

## After the fire: Perceptions of land use planning to reduce wildfire risk in eight communities across the United States

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### ABSTRACT

Wildfire losses are increasing across the United States, and yet land use planning to reduce wildfire risk is not federally mandated and is rarely used by local jurisdictions. We examined local government staff and leaders' perceptions of land use planning and regulations to reduce wildfire risk, in a range of communities, after wildfire risk had been made evident with the loss of homes due to wildfire. Although policy after fire was largely unchanged we found local leaders had devoted substantial attention to the subject of land use planning. Communities were dealing with a number of internal concerns, including staff perceptions of wildfire risk, staff opinions of planning and regulations, policy coordination challenges, other governmental priorities, and a lack of public support for land use planning and regulations to reduce wildfire risk. Many of these considerations were present across study sites, and thus not easily linked to characteristics of the study site (rural/urban, type of housing lost to wildfire, presence of amenity growth). The scale and scope of local government, the diversity of residents and development, and the social fit between policies and local settings all combine to determine the efficacy and use of land use planning and regulations to reduce wildfire risk. Wildfire is unique among hazards in that the threat continues to evolve along with development, requiring local communities to adapt strategies over time. Successful examples of using land use planning and regulations, in a range of settings, will be increasingly valuable in disseminating the concept of fire adapted communities.

### 1. Introduction

Wildfires are increasingly common in the United States, the result of climate change, altered wildfire regimes, and expanding residential development in close proximity to wildland vegetation [1–3]. Both suppression expenditures and damages are increasing as a result [4]. Accelerating wildfire losses have been observed in other countries as well: Australia, Canada, Chile, Greece, and Portugal have all experienced record destruction due to wildfires in the past decade [5].

Reducing wildfire losses is a daunting goal requiring a multi-part strategy across all levels of government. In the U.S., federal fire policy seeks to: create resilient landscapes and vegetation; use effective and efficient suppression; and promote fire-adapted communities where human populations and infrastructure can withstand wildfire, reducing loss of life and property [6]. Formal management of the built environment, especially through land use planning and residential regulation, is

key to creating resilient landscapes and fire-adapted communities [7–10]. Homesite-level mitigation not only reduces risk for individual homeowners, but also reduces risk of wildfire spread across the landscape [11]. In addition, as development continues there are more homes at risk on the landscape, and fires also become more frequent (fires are primarily caused by people or infrastructure) [1]. In the United States, this land use planning and management of the built environment is controlled by local governments (counties or cities) that have the authority to regulate land use (e.g., egress and water supply requirements, configuration and extent of housing, commercial uses) [8,12,13] and housing characteristics (e.g., requiring fire-resistant building materials, vegetation management and maintenance, defensible space around individual homes) [14,15].

However, unlike national efforts to reduce exposure to flooding, there is no federal mandate for local land use planning to reduce wildfire risk. Instead, local governments and communities have relied on other

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tools, such as creating fuel treatments on public land, enhancing wildfire suppression, increasing emergency response, and creating education campaigns and voluntary programs for mitigation, including Firewise communities [16–20]. These tools are all voluntary, informal, and/or broadly accepted by the public [8,21–23]. Even after a destructive wildfire reveals the inadequacies of existing efforts, local governments are still unlikely to enact land use policies to shape the characteristics and extent of housing [17,23,24]. The reasons behind this reluctance to adopt land use and residential regulation are not clear. Some research has blamed antipathy and distrust of land use planning and regulation, especially in rural and exurban areas [25,26]. When communities are growing rapidly (e.g., amenity-fueled growth in small towns), land use planning may become contentious [25,27]. Nor is it clear that all communities have the capacity and resources to pursue novel, specialized land use planning and regulations such as those specific to wildfire [28].

Among other natural hazards, such as flooding, earthquakes, hurricanes, there is more experience using land use planning to reduce exposure and hazard losses, but for these hazards as well communities often prefer to invest in emergency response capacity or education efforts rather than pursue land use planning [29,30]. Much of the experience with land use planning to reduce hazard exposure comes from urban areas [30,31] where there may be more resources for planning, and more citizen support for land use planning in general [32,33]. For both wildfire, and the broader hazards literature as well, it remains unclear when and how land use policy and residential regulations are used to reduce hazard risk, particularly in nonmetro areas. Given the decentralized nature of wildfire risk reduction programs, the diversity of municipalities facing wildfire risks, and the growing prevalence and intensity of wildfires and losses, this is a critical gap in knowledge.

As a first step toward understanding land use planning and residential regulation to reduce fire risk, we used qualitative interview data to examine government officials' and local leaders' perceptions of these tools in the five years after destructive wildfire. From previous literature on wildfire and other hazards we anticipated that concerns would relate to local capacity, residents' political support for land use planning, and multi-scalar and cross-jurisdictional influences. Working from these interview data and the emergent themes revealed by analysis, we had two main objectives. We first examined our themes by study site characteristics, noting how perceptions of land use planning related to key site characteristics, such as urban typology (nonmetro, small metro, large metro) [34], type of housing lost in wildfire (housing developed in subdivisions or on dispersed lots), the site's history of housing growth, and previous investment in wildfire-related land use planning and regulation. We then developed a conceptual framework of the considerations local governments face when using land use planning and residential regulations to reduce wildfire risk. If we are to meet U.S. Federal policy goals of making landscapes resilient to fire and helping communities adapt to fire, we must understand how and why planners and local leaders choose some tools and not others. Such insights across sites can help inform wildfire risk reduction policy and practice at local, state, and Federal levels.

## 2. Background literature

### 2.1. Land use planning to reduce hazards

Local land use planning to reduce hazards has been more studied in the broader field of natural hazards (floods, earthquakes, hurricanes, etc). Local governments have an essential role to play in reducing hazard risk and achieving other environmental/sustainability goals, because they hold authority over land use, residential regulation, building codes, and emergency response. However, taking action on hazards requires public officials to consider temporal and spatial scales beyond the annual budget cycle and municipal boundaries [35,36]. The uncertain timing and impacts from disasters, together with the expectation of federal aid for recovery, disincentivizes local hazard mitigation planning

[35].

Because disincentives are plentiful, researchers have explored the conditions under which local governments have taken such action. Past hazard exposure, citizen risk perception, nonmetro/metro setting, and resident characteristics (socioeconomic status, including rates of homeownership) have been examined as factors that may influence adoption of land use and other policy actions to address natural hazards; but findings are inconsistent [30,33,37]. Smaller and more rural places are less likely to use land use policies to reduce hazard exposure, in part due to a lack of planning capacity and resources, but this finding is not universal, and it is not clear how widely these findings may apply across the wide range of sizes, populations, and resources that characterize nonmetro settings in the U.S [32,36,38].

Beyond local municipalities, state and federal governments play a critical role in encouraging or mandating hazard planning and response, as well as coordinating policies and outcomes between different jurisdictions [33]. For example, the Federal Emergency Management Agency (FEMA) requires jurisdictions to adopt all-hazard mitigation plans (HMPs) to qualify for mitigation grants [29]. While mandates are thought to increase planning quality and efficacy [31], doubts remain, including concern that top down mandates yield plans that meet only minimum standards, are produced without substantial community input, or even result in unintended consequences such as thwarting policy innovation or fomenting resistance to land use planning [39]. Understanding the interaction between local-level factors and higher-level governmental mandates and planning, policy adoption, and hazard reduction outcomes remains an active area of research, especially for rural areas [36,39].

While local planners are key policy entrepreneurs who drive adoption and implementation of planning and regulations, relatively little is known about their perceptions of and experiences with land use policies to reduce hazard exposure [30,40]. A survey in the western US found that county planners were consistent in how they perceived the efficacy and implementation ease of policies, making tradeoffs between the two (e.g., education campaigns were more easily implemented but less effective than development regulations), but there were no consistent relationships between perceptions and planners' personal characteristics, jurisdiction characteristics, and past hazard experience [30]. A qualitative assessment of flood mitigation efforts in rural Vermont found that local action reflected the state- and federally-mandated policies (flexibility, implementation effort) as well as characteristics of each town (adaptive capacity, community support, perceived risk, and mitigation efficacy) [37].

### 2.2. Land use planning and regulation to reduce wildfire risk

Wildfire research has developed in isolation from natural hazards scholarship, in part because, until recently, wildfire suppression had been relatively successful and damages had been small in comparison to other hazards [41,42]. The practice and study of land use planning to reduce wildfire risk is accordingly still emerging. Unlike flooding or seismic hazards, there are rarely higher-level mandates for land use planning for wildfire. Federal aid and efforts to encourage wildfire mitigation are largely decentralized [43]. The federal government does encourage localities to reduce wildfire risk through land use planning, most directly through Community Wildfire Protection Plans (CWPPs).

CWPPs were created under the Healthy Forest Restoration Act of 2003 to encourage and support communities to assess and reduce wildfire risk, and to improve local capacity to prepare for and respond to wildfires [22]. Completing a CWPP qualifies the local government for state and federal mitigation funding under the National Fire Plan. Land use planners, emergency managers, fire departments, and public land managers work together to develop CWPPs, with land managers often taking a lead role consistent with their expertise in and historic responsibility for managing wildfire. Although CWPPs address the measures that homeowners and communities can take to reduce the risk of

structure loss, it is common to see more emphasis given to forest conditions and wildland fuel treatments, and less attention to changing resident behavior, mitigation around homes, or land use planning [22]. In addition to CWPPs, localities can also consider wildfire hazards in HMPs or within broader land use planning documents, such as comprehensive plans.

While CWPPs and HMPs assess the overall setting and preferred conditions, land use and residential regulations (zoning, codes, ordinances) are also used to reduce hazard exposure, in concert with community- and individual-level action (education, capacity-building, voluntary mitigation programs, etc.). At the individual home level, building codes and other regulations can dictate that homes be built with fire-resistant materials and that landscaping and vegetation around the home be maintained to reduce wildfire risk by creating and maintaining defensible space [14,44]. From the neighborhood to jurisdiction level, regulations can reduce wildfire risk by dictating the spatial arrangement of homes and parcels, limiting land uses in relation to wildfire hazard, ensuring egress and water access, and regulating when residents can ignite fires on their property (i.e., burn bans) [44,45]. Policies may be proposed or implemented not only by land use planners, but also by fire marshals, fire chiefs, building departments, or forestry agencies.

However, despite long recognition of the potential for wildfire-related regulation to reduce losses [7,46], they are rarely used to limit development or require mitigation around the home (defensible space or use of fire-resistant building materials) [8,23,47]. Where they do exist, wildfire-related regulations often focus on public safety concerns (e.g. signage, roads, water access, restricting burning during times of high fire danger) [8,47,48]. State-level mandates have seen mixed success. California has the most comprehensive requirements: since the mid-1990s

local jurisdictions must consider risk in land use planning, and enact standards for home materials and defensible space in fire hazard rated zones, although even here development in high fire hazard areas is rarely prohibited [49]. By contrast, in Oregon, all land that is zoned as Forest Resource by the state is subject to fuel thinning, but standards are not consistently implemented and enforced [21,50].

Relatively little research has examined how land use planning efforts are perceived, nor how they advance (or fail) at the local level. It seems reasonable that wildfire events might lead to regulations and land use planning efforts and, indeed, one study found that regulations for home-level mitigation were typically implemented after direct experience with wildfire [51]. However, other studies have found weak and inconsistent relationships between wildfire exposure and land use regulations [8,23,24]. Paveglio et al. [26,52] suggest that residents in resource-dependent rural areas are less likely to accept regulation as a strategy to reduce wildfire risk than are residents who live in formally organized subdivisions or who have migrated to an area in pursuit of natural amenities. A study of residents in Oakland, CA and Ruidoso, NM found residents were more willing to accept regulations when wildfire risk was high, policies were considered equitable, and government resources also devoted to education [53]. To our knowledge, research has not yet examined the perspectives of planners and local leaders nor considered community context outside the Western U.S., despite concerns about wildfire risk in communities across the country. By considering site characteristics, including metro status, housing type, and history of housing growth and land use regulation, across eight study sites, we expand upon previous knowledge and build a fuller understanding of local perspectives on land use planning to reduce wildfire vulnerability.

**Table 1**

Wildfire and study area characteristics, including key wildfire-related regulations and planning, both before and after study fires (all post-fire changes are indicated with a “+”).

Study area	Jurisdiction	Fire year	Economy base <sup>a</sup>	Urban typology <sup>b</sup>	Housing stock affected by fires	Amenity migration	Wildfire-related regulations and planning				
							Overall:	Building code	Home mitigation regulations	CWPP <sup>c</sup>	HMP <sup>d</sup>
Caughlin NV	Washoe County, City of Reno	2011	Services	Small metro	Subdivisions	Yes	Mod	Yes	Yes <sup>e</sup>	HMP <sup>f</sup> + Revising	
Hwy 31/WG SC	Horry County, North Myrtle Beach	2009	Services	Small metro	Subdivisions	Yes	Mod	Yes	+IWUI county only +Overlay city	HMP + Revising	
Loco-Healdton OK	Stephens and Carter Counties	2009	Mining	Nonmetro	Dispersed lots		Low			HMP (one county)	
Monastery WA	Klickitat County	2011	Manufacturing	Nonmetro	Dispersed lots	Yes	Mod	Yes			
Monument AZ	Cochise County	2011	Federal/State Government	Nonmetro <sup>g</sup>	Dispersed lots	Yes	Mod	Yes+	+Post	HMP + Revising	
Possum Kingdom TX	Palo Pinto County	2011	Nonspecialized	Nonmetro	Subdivisions	Yes	Low				
Station CA	Los Angeles County	2009	Services	Large metro	Dispersed lots <sup>h</sup>		High	Yes	Yes	HMP + Revising	
Wallow AZ	Apache County	2011	Federal/State Government	Nonmetro	Dispersed lots	Yes	High	Yes		HMP + Revising	
									Yes	+Revising	

<sup>a</sup> Economic Research Service, 2004 County Typology Codes. <http://www.ers.usda.gov/data-products/county-typology-codes.aspx>.

<sup>b</sup> Economic Research Service, 2003 Urban Typology Codes. <http://www.ers.usda.gov/data-products/urban-influence-codes.aspx>.

<sup>c</sup> Caughlin Ranch NV and Monastery WA had older assessment documents or CWPPs, but not current ones. LA has county-wide fire plan similar to a CWPP.

<sup>d</sup> For more information on emergency operations plans or comprehensive plans, please see Ref. [23].

<sup>e</sup> Present in both city and county in limited areas.

<sup>f</sup> Comprehensive Plan that mentions wildland fire.

<sup>g</sup> Since reclassified to small metro.

<sup>h</sup> Homes lost were concentrated within an inholding on the National Forest, divided between those that were developed independently on private land, and leased “recreation cabins” from the Forest Service.

### 3. Study areas

We examined perceptions of land use planning and regulations to reduce wildfire risk in eight study sites in the U.S. (five in the West, two in the Great Plains, and one in the Southeast), each where a previous fire had destroyed homes. This study emerged from a larger assessment of post-wildfire community-level policy changes, which considered land use planning alongside other efforts (e.g., fuel treatments, education campaigns, enhanced emergency response) [23]. Study sites encompassed a variety of socioeconomic, environmental, and governance characteristics, including large metro, small metro, and nonmetro sites, with variable histories of housing growth and amenity migration (Table 1). Although development patterns varied within study sites, we classified the housing lost in wildfires as either developed in subdivisions or developed independently on dispersed lots (typically larger, rural lots resulting in lower-density housing). We used document review and interviews to characterize community investment in wildfire-related regulations and planning as low, medium, or high, considering a broad range of regulations (zoning, road standards, water supply, subdivision regulations, building code, vegetation mitigation ordinances, burn bans) (for more detail on document review, please see Ref. [23]). Most sites had hazard mitigation plans, and were updating them after focal fires. Beyond these plan updates, we saw relatively modest change in fire-related regulations and planning after the focal fires (we provide more detail for each site below) (Table 1). Throughout the paper we refer to each study site by combining the wildfire name and state where it occurred (Table 1).

All fires we studied destroyed 20 or more homes, except for the Monastery WA site, where housing loss was overestimated in initial fire reporting documents. However, we retained this site because interviews made it clear that this was a significant wildfire event for local leaders and residents. We selected the 2009 Highway 31 fire in Horry County/North Myrtle Beach, South Carolina but respondents also discussed the 2013 Windsor Green fire that destroyed over 100 homes in six condo buildings in Horry County, so we included both fire incidents and jurisdictions in our study (Hwy 31/WG SC). Below, we briefly describe each study site, organized by the extent of wildfire-related land use planning before focal fires (low, moderate, and high).

Two study sites, both in the Great Plains (Possum Kingdom TX and Loco-Healdton OK), had low investment in land use planning to address wildfire risks. Both sites were nonmetro areas, lacked building codes, had few hazard planning documents, and did not have CWPPs. After the focal fires, neither site reported changes in wildfire-based regulations or planning after the focal fires (Table 1). The two sites differed in the character of housing lost and development history. Possum Kingdom TX is a vacation destination with mostly second homes, many developed in subdivisions tightly grouped around Possum Kingdom Lake, far from the county seat. The Loco-Healdton OK complex of fires burned across a broad rural area of Oklahoma dominated by ranching and resource extraction, with modest, primary homes.

Four sites made moderate use of wildfire-related regulation and planning before focal events. All had building codes, and one community revised its codes after the wildfire (Table 1). Two sites (Monument AZ and Monastery WA) were in nonmetro counties, where housing affected by fires was dispersed across rural properties. There had been only modest amenity- or retirement-fueled housing development in these areas. The other two sites (Caughlin NV and Hwy 31/WG SC) were small metros that had grown substantially in recent decades, with an influx of retirees and those desiring natural amenities. Most housing lost in these two fires was in subdivisions governed by homeowners associations (HOAs), and in both sites, fire spanned a city and surrounding county. Among all four of these locations only one, Caughlin NV, had mitigation regulations (building materials, defensible space) for a portion of the affected area before the fire. After the fire, these were enhanced in the county, but not the city of Reno, as part of a state-wide effort to implement international WUI codes. One study site created a

CWPP after the fire, but CWPPs were otherwise absent in these sites (Table 1).

Our final two study sites had the most extensive wildfire-related regulations and planning prior to focal wildfires. The Wallow AZ site was in a nonmetro county with dispersed, rural housing and a mix of primary and secondary homes, with seasonal residents coming mostly from the Phoenix urban area. There were no requirements for mitigation (materials, vegetation) for homes, but the community did develop a CWPP before the fire, and was revising it afterward (Table 1). The Station CA site in Los Angeles County had a long history of land use regulation and planning and extensive requirements for building materials and defensible space, as required by the state of California. Although a large metro county, the housing destroyed in this fire was a concentration of primary homes on small lots, tightly clustered along a road in a small inholding in a National Forest. Houses affected were both privately-owned and Forest Service leased "recreation cabins," which were in fact inhabited full-time.

### 4. Methods

To develop a sampling plan and interview protocols, we reviewed secondary sources, such as media sources and government documents, then gathered primary data through interviews with local government officials and community leaders. We used a standardized protocol with all interviewees, consisting of a set of open-ended, semi-structured questions focusing on wildfire history, damages, resident risk perception, and community-level actions taken after wildfire experience. We used interviews to confirm document review (described above), determine any post-fire changes made to plans and regulations, and solicit respondents' perspectives on land use planning. Qualitative research on land use planning is valuable because it supplies a deep understanding of the full cycle of policy implementation, beyond what can be garnered from document review, including why certain measures are—or not—pursued, how policies are implemented, and perceived outcomes in risk reduction [19,37,48,54,55].

We identified informants through wildfire reports, web searches, and newspaper articles about wildfires. Informants also suggested others we should interview. In total, we interviewed 80 people, including county and city government staff (planners, emergency managers), municipal and rural area fire chiefs, state and federal land managers (foresters, natural resource managers, fire managers), university extension agents, real estate agents, and community leaders who were actively involved with wildfire recovery and mitigation (e.g., head of a civic association). We conducted interviews with individuals or in pairs, and in a limited number of cases, small groups (maximum of four) (e.g., multiple members of a planning department). Interviews were one to one and a half hours long. We conducted all interviews between December 2014 and November 2015 (on average 5 years after fires), with 6–12 informants per site. Interviews were conducted in person if possible, with several interviews held over the phone due to scheduling constraints.

After professional transcription, we analyzed interview data to investigate how local leaders and planners perceived land use planning and residential regulations, identifying broad themes about the challenges and benefits of using regulations and planning to reduce wildfire risk. We used open coding to organize concepts into initial categories, followed by focused coding to organize material into themes (Corbin and Strauss 2015), working in QSR Nvivo 11 software [56]. All authors collaborated on code development, and Mockrin then conducted the coding for the analysis to examine emergent themes. Quotes used below are attributed only to the location, to avoid identifying individuals, and have been edited for clarity. The themes we found reflect the broad array of choices and the autonomy of U.S. communities. While this is not intended to be an exhaustive list of concerns or challenges related to wildfire risk reduction through planning and regulations, the key themes discussed below emerged in interviews across multiple sites and suggest common factors considered by local governments and leaders regarding

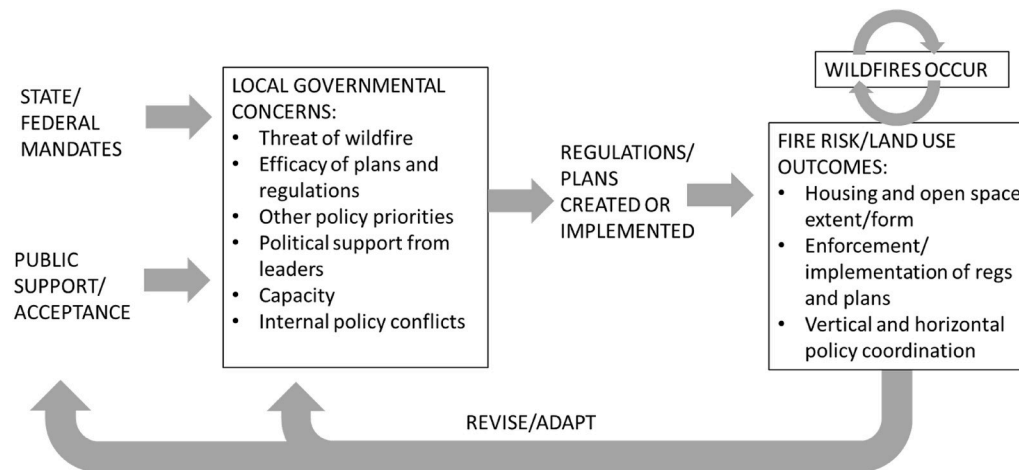


Fig. 1. Conceptual model of local government implementation of land use planning to reduce wildfire risk over time.

land use planning and regulation to reduce wildfire risk.

## 5. Results

We grouped the concerns of planners and local leaders about creating and implementing plans and regulations to reduce wildfire risk into six key themes. The first three were specific to efficacy, practicality, and ease of land use planning and regulations, while the next three were more far-ranging concerns about public acceptance of regulations, policy coordination, and adaptability of regulations and planning. These themes were not mutually exclusive, and were often interrelated. In addition, we highlight instances where respondents identified benefits of using regulations and planning to reduce wildfire risk. We discuss the characteristics of study sites where themes emerged, examining patterns in theme presence by metro status, housing type, and history of housing growth and land use regulation. Finally, we combined themes into a conceptual framework of local and external factors considered by local governments, over time, in reducing wildfire risk through land use policy (Fig. 1).

### 5.1. Land use planning and regulations not necessary and/or effective

In several study sites, local government staff themselves stated that they believed formal approaches to reduce wildfire risk through planning and regulations were unnecessary and/or ineffective. This theme emerged most frequently in nonmetro locations where there had been low or moderate past investment in wildfire-related land use regulations, and housing was developed independently on dispersed lots. In sites with these concerns, there were also concerns about public acceptance of regulations or land use planning or land use planning (discussed in 5.4 below).

Local officials' concerns about these efforts were diverse. In some cases, regulations were seen as unnecessary, because residents would take these actions independently or at the behest of insurance companies:

*"Insurance companies require folks that live in those areas to have metal roofs and to thin their properties and to do that stuff. So we haven't really duplicated what they're doing."*—Wallow AZ

*"Commissioners don't like to have new regulations that force people to, in some cases, use common sense."*—Monastery WA

Concerns with planning reflected a perceived lack of interest from the general public but also skepticism from professional staff themselves:

*"If the community doesn't understand what this [CWPP] does it's a piece of paper that's on a shelf."*—Loco-Healdton OK

*"I've scanned [the CWPP] one time and it was a lot of mumbo-jumbo stuff that we already know we're going to be doing."*—Cochise County, AZ

Finally, despite the recent wildfire history, officials in one site did not see fire as an on-going threat that should be addressed by regulation:

*"We don't turn a blind eye to it but we don't see a fire as a continued threat .... we feel like we have pretty good, adequate coverage throughout the city to continue building under the international codes with minor amendments to them."*—Caughlin NV<sup>2</sup>

In each instance, local government staff or leaders saw no need for land use planning or regulations to reduce wildfire risk, either because the threat of wildfire did not warrant it, or because such regulations would duplicate common sense or efforts already in motion (e.g., CWPPs as "things we're already going to do").

### 5.2. Limited resources and capacity

Multiple respondents were concerned they did not have the resources and capacity necessary to pursue planning and regulation to reduce wildfire risks. This theme was common in nonmetro sites, typically where there was low-to-moderate investment in land use regulations or planning related to wildfire, and housing was developed independently on dispersed lots. Resources and capacity were seen as a limitation to creating, implementing, and enforcing plans and regulations. For example, if fire departments were volunteer-led or there was no fire department coverage, the community had limited ability to do outreach about or enforce mitigation requirements. Beyond fire departments, government resources in general could be limited:

*"The communities that we deal with, and we're talking about small communities, the mayor might be your receptionist .... It's hard to find the fire-adapted community when you have one person or a staff of three."*—Loco-Healdton OK

Some of these sites had more urgent concerns about housing quality, so that wildfire mitigation was not a priority:

*"There are a lot of small, rural communities in Oklahoma that have adopted building codes, but the authority to enforce may not be there ... in*

<sup>2</sup> This respondent was from the city of Reno, officials in the surrounding Washoe County were more concerned about wildfire risk.

rural Oklahoma ... it's the good old boy, the contractor, let's get it built, let's do the best we can. We don't have the money. "—Loco-Healdton OK

"If somebody was going to try to install a pre-code double-wide or two single-wides [trailers] and bolt them together, they probably wouldn't even apply for a building code ... There's a lot of that, and the county is pretty much powerless to do anything about it. "—Monastery WA

These concerns were particularly acute in the Monastery WA site where local government was particularly concerned about residents living in improvised housing (trailers, outbuildings, vehicles), substandard homes, and lacking access to utilities (heat, running water).

Concerns about financial resources were not limited to these sites, but were relative to the size and scope of the wildfire management challenge. For example, the Hwy 31/WG SC site had fewer concerns about housing quality, but the enforcement burden was still seen as prohibitive, particularly because subdivisions had been developed adjacent to protected open space:

"We have so much land here. How are you going to go property to property and say you're not maintaining your 100-foot buffer? I mean, that would be everybody in Horry County. "—Hwy 31/WG SC

### 5.3. Concerns about real estate and economic development

In a number of sites respondents raised concerns about economic impacts of wildfire-related regulations, specifically how such efforts might negatively impact real estate development. These study sites all had a recent history of housing growth driven by people seeking natural amenities and/or retirement homes, but were diverse (nonmetro and small metro, homes developed in subdivisions and on dispersed, rural lots). Real estate development interests were powerful in local politics:

"Planning and Zoning is really kind of where some of this stuff needs to start. But, you have to have the political support to make those changes and when you're in a community where development drives the bus it's difficult." —Hwy 31/WG SC

Concerns about economic impacts were often specific to particular regulations: adding sprinklers, increasing road connections between subdivisions, and setting land aside for buffers were all mentioned as ideas that would reduce wildfire risk, but increase costs/reduce profits for developers. One respondent thought fire-resistant materials were unattractive, and that their use would thus decrease housing values. In other instances, the respondents reported a broader concern that any type of regulations would decrease profitability of real estate development or displace development to locations with fewer or no regulations:

"If I bring in the 2003 codes and we grandfathered some stuff, what does that do? You don't want to discourage growth, you don't want to discourage people building. "—Possum Kingdom TX

Across a range of settings, local governmental staff who worked in building and planning roles emphasized their role in facilitating building and real estate development:

"Every piece of property is buildable in my opinion, and where there's a will there's a way. "—Monastery WA

"Part of the County's stance is that if it's private property, people do have a right to develop ... We can't completely deny someone the ability to do some kind of building, which generally means a single-family home. "—LA County

Even where amenity growth was not a factor, government staff spoke about the importance of facilitating development, to serve residents and support the local economy. Across sites, therefore, local government officials consistently emphasized the importance of facilitating residential development, although for different reasons (serving individual

residents, growing the tax base, enhancing the local economy).

### 5.4. Public objection to land use planning and regulations

Public objection to land use planning and/or regulations to manage wildfire risk on private property was the most common concern across study sites. These considerations were particularly common in nonmetro sites with limited wildfire-related regulation and planning, where the housing affected by wildfires had been developed on dispersed lots. Here, even basic residential regulation (e.g., a building code) could exceed the tolerance for regulation, and any land use planning was considered contradictory to current norms and lifestyles:

"People move here to be out in the country, and if we have zoning efforts that mitigate that, then they're not in the country. "—Monastery WA

"We've actually had members of the planning commission who have pretty much stated that zoning is unconstitutional. "—Monument AZ

Respondents also used language that invoked physical conflict when talking about the possibility of such regulations being enacted:

"When you start talking regulations, mandatory code, those are fighting words ... there's a whole bunch of people from your state that didn't like what's going on, and they moved to Oklahoma to be left by-God alone. "—Loco-Healdton, OK

"After some of the fires in the '90s in Bend [Oregon] that burned houses, insurance companies and the Forest Service partnered up and essentially forced Firewise on communities. I don't think some of the places I've worked that would work at all. You'd be met with a firearm. "—Wallow AZ

Rejection of regulations and preferences for privacy, independence, and rural lifestyles extended across study sites, including those where housing was developed in subdivisions, where there were more land use regulations and planning in place, and in metro areas. Across these diverse settings, respondents talked about how a general dislike of regulation shaped communities, played a role in the identity of the broader area (county, state), and related to the histories and identities of residents themselves.

For example, Possum Kingdom TX had little land use regulation or planning (no zoning or building codes), although housing and residents were in many ways typical of suburban, formal residential developments: homes were densely clustered around a lake in an otherwise rural setting, many subdivisions had HOAs, and homeowners were primarily from urban areas where land use regulations and planning were common. However, informants saw the lack of regulation as a respite from urban settings with large scale institutions and complex networks of regulatory enforcement, and also as a welcome release from the previous land use regime (when lots could only be leased from a state agency which controlled vegetation management):

"We don't enforce the speed limit in there, we don't enforce seatbelt rules and all that stuff; those are private roads. "—Possum Kingdom TX

"I don't think the lake community is receptive to regulation because they had very onerous regulations, you know, very recently. I mean, it's in our recent memories, and that's one of the attractions, moving out here, is the lack of rules "—Possum Kingdom TX

Even study sites that had moderate to high investment in land use regulations and planning retained some antipathy to such efforts. For example, in Station CA, many homes lost in the study fire were located in a rural inholding within a National Forest, and pre-dated land use and hazard mitigation regulations for larger, metro Los Angeles County. Local community leaders espoused the typical interest in privacy and natural amenities seen in other WUI areas. Similarly, in the Caughlin NV site, a small metro where housing was developed in subdivisions within

and just outside Reno, respondents situated challenges in using land use planning in a context of broader state culture and history, from the “Wild West” to the present-day Burning Man festival. In South Carolina, the Hwy 31/WG site included a large and diverse county, Horry County, which had grown dramatically over past twenty years in population, primarily in dense suburban subdivisions. Despite this housing growth, long-time residents and people in more rural areas of the county rejected land use planning and regulations:

*“Horry County, like a lot of places, their land is their land, ‘you don’t tell me.’ A lot of [it] is deep history of agriculture. Horry County is a big place, but up until the last 20 years, has been a small place population-wise. We’re not even a generation away from how it used to be.” Hwy 31/WG SC*

These norms and attitudes also affected implementation and enforcement of regulations. Across sites, residents would often resist requirements: asking fire department staff for personal exemptions; applying political pressure on those enforcing regulations; or using workarounds to avoid triggering regulations (replacing only small portions of a roof at a time, or building a home just under a certain square footage). Many study sites described limited political will to enforce even modest requirements, such as requiring reflective address signs (Monastery WA). In one site (Monument AZ), residents could opt out of building code inspection in some rural areas of the county. Even in the Station CA site, a large metro with a highly trained and resourced fire and forestry department, enforcement was described as a collaborative effort:

*“It’s hard to enforce [defensible space] sometimes with owners that want their privacy or they have \$25,000 work that needs to be done. We cannot tell them, ‘Okay, well today’s this day. I’ll be back in a month and all this better be done.’ It’s hard to do that. We try to work with them as much as we can.”—Station CA*

Across sites therefore, local government and fire department staff often focused on education and working with homeowners, in locations with and without wildfire-related regulations.

### 5.5. Coordination and scale

For both regulations and plans, respondents had concerns about coordination and scale. Coordination within jurisdictions could be challenging, given that different land use regulations or planning goals could be in conflict, and that jurisdictions were often large and diverse in population and housing characteristics. There were also challenges of coordination across jurisdictions, including horizontal policy coordination between neighboring jurisdictions and vertical coordination between different levels or scales of government. However, respondents also discussed ways that policies and planning over different scales aligned and reinforced planning and mitigation goals, and the benefits of working over large scales.

#### 5.5.1. Internal policy coordination

Where wildfire-related regulations and planning had already been implemented, informants discussed challenges with opposing goals or conflicts with non-fire related planning efforts and regulations. We saw this concern in places with minimal wildfire-related regulations and planning, as well as those with more investment in formal management efforts.

A classic example of such a conflict would be an ordinance that restricts tree removal, thus preventing residents from maintaining defensible space. Two of our study areas had eliminated their restrictions on removing trees (Possum Kingdom TX, Wallow AZ). In other sites conflicts remained. The Station CA site had a number of such conflicts given the long history of land use planning and regulation, and because of the complicated regulatory environment (some of the housing affected by

the fire was leased from the Forest Service). For example, the county’s fire and forestry department (one entity) was charged with ensuring defensible space, as well as protecting native oak trees, while still considering restrictions on water use due to drought (i.e., irrigating lawns). Similarly, Forest Service objectives for resource management and historic preservation could be in conflict with creating defensible space around Forest Service leased cabins. Conversely, in some locations, standards converged, so that requirements put into place for one issue also helped with wildfire (e.g., roofing standards for snow-loading or wind helped with fire).

Other challenges with coordination extended beyond any specific regulation or planning goal. In both metro and nonmetro sites, respondents had concerns about how to effectively plan for and manage development and wildfire risk in large and diverse jurisdictions:

*“I didn’t think a one size fit all for all communities [would work] because each community has different issues. So L.A. County is probably the only county in the country that doesn’t have a CWPP.”—Station CA*

*“We have two counties. We have urban, Sierra Vista area, where people want building codes. They want zoning. They want it to be [more urban]. They want to be able to tell their neighbors—or make us tell their neighbor to trim their grass. Then, we have east of the San Pedro River, ‘My family’s been here a hundred fifty years and we never had building code. And the house is still there. Why do we need it?’ ... it’s just like two different worlds.”—Monument AZ*

These concerns were not universal, however, and other respondents, even in the same sites, talked specifically about the value of doing larger, county-level planning, or presented ways that local government was working across diverse areas. For example, in Station CA, variation in settings was reflected in regulations and operations: only designated wildfire-rated hazard areas (as determined by the State) are held to wildfire-related regulations and codes. Residents in more rural areas with wildfire risk did not pay for the medical emergency calls more common in higher density parts of the county, and vice versa. Some respondents also saw value in larger-scale planning. Two of our study sites did have county-wide CWPPs, and there was interest in developing one in Hwy 31/WG SC:

*“I would like [CWPPs] to go County-wide because that reaches a different level than just this one house. We would be able to say, ‘y’all are higher risk than this area over here’ so maybe we can tailor some of those zoning codes and things like that to match and see some larger setbacks.”—Hwy 31/WG SC*

#### 5.5.2. Horizontal policy coordination

When discussing government-led, formal action to reduce wildfire risk, multiple respondents mentioned the challenges of coordination across local entities and agencies, or where land jurisdiction transferred from one entity to another across adjacent lands. These concerns were most common in locations where some regulations were present, typically metro study sites.

Local officials and community leaders themselves faced the challenges of complying with regulations across land managers and jurisdictions. For example, in Station CA, the LA County staff had to comply by Forest Service regulations to replace infrastructure that was damaged in post-fire flooding, and in Hwy 31/WG SC site, HOAs were trying to get approval from Army Corps of Engineers to thin vegetation in undeveloped wetlands near homes. For both the Caughlin NV study site and Station CA sites, regulations differed across a complex patchwork of city and county landholdings:

*“It’s insane to see how we got patchwork jurisdictional authority in that area .... you can have, literally right across the street, this is City of Reno, this is Truckee Mills Fire Protection District and what they enforce may not jive with what we enforce”—Caughlin NV*

The Station CA site was even more complicated, as LA County encompasses 88 distinct municipalities and federal land. The County provides fire services to approximately two thirds of cities within its boundaries, with a variety of standards for fire-resistant materials and defensible space. The State of California's fire hazard severity zones cut across jurisdictions and supersede local regulations, requiring state-level standards in building materials and defensible space at a minimum. Lastly, for those homes in close proximity to Forest Service land, compliance with county standards for defensible space would require residents to manipulate vegetation on federal land. After the Station fire, the National Forest created a new program to allow such vegetation treatments, yet it was complex and had not yet been widely used several years after it was created.

### 5.5.3. Vertical policy coordination

Nested, or vertical, governmental policy coordination was also cited in a diverse array of study sites, both as a challenge to and as a benefit of using planning or regulations to reduce wildfire-related risk. In some cases, vertical or top-down policy structures impeded or hindered the use of wildfire-related regulations and planning. For example, in Texas, only locations with populations over 250,000, or adjacent to such a city/county, are authorized to adopt a fire code [57]. In Hwy 31/WG SC, bans on fireworks had to be implemented at the individual street level, and there was a history of conflict between state authorities and their local counterparts on imposing burn bans. Stricter federal requirements for air quality during prescribed burning were welcomed by one local leader:

*"We do have more protections [during burns], by federal law, which was great because it's hard to get that type of action from our state. They're libertarians."—Hwy 31/WG SC*

However, there were also ways in which state-level action and policy had led to or required the adoption of wildfire related regulations or plans. Most notably, state-level mandates for wildfire-related standards for building materials and defensible space in California and Nevada had resulted in regulations about homesite-level mitigation. However, in Nevada local jurisdictions were given flexibility in implementation so that standards were adopted in only part of the Caughlin NV study area (Washoe County, not city of Reno) (Table 1). Beyond wildfire, federal mandates for all hazard mitigation planning through FEMA were generally accepted by local government, and most study sites had developed HMPs:

*"Because FEMA gives us money, we comply with the regulations and requirements that FEMA requires, which is good, I think. And, yes, they're high in the chain of command."—Monastery WA*

Such coordination up to federal levels was not without its own challenges. For example, in Possum Kingdom TX, the emergency operations plan went through a regional Council of Governments before going to the state and federal levels, requiring multiple layers of review and coordination. However, such nesting could also facilitate the participation of smaller localities who had less capacity for planning or emergency response. For example, in the Hwy 31/WG SC site, smaller cities were included within Horry County's HMP.

### 5.6. Adaptability of planning and regulation over time

Lastly, respondents in all study sites had concerns about revising land use and planning over time to reduce wildfire risk, both about how to reduce wildfire risk once housing and infrastructure had been established, but also how to update regulations and plans over time. The specific nature of the concerns varied with the setting and its landscape. For example, in nonmetro areas where there were relatively few wildfire-related regulations, respondents' concerns about updating regulations and housing were focused on infrastructure (e.g., how to

widen roads or upgrade water supplies). In the metro sites there were concerns about how to reduce wildfire risk while also preserving open space, particularly after housing was already developed and open space protected:

*"Open space is a tremendous draw when you first begin a development. People love the idea of trails and horse trails and all this open space. Usually when the developments are new, [open spaces] are attractive and they are maintained, but over time they become less and less so, and they just become this tunnel channel of fuels that can carry fire."—Caughlin NV*

*"As far as the counties and cities go, are you going to change much in how you build up against the Forest or within the Forest? Because we're going to continually have requests [for vegetation modification] from private landowners that have inholdings within the Forest, and we're going to have to address it. It seems like some of those things could be identified up front when some of these planning efforts are going on."—Station CA*

In addition, once zoning was established and housing had been developed, it was unclear how much housing could change in response to wildfire risk:

*"Once you have these development plans [for a condo complex] approved you can't hold them to do something else. They reconstruct the way that it was before."—Hwy 31/WG SC*

*"I think it's in the back of everyone's mind that zoning should have been done differently from the beginning."—Hwy 31/WG SC*

These concerns existed although the regulations themselves (zoning, building codes) are in fact designed to be updated over time. However, even that process was not without its challenges. In some cases, the standard update cycle meant that communities did not re-examine policy after a wildfire because their codes were not scheduled for review at that time. Over time as regulations accumulated, codes became increasingly challenging to work with. This concern was notable in the Station CA site due to the long timeframe of land use planning:

*"Our zoning code is about this thick; it was established in the 1930s and it's still in the same language. It talks about things from the 19th century that we still have to deal with."—LA County*

However, issues of accumulating regulations were also mentioned in Possum Kingdom TX—a study site with nearly no regulations related to building—as a reason to not pursue such efforts:

*"You've got to be fair to your community and ease in some rules. So, that's the fine line we walk with starting to have codes and ordinances and all that. We need something, just what is it? Then you start increasing it in time ..."—Possum Kingdom, TX*

Conversely, in places with low investment in wildfire-related regulations, respondents suggested that a lack of regulation was an advantage because it meant that informal, community-driven efforts, which they saw as more flexible, could quickly emerge after wildfire.

### 5.7. Conceptual framework

In combination, the emergent themes from our analyses gave rise to a conceptual model of local wildfire-related land use policy implementation over time in the U.S. (Fig. 1). The vast majority of these considerations and outcomes of land use planning were local in nature, many of them internal to local government (Fig. 1). External policy did influence the adoption of land use planning and regulations, but higher-level mandates from the state or federal level are rare (the state of California is a notable exception). In our framework, we placed external policy mandates, as well as local public acceptance and support, at the start of our model. These elements inform and feed into local government deliberations regarding policy change and land use planning. Local staff



then weigh a number of internal factors: staff perceptions of wildfire risk, perceived efficacy of proposed and existing plans and regulations local government capacity and funding, the importance of wildfire mitigation relative to other policy or local needs (e.g., broader housing quality concerns, economic development through real estate), internal policy conflicts at the local level and within government, and support from elected leaders (e.g., county commissioners) (Fig. 1).

The policy development outcomes that result from internal policy deliberations are on the right-hand side of the model. As development proceeds local leaders will continue to assess the effectiveness of wildfire and land use outcomes of their efforts—including the efficacy of regulations, the extent and type of housing and open space created, coordination issues within and outside their jurisdiction and among landowners and agencies—while also amassing experience with wildfire events and change in climatic conditions. Feedback loops demonstrate how these outcomes and wildfire experiences can influence internal local governmental consideration of future land use planning efforts, as well as public support for such efforts, and external mandates (e.g., state policy). We acknowledge that local events and land use outcomes such as wildfire or housing development do not always lead to changes in public support for land use planning, to state/federal mandates, or shifts in those considerations internal to local government. However, the staff and leaders we spoke with were clearly referencing their lived experiences with development and land use planning in these landscapes, and adjusting their thoughts and evaluations accordingly. This iterative model captures pathways for feedback over time.

## 6. Discussion

Land use planning and regulation are often proposed as worthwhile tools to shape both how and where we build and live in fire-prone landscapes, yet they are rarely used, and minimally revised after wildfire (particularly regulations) [17,23,24,58]. However, our interviews with local government and community leaders revealed a rich, multi-faceted consideration of policy beneath these calm exteriors of minimal or unchanged land use policies related to fire. Local government staff and leaders made clear that they were weighing a variety of considerations, many of them internal to their local government.

Some of these concerns were those we expected to find, based on previous research in wildfire- and hazards-related land use planning [25,26,37]. Government capacity, public acceptance of land use planning and regulations, and issues related to policy coordination all emerged as important factors in this study. However, there were other important factors as well, including staff perceptions of planning and regulatory tools, the adaptability of these tools, and other policy concerns (housing stress, economic growth). These deliberations, in both nonmetro and metro sites, were nuanced, and extended beyond the narrative of rural residents resisting all land use planning as a matter of principle, due to self-interest and/or property rights.

### 6.1. Emergent themes in relation to study characteristics

For several of our themes, we could clearly link concerns to the characteristics of the study site. For example, government staff in sites with a recent history of amenity growth respondents were focused on maintaining economic growth through real estate development. Across our nonmetro sites many respondents shared similar concerns about local government capacity, the efficacy of/need for land use planning, other policy goals, and public acceptance of land use planning. Sites with more investment in land use regulation and planning (typically metro sites) were those that grappled with policy coordination, within and across jurisdictions.

However, we also found that challenges were not unique to any one type of site: metro sites had more resources, but not unlimited capacity for enforcement and implementation; areas without amenity growth still wanted to facilitate housing development; and in a metro area newly

facing wildfire issues, some did not see wildfire as an ongoing threat. Of all themes, the public acceptance of and compliance with land use planning to reduce wildfire risk was the most widely discussed, but not only in nonmetro sites where housing was developed as dispersed, individual homes. Perceptions of regulations and land use planning appear to be shaped by much more than the current-day characteristics of residents or form of the built environment.

Possum Kingdom TX was a particularly notable example: many homeowners were resistant to land use regulation or rules of any kind (e.g., seat belts and speed limits), yet most lived in urban areas, and their vacation homes were developed in dense subdivisions. This site contradicts the idea that residents who live in formally organized subdivisions or who have migrated to an area in pursuit of natural amenities will readily accept regulations to reduce wildfire risk [26,52]. Attitudes toward land use policy and regulation appear to be shaped by many social cultural, and geographic factors including the history of housing development and growth/hazard regulation, hazard losses over time, amenity migration, and population change. In communities where both land use and resident populations are changing over time, social dynamics are fluid; those who start as new arrivals in search of natural amenities eventually become long-time residents [59], and gain knowledge about wildfire risk over time as well [60].

Much of the complexity we found emerged because we worked at the level of local government. Respondents discussed notable diversity in residents within a jurisdiction, and were knowledgeable about residents and community dynamics. What sociologists term ‘social fit’ has only recently been considered in environmental governance, but suggests that governing institutions will be more successful when they reflect the interests, values, beliefs, and needs of groups at the appropriate scale [37,61]. In our sites, land use planners and other government leaders were grappling with these issues of fit as they discussed the challenges of devising policies to work across different development densities, wildfire risks, and land use planning preferences. For example, local leaders described residents who lost homes in the Station CA site as typical WUI residents who valued rural lifestyles, privacy, and natural amenities, yet when these homeowners attempted to rebuild, they found themselves grappling with a large metro government bureaucracy and extensive land use regulations around wildfire risk. In other study sites where wildfires affected residents in newer suburban subdivisions, these subdivisions were situated within large, still-rural counties where wildfire-focused land use planning was not accepted county wide (Hwy 31/WG SC and Monument AZ). At the neighborhood- or community-level (smaller than city or county), the characteristics and perceptions of residents and their immediate neighborhoods can only reveal part of the story.

In addition, our findings suggest that understanding the perceptions and motivations of government staff and local leaders themselves will be important to understanding land use planning, particularly in rural areas. In several instances professional staff had doubts about the need for and efficacy of land use planning or regulations to reduce wildfire risk, even after destructive wildfire. This is consistent with other hazards research: for example, rural land use planners in Vermont remained unconvinced that flooding was a threat, even after repeated floods [37]. We suggest this reluctance to modify planning and regulation might stem in part from the way local planning and building staff saw their roles as critical to encouraging housing development and economic development. Similarly in coastal and flood-prone regions, municipalities encourage and compete for growth (“growth machine”) [62,63], even after a disaster [64], and despite long-term negative consequences for disaster vulnerability or sustainability. With wildfire, however, the presence and growth of housing itself increases the risk [1], making it all the more important to consider the community-level costs and benefits of development in fire-prone settings. Although there is increasing information available on the direct costs of using fire-resistant materials in construction [65], understanding the regional economic effects (i.e., indirect and induced costs) of land use planning and regulations is far

more complex, and varies with context [66]. Furthermore this “growth machine” mentality did not characterize all government employees we spoke to; emergency managers and fire department staff were more concerned about the challenges to public safety they faced as housing development and population increased. Research to date has not addressed the effects of such divergent priorities on progress to becoming a fire-adapted community.

## 6.2. Implications for management and policy

There are many different paths and activities that communities may take in order to become “fire-adapted” [20,55,67], and we show here that non-action on land use planning can occur for a vast variety of reasons. Our conceptual model suggests some initial areas where technical expertise and support may be valuable for local government staff. For example, concerns about capacity, the efficacy of plans and regulations, limited knowledge of wildfire risks, other policy priorities, and policy coordination are all areas where technical assistance and networking might suggest novel solutions or raise awareness. For technical assistance, the USDA Forest Service funded Community Planning Assistance for Wildfire project (CPAW) provides expertise via consultants for local governments. As of 2018, 61 communities in 13 states had received some kind of technical assistance through CPAW. The Fire Adapted Communities Learning Network (FAC Net) is a national network of people working to build wildfire resilience capacity, created by a partnership among The Nature Conservancy, the Watershed Research and Training Center, and the USDA Forest Service. The FAC Net provides a way to spread knowledge and practice among peers, and demonstrate fire adaptation in a diverse variety of settings.

Our findings reveal a need for more diverse examples of adaptation, specifically for actions taken in land use planning. Currently, many of the examples of land use planning to reduce wildfire hazard are from communities experiencing growth. Many of these models emphasize developing housing and infrastructure in an optimal manner, in communities of modest size, with at least moderate resources for land use planning [44,45,68]. However, in our study sites, those places with the most capacity, and ability to best pursue land use planning, were typically also places with extensive housing development. As a result, the political capacity and policy investment required was daunting: reconfiguring existing neighborhoods, coordinating policy within and across jurisdictions, and determining how new rules would interact with those already in place required forging new ground. For other resources as well, the reactive nature of planning is known to compromise its usefulness: for example, conservation-focused land use policy often emerges after substantial development when physical form may be irreversible and the reconfiguration of institutions, difficult [38]. The best practices for updating land use and regulations in fire-prone communities are still being developed [45]. While there is information available about retrofitting for wildfire mitigation, such advice is typically focused on changing home materials or increasing defensible space, not retrofitting entire neighborhoods or communities. Urban planning does consider retrofitting more broadly, but with a focus on adding urban characteristics such as housing density or public transportation to sub-urban/exurban areas [69], different goals and tactics than for those seeking to reduce risk in fire-prone areas.

At other end of spectrum, rural communities could benefit from modifications to the current model of fire-adapted communities, particularly when resources are minimal and where unmet human and social needs compete with hazard preparation for scarce resources. Land use planning tools suitable for use in rural places are still in development; planners have been criticized for trying to use urban tools in rural settings, and for considering rural places most directly when they are focused on managing rapid growth [32]. The fire-adapted communities model may also be harder to apply in rural places where informal institutions are key in arbitrating land use, and where there are few official staff positions, few existing land use efforts (e.g., no building codes), and

many other urgent concerns like poverty, health crises, employment, or education [28]. In some of these places social ties may be inadequate to support collective action [52]. However, despite the difficulties of enacting land use policy to reduce wildfire risk, we suggest that even in the most rural areas, land use planning and regulations to reduce wildfire risk are important to consider. Infrastructure such as roads and water supplies are critical for public safety, and challenging to upgrade after development. Such land use regulations related to infrastructure are typically most palatable to government staff and citizens, and building support for these efforts can draw upon appeals to consider public safety, firefighter safety, as well as equity in bearing the responsibility of wildfire mitigation [21].

Beyond the local level, experience with other hazards suggests that state and federal resources are critical to supporting hazard risk reduction through land use planning. Without higher-level requirements for regulations or land use planning, the federal government provides land use planning assistance via CPAW, FAC Net, and similar programs, and encourages communities to write CWPPs. For under-resourced communities such external assistance may be critical. Linking these local efforts via regional planning efforts can also provide an efficient way to address hazards in more rural areas [39,70], and will strengthen coordination across jurisdictions [27], something our respondents struggled to maintain.

Our results also revealed diversity in local government and community expertise and interest in land use planning. Although building department and planning staff could have competing priorities (hazard-reduction, safety, continued real estate development), fire department and emergency response staffs had fewer such conflicts. These staff and volunteer fire fighters, as members of the local community, can be vital participants in land use planning. Alternatively, while some suggest that HOAs can take leadership in wildfire risk reduction, we found that HOAs were inconsistently pursuing these goals in some communities (Hwy31/WG SC) and not focused on fire hazard reduction in others (Possum Kingdom TX and Caughlin NV).

Ultimately, sharing examples of successful use of land use planning and regulations, in metro and nonmetro places alike—what Lyles et al. [29] term “leading edge” places—will be critical to expanding our conception of fire-adapted communities. Lessons learned in rural planning and hazard management have much to contribute [32] but ultimately, flexible and creative solutions will be required whatever the setting. In many ways the challenge with wildfire mitigation is that the risks and development pressures are widely dispersed across much of the country; this is no more an urban issue than it is a rural one. Our study highlights the value of diverse models of fire adaptation where local government can nimbly respond to wildfire risk, meeting the hazard where it is, and as it morphs over time.

## 6.3. Additional considerations

Both in nonmetro and metro places, land use planning and regulations will be only part of the portfolio pursued by local government and communities. We acknowledge that informal rules, norms, cultures, social networks, and education campaigns also contribute to fire-adapted communities and that localities can be quite inventive after wildfire [19]. We note too that our interviews were focused on a limited number of communities, and conducted only with local government and community leaders, rather than residents. In addition, our findings come from settings where losses were less than a few hundred homes—this work occurred before the 2017 and 2018 wildfire losses in northern California—where land use policy change after destructive wildfire was minimal [23]. Finally, although we discussed land use planning and regulations with our respondents, we did not have the means to assess the effects of reported actions, which is part of the full picture of land use planning to reduce hazard vulnerability [71]. It is challenging to anticipate the wildfire risk reduction impacts of different land use planning schemes [70], or land use outcomes of broader planning efforts

[72].

## 7. Conclusion

A growing need for wildfire risk reduction in residential settings has led to development of an array of alternatives and strategies intended to reduce the threat of home loss to wildfire. Land use planning and regulation appear to many as a common-sense solution, one that any local government has the authority and expertise to undertake. Yet these tools have not proven popular at the local level. Our efforts to better understand why uncovered some well-known factors such as local government capacity, policy coordination challenges, and a lack of public support for land use planning and regulations, but also revealed the significance of internal government factors, of social needs more urgent than wildfire risk reduction, and of skepticism among local staff about the effectiveness of formal management. Many of these challenges were present across study sites, both urban and rural. We offer recommendations for initial investment technical assistance and networking, and suggest continued efforts to share successes stories widely, from metro and nonmetro places alike.

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## Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.ijdr.2019.101444>.

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