ORIGINAL ARTICLE

Network governance in the use of prescribed fire: roles for bridging organizations and other actors in the Western United States

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Abstract

Dangerous wildfire conditions continue to threaten people and ecosystems across the globe and cooperation is critical to meeting the outsized need for increased prescribed burning in wildfire risk reduction work. Despite the benefits of using prescribed fire to mitigate wildfire risks, prescribed fire implementation is still challenging. Collaboration and capacity-building can help address policy and capacity barriers inhibiting prescribed fire. We conducted 53 interviews across four case studies in the western United States where federal land management agencies and cooperative actors are working together to accelerate the implementation of prescribed fire to understand the range of actors and associated roles they play. We found that interviewees identified 67 different organizations spanning local to national scales that played a variety of roles to support prescribed fire implementation, mainly communications, prescribed burn labor, fundraising, burning expertise, and burning on neighboring lands. Many actors did not serve in intentional bridging roles, but they filled key roles in the governance networks necessary to implement prescribed fire. Typologies of actor roles can illuminate potential pathways to addressing capacity constraints in achieving wildfire risk reduction. Yet, in networked governance systems, there is a need to distinguish between those in bridging roles and other types of actors who bring capacities to key governance challenges. The growth of networked partnerships working on wildfire risk reduction is reflective of broader global environmental governance trends of increased reliance on non-government actors and the need to work at larger spatial extents.

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Introduction

Dangerous wildfire conditions threaten people and ecosystems in fire-prone regions in the world, and the problem is only likely to get worse (McWethy et al., 2019). This adversely affects human life, property, public health from smoke, greenhouse gas emissions, grazing and reserve land conditions, forest cover, and economic outcomes (Gill et al. 2013). At the same time, fire is inevitable and often critical for ecosystems and landscape health (Russell-Smith and Thornton 2013). Decades of fire exclusion have created a "fire deficit" in many fire-dependent ecosystems (Parisien et al. 2020) where the lack of fire contributes to less resilient ecosystems and increased fuel loads and wildfire risk (Abatzoglou and Williams 2016; Marlon et al. 2012).

Reintroducing fire can improve ecosystem health and decrease fire risk. Prescribed burning can be used to reduce fuel density when the weather is conducive to fire control and smoke dispersion (Ryan et al. 2013). It is often a critical

step to restore and/or maintain a natural range of fire conditions, particularly in forest types that are dry or adapted to frequent fire (Kalies and Kent 2016; Stephens et al. 2020). Many communities have long co-existed with fire sustainably, such as Indigenous and Tribal peoples in North America (Lake et al. 2017); aboriginal people of the Western Desert of Australia (Bird et al. 2018); and indigenous communities in Venezuela, Brazil, and Guyana (Doerr and Cristina 2016; Mistry et al. 2016). The historic and current role of Indigenous fire stewardship[1] by various Indigenous, Aboriginal, and Tribal peoples is critical to understanding humans' complex relationship with fire, as well as to integrate different systems of knowledge for living in fire-prone ecosystems (Armatas et al. 2016; Doerr and Cristina 2016; Huffman 2013). In many landscapes, there is an increased interest in learning from and reestablishing the practices of Indigenous peoples who used fire to manage their lands to meet a range of societal needs (Kimmerer and Lake 2001; Russell-Smith and Thornton 2013; Burrows and McCaw 2013).

Despite the importance of prescribed fire as a fire management tool, it can be controversial and challenging to use, particularly in densely populated, fire-prone areas, and as conditions on the ground and levels of risk change over time (Burrows and McCaw 2013; Russell-Smith and Thornton 2013). Research on prescribed fire across the globe, as compared to wildfire, has been limited to date, and is needed to inform natural resource management (Hiers et al. 2020). Although the literature is limited, there is an increasing understanding of common challenges to implementing prescribed burning across the globe. These challenges transcend jurisdictional, administrative, or regional boundaries and many relate to cultural, socioeconomic, and land use and jurisdictional issues more than a lack of fire-ecology knowledge (Fernandes et al. 2013; Russell-Smith and Thornton 2013). Challenges faced in fire-prone southern Europe (Fernandes et al. 2013; Turco et al. 2016), North America (Ryan et al. 2013), southwestern Australia (Burrows and McCaw 2013), and South Africa (van Wilgen 2013) for implementing prescribed fire, and traditional field burning in Ireland (Carroll et al. 2021), focused on lack of policy or funding support and societal acceptance, understanding, and risk aversion (as also found in Russell-Smith and Thornton

2013). Previous studies across fire-prone regions of the world have identified commonalities about the need to adapt to local social and cultural conditions, as well as engage with and inform local and regional communities (Carroll et al. 2021; Miller et al. 2020; Quinn-Davidson and Varner 2011; Russell-Smith and Thornton, 2013; Ryan et al. 2013; Schultz et al. 2019).

There is a growing desire to increase the use of prescribed fire within the United States (US), but implementation has remained stable or decreased over the last two decades (Kolden 2019), despite potential ecological and economic benefits of using prescribed fire to mitigate wildfire risks (Burke et al. 2021). A limited number of studies have identified specific factors that inhibit or facilitate greater use of prescribed fire and they generally examine only federal or state lands. Key barriers include lack of capacity (e.g., insufficient funding or workforce during burn windows), policy factors (e.g., air quality permitting rules that restrict allowable times to conduct prescribed burns, varying standards between agencies in legal compliance), incentive- and risk-related factors (e.g., fear of liability and negative public perceptions), and biophysical factors (e.g., weather constraints, like wind speed or relative humidity) (Miller et al. 2020; Quinn-Davidson and Varner 2011; Ryan et al. 2013; Schultz et al. 2019). These studies also highlight the importance of collaboration and capacity-building to increase prescribed fire considering steady federal funding declines, the need for budgetary flexibility that can be found through partnership agreements, the need to engage expertise housed outside the federal agencies, and opportunities that collaboration offers for institutional innovation and experimentation (Abrams 2019). Building and maintaining partnerships to increase prescribed burning can occur at multiple scales (Miller et al. 2020; Russell-Smith et al. 2019; Schultz et al. 2019; Schultz and Moseley 2019). For instance, partnership and coordination among air and land managers at the state level, and between federal and state agencies, are important for problem solving, sharing resources, and leveraging each other's capacities (Schultz et al. 2019). At the local level, collaboration can help build agreement in the community about forest restoration needs and approaches (Schultz and Moseley 2019). Establishing interagency and partnership agreements can ensure prescribed fire and related restoration work occurs strategically, when and where it is needed (Schultz et al. 2019).

Federal land management agencies in the US have become increasingly reliant on non-government actors to leverage capacity and work at larger spatial extents in part because government resources for forest management have become increasingly limited (Abrams 2019; Arts et al. 2017). In the US, this trend began in the early 1990s with the emergence of "ecosystem management" and "collaborative governance" approaches (e.g., building agreement among

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[1] "Indigenous fire stewardship (IFS) is the use of fire by various Indigenous, Aboriginal, and Tribal peoples to (1) modify fire regimes, adapting and responding to climate and local environmental conditions to promote desired landscapes, habitats, species, and (2) to increase the abundance of favored resources to sustain knowledge systems, ceremonial, and subsistence practices, economies, and livelihoods. IFS is the intergenerational teachings of fire-related knowledge, beliefs, and practices among fire-dependent cultures regarding fire regimes, fire effects, and the role of cultural burning in fire-prone ecosystems and habitats." (Lake and Christianson 2019).

local stakeholders to overcome legal gridlock regarding future forest management) (Schultz et al. 2012). "Network governance" of public lands has emerged more recently and goes a step further by engaging non-public actors (e.g., private and civil society actors) more directly to contribute resources or perform functions that federal actors may struggle to provide (Abrams et al. 2017; Alexander et al. 2016; Newig et al. 2010). The opportunities for institutional innovation in network governance can include experimentation and pragmatic solution-oriented approaches, such as joint planning or management, using new funding, contracting mechanisms and tools in different ways (Abrams 2019). *A key question is how actors within prescribed fire networks might work together to solve problems, in this context of networked governance.*

A "network" is a group of actors who are linked together and interdependent with regard to some goal, but who do not necessarily share an identity (Nowell and Steelman 2012). Networks can be loose associations of actors that have a shared interest, and one of these interests may be a general desire to limit damage from a potential future event, like a large fire or drought. We define our network of interest as *the collection of individuals, organizations, and agencies that are involved in supporting prescribed burning* (Nowell and Steelman 2012). Actors within the network span a range of organizational forms, from agencies and other bureaucratic organizations with formal mandates and roles in prescribed fire, to emergent structures such as organizations that develop in response to crises or other issues (Nowell and Steelman 2012 citing Neal and Phillips 1995; Stallings and Quarantelli 1985). Actors in a networked governance system may play a variety of roles, and individual actors may play multiple roles. For example, a private landowner may engage in fire management to protect their own property but be part of a larger network of individuals looking to reduce forest fuels across a larger landscape.

The environmental governance literature recognizes the need for bridging organizations that can address problems at different scales (Davis et al. 2021; Cash et al. 2006; Crona and Parker 2012). Bridging organizations support interorganizational collaboration and bridge different knowledge systems and skill sets (Crona and Parker 2012), such as supporting collaborative initiatives (Schultz 2009); providing arenas for new forms of learning, trust making, and conflict resolution (Berkes 2009); and acting as knowledge or data brokers (Crona and Parker 2012). Bridging actors are critical in facilitating the flow of information and influence across networks (Berdej and Armitage 2016; Faas et al. 2017; Kapucu 2006) and sometimes can access resources from more sources than any one organization can on their own (Bodin and Crona 2009; Faas et al. 2017).

Although studies to date suggest that partnerships and collaboration facilitate greater use of prescribed fire, little is known about the specifics of *how* networked partners achieve this goal. Research on this topic has covered either somewhat limited geographies, mainly in California (Davis et al. 2014; Miller et al. 2020) and New Mexico (Allbee and Krasilovsky 2019), or has only been studied at the state (not project) level for the western US (Schultz et al. 2019). Lessons from other fire-prone regions identify examples of challenges and opportunities for prescribed fire implementation, but do not examine the roles and types of networked partners working together to accomplish burning. Federal land management units likely use unique strategies and partnerships to navigate challenges to prescribed burning given their local context and capacities. A network governance lens can provide key insights into the types of actors and their roles in prescribed fire collaborations across contexts.

In this paper, *we characterize the diversity and respective role(s) of actors engaged in partnerships and other cooperative arrangements that seek to increase the use of prescribed fire.* We recognize that actors might be in bridging roles or more loosely associated with the network. To this end, we investigated the roles played by cooperative actors in four case study areas where US Forest Service (Forest Service) and Bureau of Land Management (BLM) units and networks of partners are working together to accelerate the implementation of prescribed fire. We focused on understanding the innovative ways that federal land management agencies and other cooperative actors working collaboratively to increase their capacity to apply prescribed fire in the Western US. A key emergent theme from this research focus was on creative partnerships as a key form of innovation. The analysis presented here is a deeper examination of the diversity and types of partnerships identified in our case studies.

Our aims with this research were twofold: (1) to contribute to applied research on the roles different actors can play in addressing federal agency capacity limitations to support efforts to reduce fire risk, and (2) to improve understanding of the scales and functions of actors in networked governance, including proposing a typology of partner types that can be built upon in future network governance work.

Methods

Case study selection criteria

Public (federally managed) lands in the western US provide a useful context for studying opportunities to accomplish prescribed fire through cooperative partnerships, due to the large portion of lands managed by federal land management agencies. The Forest Service manages 78 million hectares of land in the US under a broad multiple-use mandate, which includes a focus on improving the ecological health of ecosystems through the restoration of natural processes such

Table 1 Case study selection criteria

Selection criteria category	Criteria
Practicality Feasibility of successfully completing interviews with relevant stakeholders	• Willingness and interest of unit to participate • Accessible locations for researcher visits • A current active prescribed burning program
Comparative potential Potential to compare cases	• Balance of Forest Service and Bureau of Land Management units • Diverse challenges present (e.g., with and without workforce challenges, with and without strong administrative support for burning, with and without smoke permitting limitations) • Diverse strategies employed to address challenges
Relevance Units that are strategically increasing prescribed fire application	• Uniqueness of strategies for increasing prescribed fire accomplishments • Actors working across land ownerships • Actors working with different cooperating organizations • Burning in proximity to populations, some near the wildland-urban interface

as fire (Wurtzebach and Schultz 2016). The BLM is also a multiple use agency, with core programs in grazing, mining, and logging. The BLM manages 256 million surface acres (103 million hectares) as well as 700 million subsurface acres (283 million hectares) of mineral estate (Skillen 2009).

We selected four case studies using criteria (Table 1) that were determined a priori to enable us to identify a balance of BLM and Forest Service units that were using diverse strategies to address a variety of barriers to implementation of prescribed burning. Our intention was to select units that were representative of the diverse challenges that units throughout the Forest Service and BLM may face. Key informants offered recommendations for case studies during prior related research interviews.

Case study descriptions

Our four case study areas (Fig. 1; additional detail in (Schultz et al. 2020)) included the following:

(1) *Colorado: San Juan National Forest and Tres Rios District (BLM).* The San Juan National Forest (NF) covers around 1.8 million acres of high-desert mesas and alpine peaks in southwestern Colorado. The San Juan NF's integrated fuels target is around 20,000 acres (8093 hectares)/year, which is accomplished through both thinning and burning.

(2) *New Mexico: Socorro Field Office (BLM) and Cibola National Forest.* The Socorro Field Office of the BLM's Albuquerque District manages 1.5 million acres (607,028 hectares) of surface lands in south-central and western New Mexico. Interviewees indicated that the Albuquerque District's 2019 fiscal year prescribed fire target was 10,000 acres (4,046 hectares), and they completed 7,014 acres (2,838 hectares). The mountainous Magdalena Ranger District (RD) on the Cibola NF in central New Mexico covers approximately 800,000

acres (323,748 hectares). The Magdalena RD significantly increased their overall use of fire over the past approximately 10 years and burned about 5,000 acres (2,023 hectares) with prescribed fire in 2018.

(3) *California: Sierra National Forest.* The Sierra NF encompasses around 1.3 million acres (526,091 hectares) on the western slope of the Sierra Nevada Mountains in central California. It borders national parks, other national forests, and county and private lands. The Sierra NF has increased its fuels reduction targets to reduce fire hazard from extensive tree mortality. Fuels program staff noted their fuels reduction target in 2019 was about 11,000 to 12,000 acres (4,455–4,856 hectares)/year.

(4) *Oregon: Rogue River-Siskiyou National Forest.* Oregon's 1.8-million-acre (728,434 hectare) Rogue River-Siskiyou NF spans across southwestern Oregon and northwestern California. Interviewees described the Rogue River-Siskiyou NF's annual hazardous fuels reduction target as 6,500 acres (2,630 hectares)/year in fiscal years 2018 and 2019. The Forest exceeded their targets in recent years, nearly doubling it in some years.

Sampling

We conducted purposive sampling (i.e., identifying key individuals based on our knowledge and prior interviews) and snowball sampling (i.e., identifying additional interviewees as we proceeded, based on interviewees' recommendations). We typically began recruitment with a key contact, such as a fuels program leader for the unit. With their referrals and further snowball sampling, we compiled a list of line officers, staff officers, fire management officers, and others with the land management agency as well as individuals outside the agencies who were knowledgeable about the local prescribed fire program (e.g., representatives from non-governmental organizations, air quality regulatory
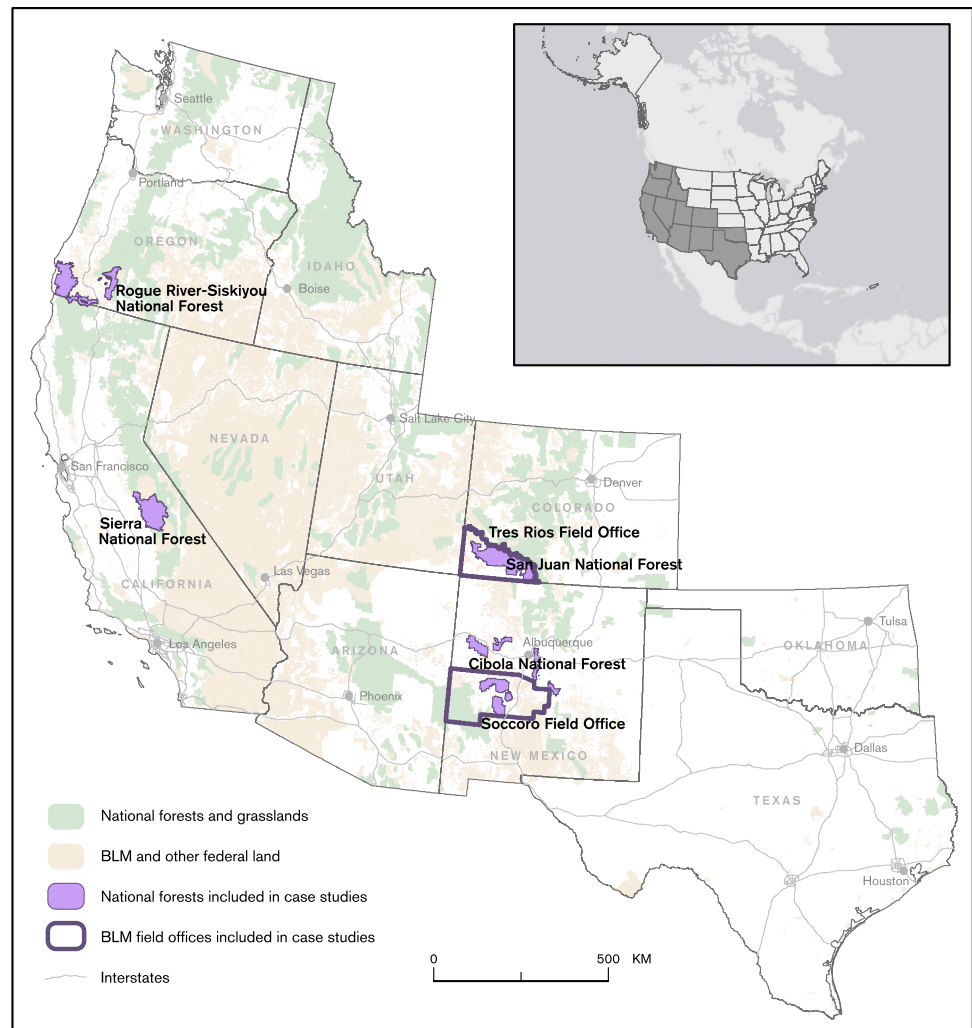
Fig. 1 Map of the four case study areas

Table 2 Summary of interviewees from each case study

Case studies	Total # interviews	Total # interviewees	# federal agency interviewees	# state agency interviewees	# non-agency interviewees
San Juan National Forest and Tres Rios Bureau of Land Management Field Office	17	22	14	3	5
Cibola National Forest and the Socorro Bureau of Land Management Field Office	12	15	7	2	6
Sierra National Forest	13	14	9	3	2
Rogue River-Siskiyou National Forest	11	11	7	0	4

Some interviews were conducted with multiple people at once. "Agency" interviewees include personnel from state and federal land management agencies and air regulators. "Non-agency" interviewees include representatives from local government, NGOs, collaborative groups, prescribed fire councils, local fire departments, and contractors

agencies, local wildland fire districts, and state and tribal fire and forestry agencies). For each case study, we interviewed all willing key individuals until we reached a point where we were no longer hearing new themes with regard to our research objective.

We conducted 53 semi-structured interviews with 62 interviewees in 2017 and 2018 across the four case study areas (Table 2). We interviewed between 11 and 22 individuals per case. Our sample included a balance of federal agency (e.g., Forest Service, BLM), state (e.g., air quality control divisions, wildlife agencies), and non-agency

interviewees (e.g., city employees, NGO, private contractors, local fire districts) (Table 2).

Data collection and analysis

Our semi-structured interviews focused on challenges and barriers to implementing prescribed burning, facilitating factors that have enabled successes in implementing prescribed burning, and opportunities for more prescribed burning. Example interview questions included the following:

1. What are the actionable opportunities for overcoming policy barriers in national- and state-level policy interpretation?
2. What are the mechanisms for accomplishing more prescribed burning?
3. What roles do (local, state, and federal level) partners and other supporting actors play in accomplishing prescribed burning?
4. How have field-level managers overcome perceived policy barriers where increases in prescribed fire application have occurred, and what factors have supported them?

Thematic analysis and coding

We recorded and transcribed all interviews and used typical social science analytical and thematic coding procedures (Saldaña 2015) to systematically code our interview transcripts. We began with an a priori coding structure that included three categories: challenges and barriers to implementing prescribed fire, facilitating factors for implementing prescribed fire, and relevant context. We then used an inductive coding strategy to develop sub-codes within our three overarching categories. "Actor roles" emerged as a prominent sub-code and theme (Schultz et al. 2018, 2020). This code was used to track any arrangement where multiple organizations shared funding, labor, equipment, resources, or supported each other collaboratively to plan and implement prescribed burning. This paper is a deeper analysis of this emergent "Actor roles" sub-code.

Identification of actor organizations and roles

To explore the types of roles of different actors in our case studies, we exported and systematically coded all interview excerpts from our "Actor roles" sub-code. We recorded each unique mention of an actor and interviewees' descriptions of the role(s) that the actor had played in facilitating prescribed fire. We then inductively coded each role that an actor had played. The two lead authors reviewed all interview excerpts and actor role codes to resolve any inter-coder discrepancies. We generated a full list of all actors mentioned and

populated dummy variables to represent when interviewees indicated whether or not an actor had played a given role. Importantly, our analysis does not represent an exhaustive list of actors or the roles each actor played; rather, it represents the salient relationships and roles that interviewees mentioned in response to interview prompts about their strategies for filling capacity gaps.

Interviewees across all cases identified other Forest Service units as critical cooperators, but we did not consider resource sharing among Forest Service units to fit the purposes of this analysis, since our focus was on actors external to the Forest Service or BLM. We have accordingly excluded other Forest Service units from the main focus of this analysis and address this type of intra-agency coordination in a separate section in the Results. We have similarly excluded BLM as an external actor in our New Mexico and Colorado case studies, because BLM districts were our explicit units of analysis in those cases. No BLM units were the focus of our analysis in Oregon, so we have retained the BLM as a participating actor in that case. BLM was not mentioned as a supporting actor in the Sierra NF case.

Classification of actors by type and scale

We classified each actor into categories in order to understand what kinds of organizations were supporting the implementation of prescribed fire with federal agencies. We classified each actor organization in terms of 10 different organization types (e.g., NGO, Coalition, State agency) (Table 3). We further classified each organization by scale (e.g., local, state, national/regional). Organizations were considered "local" if they operated at a community or watershed scale, "state" if they were operating across the state, regional if they worked in multiple but not all states, and national if they operated in most or all states in the US, and for one organization that operated internationally. We combined organizations working at a "regional" (multi-state) scale with those working at a "national" (all states) scale because just two organizations operated at the "regional" scale, and we observed no differences between the groups.

Identification of primary roles played by different actors

Finally, we estimated how consistently interviewees identified different types of organizations as playing particular roles in supporting the implementation of prescribed fire. We did this by calculating the proportion of organizations within each organization type that were identified as playing each actor role. For example, interviewees identified five fire protection districts helping to support prescribed burning, four of which they described as providing prescribed burning labor support. Thus, we calculated that there was an 80% consistency with interviewees identifying prescribed

Table 3 Actor organization types and categorization

Type of organization (and number)	Example organizations
NGO • Local (12) • National/regional (5)	Chambers of commerce Forest and watershed groups National and international environmental and forestry organizations
Coalition • Local (7) • National/regional (3)	Watershed and fireshed coalitions Burn teams Forest Management Task Force Fire Learning Network
Local government (7)	City and county governments County health departments
Fire protection district (5)	Fire protection districts Fire and Rescue Unit
Private landowner (3)	Private landowners
State agency (11)	State environment departments Watershed Enhancement Board Division of Fire Prevention and Control State universities
Federal agency (10)	Bureau of Land Management Natural Resources Conservation Service US Fish and Wildlife Service National Park Service
Private business (4)	Forestry and wildfire suppression contractors

burning labor support with fire protection districts. Similarly, just one of out of the five fire protection districts was identified by interviewees as helping with communication and advocacy about prescribed fire (20% consistency). The higher the number, the more commonly that type of organization was described by interviewees as playing that particular role. We provide supporting quotes to explain the identified roles, in text and in Fig. 3.

These consistency estimates should not be treated as absolute representations of organizations' work, because actors may play roles that were not salient to interviewees at the time of the interview. Rather, these consistency values can be interpreted as a measure of the relative salience of different roles that each type of organization has played. The percentages shown in Table 4 help us to describe the relative frequency of themes, rather than provide a detailed quantitative assessment of our qualitative data.

Results

Below we report our findings on the extent and nature of cooperative partnerships in each of our four case study areas working to accelerate the application of prescribed fire. Our findings are organized into two sections: (1) description of actor organizations (number, scales, and types of actors), and (2) roles of organizations (identified by interviewees) in supporting the implementation of prescribed fire on our case study units.

Actor descriptions

Number and scales of cooperative actors

Across all four case studies, interviewees identified 67 unique cooperative actors who supported application of prescribed fire. Nineteen of these 67 actors were identified multiple times across multiple cases. For example, interviewees identified The Nature Conservancy as a cooperator in all four cases (different state chapters). Including these multiple-mention organizations in the individual counts for each case study, interviewees identified an average of 21 cooperative actors per case study. Individual case studies ranged from 24 identified actors in San Juan NF and 14 identified actors in Rogue River-Siskiyou NF.

The cooperative actors operated at small and large geographic scales: 47% operated at the local scale ($n = 36$ out of 76 mentions of actors in different case studies), 15% at the state scale ($n = 11$), and 38% at the national or regional scale ($n = 29$).

Types of cooperative actors

Identified cooperative actors represented a variety of sectors (Table 3) with nongovernmental organizations most common ($n = 17$ out of 67). Interviewees also identified state agencies ($n = 11$), coalitions ($n = 10$), federal agencies ($n = 10$), local government ($n = 7$), fire protection districts ($n = 5$), private businesses ($n = 4$), and private landowners ($n = 3$). Coalitions were defined as a group

Table 4 Actor types linked to roles in supporting prescribed fire accomplishments, as identified by interviewees. Percentages shown in table represent the proportion of each type of organization that interviewees identified as performing each respective role. The darker the shade, the greater the proportion of organizations in that type that were conducting the identified role. For example, interviewees identified five fire protection districts helping to support prescribed burning, four of which they described as providing prescribed burning labor support. Thus, we calculated that there was an 80% consistency with interviewees identifying prescribed burning labor support with fire protection districts. Shading is by percentage, in quartiles, with zero unshaded and 75% and above as the darkest shade. It is important to note that the percentage is listed in the table help provide perspective about the relative frequency of these different roles, but are not intended to be a quantitative analysis of our interview data (as described in the Methods)

Type of organization (and number)	Communication, outreach, and advocacy	Prescribed burn labor	Fundraising	Prescribed burn expertise	Neighbor burning	Forestry labor	Project coordination, administration, and priority setting	Monitoring, survey, and compliance	Equipment	Technical assistance and science
NGO (17)	59%	35%	53%	35%	24%	18%	29%	6%		6%
State agency (11)	55%	36%	55%	36%	36%	27%	45%	36%	18%	
Coalition (10)	60%	30%	20%	20%	10%	10%		10%	10%	10%
Federal agency (10)		50%	30%	30%	40%		10%		20%	20%
Local government (7)	43%	14%	29%		14%	14%		29%	29%	
Fire protection district (5)	20%	80%		40%	20%	20%				20%
Private business/ contractor (4)	25%	75%		25%	25%	75%	25%			25%
Private landowner (3)					67%	33%				
n	27	26	22	18	18	13	12	8	7	6

of actors (NGOs, government, and other entities) that had come together for a common purpose, such as forest and watershed restoration. This is distinct from a network where different entities might be connected due to areas of common interest, but are not necessarily focused on achieving one common purpose. Coalitions often pool their resources (e.g., sharing equipment or trained personnel, co-writing communication or outreach plans) or co-create visions, advocacy, or support coalition staff for a common purpose.

Notably, interviewees did not identify any partnerships between our case study units and Tribal governments, despite recognition by interviewees that nearby Tribes were engaging in cultural and prescribed burning on their sovereign lands. One interviewee described

working to incorporate cultural burning into the Forest's plans. Another interviewee explained that the Bureau of Indian Affairs had their own burn program and therefore they didn't share resources with each other. They said:

> It [BIA] is a different agency. It's a different budget. In the past there hasn't been a whole lot of involvement and I don't think it's due to any kind of funky relationships by any means. I think it has a lot to do with taking care of employees in-house, so like when [BIA] burns, they really don't need a whole lot of resources just because not a whole of urban interface involvement and the resources that they would need are just down the street.

Fig. 2 Roles played by organizations in supporting prescribed burning organizations in supporting prescribed burning. Figure illustrates the relative frequency with which interviewees identified different roles. Each square represents a cooperative actor identified in that specific role. Colors vary by role type

Actor role description	In interviewees' words
Communication, outreach, and advocacy	
• Advocacy and lobbying to decision-makers to support prescribed fire • Outreach and communication about prescribed fire and smoke events • Educational programming for public audiences about the role and need for prescribed burning	"…adaptive wildfire community representatives [can] kind of be the face and the voice of the Forest Service as opposed to some non-personal type of flyer you send out… building those relationships with our partners, communicating what their needs are, and what their planned activities are going to be." "They are definitely involved in getting the word out to people - and especially local people - in regard to the importance of fire and how to go about it and drumming up interest and knowledge." "The [local NGO partner] has been a really important partner… They really understand, especially because of the last couple of summers, the threat of fire and what smoke can do economically…They've really helped keep the fire and watershed issue front and center with the business community. I think that's been really helpful for the public to see." "We created a whole program about smoke, coping with smoke… to support the prescribed burn program in getting people information about smoke and health, and staying healthy during smokey days when we're burning…The [local NGO partners] ha[ve] been a huge supporter of that."
Prescribed burn labor	
• Providing prescribed burn workforce labor, including crews and additional trained people to help burn • Recruiting and/or providing prescribed burning training, like Prescribed Fire Training Exchanges (TREX) • Recruiting and/or providing insurance for volunteers to assist with burn events	"Sometimes [agency employees] are available, sometimes they're not. [Contractor crews], if we call them up, boom, they're there. We know what to expect. They know what to expect. We plug them in, and they work. There is no chance that they're going to get pulled away." "This past summer, the only way they were able to do a couple of their larger, two, three, four-thousand-acre burns was because they were able to staff it with a lot of state and other resources… they plan proactively upfront to make all of that happen." "[TREX is] a way to get some short-term capacity…. [but] the process that leads up to day one of the TREX is actually, to me, far more important than what happens at the TREX itself…that process is engaging the vocal partners, finding resources, tapping people's expertise and resources in important ways… Relationship building is what lasts. Partnerships remain and that tends to lead to… additional cooperative burns, thinking outside the box… I see particularly landowners, volunteers, and smaller non-profits get the TREX training and then [are] available for the agencies and non-profits who are trying to burn."
Prescribed burn expertise	
• Sharing specialized prescribed burning expertise (e.g. burn bosses or inspectors) • Smoke and weather expertise • Building local expertise through specialized training	"We actually have some of their [TREX] burn bosses cover as prescribed fire burn boss on our prescribed burns. Not during the implementation phase, but during the holding phase… We can't do this without our partners…." "We have partners from [NGOs and coalitions] and many of these have significant qualifications… If we would have to pay for those employees, we'd have another probably 60 or 80 thousand dollar deal just for the work that the partners contributed."
Fundraising	
• Providing direct financial support for prescribed burning and related efforts • Helping to fundraise for prescribed burning projects	"In order to get a lot of that fuels work done, it needs to be supplemented with outside funding, not just what's generated during the project. This is where the partners have really been very helpful." "The biggest partner I will give you is [state agency]…they've helped fund some of our work. We had a Good Neighbor Authority-like agreement before there was Good Neighbor Authority, and now we have a Good Neighbor Agreement with them. So, we use state dollars from [them] for some burns that were wildlife habitat improvement. And then state forestry has… fund[ed] some key mechanical work that is prior to entry with prescribed fire and some of it prescribed fire work. So yeah, we've got some pretty active partnerships, mostly with state government."
Neighbor burning	
• Supporting private landowners who want to burn on their own land • Administering burns on neighboring land • Coordinating burns on different jurisdictions	"Sometimes the private landowner comes and says, 'I want to do prescribed burning,' [or it's me] convincing the landowner to do it…. [The state has] a cost share for the landowner to go in and do vegetation management. So, they'll go in and pile or remove dead trees… Our forests are so overgrown, the risk is really high… But if one of our programs works with the landowner to get a lot of that out of there, then I can help maintain that work with prescribed fire." "Our organization is really focused on private lands. But, of course, especially where we're touching [public land]… wildfire, water and wildlife don't recognize that boundary. And so, if we can work together and push our mutual objectives further, then that's really worth it to me. Working within our partnerships and working collaboratively I think gets us all where we want to go, faster and better."

Actor roles

Interviewees described a variety of different roles that actors played in supporting prescribed burning, which we grouped into ten themes (Fig. 2). The most common roles were providing communications support ($n=27$ organizations of 67 total) and prescribed burn labor ($n=26$). Other common roles included fund raising assistance ($n=22$), prescribed burning expertise ($n=18$), and helped burning on neighboring lands ($n=18$). A smaller number of actors provided forestry labor ($n=13$); project coordination, administration, and priority setting assistance ($n=12$); monitoring, survey, and compliance support ($n=8$); equipment sharing ($n=7$); and technical assistance and science support ($n=6$) (Fig. 3).

Interviewees indicated that similar actors (e.g., same scale and type) played similar roles across case studies (Table 4). Some actor types (NGOs, state agency, coalitions) generally played a wider variety of roles compared to others (e.g., private landowners, businesses, and fire protection districts). We also found that, when viewed by *actor type*:

Fig. 2 (continued)

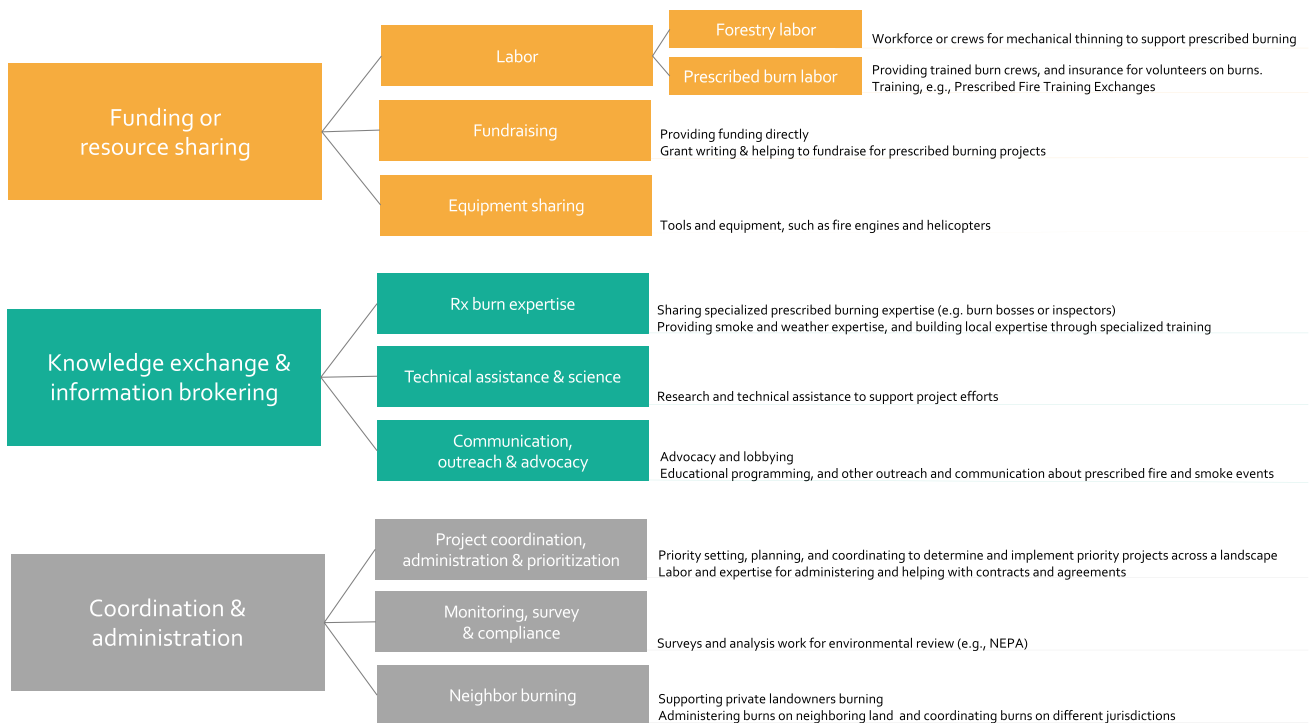| Forestry labor	
• Workforce or crews for mechanical thinning to support prescribed burning	"We use contracted crews here a lot on the [forest], some of that's for our mechanical thinning, some of that's for our prescribed fire… The contracted crews are a little more expensive than our agency employees there... that work's getting done, but it costs a little more."
Project coordination, administration, and priority setting	
• Priority setting, planning, and coordinating together to determine and implement priority projects across a landscape	"We want to be planning projects that cross jurisdictional boundaries and where we can just keep lighting down the hill and cross through [federally managed land] and cross through private all on the same day with the same project… Partnership agreements helps facilitate that. But they're also setting us up… to help build that environment where we can start seeing more of those multi-jurisdictional burns on the ground."
	"it was a collaborative proposal. Mostly put together by [partner NGO] but with support from [partner NGO], and the National Forest. We kind of all sat in on what that could look like. Details were all hammered out by [partner NGOs] mostly."
• Labor and expertise for administering and helping with contracts and agreements	"We have sat down with [USFS] quite a few times to write up agreements, which have allowed us to incorporate fire departments and counties into the federal program so that the feds can actually funnel their money through us and provide funding, such as overtime, pay for equipment, that sort of thing, for the counties and departments so that they can go out and burn with the federal partners and be compensated."
Monitoring, survey, and compliance	
• Surveys and analysis work for environmental review (e.g., NEPA)	"We started exploring utilizing contractors to come in, whether it's enterprise or private, to come in and do some of these surveys."
Equipment	
• Tools and equipment, such as fire engines and helicopters	"[Federal agency] are in the same boat we are. They lost all of their prescribed burning staff and their funding… But we tend to try and share resources. When they do need something, they'll call us up and we'll send engines or crews in to help them out. And [when] we need some help they'll send their resources out if they have them."
	"We support each other. We have mutual aid agreements so we both respond during a wildfire and those same crews and engines are available for backup and support when we do prescribed fire. So, I think we're in a really great place as far as our working with our partners."
Technical assistance and science	
• Research and technical assistance to support project efforts.	"They brought in a researcher from [university] to talk about the differences, between a wildfire smoke and prescribed fire smoke, health impacts, duration, all that good stuff. They really did a fantastic job of setting up this three-part series saying, 'Hey folks, we're going to have fire this year, whether it's wildfire or prescribed or maybe both'…. having partners like that community, you can't replace it."

Fig. 3 Descriptions of actor role themes in supporting prescribed burning

- **Fire Protection Districts and private businesses** were most commonly associated with sharing resources through providing prescribed burn labor (as well as forestry labor for private businesses).

- **Coalitions** were most commonly identified as providing communication support, with a few organizations also resource sharing through prescribed burn labor.

- **State agencies** were most commonly associated with providing communication and funding/fundraising support, and some were also identified as helping with project coordination and prioritization.
- **NGOs** most commonly filled communication, advocacy, providing funding, and fundraising roles.
- **Local government** most commonly provided prescribed fire communication, outreach and advocacy, and some fundraising, monitoring, and equipment support.
- **Other federal agencies** (e.g., federal agencies that differ from the case study units) conducted a more limited set of tasks than local-level actors. They were not strongly associated with any particular roles but were sometimes associated with providing prescribed burn labor.
- **Private landowners** were most commonly associated with burning on neighboring lands.

If viewed by *role*, a number of patterns were found:

- **Communication and advocacy** tended to be done by coalitions, NGOs, and state agencies.
- For example, in Oregon, several interviewees discussed the value of non-federal partners' engagement and outreach in the community for building social license for their prescribed burning. In Colorado, an interviewee explained how a local nongovernmental partner was supporting their work as,

> *[They] did flyers out to…like a 10-mile radius to all the public and it was piece of paper saying, "Hey, we're planning to do a prescribed fire in September. This is what you can expect for this amount of time. And this is why we're doing this [prescribed fire]." And [they] explained it very well…these adaptive wildfire community representatives [can] kind of be the face and the voice of the Forest Service as opposed to some non-personal type of flyer you send out.*

- In New Mexico, interviewees described their Fireshed Coalition, along with an NGO partner as conducting community outreach, organizing events for community members to ask questions about their prescribed fire work, and "*really assisting and promoting that outreach and backing up the city and Forest Service*" for their collective projects.
- **Labor or trained workforce support**: Prescribed burn labor was linked to fire protection districts, private contractors and, to a lesser extent, other federal agencies, while forestry labor tended to be provided by private contractors. For example, an interviewee in the California case described the use of contracted crews to do mechanical thinning work, "*We use contracted crews here a lot on the Sierra, some of that's for our mechanical thinning,*

some of that's for our prescribed fire….[so the] work's getting done, but it costs a little more than our [agency] employees here."

- In New Mexico, an interviewee explained,

> *There is a big role to play for the nonfederal partners in helping get more burning done…Just this past fall through [the]cooperative model, we [were] able to bring 23 non-Forest Service fire fighters on to a Forest Service burn…We were about almost half [the total burn workforce] and we weren't just a grunt force, we also had single resource bosses and task force leaders plugged in. We were pretty well meshed in the structure. I think the more partners that can support the fed[eral agencie]s, the more feds can burn because I don't think if we didn't provide those 23 individuals with those qualifications, the [agency] wouldn't have burned or if they did burn, they wouldn't have done the hard part that has this tricky ridge that they needed people on….*

- **Fundraising and funding support** tended to be provided by state agencies and NGOs. In New Mexico, a state agency partner described their fundraising support as,

> *[Our agency is] working with our partners to promote fire and prescribed fire as much as possible…Sometimes that means helping to write grants and agreements to promote the use of fire directly.* They went on to explain how their agency also sometimes directly funds this work as well, saying, *…there's been a lot of times where…we have shared interest in a landscape with, say the Forest Service, and we'll help fund the NEPA (National Environmental Policy Act, assessment of environmental effects of proposed federal agency actions) document being created. And then we'll sometimes follow up with the archeology surveys...*

- In California, state agencies have provided grant funding to accelerate federal forest restoration work. One interviewee explained,

> *We have a few grant sources that we currently have that we're utilizing. Two of the big ones are from the state. [State agency] had set up some grants for some work to be done in certain areas with certain criteria. We applied. We got some grant funding to do some planning of projects and implementation.*

- **Prescribed fire expertise** was linked to many different types of actors (except local government and private landowners). For example, an agency interviewee in Colorado discussed key nongovernmental partners for this work, explaining, " *…we actually have some of their*

[environmental nongovernmental organization] burn bosses cover as prescribed fire burn boss on our prescribed burns. Not during the implementation phase, but during the holding phase. So it works. We can't do this without our partners."

- Federal agencies were sometimes seen as having expertise that they could share with other partners to increase the overall pool of trained prescribed fire experts. In California, an interviewee explained,

CalFire is trying to really get back into the prescribed fire again. When you're dealing in timbered landscapes in the central Sierras, we don't have a lot of people that have the techniques to burning timber, where the Forest Service does. So, by sending our folks out to work with their burn folks, it's giving my folks those skills and techniques to get the right effects in the timber with prescribed fire.

- **Neighbor burning** was mostly linked to private landowners. One key example of this in Oregon was a non-profit grassroots organization specializing in forest and watershed restoration projects being able to conduct prescribed burning on private lands in key project areas. Sometimes landowners realized they wanted to implement fuel treatments on their land after observing work done on federal or state land. One Oregon interviewee explained, "*These jobs we're doing right now, I got adjacent land owners calling me: 'Oh, that work you're doing is so great up there. What will it cost to do [similar] work on my property?*'" However, interviewees reported that, more often, agencies worked to engage nearby landowners for strategic reasons, as one California interviewee explained:

Sometimes the private landowner comes and says, 'I want to do prescribed burning,' [but] It's more me actually going out there and finding the strategic place that I think we need to do it, then convincing the land owner to do it… So, our forests are so overgrown, the risk is really high in, there's so much fuel. But if one of our programs works with the land owner to get a lot of that out of there, then I can help maintain that work with prescribed fire.

- In some cases, interviewees also discussed how some federal agencies had agreements in place to burn on each other's lands, especially with BLM being able to conduct prescribed burns on other federally managed lands, such as National Park Service. In others, they discussed dividing up prescribed fire implementation responsibilities on shared boundaries, such as in California, "*the Forest and CalFire had always been really good at working across boundaries on fuel breaks, [saying] 'We'll do it this [part this] year, you do [the other] next year.*'"

- **Project coordination and prioritization** was most often identified with state agencies but was not strongly tied to any group as it involved a wide variety of roles. This work was often linked to other roles such as outreach, communication, and resource sharing. Interviewees described partner actors coordinating priority setting activities for the landscape, and leading planning, and coordination among actors for determining and implementing priority projects across a landscape.

- **Monitoring**, **compliance, and equipment and technical assistance** were not strongly linked to any actor types, but mostly came from actors operating at the local or state level. In Oregon, interviewees talked about how their local partners (e.g., NGOs and others in their partnership) had supported monitoring efforts from the beginning of their collective work, including,

…providing different levels of workforce that you can draw from. I'm able to have them go look at a unit if I need to. They've been really strong in helping us do monitoring, before monitoring and after monitoring. There's pieces of that that we've just broke out from the beginning. It seems to work really well, all in all.

Typology of actor roles

Overall, three overarching roles can be identified from the ten themes we grouped actor roles into conducting to support prescribed burning: Funding or resource sharing; knowledge exchange and information brokering; and coordination and administration (Fig. 3). The overarching role of funding or resource sharing included the roles of fund-raising assistance, providing prescribed burn or forestry labor, and equipment sharing. The overarching role of knowledge exchange and information brokering included the most common theme of providing communication support, as well as prescribed burning expertise, and technical assistance and science support. The overarching role of coordination and administration includes helping burning on neighboring lands, project coordination, administration, and priority setting assistance; monitoring, survey, and compliance support.

Internal coordination within the Forest Service and BLM

We do not consider collaboration among units within the federal agency or agencies that correspond to each case study as an external collaboration or partnership in the context of this research. However, it is important to highlight that interviewees across our case studies often described a wide range of collaborative work with other units within their own agency. Interviewees in Forest Service case study

units described how they shared funding, equipment, staff, fundraising, and outreach tasks with neighboring or nearby forests, research station(s), and Regional and Washington Office staff. One internal agency coordination strategy that interviewees described as a successful model was the "TRI-FRI" agreement which allowed the Cibola, Santa Fe, and Carson National Forests in New Mexico to pool their resources, workforce, and accomplishment targets (the required levels of accomplishments for prescribed burning, e.g., hectares burned per year) in order to pursue priority projects across all three forests. One interviewee said, "*The three forests in northern New Mexico… establish[ed] the priorities and the folks who can help implement prescribed fire… to make sure that their priority project at least has the necessary resources… it seems to have worked out really well. There's a lot of passion there for this.*" Our BLM case study units similarly worked with other BLM units to leverage equipment and labor.

Discussion

This research shows that a range of actors with diverse capacities and resources (e.g., workforce, equipment, expertise) support cooperative networks that are working to implement prescribed fire across the US West. These actors operate at different spatial extents and governance levels to fill capacity gaps and work across administrative and jurisdictional boundaries. The actors are often necessarily nimble and responsive, working to fill specific, place-based needs to overcome challenges to supporting more prescribed burning.

We found that a majority of cooperative actors in our case studies were based at the local level, which underscores the value and potential of local collaborations, particularly given that many challenges in building and maintaining necessary partnerships for prescribed fire are often locally specific (Miller et al. 2020; Russell-Smith et al. 2019; Schultz and Moseley 2019; Schultz et al. 2019). Local-scale cooperators can help build "flexibility to adapt to local circumstances that capitalize on organizational strengths" (Kelly et al. 2019). Bridging organizations, like NGOs and coalitions, working within a networked governance structure can provide critical capacity for identifying and filling a variety of project needs. They can also connect actors so they can leverage their capacities to support implementing prescribed fire. We found that local NGOs were often involved in planning and prioritization, while coalitions (often comprised of many actors across the landscape) often conducted communication, outreach, and advocacy. Through these various activities bridging organizations can also help to build trust (Folke et al., 2005; Lubell et al., 2014), and social learning (Berardo and Scholz 2010; Hileman et al., 2018; Pahl-Wostl 2009).

Actors working at different levels were engaged in all stages of prescribed fire implementation, from planning and preparation to burning. For instance, interviewees said state and federal agencies shared resources, often by communicating through state-level collaborative forums. Case study units also developed regional partnerships at sub-state levels to pool their resources, such as the TRI-FRI agreement. This evidence suggests that collaborating actors are increasingly involved in shared decision-making, planning, and implementation on federally managed forestland, thus filling key roles within a multi-level, networked governance system (Abram 2019). Researchers have found the same in other natural resource management contexts that transcend jurisdictional boundaries, such as fire management (Charnley et al. 2020; Greiner et al. 2020; Scarlett and McKinney 2016; Stoker 2006).

There has been limited research to date on the myriad roles different actors play within network governance, and we contend this area of inquiry bears further investigation. Hileman et al. (2018) noted in describing the importance of better understanding actor roles, writing that "Explicitly examining different forms of collaboration (e.g., planning, funding, implementation) and bridging ties (e.g., sectoral, geographic level, mandated/voluntary) would further enrich research on robustness in governance networks" (p. 695). Berdej and Armitage's (2016) social network configurations for bridging organizations identifies three different network configurations of bridging activities: collaboration, knowledge-exchange, and funding or resource sharing. Our work complements these previous efforts to build a typology of cooperative actor roles by identifying distinct types of roles that actors can play within networks for accomplishing prescribed fire (as illustrated in Fig. 3). This typology of actor roles can help to illuminate potential pathways to address capacity constraints in achieving wildfire risk reduction across landscapes. Yet, we also suggest that in networked governance systems there is a need to distinguish between those in bridging roles and other types of actors who bring capacities to key governance challenges but are not working as bridging actors or organizations. Berdej and Armitage (2016) note this as well, explaining, "understanding the organizations that occupy bridging positions, and how they utilize their positionality in a governance network is emerging as an important determinant of successful conservation outcomes (p. 1)". For example, many of the actors identified in this study did not serve in intentional bridging roles, but their roles were still a key part of the governance network necessary to implementing prescribed fire.

Actors in our study played a range of bridging roles (e.g., outreach and communication, planning, and prioritization), which is important to strong governance systems (Crona and Parker 2012; Hileman et al. 2018). They did not operate in an institutional vacuum, rather their approaches are shaped by contextual influences (Boakye-Danquah et al. 2018). Our

findings support prior work describing bridging and boundary organizations as a range of actors that "help facilitate governance processes that individual actors cannot address in isolation" (Hileman et al. 2018, p. 684, citing Bodin and Crona 2009; Brown 2013; Crona and Parker 2012; see also Davis et al. 2021). Organizations in our study supported prescribed burning efforts and performed roles adapted to local-level project needs, aligning with prior findings that organizations directly or indirectly provide resources and funding (Berkes 2009; Newman and Dale 2007), and operate at different levels (Davis et al. 2021; Jacobson et al. 2021; Berdej and Armitage 2016; Sternlieb et al. 2013). Bridging organizations vary in sectors and sizes and can broker information across a range of actors (Davis et al. 2021; Berdej and Armitage 2016; Schoon et al. 2017; Sternlieb et al. 2013), as NGOs and coalitions frequently did in our cases. In addition, clarity around the roles, functions, and interests of actors on all sides of a boundary can facilitate more effective collective action toward shared goals, across diverse jurisdictions (Jacobson et al. 2021).

At the same time, many actors in our study primarily brought capacity to support prescribed burning; in other words, some actors were purely working to fill capacity gaps. For example, the Forest Service or BLM might not have enough of a skilled workforce internally to conduct a burn, but by contracting with a private business, they were able to navigate institutional limitations to accomplish forestry or burning work. Similarly, Fire Protection Districts and some other federal agencies were providing these labor-intensive services as well. In some cases, actors coordinated activities at the same time, but did not necessarily bridge any boundaries. For example, our "neighbor burning" theme focused on private landowners and state and federal agencies coordinating logistics with other entities to each burn on their own lands.

In some cases, federal agencies might benefit from the support of bridging actors, but the agencies themselves cannot serve in this role due to their own limitations (e.g., legal mandates, lack of public legitimacy). As a result, they then engage an outside actor to fill this role. Examples include hiring an NGO or other actor to convene planning or decision-making meetings or working with a local NGO to support public education or facilitate collaboration with local landowners. This highlights the importance of diverse types of actors with diverse mandates, skills, and relationships working together in a networked and complex governance system. Additionally, this also suggests the value of having some redundancy in actors' roles as unexpected disturbances (e.g., staff turnover, change in legal mandates, shift in social license, catastrophic wildfire, other climatic changes) occur. Redundancy within a network can make it and its capacity to respond to crises more resilient (e.g., Jahn and Johansson 2018). By networks of actors considering how potential disturbance factors may affect actors within their own network, they can proactively build redundancy and contingency plans for a robust and resilient network that can withstand interruptions. The motivations for this range of actors to take on the roles they do is often responsive to emergent issues in their local area, the scale at which much innovation in forest management in disturbance-prone landscapes has occurred in recent decades (Schultz et al. in press). Actors may be motivated by events such as highly visible and catastrophic wildfires impacting drinking water infrastructure (Huber-Stearns et al. 2019), or the potential to work at an increased pace and scale with new strategies and potentially new funding sources from partners (Schultz and Moseley 2019).

Finally, Tribes were not noted by interviewees in our case studies as main partners despite increasing recognition of the importance of revitalizing traditional Indigenous fire stewardship practices on the land. Greater effort may be needed for federal land management agencies to develop new and advance existing partnerships with Tribal communities, strengthening intercultural growth and participatory land management (Russell et al. 2021). A deeper understanding of Indigenous fire stewardship and the authority and resources needed for Indigenous, Aboriginal, and Tribal people to integrate Indigenous fire stewardship practices into prescribed fire networks may support multiple stakeholders' and rightsholders' goals and objectives. This would strengthen both Western and traditional knowledge systems (Lake et al. 2017). We can develop more integrated approaches to coexisting with fire by developing and strengthening communication, understanding, and trust among partners and networks (Lake et al. 2017), as well as transforming Western knowledge systems and structures for burning.

Conclusion

We sought to explore cooperative actors' roles, bridging and otherwise, in the context of prescribed burning on federal lands in the Western United States. Our research can help organizations looking to increase the use of prescribed fire to more efficiently identify strategies to fill their capacity gaps and other needs through cooperative partnerships. Our work also deepens the understanding of the range of actors and diversity of roles they play in networked governance systems. Identifying specific actors, the different types of roles each might play, and how they work together in this arena can provide insights into the range of capacities and skills necessary to navigate challenges to implementing prescribed fire. Our case studies revealed local-level experimentation and innovations that align with Abrams' (2019) description of the "pragmatic problem-solving at local to regional scales that represents the creative heart of network governance"

(p.6). At the same time, even in networked governance, the influence of bureaucratic institutions and associated hierarchal systems is often still strong (Abrams et al. 2017). Governance systems in fire-prone landscapes across the globe must evolve and adapt to new structures for prescribed fire and other wildfire risk reduction; some innovations may not be easily integrated into existing institutional structures.

Wildfires have growing impacts on important human and ecological values across the globe, and the need to understand how to safely and efficiently allow fire to play its natural ecological and fuels management roles is of increasing interest. However, implementing prescribed fire at a meaningful spatial scale is rarely a simple process as it often requires a range of supporting actors to overcome capacity constraints and conflicts, address short- and long-term risks, and identify innovative strategies to accomplish burning. There is a clear need for improved understanding of social science aspects of prescribed fire, such as the need for prescribed fire research agendas that "include clear and prominent consideration of the full range of ways social science could help improve our understanding of prescribed fire management practices, the burden of intentional action, and how societies can better adapt to fire" (Hiers et al. 2020, p.11).

Strategic approaches for coordinated communication and decision making among diverse actors will be important for moving toward more long-term wildfire management strategies in the US and beyond (Greiner et al. 2020; Schultz and Moseley 2019). The ability to increase organizational recognition of and engagement in networked wildfire governance systems that can tailor partnerships and actor engagement to fit local contexts and organizational landscapes will be critical to successfully improving ecosystem resilience and reducing future wildfire risk.

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