements, the city of Santa Rosa had increased requirements for new roofing materials to prevent windblown embers from igniting homes.

> "Are we going to make it safer and stronger? Absolutely, we have to. We have great laws, not new, but we have some pretty good laws that are targeted at building in most wildland-urban interface areas. Which, most of the homes that were destroyed were not built to those standards because they were built prior to the standards being enacted … We added some additional measures […] over and above the state code. […] [I]t's called the Class-A Roof, [which] has to be installed if you're doing re-roof[ing]. Nobody has to go and replace a roof and immediately put on a new roof, but if you're going to do a roof, you have to have this classification." – LG05

Termed a "soft touch" approach, some respondents advocated for it, while others questioned whether it went far enough to reduce the risk for residents, describing the improvements as incremental rather than transformative risk reduction:

> "So, the kind of the Faustian agreement we made was, we're going to have people, allow people to rebuild. And they're going to be taking older homes, which, on average, they're 1940s vintage, building them according to the much safer, current code and providing defensible space around all of those homes. That's not to say it's safer now. They're still narrow, one lane roads. It's not ideal, but it's better and it's what we can afford." – LG02

> "They allowed homes to be built, up to, 20% larger than the house they were replacing to compensate these poor families who lost everything. So now you have larger homes on the same size lot, with no fire requirements. So, they may not have the WUI vents on them. Most of them have their wood fences built right up to the house, again, with their wood bark mulch landscaping. I'm not making this up. You drive through Coffey Park, today, and that's the way it is. It absolutely enflames me. I just, I cannot figure out why we are allowing ourselves to just simply roll back and continue to do the same thing we've always done, thinking, it'll be different next time. Isn't that the definition of insanity? But that's what we're doing." – SG08

4.1.5. Synergy: integrated planning & programming

Integrating wildfire mitigation more thoroughly into existing plans and programs represented another synergy between mitigation and recovery. At the state level, one example was the creative combination of FEMA Public Assistance (PA) Program funds used for recovery of public infrastructure with funds available via the Hazard Mitigation Grant Program (Sections 406 and 404, respectively, of the Robert T. Stafford Disaster Relief and Emergency Assistance Act). Coalescing funding from these programs, available in presidentially declared disasters, allowed infrastructure to be upgraded for current population demands and future hazard conditions:

> "What if we build it back bigger, better, and stronger? So that we increase the size and the capability for that drainage to happen after a fire. So 406 is really, it's not just fixing it; it's making it bigger and better and stronger. […] So, you know, the opportunity may not have been there before, but now that we've had that fire and now that we're looking at it, let's look at the capability. Is it appropriate for the population in the location where it's at now?" – SG02

At the local level, we also saw instances of comprehensive and small-area land use plans incorporating wildfire mitigation, Community Wildfire Protection Plans (CWPPs) being revised/integrated into mainstream planning, and capital stacking of projects that served multiple goals (e.g., housing reconstruction, economic development, wildfire adaptation). For instance, the City of Santa Rosa and Sonoma County created a Renewable Enterprise District (RED), where a former mobile home park outside the WUI was redeveloped as a higher density, wildfire hardened, mixed-use development with climate adaptative features; to emphasize equity in recovery, former park residents were given priority to purchase rebuilt units. In Butte County, a similar community plan for the unincorporated Upper Ridge area also reconsidered what a fusion of housing replacement and fire safety goals could achieve. The community plan and resultant programming abated the wildfire risk posed by a former 40-acre golf course. The plan charged a newly formed community organization with the responsibility of maintaining the property and establishing a disc golf course as a neighborhood-scale wildfire buffer. The former golf course owners continued to own the land but agreed not to charge the community for its use so long as the organization mowed and maintained vegetation. Although this plan reduced the wildfire risk and created a public amenity, it was unclear how the presence of the amenity would influence future development.

> "… it's pretty much the trade off, we're taking care of it for them and for the community, too, because now it's a fire buffer for the homes that are– had survived and also new homes that are coming back. And since people know that we're actually taking care of the property, people are coming up and saying well, you know, I wouldn't mind having a home bordering the golf course again, even though it won't be a golf course anymore. It's going to be a park in the future, we hope" – CL05

4.1.6. Synergy: community organizing

Finally, respondents identified several instances of community organizing that emerged post-fire capable of furthering goals of recovery and risk reduction. For example, at the organization level, new collaborations created potential for affordable and safe housing:

> "There's a collaboration between Habitat for Humanity, Community Housing Improvement Program, which is a local affordable housing developer, and an organization that was formed post-Camp Fire, called Rebuild Paradise. Those nonprofits came together … to form [an] entity that could take properties and either commit them to open space or develop them, depending on where they're located." – LG04

At the household level, Sonoma County's 'block captain' program, first organized to disseminate information on recovery, later functioned as a conduit for public education/participation in mitigation and preparedness, and was harnessed for future wildfire response:

> "Another great thing that I would recommend: block captains. So, we had fire survivors as block captains. We had weekly meetings, you could ask about anything, you could share information. So, 2019 fire comes around, who do you want at the Local Assistance Center? Block captains from the 2017 fire. People who've been through what you've been through, telling you how to prepare for it. You know, you can do all the nice things you want with county government, but those people are just wonderful, and they show up in numbers." – LG02

4.2. Vegetation management

Several tensions emerged around vegetation management, on individual properties and across the landscape. At the same time, there was a broader overarching synergy seen between overall forest risk reduction and ecological recovery (Table 2).

4.2.1. Tension: excess dead timber

Dead timber posed a stumbling block for future risk reduction, ecological recovery, and often, rebuilding. Standing, dead trees blocked access to property, posed risks to existing infrastructure, and had to be removed from building sites prior to repair or construction. Given that the cost to remove one tree could range from several hundred to several thousand dollars, dead trees presented a sizable recovery hurdle for residential property owners. Once felled, the timber was cumbersome to haul away. The lack of financial incentives to remove biomass complicated efforts to manage vegetation regrowth and keep overall fuel loads low to prevent future wildfires. However, some interviewees suggested the potential for this tension to become a synergy, given the right economic conditions:

> "And it has just not really been feasible to get anything approaching the amount of money that is needed to rehabilitate people's lands. When I say rehabilitate, I mean just even removing standing dead trees that are right next to people's homes, in many cases. So, the wildland will be left on its own to recover. […] If the landowner is very lucky, they'll get some subsidy towards that because there's no– you can't really make any money removing trees anymore, which is ironic, given how we got into the situation. […] In Butte County, the land really isn't an economic player. We don't have a mill. The Fire Safe Council has this big initiative to try to get a biomass facility in the county because they realize, and rightly, that having an economic component to forest health management is the only way it's going to happen." – CL16

4.2.2. Tension: fragmented land ownership

Fragmented land ownership leading to fragmented decision-making proved a major stumbling block across all our study communities when it came to planning and executing effective landscape-scale vegetation treatments that reduced the risk of wildfire. The issue, however, manifested differently in towns than in rural areas. In towns, coordinating action to establish fuel breaks or open space buffers around developed areas was complex, due to the number of residential parcels near the edge of development, ownership status, and different recovery timelines:

> "… it's 14,000 individual decisions. And so, getting any sort of concurrence is very difficult. And the fire didn't burn– there's just standing houses all over the place. And so, any sort of conversation around we're going to take this segment and create a fuel break and buy up those properties is, well it's taking someone's home. So, it's a very difficult conversation to have." – LG04

> "There are […] a lot of properties here, where the people just abandoned their property. They just left. And, for whatever reason, are disinterested or traumatized […] They don't even want to think about trying to clear or clean up their property or take down their dead trees. And it may be affecting somebody next door to them, who does want to be here, who does want to rebuild. And so, there's tension between property owners in a lot of cases." – CL05

Also in a town setting, roadside fuel breaks and vegetation abatement on privately-owned lots were difficult to implement due to parcel fragmentation. For instance, at the time of our interviews, Butte County was working to update their weed abatement standards, to place more responsibility on landowners to contribute to county roadway clearing. Additionally, recognizing the challenges posed by unmanaged vegetation when structures were in proximity on small parcels, municipal vegetation standards emphasized enforcement and resources. However, due to the size and configuration of parcels and the proximity of neighboring structures, a single homeowner might be unable to create the required 100 ft of defensible space on their own property alone.

Tensions around coordinating vegetation extended to rural areas with sparse development, but in these cases, questions revolved around proper fuels management on large tracts of land and appropriate vegetation management strategies in the context of forest recovery. Adjacent landowners, whether they were public entities, private owners, or a mix of the two, often differed in their approaches to vegetation management:

> "Because we've got 160 acres, we're surrounded by BLM [Bureau of Land Management] land, which they have not been very active in doing anything about the fire danger that exists on that. We're also behind […] Calpine, the geysers […] that very large geothermal field here. And while they maintain really good practices of clearing and making sure that their […] power plants

and facilities are fire resistant, the vast majority of the land that they own, they just don't have the capacity to deal with." – CL04

Reasons for tension over vegetation management ranged from a lack of resources (e.g., equipment, staff, funding) to effectively maintain fuels to a lack of knowledge or responsibility. Particularly on private lands, the presence of seasonal or absentee landlords, rugged topography, or subdivided, undeveloped "paper" lots in rural areas further thwarted cohesive vegetation management efforts.

4.2.3. Tension: state environmental policy

The California Environmental Quality Act (CEQA) was mentioned repeatedly as a key barrier to pursuing vegetation mitigation and risk reduction across multiple ownership plots, even when working on funded projects that were state priorities and aimed at reducing wildfire risk. Passed shortly after the National Environmental Policy Act (NEPA) in 1970, CEQA similarly requires an environmental impact analysis and public disclosure for proposed state and local projects. Relative to NEPA, CEQA includes stronger private enforcement mechanisms, meaning private citizens and special interest groups can more easily sue to stop any potentially harmful project; CEQA further compels the state to address such grievances, thereby triggering additional reviews [61]. Beyond disrupting polluters, CEQA has recently been criticized for preventing actions that could promote climate resilience and alleviate housing shortages [62,63].

Regarding vegetation management, each project must undergo independent review, rendering small-acreage projects inefficient for community-based organizations with staff and time constraints. Additionally, were a grievance to be filed against a proposed fuel treatment, additional reviews could delay action for multiple years (and fire seasons). Respondents suggested that an attempt to streamline via Cal Vegetation Treatment Program Environmental Impact Report (VTP EIR), created with the intention of reducing redundancies in CEQA, thus far had not helped.

> "We're not against CEQA, we want to be able to make sure that the environment is being protected. But what we find is that the system to get through the paperwork process, depending on which avenue you go, can take perhaps up to two years. […] When that's all said and done, a long time has passed, and people are fatigued. They are wondering if they are going to still come help us. […] So, we need something more like a countywide mitigated negative declaration that says, look, if it's an evacuation route or someone's got defensible space, it's exempt from CEQA with these mitigations." – CL11

> "And then I think the real kicker that creates a lot of barriers is the legal implications and CEQA … My example for this is: in the PG&E [Pacific Gas and Electric] settlement money that the county of Sonoma received, they allocated $4 million for vegetation management on private property. Super sexy! Do it right away. [But] there was no infrastructure in place to disperse that money right away, let alone any sort of context or information or reference around the legal implications of what it would require to be the lead agency held responsible for CEQA, and what can be done during that timeframe." – CL14

4.2.4. Synergy: ecological recovery as wildfire mitigation

Despite the challenges to carrying out ecological restoration and risk reduction, respondents noted that in many ways ecological recovery and wildfire mitigation were synonymous goals in forested settings, and that wildfires had brought about urgency and new partnerships to vegetation management. Improving forest health through prescribed fire is an emerging area of collaboration between multiple stakeholders including federal and Tribal governments:

> "We currently are, we just signed a really innovative agreement with the Forest Service. You know, a lot of the land in Lake County is public lands under management of either Forest Service or BLM. And we just signed that agreement that is the first, it'll sort of set us up to start engaging in fuels reduction and fire recovery work in the Forest Service on the ancestral land of our main partner tribe. So, we're really excited about that opportunity to kind of bring in the ecological recovery work with also bringing in traditional knowledge into some of the land management and looking at the land from that more cultural perspective." – CL12

4.3. Economic recovery

Community-level economic recovery and development was also a key policy priority for interviewees, highlighting tensions between desired economic growth/recovery and risk reduction, as well as a potential synergy with economic development that could fund mitigation programs (Table 2).

4.3.1. Tension: incentivizing & managing growth

Beyond the challenges of affordably reconstructing dwellings and businesses destroyed by wildfire, interviewees saw new residential development as a means for addressing California's housing demands and developing local economies. However, accommodating growth with risk reduction, across different levels of government, was challenging.

State policymakers set different targets or goals for local areas (about climate adaptation, fair housing goals, housing supply), but they do not regulate land use. At the building-level as well, the state mandates standards for materials and defensible space in rated FHSZs, requires plan elements, and plays a role in road safety; however, the local government is charged with enforcement. In this way, local governments face complex political pressures around recovery and development as they negotiate multiple, sometimes conflicting goals for housing growth, affordable housing, enhanced environmental quality, and reduced wildfire risk. The regional housing

needs allocations (RHNAs), which prescribe the location and number of homes to be built across a multi-jurisdictional planning region, and which must be accounted for in a General Plan's housing element, were seen as particularly challenging:

> "We're about to update our housing element, and our [local] Association of Governments does the reallocation within our county for all the local jurisdictions. It's a real challenge for the unincorporated community because we obviously think development should happen in the incorporated communities where there's infrastructure support services, all of that type of thing. And there's just always a tension. We can't, it's so hard to meet the RHNA numbers. And then, particularly now, as the cost of building supplies, shortage of labor, all of that is going up." – LG04

> "I see a lot of dial-turning in policy to try to accommodate those allocations and it does oftentimes result in conflict and, I think, with a lot of pressures around land use planning, we're watching communities struggle with, not just trying to mitigate the growing threat of wildfire, they're also having to respond to mandates to meet their affordable housing requirements and their fair housing requirements. We have, in California, [progressive] fair housing requirements, a little bit more stringent than the federal program." – SG03

Given the state-level emphasis on risk reduction and increasing development in urban areas or places that are already developed, leaders in rural counties questioned how they could continue to grow housing and local economies. One proposed development in Lake County was desired by the local government for economic development, but fire concerns were preventing the project from moving forward:

> "It's an old cattle ranch […] and it has burned several times […] So, the developers have done an amazing job looking at how to make this area– it will change Lake County. It really will. With the jobs, the property values, the people coming in. This is a once in a lifetime opportunity for our county. And the designers and the developers have met with the community many times [and] worked on this for many years. They have many strategies in there for mitigation, grazing, roof sprinklers, fire breaks, a state-of-the-art fire station, heli[copter] pad, it has a lake, it will have a hydrant system, it's amazing. But it's wrapped up in litigation. And the California Attorney General has joined the litigation, because they don't want development in a fire prone area. If this development doesn't go through, no development will, and we will forever be in this place that we're at, stuck economically, socially, we will miss this opportunity. So, these are the discussions that are happening at the state level that we have no local control of it, if they take this project from us." – LG06

Differences in contractor capacity, economies of scale, and median housing values across our study counties led to concerns about rebuilding in rural, less affluent communities. Without the population and infrastructure (e.g., sewer) to support large, planned subdivisions, rebuilding there was slower and less efficient. Multiple fires in quick succession further constrained contractor availability, particularly in less affluent places.

> "[Lake County is] not an area where there's been a lot of development in the last several decades. So, most of the housing stock was built in the [19]70's and [19]80's […] the houses were built one at a time by contractors building spec homes. We don't have developments. […] And then in 2017, just two years later [after the Valley Fire], we have all the Napa and Sonoma Fires. And so, anybody that was coming into Lake County to help with rebuilding just left because you can get twice as much in a more affluent area. And so, our recovery has absolutely come at the cost of their recovery." – LG06

> "In Santa Rosa and the Coffey Park neighborhood, and it's amazing how many of the houses there have been built back. […] Anecdotally, from me driving around through there, it's 95% plus, right? And 85%, I'd bet, were rebuilt within a year or so [of the Tubbs Fire]. And this is just my opinion, […] it's because it's right off the 101 [freeway], it's not that far from the Bay Area, and you have economy of scale and the densely populated neighborhood, which really helped to contribute to contractors being able to come in and rebuild quickly and efficiently, and, by California standards, […] cost-effectively." – SG05

4.3.2. Synergy: accessory dwelling units

Against this challenging economic backdrop, there were two policy initiatives in which economic recovery and risk reduction were potentially combining synergistically: increased use of accessory dwelling units (ADUs) and cannabis revenues in Sonoma and Lake Counties, respectively. Respondents noted that starting in 2017, there had been a push at the state level to streamline building accessory dwelling units (ADUs), with ADUs seen as a relatively affordable way to increase housing. In some instances, when people were rebuilding after wildfire, they were able to add an ADU, taking advantage of the new regulations that had been promulgated throughout the state. While Santa Rosa had lost 25 ADUs in the fire, for example, more than 100 were being built after the fire, as of 2024 [64]. However, our respondents noted that while it was easier for ADUs to be added in urban settings where sewer systems and denser development already existed (and where dwellings would hopefully face less wildfire risk), these same places found themselves dealing with concerns about crowding and density.

> "The neighborhoods [in Santa Rosa] are not happy with increased density, from what used to be this cool little historic area with lots of space. Every lot could have an ADU on it if they wanted. So, you have a block of 30 homes, add 30 more cars that need to be parked. It creates a problem … I hear the results of relaxing rules … [That said] ADUs, in my opinion, I think they're a great thing. [ADUs help people] afford their own home and [provide another house] at an affordable rate. And that's needed throughout the country, but we certainly see it here. The mortgage and rent rates here are just unbelievable." – LG05

Conversely, in more rural places, such as the town of Paradise, adding an ADU was more complex because it was treated as a second

household requiring additional septic capacity.

> "It's not cut and dry … The town [of Paradise] said that ADUs are allowed, and as long as you have the septic capacity [and meet minimum square foot sizes] you can do it. You just have to do more planning and more thought, it's not just like we can fit it, let's do it." – CL15

4.3.3. Synergy: cannabis revenues

Among our study communities, Lake County was the smallest in population, with long-standing concerns about economic development and physical isolation. The county had seen a rapid increase in new revenue from cannabis cultivation, providing vital funding for county services and disaster risk reduction efforts. However, planning for spending the funds had, thus far, been stymied by turnover and limited capacity in county government. Community leaders were skeptical whether the economic benefits could be retained locally, given that most capital investments in cannabis originated in the Bay Area and growers were not from Lake County.

> "In the last year, we got over $8 million in Cannabis revenue. The year before that we got $150,000. So, you can see what's happening. It's a big opportunity. It's a new industry. We're committed to investing that money in disaster preparedness, prevention, law enforcement, water resources, environmental protection, education … We don't have the money problem right now. We have a capacity problem." – LG06

5. Discussion

Across the globe, the goal of building back better is central to disaster recovery, with the aim of using post-recovery funding and opportunities to reduce future vulnerabilities [20,21]. This study investigated the ways in which such risk reduction actions were being integrated into recovery in three northern California counties impacted by repeated wildfires from 2015 to 2021. Through our interviews, we found that government and community leaders alike were concerned about wildfire risk and recognized the need for action in three related policy areas—housing reconstruction, vegetation management, and economic recovery—to simultaneously accomplish the goals of recovery and risk reduction.

We identified several key synergies across these policy priorities that reduced or had the potential to reduce vulnerability through recovery. For instance, house-level improvements in building materials, small area plans incorporating defensible space or hardened construction, and partnerships among individuals (e.g., block captains) and organizations (e.g., BLM and Tribal entities) fostered the restoration of social, ecological, or built landscapes in safer, more fire-adapted ways. On the other hand, many of these synergies were limited in scope and, often, in funding.

Tensions between recovery and risk reduction stemmed from multiple factors, but underscored the broader structural challenges in this setting, including the scale of wildfire impacts to both WUI housing and adjacent ecosystems, California's pervasive affordable housing shortage, the cost and availability of insurance, and regional competition for economic development. Many of these tensions also became more pronounced at larger spatial scales or over longer time frames. For example, at an individual parcel level, removing dead trees and complying with risk reduction measures in recovery could be costly and time consuming for homeowners. By comparison, at a community level, reconsidering the form and sensitivity of development and open space–including roads and access that influence safety, vegetation mitigation, collaboration across ownerships—was far more challenging after wildfire.

After wildfire, the primary focus for many was on facilitating housing and economic recovery, recognizing that prolonged housing instability negatively affects residents' health, quality of life, and economic well-being, with further implications for community recovery [45,65,66]. Like the post-disaster period after other hazard events [67–69], intangible factors like place attachment and disaster-induced trauma influenced both household decisions and community level conversations about wildfire recovery and mitigation [70]. Observed post-wildfire adaptations tended to be small-scale, patchwork, and incremental rather than transformational. For example, as insurers like State Farm, the largest home insurer in the state, no longer offer new insurance policies to individual homes or businesses in California due to the cost of rebuilding and the wildfire risk, it will become tougher to adequately insure homes across the state [71,72]. Meanwhile, the California FAIR plan, instituted in 1968 to ensure property owners have access to insurance, is increasingly at risk of insolvency in the face of a major fire, with a nearly three-fold increase in their policyholders from 2018 to 2024 due to insurers pulling out of the market [73,74]. Ultimately, rebuilding dynamics over time will likely lead to more infrastructure in hazard prone areas, as real estate interests capitalize on demand for housing and lower property/land costs and as homeowners rebuild with current insurance payouts while the government considers strategies to reduce risk [25].

5.1. Missed opportunities

Building upon the tensions and synergies identified, we highlight several missed opportunities to support comprehensive socio-ecological wildfire mitigation through recovery. These missed opportunities stem from both interviewee responses and observations made by research team members who have studied recovery after a variety of hazard events.

5.1.1. Incentivizing fire-adapted building standards beyond FHSZs

Wildfire losses in California extend beyond state responsibility FHSZs into urban areas that may not require the same wildfire standards [75]. After wildfire in 2017, the City of Santa Rosa improved standards for roofs, but did not pursue broader standards required in FHSZs in Sonoma County. Although rebuilt homes used higher quality materials than original post WWII-era construction,

the lack of upgraded requirements was considered a missed opportunity by many, given that this area has burned repeatedly, housing is densely developed (i.e., there is potential for house-to-house fire spread), and voluntary homeowner mitigation via materials may be uneven [76], even after wildfire losses [12,77]. We note as well, that for others, this improvement was an opportunity for synergy: that is, perspectives on such incremental enhancements are by no means uniform across participants. More broadly, non-burned houses are not required to make building upgrades, and there is an immense need for retrofitting older homes [76]. The potential for forthcoming insurance premium reductions for wildfire-safe homes may create new incentives to fund and encourage mitigation beyond what is required within FHSZs [78,79].

5.1.2. Upscaling ecological recovery efforts

Although the goals of ecological recovery and wildfire mitigation aligned in many forested areas in northern California, a combination of geographic, legal, and social barriers made upscaling vegetation management efforts challenging. The tasks of removing excess dead timber and restoring vegetation were not integrated with housing recovery mechanisms, so one could rebuild a home, but still face substantial challenges engaging with the vegetation on their property. Coordination of these activities by a single entity (as we observed only in Sonoma County's Permit and Resource Management Department), may be one opportunity for accomplishing such tasks.

Conducting vegetation work beyond individual parcels, and over public and private ownerships, is widely recognized as a central challenge but vital need in wildfire risk reduction nationwide [80,81]. These challenges remained in our study sites post-fire, despite the increased community interest in fuel treatments. It was also challenging to work across properties when the geography of rural wildfire risk meant one's road neighbors were not necessarily one's wildfire neighbors (e.g., adjacent properties across a canyon), and the uneven post-fire rebuilding meant that some properties were not being actively managed. Rebuilt housing could be interspersed or 'checkerboarded' with unmanaged lots. This post-disaster phenomenon is common across hazard types (cf. [82,83]), but with wildfire, these unmanaged lots augment neighboring hazard risk (in contrast to flood recovery). Against this challenging backdrop, newly formed partnerships, discussion of new timber markets (e.g., biomass facilities), and broad stakeholder agreement on the importance of this work suggest future opportunities to work collectively. Given the challenges with complex terrain, watersheds may form another scale for organizing vegetation management efforts (rather than jurisdictional units or road networks).

5.1.3. Integrating general planning with radical mitigation planning

Although the time after wildfire may appear opportune for mitigation planning given the array of post-disaster funding sources and the supposed 'blank slate' for reconstruction, in reality, such planning is difficult [43,45]. Pressure from residents and politicians favoring rapid rebuilding, coupled with strong demand for housing, limits planning opportunities, and in turn, the scope and scale of improvements [84]. The synergies observed in the handful of successful neighborhood plans (Upper Ridge, RED) underscore the potential for opportunity, but interviewees suggested that radical mitigation planning in blue-sky times, and in concert with general planning, would be important to further potential changes to development patterns on a larger scale. While the efficacy of buyouts to reduce wildfire risk is still debated [85], exploring these efforts could consider all-hazards opportunities to reduce future risk (fire and co-occurring hazards like flooding, landslides, or seismic hazards). Alternatively, transfer-of-development rights or similar growth management approaches may present opportunities to reduce wildfire exposure in the highest risk areas and compensate people who do not want to rebuild [86].

5.1.4. Formalizing collaboration and knowledge exchange between local governments

Despite the proximity of these three counties, shared challenges of navigating repetitive wildfire losses, and acknowledgement of the role of regional economic dynamics in recovery, our research uncovered no examples of a regional plan or public body to support knowledge exchange between sites. Currently, only a handful of nonprofit organizations appear to be engaged in efforts that support such co-learning from wildfire recovery. Some short-duration collaborations emerged between neighboring local governments who shared aims or depended on a common resource; however, the dissipation of such relationships and knowledge gained in the process represented a key missed opportunity. Given the uneven local government resources across locations, our interviews suggest that formalizing and sustaining collaboration and exchanges might have been particularly helpful in lower-capacity and more rural locations.

5.1.5. Involving local leaders in state-level policy formulation

Despite shared state and local responsibility for managing fires and a unifying desire to support wildfire mitigation, actors at both levels acknowledged that coordination was challenging. State-level policy formulation, such as RHNA targets, were seen as something local actors had to respond to, not a goal locals were able to shape. Furthermore, local interviewees noted difficulties in satisfying multiple state-level directives with divergent aims. Local governments are also the agencies that navigate and guide rebuilding, in compliance with state guidelines. Although California is unique in having such widespread and comprehensive guidelines, such requirements were seen as more of a ceiling than a floor (e.g., rebuilding occurring in remote areas with hazardous vegetation and limited emergency ingress/egress was couched as a risk reduction success because the home materials were improved).

5.2. Limitations & future research

This study is not without limitations. Foremost among them, we garnered limited participation from federal agency officials ($n = 1$) despite multiple follow-up attempts, and our reliance on purposive and snowball sampling may have limited inclusion of key

perspectives (e.g., indigenous stakeholders, public and private utilities, impacted homeowners not in leadership positions). At the request of interviewees, we conducted several interviews with multiple participants, which created the potential for reactivity, especially when a superior and their subordinate(s) were interviewed together. Moreover, agency/organization representatives not wishing to conflict with overall agency views and goals may have been less than candid with their responses in the presence of co-workers or superiors.

Future research could further consider the role of household-level decision making in risk reduction during recovery, including the roles of place attachment, insurance coverage, and availability of state and federal recovery resources. This study represents one discrete time period, but longer-term, these locations and the state of California have continued their mitigation planning, risk reduction work, and policy development. Thus, following unfolding patterns of wildfire exposure, losses, and development into the future could provide valuable new information on long-term risk reduction. Additionally, comparative research on interactions between long-term recovery and mitigation activities across multiple hazard types holds potential for illuminating broad-based policy opportunities.

6. Conclusion

Throughout the post-wildfire period, members of recovering communities negotiated how best to promote values of safety and fire-adaptedness through home reconstruction, vegetation management, and economic recovery, while balancing expediency and cost minimization. Such negotiations resulted in efforts that reduced overall wildfire vulnerability of the housing stock and led to a variety of novel land use planning efforts and partnerships but did not significantly transform building and open space patterns. Fragmented decision making at multiple levels–among neighboring property owners, among economically interconnected local jurisdictions, and between local stakeholders and state-level policymakers—thwarted progress toward sound compound risk governance. Despite broad agreement that wildfire risk is a pressing, chronic, socio-ecological challenge, mechanisms to support stakeholder knowledge exchange, upscale mitigation activities, and supercharge collective action remain limited. Broadly, there are questions about whether response resources can continue to keep pace as wildfires grow in extent and severity, fueled in part by a developing WUI (where more people and houses may increase ignitions). There are also questions about whether forests can endure the growing and repetitive wildfire threat in a non-stationary climate. Given that many communities will likely face increased exposure and sensitivity to future wildfires, findings from our study communities may prove transferable. Despite substantial tension observed between aspects of wildfire recovery and mitigation, stoking those flashpoints that synergize these goals may provide viable pathways for proactive community adaptation.

CRediT authorship contribution statement

Ronald L. Schumann: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Miranda H. Mockrin:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Balakrishnan Balachandran:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis. **Sherri Brokopp Binder:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Conceptualization. **Alex Greer:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

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Data availability

Data will be made available on request.

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