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Collaborative Action in Informal Social Networks of Wildfire Managers in

Northwestern Wyoming

by

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A thesis submitted in partial fulfillment of the
requirements for the degree of

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in
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ABSTRACT

Wildfire is a cross-boundary, collective action issue. Previous research has demonstrated the importance of collaborative relationships in wildfire for purposes such as increasing capacity, trading information, and facilitating landscape-scale mitigation projects. However, a stakeholder's location in social networks, as well as personal factors, may impact their collaboration. Furthermore, stakeholders must prioritize their own organizational goals and responsibilities, which may differ from those of their collaborators. I used interview and survey methods to investigate these questions in the context of wildfire management professionals in northwestern Wyoming. For the interviews, I selected 12 individuals with high betweenness centrality who were involved in wildfire management in different organizations and locations throughout the study area. I used semi-structured interviews and asked participants to describe how they use collaboration to accomplish both collective and organizational goals for wildfire management. I found that managers' answers to this question could be divided into four themes: (1) Deciding when collaboration is and isn't the right tool, (2) Utilizing jurisdictional and organizational differences, (3) Finding or designing multi-benefit projects, and (4) Choosing collaborators and building relationships. For the survey, I used chain referral sampling and asked about managers' participation in 8 collaborative actions, as well as their scope and focus of work, their gender, their role in wildfire management, who they worked with most frequently. I then modeled managers' participation in the collaborative actions using betweenness centrality, gender, focus, scale, and role as predictors. I found that higher betweenness centrality, a focus on

wildfire, and working at the scale of multiple communities or jurisdictions all increased collaboration. Holding the self-identified roles of coordinating across jurisdictions or interests, engaging with landowners, providing leadership or authority, and responding to emergencies also increased collaboration. When all of the variables were combined in a single model, I found that working at the multiple community or jurisdiction scale and holding engaging, coordinating, or responding roles had the most significant impact on collaborative action in a combined model. I found that managers who identified as women had lower collaborative scores, possibly as a result of gender bias in the natural resource and wildfire fields. I also found that men were much more likely to nominate other men in the chain referral portion of the survey, suggesting that gender bias may influence research using this method.

Dedicated to

Antonio Bezerra, Carlee Steppe, Carissa Adams, Lukas Badger,

Serena Walker, and Briana Cairco-Cary

ACKNOWLEDGEMENTS

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CHAPTER 1: Introduction

Fire is a natural and essential part of many ecosystems, including in the western United

States (Bowman et al. 2011, Scott et al. 2014). From naturally occurring fires due to

lightning strikes, to managed burns led by Indigenous people, fire has impacted the

evolution of plant, animal, and human communities for millennia, but the context within

which humans approach wildfire is changing (Calkin et al. 2015). As human communities

expand into fire-prone landscapes, this leads to both an increase in human-caused fire

ignitions and an increase in fire risk to humans and human values (Downing et al. 2022,

Radeloff et al. 2018). Climate change, community culture, and different political

structures can all influence the way we prepare for wildfire (Bowman et al. 2011,

Carpenter and Brock 2008, Paveglio et al. 2015). However, these differences do not

change the fact that wildfire affects people across jurisdictional boundaries, and that

neighboring land managers' decisions impact each other's risk exposure. Because of this,

wildfire management is a collective action problem (Charnley et al. 2020, Hamilton et al.

2019). The challenge is facilitating collaboration on wildfire risk mitigation between

people and organizations with different perspectives, missions, circumstances, levels of

knowledge, connections to the land, and resources (Paveglio et al. 2012). How do people

work together to create healthy relationships with fire-prone landscapes? The answer to

this–just like fire behavior and human culture–depends on where you are working. Even

national efforts to encourage and facilitate collaboration, such as the National Cohesive

Wildland Fire Management Strategy (USDA and USDOI 2014), acknowledge the

importance of local action led by local people engaged with the local culture and context.

In this project, I investigated two separate but related questions. The first concerns the ways that people work collaboratively on wildfires while still working towards the goals outlined in individual organizational missions or plans. I asked: how do wildfire managers use cross-boundary collaboration to achieve organizational goals? I wanted to learn what managers thought about when they approached collaborating with people outside of their organization or their region, and what local context influenced their decisions. The second question concerns what leads to effective collaboration–what makes people work on time consuming and sometimes resource intensive efforts such as joint research or management projects and memorandums of understanding. In particular, I was curious about how a person's professional relationships (measured through a metric called betweenness centrality), job characteristics, and personal factors impacted their collaboration on wildfire. I asked: how do network position, gender, scale and focus of work, and role influence the cross-boundary collaborative actions of wildfire managers? The main goal of this research is to affirm, improve, and share strategies that, while not universal, can inform wildfire management practice in similar locations.

I addressed these questions in the study region of Northwestern Wyoming. This region contains multiple National Forests and National Parks and was identified as a hotspot for wildfire risk transmission from USFS to other land jurisdictions (Evers et al. 2019). It is a popular recreation center, and its forests–including aspen, spruce-fir, and Douglas-fir forests–are adapted to infrequent, high-intensity fires (Scott et al. 2014). This region is important to study not because it is emblematic of other regions facing risk from wildfire, but because its struggle to adapt to its unique relationship with wildfire is one that is

being faced all over the world. As other researchers have pointed out, wildfire management must arise out of and adapt to local human culture and ecological context (Paveglio 2021); this region provides an example of how the people of Northwestern Wyoming are adapting to wildfire in their particular context.

In Chapter 2, I first introduce the background for my qualitative research. I discuss collective action and collaboration, including literature that emphasizes the importance of collaboration in natural resource management and literature that questions how effective collaboration is in achieving management goals. I review literature on the influence of organizational, community, and personal differences on collaboration, and I also incorporate literature on polycentric governance and its relevance to wildfire mitigation networks. I then describe my qualitative methods, which involved semi-structured interviews with wildfire managers in the study region and a general inductive method of analysis. Next, I present and discuss my results, organized into four main themes and contextualized with literature. I then describe the main implications of these findings for wildfire management. Finally, I conclude the chapter with a brief overview of my findings and their implications.

In Chapter 3, I introduce the background for my quantitative research. I review literature on collaborative behavior and social networks, specifically in the context of wildfire management. I also discuss the influence other factors can have on collaboration. Next, I describe my quantitative methods, which involved using a web-based survey, distributed via a chain referral method, to both build a network of wildfire managers in the study region and to collect data on those managers' collaborative behaviors, gender, scale and

focus of work, and roles. I then created 5 generalized linear models (GLMs) to describe the relationship between collaborative behaviors and managers professional relationships, job characteristics, and personal factors. After presenting the results of these models, I then discuss those results in the context of the literature on social network position, gender, and collaboration. Finally, I conclude the chapter by reviewing my findings and their implications.

In Chapter 4, I describe the ways that these two studies, the qualitative and quantitative pieces, work together to explain what makes collaboration in wildfire management happen, and what makes it effective. I briefly review the main findings and implications of both chapters and describe my contribution to the literature. The interviews allowed me to explore themes and answers that may be unique to this study region, building a narrative answer to my research question that could contain variables I may not have thought of myself as an outsider to the study region. Meanwhile, the survey allowed me to test specific hypotheses regarding quantifiable variables. Together, these methods produced a more nuanced and detailed answer to my research questions than either could have accomplished alone.

Taken as a whole, the main contributions of my research include the following:

1) describing four strategies that wildfire managers employ to promote successful collaboration on wildfire management while simultaneously progressing individual organizational goals;

2) empirically describing the influence of wildfire managers' professional relationships, specifically the degree to which they connect others who are otherwise disconnected (called betweenness centrality) and collaboration, where higher betweenness centrality resulted in more collaborative action;

3) demonstrating that gender bias may influence both collaboration in wildfire contexts and researchers' ability to understand who is connected to whom in wildfire management, underrepresenting the contributions of women; and

4) empirically describing the roles that foster increased collaboration in wildfire management, namely roles that include coordinating across jurisdictions or interests, providing leadership or authority to address fire risks, engaging landowners or homeowners about fire, and responding to emergencies when called.

These results could help inform hiring and training strategies for organizations engaged in wildfire management, helping to target the specific factors that help increase cross-boundary collaboration. It should also motivate organizations to address gender bias in their workplaces and in their fields more generally, ensuring that all workers are recognized and supported in their work. Research should further investigate the role of gender bias in collaboration and in chain referral methodologies. Finally, this research could facilitate the formation of best practices for cross-boundary collaboration on wildfire in the study region, encouraging managers to pursue effective projects and relationships.

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CHAPTER 2:

Strategies for building successful collaboration in wildfire management while meeting organizational goals

ABSTRACT

Wildfire risk mitigation is a cross-boundary issue, requiring collective action on the part of managers and landowners to address. In northwestern Wyoming, as in other regions, managers must balance the need for healthy forests with the need for residential and recreational safety. Working together across boundaries towards the overarching goal of fire adaptivity may be challenging in the face of different organizational missions and directives. I used semi-structured interviews with highly collaborative wildfire managers in the study region to understand how managers use collaboration for both collective and individual organizational goals. I found four main themes in answer to this question. Managers work towards successful collaboration by (1) deciding when collaboration is and isn't the right tool, (2) utilizing jurisdictional and organizational differences, (3) finding or designing multi-benefit projects, and (4) choosing collaborators and building relationships. These results reveal that managers use collaboration as one of many tools at their disposal, and that they understand the conditions under which it works well for their needs.

1. INTRODUCTION

1.1 Wildfire as a collective action problem

Wildfire risk reduction is a collective action problem that requires cross-boundary collaborative efforts to effectively address (Charnley et al. 2020, Downing et al. 2022). Fire management strategies since the colonization of North America have created a positive feedback loop, where increased development in fire prone ecosystems leads to increased suppression of fires that occur near those human values (Calkin et al. 2015). The suppression of all fire leads to the buildup of wildland fuels, which increases the likelihood of fires that threaten human values, and therefore necessitates more suppression (Fischer et al. 2016). This cycle can be described as a rigidity trap, meaning that whole socio-ecological systems are trapped in high stress behaviors that limit their ability to adapt to changing ecological and social conditions (Carpenter and Brock 2008). Significant effort has been made to de-emphasize suppression-only fire management tactics (U.S. DOI 2009, Manchin 2021). Collective action among landowners and managers, government agencies, and non-governmental organizations across landscape scales will be necessary to propel fire prone socio-ecological systems out of the fire suppression cycle and into a more adaptive relationship with wildfire.

Wildfire easily crosses boundaries formed by cities, states, or fences between neighbors. Simulations based on historical fire and current land cover in Central Oregon estimated that over 50% of burned area resulted from wildfires started across jurisdictional boundaries, and nearly 70% from different land tenures (Ager et al. 2017). A simulation

found that 50% of fires occurring on state, county, and Wildland Urban Interface (WUI) lands were transmitted from other land tenures (Palaiologou et al. 2019), and historical data reveals that 6.9 million ha of land burned between 1992 and 2019 due to cross-boundary fires (Downing et al. 2022). Human values are at greater risk the more intermixed they are with flammable wildlands, and these WUI designated lands are among the fastest growing land types in the United States. The proximity of humans and human values to forested land has implications for wildfire management, increasing the likelihood of human ignitions and making it dangerous to let naturally occurring wildfires burn (Radeloff et al. 2018).

Simulations show that areas like the WUI with high tenure heterogeneity (the "checkerboard effect") were more vulnerable to transmission (both incoming and outgoing) and faced greater hurdles to suppression and mitigation (Palaiologou et al. 2019, Downing et al. 2022). Part of the reason this "checkerboard effect" can be so vulnerable is that different land tenures tend to have different management goals and strategies for wildfire (Reiners 2012). Response diversity to wildfire only imparts resilience to the landscape when each of the various management practices in an area individually increase resilience (Charnley et al 2017). The best way to ensure that heterogeneous landscapes are resilient to fire is to promote collaboration in planning and management for wildfire.

1.2 Collaborative tools and polycentric governance systems

National initiatives such as the National Cohesive Wildland Fire Management Strategy
(USDA and USDOI 2014) attempt to promote and incentivize cross-boundary
collaboration. However, differences in organizational or personal perspectives can create
barriers even between people who have common goals, causing them to measure success
differently (Cheng and Randall-Parker 2017, Fischer and Jasny 2017). Differences in
community values and culture can also make it difficult to create landscape scale plans
that everyone is happy with. For instance, some communities may value economic
factors, such as the ability to obtain merchantable timber from a thinning project, where
other communities may be more concerned about wildlife impacts (Paveglio et al. 2015).
People may also exhibit contradictory values, such as valuing sport hunting and fishing
but not wilderness or wildlife habitat, or valuing recreation but not wilderness
designation (Clement and Cheng 2011). Even at the managerial level, organizations may
be siloed according to mission (i.e., fire protection vs. forest restoration), and limit their
collaboration to organizations with the most similar objectives (Fischer and Jasny 2017).

Effective collaboration requires the ability to incorporate those community specific
values and needs while working towards the common goal of resilience to wildfire.
Despite any number of reasons that people in the same fireshed may be different, they are
still linked ecologically and therefore need to maintain corresponding social ties to
facilitate coordination in adaptation (Hamilton et al. 2019). Charnley et al. (2020) found
that specific factors such as building on existing relationships, having dedicated staff

devoted to collaborative projects, having ample funding for fuels treatments, as well as the participation of neighboring landowners, incentivized landowners to participate in collective action for wildfire mitigation in several Joint Chiefs Landscape Restoration Partnership projects on the West Coast. Absentee land ownership and lack of outreach from federal partners may disincentivize landowner participation in wildfire risk reduction programs.

As managers collaborate towards the shared goal of wildfire resilience, it is important that they keep in mind that what constitutes adaptive capacity will vary from community to community. Generally, adaptivity necessitates connections both to local expertise and wider networks of knowledge. Paveglio et al. (2009) described the adaptive capacity of a community as the interaction between demographic/structural characteristics, place-based knowledge, informal interactions/relationships among residents, and access to scientific/technical knowledge networks. Paveglio et al. (2015) further emphasized the importance of community values in building wildfire resilience by outlining 4 community archetypes, describing the strategies for fire adaptation that may be most effective given various community factors including urbanization, trust in agencies, and formal versus informal communication networks.

At an organizational level, managers have to not only be responsive to the most acceptable management tactics to the general public, but also translate that into actionable collaboration between multiple stakeholders. Differences in organizational structure can cause purely logistical challenges in collaboration, such as the fact that

government agencies may move more slowly than non-governmental organizations or the private sector due to greater public scrutiny and regulatory constraints, or the fact that state land trusts and private managers need to be able to turn a profit in their management work, which constrains the types of projects they can take on (Reiners 2012). However, this diversity in approach can lead to fruitful collaboration when applied creatively. Steen-Adams et al. (2021) found that the USFS was able to address the mountain pine beetle outbreak in the Black Hills (1996-2016) by leveraging different strengths and tools available to diverse partners. In this way the USFS was able to combine their access to federal funding with the hiring freedom available to local Conservation Districts. This method of "filling in the gaps" can be a good way to coordinate between diverse groups. These collaborations can also serve to magnify the capacity of all organizations involved, as information is shared between groups and burdens are spread between them (Huber-Stearns et al. 2021).

Collaboration is a general term that can mean many different things. It can be applied in top-down contexts or rely on democratic processes to operate. It can also describe interactions that happen between laypeople, between managers, or in groups that combine both. The Incident Command System used to organize action during wildfire response uses hierarchical organization to facilitate collaboration. This is extremely effective in an emergency, where efficiency and speed are paramount, but in non-emergencies, top-down directives on wildfire management can fail to consider local context, which can negatively impact the effectiveness of these directives. Mitigation efforts and the building of fire-adapted communities may be better characterized as polycentric governance

systems. Polycentric governance systems are neither hierarchical like emergency response structures, nor decentralized, which would lead to fragmented management. Instead, they combine the local autonomy and expertise usually found in decentralized systems with the cross-boundary focus usually reserved to large hierarchical systems. In this type of system, there is the potential for organizations to supplement each other's capacity and knowledge and incorporate multiple viewpoints for more robust action (Kelly et al. 2019). One challenge for managers organizing for fire-adapted communities is that collaboration often has greater payoffs when a resource is in imminent crisis (Holley and Gunningham 2011). This means that fostering collaboration before a fire occurs can be more difficult than doing so during an active fire, particularly where landowners are involved. Interestingly, the polycentric systems that may form for mitigation efforts are probably not totally separate from the hierarchical structures important for emergency management, possibly indicating that managers rely on the strength of collaborative ties formed during a fire to continue work after a fire (Faas et al. 2019).

Social ties have to bridge the common divides present in wildfire networks, such as land ownership, the types of management activity communities are willing to participate in, organizational divides, and different ideas or knowledge about fire. The boundaries in wildfire management are bridged in multiple ways; Davis et al. (2021) outline four categories of Boundary Spanning Features (BSF): boundary people or organizations, boundary objects, boundary concepts, and boundary settings. Boundary organizations include fire science exchange networks, the US Fire Learning Network, or other

organizations that directly facilitate cross-boundary work on wildfire. Often, an individual person can serve as a cross boundary facilitator, and these people may be referred to as "bridgers" (Burt 2000). Boundary objects are things like memorandums of understanding, charters, potential operational delineations (PODs), or any other document or artifact that guides collaborative relationships. Boundary concepts include the ideas of cross-boundary risk transmission and resiliency, and are theoretical or conceptual framings for wildfire that, when shared between two parties, can help facilitate a common understanding of the problem and thus improved collaboration. Boundary settings can be physical or theoretical, such as the Cohesive Strategy and dialogues about "all-hands" or "all-lands" management. All BSFs are tools that managers can use to help mediate interactions with diverse stakeholders and collaborators. However, as Paveglio et al. (2015) highlight, not all of these tools will be appropriate or useful in all contexts.

The literature reviewed above suggests that (1) collaboration is important in wildfire management, (2) wildfire management should be community and context dependent to be effective, and (3) polycentric systems of governance for may be more appropriate than hierarchical ones for wildfire mitigation and adaptation, but that they are intertwined with response systems. The challenge for managers, then, is how to operate collaboratively in a diverse polycentric system while still accomplishing individual organizational goals.

1.3 Study Area

Northwestern Wyoming is one of 20 hotspots for wildfire transmission from Federal to non-Federal land in the US West (Evers et al. 2019). This is largely due to the hulking

presence of the Bridger-Teton National Forest on the landscape, and the many towns that are situated at its edges. However, the communities and social systems in this region do not form a cohesive cultural, or even ecological, landscape. Although large wildfires on the BTNF may impact different communities or social values in this landscape, collaboration will be impacted by more than proximity to the forest's boundaries. The forest itself includes four mountain ranges and five different forest types (dry spruce-fir, subalpine woodland, wet spruce-fir, aspen, and Douglas-fir), each with a different relationship to fire. Fire is considered regenerative for these forest types and their associated flora and fauna (Scott et al. 2014). However, suppression is necessary when fires approach the nearby towns or threaten other social values of the landscape. Scott et al (2012) found that a mean 207 ha per year burned in the Bridger-Teton National Forest between 1990 and 2009; without suppression, modeling found that this could have been 14,431 ha per year, indicating the incredible impact that suppression has on the amount of fire on the landscape. Agency land managers are increasingly attempting to allow a greater amount of fire through tactics that evaluate the risk of letting ignitions burn based on timing or location; however, in practice this can be difficult when human communities feel threatened. Increased collaboration and cross-boundary planning could potentially help hit this sweet spot of more fire for restoration purposes, while maintaining safety for humans.

1.4 Research Objectives

In this study, I investigate how managers balance striving towards organizational goals with the need for collective action on wildfire management. I conducted semi-structured

interviews with managers from diverse organizations and locations in the study area, asking about how they form and maintain collaborative relationships, what constrains collaborative action, and how they navigate their jobs. I analyzed the transcribed interview data, and here present four themes in answer to my research question.

2. METHODS

I conducted 12 interviews with professionals in Wyoming whose work involves wildfire management or preparedness at some level, and who I determined to be central to the wildfire management network in the region based on our previous survey work in the spring of 2022 (survey described in previous chapter). All interviewees worked in the western half of the state; we focused on this region due to its designation as a wildfire transmission hotspot (Evers et al., 2018), its large forested areas, and the existence of several fire-focused collaborative groups. I conducted all in-person interviews in June 2022, and all virtual interviews between June and September 2022.

2.1 Data Collection

I selected interview participants from among the professionals who took our survey, which employed a chain referral sampling method, earlier in 2022. Using the survey results, I constructed a network map of participants and calculated betweenness centrality scores for each person. Betweenness centrality describes to what extent a person connects otherwise disconnected groups of people within a social network. People with high

betweenness centrality scores are therefore likely to be collaboratively engaged with multiple groups and can potentially provide insights on collaboration in the network. I purposively selected interview participants from among those people who had the highest betweenness centrality scores, sampling for a range of job types and organizations. I contacted 17 people via email requesting an interview, and I was able to meet with 12 of them either in person or virtually. I interviewed 4 women and 8 men. Five interviewees were affiliated with the USFS (Shoshone, Caribou-Targhee, or Bridger-Teton National Forests), 2 interviewees were from local fire departments, and one interviewee each was from a town council, Wyoming State Forestry, Wyoming Game and Fish, a Conservation District, and an independent wildfire mitigation company.

The interview questions asked about how managers work across organizational boundaries on collaborative wildfire related projects. I asked how collaborative relationships start, how they decide which organizations would be most beneficial as collaborators, how personal relationships impact collaborative projects, and how effective they feel collaborative projects have been at increasing wildfire resilience in their area. Lastly, I asked them about their hopes for the future of wildfire resilience and collaboration in their area and invited them to share any additional thoughts with me. Most information interviewees shared was related to their jobs, but occasionally they expressed frustration with an organization or a particular person; I do not report the names or identifying information about interviewees to keep these comments confidential.

I acted as the primary interviewer on all of the interviews, with assistance from Liam Resener on eight interviews and Christian Heisler on one interview. Factors that seemed to encourage openness and trust from the participants included our positions as students and researchers, our interest in wildfire, and respondents' moderate familiarity with us from the earlier survey. We are all also white, and all of our interviewees were white. This is relevant particularly because the Wind River Reservation was a part of our research area, and we made an effort to include tribal fire managers in the survey portion of our study but were unsuccessful. It is possible that the fact that we were not from Wyoming could have created some distance between us and the participants, or even motivated some of the people I contacted not to accept an interview with us. In addition, the fact that none of us have on-the-ground experience in wildfire management could have created confusion during the interviews, or possibly led me to ask questions that were less pertinent to the participants than I anticipated.

I conducted seven in-person interviews in Wyoming during a two-week period in June 2022. We met at locations that were convenient to participants–outdoor cafes, parks, or places of work. An additional 5 interviews were conducted via Zoom (Zoom.us, San Jose, California), between June and September 2022 to accommodate our participants' schedules. The interviews ranged from 60-90 minutes. I used Otter (Otter.ai, Mountain View, California) to record and transcribe all in-person interviews. For Zoom interviews, I used Zoom's embedded recording function and then fed the audio into Otter.ai for transcription. I manually cleaned the transcriptions, removing non-word verbalizations, correcting the spelling of names and acronyms, and adjusting punctuation to make the

transcripts more readable. This clean-up also served as my first opportunity to read

through the transcripts and begin to familiarize myself with interview themes.

2.2 Data Analysis

I loosely adhered to the general inductive approach (Thomas 2006) to analyze my data,

starting with inductive coding and then gradually becoming more deductive as I became

familiar with the interviews and decided on main themes.

I first read through all of the interviews and wrote memos about what seemed most

striking from each interaction, what seemed important to the participant, and what my

impressions were of the interaction. I then used Atlas.ti (Atlas.ti, Berlin, Germany) to

open-code the 12 interviews, developing nearly 150 codes and sorting them into broader

code groups. I periodically downloaded the code list from Atlas.ti and put the individual

codes onto a Miro board (Miro.com, San Francisco, California), which allowed me to

group, combine, and rearrange codes into broader themes. After my initial reading of the

interviews, I pulled out the code groups that I found most salient. My final codes deviated

from my initial research questions as I allowed my growing understanding of the

interviews to modify my research question. With my revised research question and

codebook, I read through the interviews again to build a thorough understanding of how

these themes were discussed by my participants.

I report my findings using the themes identified through my data analysis. In the next

section, each theme is supported by verbatim quotations that serve as evidence of that

theme. I identified quotes only with the organization or job the interviewees are associated with, and not with their primary work location. I have also generalized some job titles to maintain confidentiality.

3. RESULTS AND DISCUSSION

Organizations involved in wildfire management collaborate in part because they have to. Interviewees described how in NW Wyoming's vast landscape, as elsewhere, achieving landscape-scale wildfire resilience requires coordination and cross-boundary cooperation. However, these organizations must reconcile the requirements of collaboration with their own mission statements, jurisdictions, and directives (Charnley et al. 2017, Head et al. 2016, Reiners 2012). My interviews focused on how managers use those collaborative relationships to serve the goals and directives they have. I have divided the answers into four themes: (1) Deciding when collaboration is and isn't the right tool, (2) Utilizing jurisdictional and organizational differences, (3) Finding or designing multi-benefit projects, and (4) Choosing collaborators and building relationships. These main themes are further divided into 2-3 sub themes each.
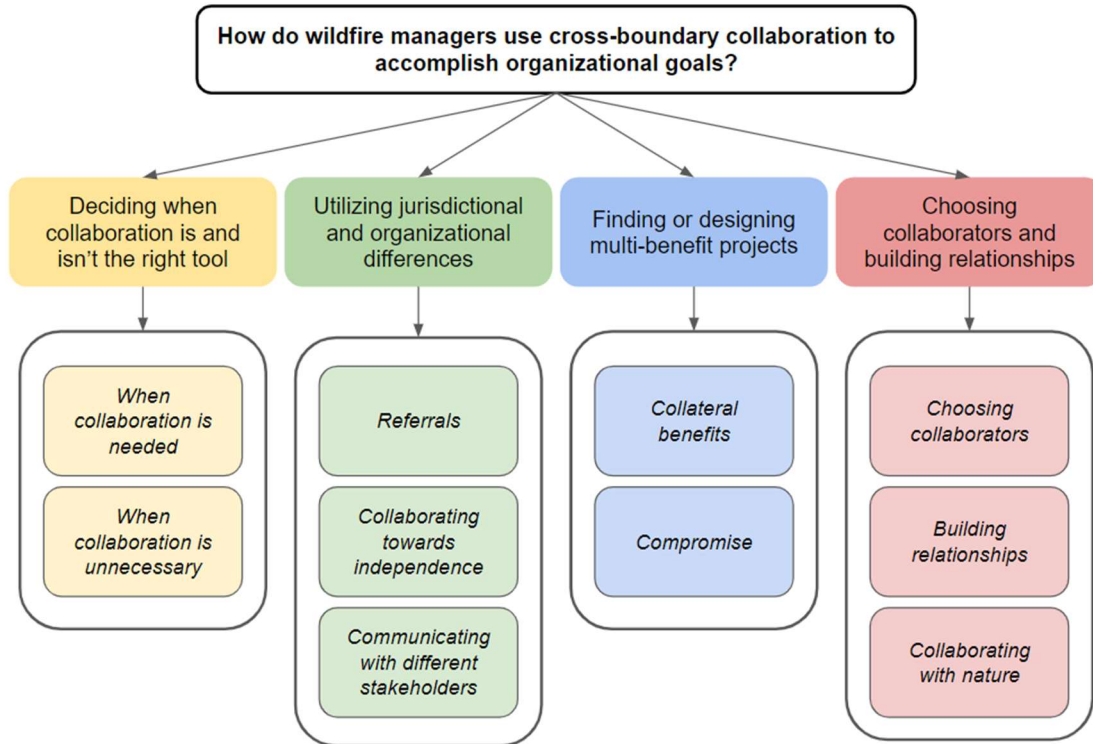
Figure 1. Diagram showing four main themes along with sub themes identified during interview

analysis.

3.1 Deciding when collaboration is and isn't the right tool

One of the first things highlighted by my interviewees was that organizations and

managers need to determine when collaboration is necessary. Several participants talked

about collaboration as an attractive buzzword that can be seen as an antidote to the siloed

decision-making of the past. However, interviewees also reflected that not all projects

benefit from collaboration, and that collaboration is a tool that comes with its own

pitfalls, a theme that has been explored in the literature (Koontz and Thomas 2006,

Lubell et al 2017). Collaborative decisions can take longer to reach, and organizations

can be at the mercy of other collaborators' timelines. To serve their own purposes, wildfire practitioners may need to take unilateral action.

One of the most-cited reasons to collaborate was to increase organizational capacity. Many participants, including one Fuels Management Officer (FMO) with USFS (a), talked about how much land there was to manage compared to how few people were tasked with managing that land: "Everybody's short staffed for the vastness of the landscape here. And so we rely very heavily on each other to be successful." Collaborative relationships allow organizations to call on other groups for additional people and funding when necessary (Steen-Adams et al 2021). Another reason is to coordinate messaging to the public, both residents and tourists. Organizations often coordinate with each other to determine the timing of burn bans and to communicate best practices to campers, hunters, and residents in their various jurisdictions.

Several participants said that highly visible, public-facing projects benefit from collaboration in terms of public perception and support. This claim is not well supported in the literature (Sinner et al. 2016, Tadaki et al. 2020), however, according to a Fuels Management Officer (b) with USFS, "we're not making friends" by making management decisions unilaterally. Collaborative processes, on the other hand, which incorporate other organizations' and/or public input, can elicit more public confidence in a project. A fire prevention specialist with USFS described how involving collaborators can change the public's view of a project:

> We want our state and our local folks [involved]. You know, when we're out there burning, we invite them so that if [the public] hear it from Game and Fish like, 'oh, this project is good. We need this project, because it's helping us with elk management.'...Because 'Oh, elk? Well, I thought [USFS] were just going out there to burn because they just have money to burn, you know, but this is for elk?' You know. So hearing the message a lot coming from other people is extremely important.
>
> *–USFS Fire prevention specialist*

Other interviewees echoed this sentiment that public perception improves when multiple organizations are involved in a project. Some noted that direct involvement may not be a requirement–just having another organization publicly voice support for a project, or "celebrate each other's successes" as some put it, can be extremely helpful in garnering public acceptance.

Collaborative outreach can be important to solicit expertise from other organizations or constituents for a given project. One participant with a Conservation District expressed regret that certain voices weren't heard prior to a new local ordinance barring the use of wooden roof shingles, which are very popular in the area. While the interviewee felt the ordinance was necessary from a fire safety standpoint, it angered local businesses that sold wooden shingles. These businesses would have preferred the new ordinance to simply require all roofs to be made with Class A (highly fire-safe) materials, since this would have allowed them to continue selling wooden shingles as long as they were Class A. If businesses had been consulted, an ordinance could have been created that was more popular and produced better economic outcomes.

In other situations, such as managing a naturally occurring wildfire on a single jurisdiction, collaboration may not be necessary. However, there may still be benefits to collaboration in these cases. A Fuels Manager with USFS described why they collaborate with other groups even when a wildfire appears contained within USFS land:

> Ultimately, if it's within the administrative boundaries of the Forest, it's our call. However, you know, Mother Nature knows no boundaries, right? And we're not going to say that it's going to stay here. So even when it appears like, you know, it might stay there and stay on the Forest for the short term, we still are going to collaborate with a group of people.
>
> *–USFS Fuels Manager*

This interviewee described how collaborative decision making is a responsible practice in unpredictable situations like wildfire. Collaborative decision making allows organizations to preemptively voice their priorities and approach to future risk. Even when organizations ultimately have the right to operate independently, continued collaboration helps prepare for an uncertain future.

In some situations, interviewees felt that collaborative meetings and groups are not the right tool for the job. Several study participants reflected on organizational autonomy within their own jurisdictions, noting that sometimes the most efficient way to accomplish organizational goals is to operate independently. Several participants said that there is general agreement among partners around fuel reduction work. In contrast, naturally occurring wildfires that are managed for resource purposes (some participants called these "managed wildfires" or "fire-use fires") can be more contentious. When

there are disagreements, it may not be possible to sway action on another organization's jurisdiction:

> Sometimes [collaborators] don't come to solutions. Sometimes it's just 'agree to disagree' on things. And if we're the lead agency on wildland fire response, you know, obviously, it's our goals and objectives that are going to kind of take point. And then the other partners, you know, they might walk away not meeting their intent or what their expectations are, but understanding that we have to follow our Forest Plan.
> *–FMO (a) with USFS*

This perspective emphasizes that organizations have boundaries as they work within a certain plan or set of goals that may have limited flexibility (Reiners 2012). Some organizations or managers may default to those organizational boundaries, especially in cases where an issue is not directly perceived as a cross-boundary issue or when collaborative goals for fire resilience or preparedness are seen to run contrary to organizational mandates, mission, or directives. One participant with Wyoming State Forestry also mentioned "the science" as its own directive, one that didn't necessarily always require collaboration to act on:

> ...sometimes it's like okay, we have the science. Like, let's just follow that. I mean, obviously, there has to be some level of opportunity for public input, but as far as, like, initiating a super collaborative set of public meetings or collaborative meetings, I think oftentimes that ends up with just you know, circular conversations. We don't get far.
>
> *–Wyoming State Forestry employee*

Study participants also highlighted that collaborative efforts cost time and money, which, from their perspectives, requires clear, on-the-ground benefits in order for participants to invest in them.

> "If [collaboration gets] you somewhere then, you know, that's your milestone–the meeting in and of itself isn't really an accomplishment…with highly visible projects there has to be public collaboration. But I think when you start looking at stuff that isn't super visible, isn't super impactful to the community, I think maybe then you need to scale it back…"
>
> *–Wyoming State Forestry employee*

This perspective is also found in other research, which cautions against viewing collaboration as a cure-all (Lubell 2004, Koontz and Thomas 2006) and which clarifies that collaboration is only a means to the end of setting goals and solving problems as a group (Head et al. 2006).

Another study participant who is a private wildfire mitigation contractor said they choose their projects carefully, because collaborative projects can take up to three times as long as those they undertake on their own. If one collaborator on a project does not have sufficient time or energy to invest, it can slow the whole group down. Physical distance from other collaborators or project sites can also be a barrier to collaborative efforts, since it prevents participants from benefiting from in-person meetings and opportunities (Hamilton and Lubell 2018, Holley and Gunningham 2011).

3.2 Utilizing jurisdictional and organizational differences

Organizations that collaborate on wildfire planning or response may actually use the jurisdictional and organizational differences that exist between them to their advantage, particularly when working with private landowners. This is an indirect way to collaborate but shows managers' awareness of other organizations' expertise and capacity, indicating shared trust between organizations. In the interviews, participants described using differences to their advantage through 1) referrals, 2) collaborating towards independence, and 3) communicating with different stakeholders.

Participants who interact with landowners may encounter requests that they are unable to fulfill and subsequently suggest a consultation with one of their collaborators, a practice I call "referring". Referring landowners to collaborators in this way allows an organization to compensate for low personal and organizational capacity. A Wyoming State Forestry (WSF) employee described the limits of their job and how other organizations can meet the landowner needs that WSF is not able to:

> State forestry–we don't do wildfire risk assessments. We've kind of
> pushed that towards the counties. Just because we only have so many
> employees, and that starts to get really time intensive. And since it also
> involves a structural component, you know, the fire departments are often
> a good avenue for that.
> —*Wyoming State Forestry employee*

This quote illustrates how managers understand the strengths and capacities of different organizations in the area and rely on each other to address different elements of wildfire

resilience. This ability to supplement each other's capacity and fill in gaps is a hallmark

of successful collaborations (Steen-Adams et al. 2021). Managers are able to guide

landowners through the process of becoming more fire-safe by sharing their knowledge

of best practices and available resources, through their own and partner organizations.

The following quote is from a participant who focuses on assessments and

recommendations but does not handle financial aid related to wildfire. Despite this

boundary in their work, they still ensure that their recommended actions correspond with

the financial resources available through other collaborators:

> I have a bunch of recommendations for defensible space and potential
> control lines and hazardous fuels reduction. And [Conservation District
> collaborator] has been out there the last couple of weeks already doing
> cost share stuff with that group for thinning along the roads, because [they
> have] a Corridor Improvement cost share. So you know, a lot of the
> recommendations that I'm promoting for the homeowners, they're tying in
> [Conservation District collaborator's] cost share programs, which is really,
> really cool.
> *–Independent wildfire mitigation contractor*

In this way, referrals can help organizations restrict their work to elements of wildfire

management that they have the expertise and capacity for, while still ensuring that

landowners are left in capable hands to accomplish other tasks. Referrals also circumvent

the bureaucracy associated with many collaborative agreements, whose formalization can

be time consuming.

Several managers described an approach that I call "collaborating towards independence". They shared that while direct collaboration may be necessary to get organizations initially aligned, in the long term it can benefit organizations to instead work independently towards shared goals. Part of the reason independence is useful may be related to communicating authority and inspiring confidence in landowners, as described by an FMO with USFS:

> At the very beginning…I helped [this nonprofit] a fair amount…I think for them it has just enabled them to move forward more quickly and just be more successful in talking to people. Because when somebody understands, or displays that they know what they're talking about, maybe you have a lot more confidence, than when somebody's like, 'Well, I'm not really sure, let me get the Forest Service to come out here and give you some feedback'…they can all do it internally. It makes a huge difference.
> *–FMO (b) with USFS*

This quote serves as a counterpoint to the earlier discussion of how managers feel that collaboration can inspire greater public confidence in wildfire management projects on public land. In the quote above, the FMO describes how landowners respond better to projects on their own land when they can work directly with a knowledgeable decision maker. Collaborating on messaging and goals keeps organizations consistent with each other, but operating independently allows each to serve as an autonomous authority in their jurisdiction. Collaborative relationships with researchers may also work this way. An interviewee who is an Interagency Fire Ecologist with USFS shared that they have a close relationship with a wildfire science lab, and that they often assist in securing grant money for the lab. In return, they said that the researchers may investigate certain

questions that the participant is interested in, then "confront me with science and realities, that kind of bust up my biases about how fire is in the ecosystem". The relationship is mutually supportive, but decision-making for each group happens independently. This is a good example of how polycentric governance systems in wildfire mitigation differ from hierarchical emergency-response systems–the actors engaged in mitigation are independent and authoritative on their own, and all actors theoretically have the power to influence each other, rather than influence flowing from the top down (Kelly et al. 2019).

At other times, participants may be collaborating with landowners themselves, hoping to foster landowner independence. This was an area in which many participants expressed a good deal of frustration, as in the following quote from a local fire chief:

> I didn't make you buy a house in the trees. It's your responsibility. We're just trying to help you. But they expect us to just take care of it. It's not our responsibility…I'm trying to provide you the means, I'm trying to provide you financial assistance and educational assistance, so that you can be responsible for your property. And, in fact, for your whole neighborhood's property. Because if you don't take care of your property, then all the work they do on their property is going to be null and void because [fire is] going to spread.
>
> –Fire chief (a)

Importantly, this quote illustrates the kind of independence participants want to foster in the public, which includes a responsibility to their broader community. Interviewees described a lack of shared understanding–an important element motivating successful collective action (Charnley et al. 2020)–about wildfire risk mitigation among landowners

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in their jurisdictions. Several participants described homeowners who procured insurance policies from companies that promised to send a fire truck specifically to their house (interview participants were dubious that this would be possible but said that many homeowners believed the claim); these same homeowners took no action that would benefit their neighbors. This was particularly galling to some interviewees in Teton County, a wealthy county where many people have the money to do better wildfire mitigation, but "some of the wealthiest are the most reluctant to spend their own money, I have found", according to a WSF employee. Many organizations in the region offer cost share and grants to landowners working toward fire resilience, but managers often want to focus those resources on areas with the greatest financial need and highest wildfire risk, as discussed by the same WSF employee:

> I think if we can get back to that sense of personal responsibility, and at least taking care of your own home safety, and maybe saving the bulk of our grant dollars for those more landscape level projects where we accomplish more acres and do more for the community as a whole.
> —*Wyoming State Forestry employee*

Having landowners who take responsibility to invest in fire resilience in their own communities would free up organizational resources to target areas of highest need and work toward larger objectives.

In many cases, particularly when communicating with landowners, the person or agency who delivers a message can be incredibly important, and managers use collaboration to effectively communicate in different contexts. Ease of communication can depend on

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local reputations, which varies among agencies and between different communities (Paveglio et al. 2015). One participant, who had experienced community meetings as both a Federal employee and a private consultant, described the difference:

> In every single [public workshop we had for the CWPP], we had basically nine to 19 people…and everyone was super engaged, and no one pushed back. It's so different. Like, if I was up there as a Fed, I would have got more pushback. But as a private consultant representing [the fire district] and all the steering committee folks, yeah, there was no resistance. It was awesome. I mean, we got an applause at the end of one of our public meetings, that was so cool. Like, people were jazzed.
> *–Independent wildfire mitigation contractor*

This element is closely intertwined with the previous idea of collaborating towards independence. Participants described working with collaborators to define collective goals and strategies, but then strategically deciding which organizations will communicate these goals. Previous research affirms that leveraging existing, trusting relationships are effective practice in risk communication (Steelman and McCaffrey 2013) and in fostering collective action (Charnley et al. 2020). For example, interviewees shared that when fire departments send out a message about fire resilience, people tend to be more receptive to it than they would be if the message came through a Federal organization. As another example, a fire prevention specialist with USFS described working with multiple collaborators, including a National Park, to develop guidelines for hunter fires. However, since the Parks do not allow hunting in their jurisdiction, they did not want their logo shared on any of the guidelines produced because it might cause confusion about Park policies.

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Other times, capacity limitations or lack of contacts can prevent managers from performing effective outreach on their own. Participants indicated that collaborative relationships can remedy this problem. For instance, a Conservation District employee said they often reach out to private contracting companies to communicate Conservation District recommendations and cost-share opportunities. That way, private companies can act as a "force multiplier and talk to their clients about this opportunity. They can be kind of advocates for the program." The Neighborhood Ambassador program led by Teton Area- and Alpine Area Wildfire Protection Coalitions (TAWPC and AAWPC respectively) was also touted as a huge success in terms of increasing outreach. In this program, leaders from the collaborative groups work with homeowners that are willing to act as neighborhood ambassadors. These homeowners receive some training and then talk with their neighbors and friends about opportunities for fire risk reduction.

> So somebody in your subdivision takes on that burden of communicating to their neighbors and getting buy-in for having defensible space. It's huge. Because people resist it so much. There's just…so many social factors involved with fiddling around developed areas, and on people's property. But if you have somebody to stand up and say, 'Hey, we're doing this', who's not a federal employee, then that's really key.
> *–Interagency Fire Ecologist*

Neighborhood Ambassadors, as known members of the communities that they work in, are able to cross barriers of reputation and access that other organizations cannot. This strategy capitalizes on existing relationships (Charnley et al. 2020, Steelman and McCaffrey 2013), and can also leverage the power of peer pressure, which Holley and

Gunningham (2011) found could be helpful in fostering collaboration when combined with other incentives.

The same concept applies to collaborators with different jurisdictions. This came up most often when participants from USFS talked about how they accomplish projects on private land adjacent to fuel mitigation projects on USFS land.

> The state is that key piece that's in the middle there. I communicate with those property owners, but usually we're using the state because they have a way to go out and do projects on private land, they have funding for that, where we cannot do that without a Wyden Agreement. And that's the process. So both the Game and Fish, they have the collaborative, overarching habitat management plan, which they can fund work across boundaries. And then State Forestry is another key player there, they can go in and kind of be that middle player, middle person, between the private landowners and federal government agencies.
> –*FMO (a) with USFS*

Even when collaborators aren't working directly on a project together, their relationship and communication can still be leveraged to create more successful projects for all organizations.

3.3 Finding or designing multi-benefit projects

Organizations prioritize collaborative relationships that are more likely to help them realize their own goals. Other research has emphasized the importance of providing adequate incentives for collaborators or community members for the time that they invest in collaborative projects (Holley and Gunningham 2011), and one way to do this is to

ensure that projects address some goals of all organizations simultaneously. This is easiest when organizations have shared goals, but in some cases that isn't necessary. Several participants talked about the idea of "collateral benefits", where a project with a primary goal has a secondary positive consequence.

One of the clearest collateral benefits that participants talked about was that of improved wildlife habitat due to prescribed burns undertaken for fuels reduction purposes. According to interviewees, many prescribed fire projects are currently funded as fuels reduction projects, meaning that the main measures of success for these projects are related to fuels. But wildlife managers also use prescribed fire for wildlife benefits, since the first things to grow back after a burn are aspen forests, which provide high quality habitat. Both wildlife and wildfire-focused managers use this connection to their advantage. Wildfire-focused managers often partner with Wyoming Game and Fish (WGF) to obtain extra funding, and WGF can increase the scale of their treatments through these same partnerships, as described by a WGF employee:

> I have kind of bought a seat at the table [because] I could bring money to the table, and it's like, okay, well, you're doing this fuels project. But if instead of doing a 200-yard buffer, if you can look at this basin back here, behind, right there in that urban interface zone that you care about, I can bring extra money to the table, which is actually going to increase the effectiveness of your fuels treatment. And I get the scale and the scope of the vegetation management that I want for wildlife.
> – *Wyoming Game and Fish employee*

Wildlife focused NGOs or grants can be another way for wildfire-focus professionals to bring in wildlife dollars to support their projects. These funding relationships may also be more successful when accompanied by collateral benefits–this same Wyoming Game and Fish employee reported that their successful use of grant money for wildlife projects "[made funders] look good with the money that they [gave me]...we kind of feed off of each other that way". Successful projects enhance the reputations of every organization involved, from funders to implementers.

Smaller collateral benefits were also important to participants. One fire prevention specialist with USFS was pleased with a relationship they had built with a nonprofit organization focused on trail maintenance in the Forest. After prescribed burns, this organization could clear trails in the project area and advertise that "there's beautiful wildflowers on this mountain bike ride, because there was a prescribed fire". Because their prescribed fires are stand-replacing to emulate naturally occurring fires in these forest types, positive messaging like this can help create more public acceptance for these treatments. This same participant worked with homeowners adjacent to the forest boundary to put weather stations in their backyards. This also had the effect of alleviating homeowner concerns about smoke from prescribed burns, while also collecting important data on the treatments. Another participant, a local fire chief (a), described how joint Red Card trainings are beneficial not only to get many people from different organizations certified at once, but also to build trust and familiarity, which are essential in the event of an actual fire. Even when additional benefits seem small, maintaining awareness of them

can allow managers to capitalize on these opportunities to increase the effectiveness of

their projects and their overall resilience to wildfire.

A lack of mutual benefits can reduce collaborators' incentives to participate in

collaborative relationships. Even if they support an overall goal or project, participants

need to feel they gain something of equal or greater value to the effort they input, as

expressed by an FMO with USFS:

> I know, for me, it was tough, being part of [collaborative group]
> when…the focus is in [town 1.25 hours away]. And so, when they're
> having these group efforts, it's like, oh, well, we're gonna have this public
> meeting, and it's gonna focus on X, and it's all [town] based. And I'm
> like, 'Well, I'd like to help you guys, but my effort–I'm not going to do
> that.' Because if it was over here in [my area], I'm going to be there, but if
> there are things that I can help with, that would help, that I think like, oh,
> you're gonna do like an ambassador training or something like that, I can
> gather information that then I might be able to apply here, I would do that.
> *– FMO (b) with USFS*

This quote shows how even when goals are aligned, mutual benefits aren't assured.

Collaborators may not benefit from a project for many reasons, including due to physical

distance (Hamilton and Lubell 2018), a lack of power relative to other collaborators

(Koontz and Thomas 2006), or differences in capacity.

Even when mutual benefits can be identified, participants often need to compromise their

ideal course of action for collective outcomes. This is often the case with prescribed fire

projects, where there are many factors to consider.

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It's not just relative humidity and wind speed and temperature, but it's also, is it calving season? Is it migratory bird nesting season? Is it fall foliage season where no one wants to see any smoke? Is it hunting season where the hunters don't want a helicopter flying around? Is, you know, the vice president coming to visit? All of these things. Or you know is the– have there just been too many big fires around? Are the firefighters all gone to California? So many.

– Interagency Fire Ecologist

Grant funding and the fiscal year also impose their own restrictions. An interagency fire ecologist said that fuels teams are often pressured to burn in conditions that aren't hot or dry enough to accomplish target burn severity in order to "get it done and spend the money and get it off the books." In these situations, the participant tried their best to work with fuels teams to "direct them toward places where they would do the most good for the resource", even with less than ideal conditions.

Concessions may be made on the basis of public opinion, too, particularly when concerning more controversial management strategies like prescribed fire or managing naturally occurring wildfires.

They used to be landscape scale, but we've had to tier back, there's so much pushback, because there's just not a lot of data out there. So people are like, 'Are you sure about this, and how do you know?...They just lost that one–how do you know you're not gonna lose this one?' So what we've done is we've actually tiered these projects down quite a bit.

–Fire prevention with USFS

The opinions of other collaborators also impact strategies. An interviewee who is a local fire chief (b) said that there will be some disagreement on every fire, and that sometimes he has to defer to the opinion of whoever's jurisdiction the fire occurs on, even when the response is a collaborative effort. Compromising in this way allows managers to maintain a united front despite disagreements and continue to collaborate into the future.

3.4 Choosing collaborators and building relationships

Who participants collaborated with can have a huge impact on the types of projects they embark on, but participants noted that in many cases, organizational structures may dictate who collaborates with whom. Still, participants described various methods of both choosing collaborative partners that they could work effectively with, and building relationships with existing collaborators when no choice was offered to them.

Hiring is an obvious place where participants have choice in their work partners. One participant, a WGF employee, said that in a recent hiring process, their organization "heavily stressed communication and partnerships and working with people. And it's like, I can teach anybody that wants to learn the technical stuff…I can't teach you how to work with people." Others also emphasized "people skills" as essential for communicating with both professional collaborators and private citizens about wildfire risk reduction. Hiring people with these qualities benefits internal dynamics as well as cross-boundary collaborative efforts. However, participants don't have any say in the hiring practices of their collaborators, so other types of choosing apply to external

relationships. A Wyoming Game and Fish employee described drastically changing their work approach in response to an unworkable relationship:

> There was a wildlife biologist for the Forest Service here for many years, that was just a classic obstructionist. [They] just didn't want to touch anything. [They] thought every dead tree needed to be saved for the woodpeckers. And it's like, it was just extremely frustrating. And so for years, I didn't even attempt to do any prescribed burning on the Forest, because it's like, what's the point? And so I basically focused my effort on the BLM. And it's like, okay, well, if the Forest Service is going to be dead water for the next five years, or till whenever [they're] gone, we're just going to work on BLM, and state and private.
>
> *–Wyoming Game and Fish employee*

In this case, a difference in perceptions of what the Forest was for and how it should be managed infringed on the participants' ability to accomplish their organization's work. The participant's position as a decision-maker and their organization's many collaborators gave them the option to neglect a relationship for years in order to more effectively do their job. Previous research focused on positionality discusses how differences in opinion, perspective, and ways of measuring success can negatively impact collaborative relationships if not addressed openly (Cheng and Randall-Parker 2017). Another participant described more generally their process of moving on from a person who is "just not advocating in the same way that you are," and instead going to find "that motivated person." While turnover is often framed negatively, this finding suggests that turnover could provide an opportunity to choose new collaborators.

One participant who works in fire prevention with USFS qualified that personality, people skills, and management beliefs are only part of what they seek in a collaborator. It's also essential that they work with people in decision-making roles, "...otherwise, I'm wasting your time, you know, if…I can't make any decisions for the agency, and I'm like, 'okay, great, I'll take that back'. As opposed to, 'that sounds like a good idea. This is what I can do. And this is what I can move forward.'" Collaborative projects can be slower to initiate than those carried out by a single agency or group, and so it is important for this participant that when they are collaborating, they are working with people who have the power to move things forward.

In many cases, participants could not choose who worked on a project with them, and so instead they put energy into building a good working relationship with whomever was in that role. This helps people work with what they have in terms of collaborators, building trust and rapport in a way that sustains future work together. Several people talked about the importance of being able to text or call a collaborator without having to wait for a formal setting. One fire warden described how they prioritized building relationships with the multiple jurisdictions adjacent to their district:

> ...the relationship you develop when it's not on fire is more valuable to
> your success than anything else that we do. And so part of [our] success is
> in creating that collaborative approach that when the forest isn't on fire,
> I'm still trying to attend those meetings with the Forest Service…same
> with the BLM. The other thing is, I regularly invite them to attend our
> meetings…the payoff is that when we do respond, everybody's on a first
> name basis, you can trust those people that you're working with. And it

just makes it more likely than not that you'll coordinate with them on the actual emergency incident, and it just makes it go smoother.

–Fire chief (b)

The participant also noted that collaborators need to be comfortable with each other in order for formal collaborative agreements to be successful. The only way to ensure this was by seizing opportunities to spend time together and understand "what and how and why they make the decisions they do". Another participant said something similar about their work with Wyoming State Forest: "I think, it's really hard to trust the people you're working with and whatnot if you don't have those relationships built by just informal conversations, interactions and whatnot. And then you can come to formal meetings, collaboratives with an understanding and trust for each other." Other research similarly emphasizes the importance of building trust prior to crises or joint action (Charnley et al. 2020, Steelman and McCaffrey 2013).

A participant with the Forest Service, who described witnessing a regular clash of different wildfire mandates and missions, said that in recent years the fire world has invested in building the leadership skills of its existing employees:

In the winter, that's when the…personal growth happens. And fire–you probably figured this out, but there's a really strong emphasis on developing leadership. And it's starting to make a huge difference. Since maybe 2005, somewhere in there, this leadership emphasis has been in place, and so the folks that have been through it are making it to the main office. And some of those older folks who just defaulted to the militaristic style are retiring out and leadership is improved.

–Interagency Fire Ecologist

This participant said that suppression-oriented and ecology-oriented fire workers tend to have different leadership styles. These differences are important and valuable but can cause friction when a suppression style is applied to an ecology situation, or vice versa. Additional training helped people to be better supervisors, better listeners, and better collaborators when navigating these different situations.

Most interviewees discussed collaboration with other agencies or landowners in their jurisdiction. However, a few discussed "Mother Nature" or future generations as though they were also collaborators in wildfire resilience. As with relationships with other collaborators, participants had to evaluate how and when to balance their own organization's priorities with those of nature and future generations. Participants did not reference these considerations to negate the need to protect human infrastructure or to advocate a hands-off approach. Rather, they seemed to advocate learning from naturally occurring wildfires to determine when and how to do fuels mitigation and thinking about risk transfer to future generations when deciding whether to let a wildfire burn. This idea was most eloquently expressed by a Fuels Manager with USFS:

> So we're always trying to educate and develop a culture based on the
> latest science and what Mother Nature is telling us. And a good example
> of that is, fires are only getting bigger and longer in durations. So extent
> and duration, right. So to us as fuels and fire managers, that means that we
> have to adjust and right-size our fuels mitigation program to that as well,
> meaning we have to go bigger and longer on our fuels mitigation projects
> as well…And so, when [naturally occurring fires] happen on the
> landscape, we have to take a good look at them and decide if we want to

take the risk now and let that thing go and do what Mother Nature has intended to attempt to do over the last 200-250 years, pre-European type of settlement? Or do we want to transfer that risk to a later generation and put it out right now if we can, and then the consequences that go along with those.

–Fuels with USFS

This quote reveals that for some managers, there is a negotiation happening between "Mother Nature" and the other values at risk. This participant also seems to consider "Mother Nature" as a sort of expert consultant, looking at naturally occurring events as a way to guide management decisions. A fire prevention staff member with USFS talked about parts of the forest that "[want] to burn, right, the lightning's just trying to renew it," seeming to assign agency to the forest and the lightning in deciding when fires needed to happen. This is similar to the way these managers would talk about another agency that has certain goals and expertise in wildfire management. Youatt (2017) discusses the different types of "personhood" that people assign to nature, noting that this varies depending on culture, context, and other factors. The type of personhood evident in these interviews might be described as psychological or biological personhood, which Wight (2006) describes as the "power and capacity of self-consciousness; ability to form intentions, usually in language; ability to determine behavior according to interests, capacity of unified continuous reasoning and volition". Just as in these agency-to-agency collaborative relationships, the goals of managers and the perceived goals of the person "Mother Nature" don't always align, and compromises have to be made. However, these managers seem to think there is value in choosing to collaborate with both nature and

future generations, compromising with them and working toward the shared goal of a fire resilient landscape.

4. IMPLICATIONS AND CONCLUSIONS

This study set out to answer the question of how managers used collaboration to accomplish organizational goals related to wildfire. I found that managers in northwestern Wyoming maximize the benefit of collaboration to their organization by 1) deciding when collaboration is and isn't the right tool, 2) utilizing jurisdictional and organizational differences, 3) finding or designing multi-benefit projects, and 4) choosing collaborators and building relationships. Below, I summarize the main findings of this study and their implications for cross-boundary wildfire collaboration.

Finding 1: Deciding when collaboration is and isn't the right tool

Previous research has questions whether collaboration actually increases environmental and social benefits in natural resource contexts (Koonts and Thomas 2006). According to the managers interviewed in this study, the answer is yes–sometimes. Many managers appeared to agree with Koonts and Thomas, saying that collaboration was one of many tools for accomplishing environmental goals and could not be expected to produce enhanced outcomes in all circumstances. The fact that funding is tied to the existence of formal collaborative institutions may complicate this, and force managers to take a collaborative approach to aspects of wildfire management that aren't suited to it. Several

managers described taking a collaborative approach in contexts where it was not required, suggesting that legislating collaboration may not be necessary to encourage the practice. On the other hand, managers described frustration with the lack of collaboration and/or collective action exhibited by private landowners, indicating that additional incentives or structures targeted towards these actors may be necessary for wildfire resilience (this finding should be treated carefully since this study did not include perspectives from any private landowners). Projects like the Community Ambassadors program were praised for this.

Finding 2: Utilizing jurisdictional and organizational differences

Managers demonstrated the ability to work indirectly with each other towards the shared goal of greater wildfire resilience, functioning as a polycentric governance system (Kelly et al. 2019). From managers' perspectives, there were many advantages to working more independently from each other in some cases, and they expressed trust that when it came to fuels management and mitigation, other organizations in the area were on the same page as to overall wildfire management goals. A lot of literature has discussed how different organizations can fill in the gaps in each other's jurisdictions, capacity, and expertise (Kelly et al. 2019, Steen-Adams et al. 2021, Huber-Stearns et al. 2021), leveraging their differences for collective benefits on specific collaborative projects. The interviews in this study reveal that this may be true even outside the context of a specific project.

Finding 3: Finding or designing multi-benefit projects

Many managers discussed how essential mutual benefit was to successful collaboration, something that has been discussed in previous studies (Holley and Gunningham 2011). Holley and Gunningham specifically suggest financial compensation for collaborators that is sufficient to compensate for the transaction costs of collaboration. The concept that the WGF employee described of "buying [their] way to the table" could fall into this category, since their financial resources incentivize collaborators to engage collaboratively with them. However, participants frequently cited benefits besides money as reasons to collaborate, including improving reputation, communication, and trust among collaborators. Frequently, participants noted that physical distance kept projects from mutually benefiting collaborators. Many researchers make a convincing case for increasing the scale of coordinated wildfire management (Bowman et al 2011), but others note that collaborative processes are often less effective at large geographic scales (Hamilton and Lubell 2018, Holley and Gunningham 2011). Many participants noted that engagement with private landowners was difficult for them, and this could be one place that additional benefits need to be added, or where existing benefits (i.e., grants, cost-shares, etc.) should be rearranged to be more effective.

Finding 4: Choosing collaborators and building relationships

Managers described approaching collaborative relationships selectively and strategically. Part of their strategy was to select people whose personalities, goals, and motivation worked well with their own, and part was to select people who provided authority or benefit to the project by virtue of their position. Some managers even described "Mother

Nature" or natural processes using language that evoked collaboration and consultation, personifying the landscape and making decisions based on their relationship with this person (Youatt 2017). In all cases, managers described investing significant energy and time into those personal relationships around which collaboration was built.

Future research should further investigate personification of nature in wildfire management to understand how this unique context affects people's relationship with nature, how this relationship varies between organizations and locations, and how it influences both collaboration and management decisions. More investigation of collaborative processes from the perspective of private citizens to understand how they participate in collaboration with organizations invested in wildfire risk mitigation.

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6. ACKNOWLEDGEMENTS

CHAPTER 3

Personal and positional influence on collaboration in social networks for wildfire

management

ABSTRACT

Wildfire is a cross-boundary, collective action issue, and wildfire management professionals in fire-prone socio-ecological systems must therefore engage in collaborative relationships towards collective fire resilience. These many relationships create informal social networks of people with various affiliations and missions. Managers' locations in these social networks, as well as personal factors like gender and role, may impact their collaboration. I used survey methods to investigate these impacts in northwestern Wyoming. The survey used chain referral sampling and asked about managers' participation in 8 collaborative actions. I then modeled managers' participation in the collaborative actions using betweenness centrality, gender, scale and focus of work, and role as predictors. I found that managers who acted as bridgers (high betweenness centrality) were more collaborative than those not in a bridging position. Female managers were less engaged in collaboration than their male colleagues, possibly due to the discrimination that women face in the natural resource and wildfire fields. Female managers were also nominated much less frequently than male managers, making it possible that this finding is the result of gender bias in the chain referral sampling methods. Managers with a specific focus on wildfire were more collaborative than those with a broader focus, and managers who focused only on a single community or jurisdiction were less collaborative than those with a multi-community focus. I found greater collaboration in managers who performed coordinating, engaging, responding, and authorizing roles compared to other roles. When all factors, both personal and positional, were combined in a single model, scale of work and role (coordinating,

engaging, and responding) were most significant in their effect on collaboration. As managers work to address wildfire across boundaries, these data may help illuminate what factors facilitate managers' ability to participate in important cross-boundary collaborative efforts. They may also inform training and hiring practices, as well as reinforce the need to address biases in the workplace.

1. INTRODUCTION

1.1 Wildfire as a cross-boundary problem

Wildfire is a cross-boundary issue, meaning that its impacts span jurisdictional and organizational boundaries, and so collaboration across those same boundaries is required to foster wildfire resilience. Empirical and simulation studies show that as much as half of burned areas result from wildfires that start somewhere else, often on land that is managed by a different entity (Ager et al. 2017, Palaiologou et al. 2019, Downing et al. 2022). Areas that contain many small parcels of land are especially vulnerable, due in part to the presence of multiple different landowners or managers and the lack of consistent wildfire management policies between them (Palaiologou et al. 2019). The Wildland Urban Interface (WUI), where undeveloped forests and grasslands intermingle with developed land containing homes or other human infrastructure, can fall into this category of vulnerable "checkerboard" land. As one of the fastest growing land types in the United States, and as an area where fire can have disastrous consequences for human communities, it is an increasingly important arena for cross-boundary wildfire management and collaboration. Management strategies may need to be adapted to different land tenures, depending on the values at risk etc., but coordination is key in areas where different actors' actions will impact the risk or safety of their neighbors. Social linkages in these areas should correspond to risk interdependence (Hamilton et al. 2019).

Many parts of the United States landscape are fire adapted or fire prone in some way. Indigenous communities have managed the land using fire for millennia, but European colonizers enforced an aggressive total suppression approach to land management that has been fairly consistent for over 100 years (Bowman et al. 2011). This anthropogenic pyric shift has changed the landscape in many parts of the country (and the world). Excessive suppression can be extremely dangerous in landscapes adapted to frequent fire, leading to fuel build-up that can cause even larger and more destructive fires. This often galvanizes even more aggressive suppression so that the area falls into a positive feedback loop of large fires and expensive suppression efforts which is extremely hard to break out of (Calkin et al. 2015, Carpenter and Brock 2008, Fischer et al. 2016, Walker et al. 2004). Even in fire prone areas adapted to an infrequent fire regime, such as the forests in Wyoming, fire suppression has resulted in less fire than would be typical for these forests and has also oriented fire management to be primarily suppression-focused, neglecting non-suppression elements (Bowman et al. 2011). Effectively breaking free of the suppression cycle can be hard because suppression systems are deeply entrenched (Fischer et al. 2016) and are what people often feel strongly about.

Over the past few decades, there has been a growing recognition of the dangers of suppression-only wildfire management, and more emphasis is being placed on non-suppression activities that are important to fostering wildfire resilience (*The Federal Land Assistance, Management, and Enhancement Act of 2009 Report to Congress*; Manchin 2021). However, the legacy of wildfire suppression has left its mark. There may be strong divides between forest restoration and fire protection in some areas (Fischer

and Jasny 2017), and money may be diverted away from restoration/mitigation efforts in favor of suppression projects. Managers and decision makers have to be proactive and creative as they work towards more holistic wildfire management strategies.

1.2 Collaboration in the context of wildfire management

Collaborative relationships can be a way to both work across boundaries and bridge the gap between suppression and restoration/mitigation focused organizations or projects. Formal collaborative efforts have been encouraged in plans such as the National Cohesive Wildland Fire Management Strategy (U.S. DOI 2009), and the Joint Chiefs Landscape Restoration Partnership (2022). It is important to note that collaborative groups don't necessarily increase concrete collaborative outcomes in natural resource management; Lubell (2004) found that the National Estuary Program was more effective at creating consensus than actual on-the-ground cooperation in estuary management. However, there have also been many successful collaborative efforts in natural resource management, including wildfire. Partnerships between Tribal Nations and federal and state government agencies increased prescribed burning in Northern California (Mark-Block and Tripp 2021), and the USFS used partnerships with many diverse groups to meet the mountain pine beetle outbreak from 1996-2016 (Steen-Adams et al. 2021). Collaboration can allow groups to combine strengths and supplement each other's capacity in a way that leads to better outcomes than individual responses would (Steelman and Nowell 2019, Steen-Adams et al. 2021).

Certain factors can increase the chance that a collaborative effort will be effective. Charnley et al (2020) examined Joint Chiefs projects on the West Coasts for five collective action elements: shared understanding, communication and coordination, capacity, trust and reciprocity, and benefit/cost ratio. In the 6 study locations, the researchers found that all of these factors were active in some way, and that the absence of even one element detrimentally impacted collective action. Collaboratives can provide a forum in which people can discuss their differences and the goals that they share and build toward those group goals (Tompkins and Adger 2004). On the other hand, differences in perspective can potentially cause conflict in collaborative situations (Cheng and Randall-Parker 2017), or even prevent groups from working together in the first place. For example, Fischer and Jasny (2017) found a deep divide between forest restoration and fire suppression groups in Oregon's wildfire management network, likely due to differences in attitude and management goals.

1.3 Social networks in wildfire management

Social networks are a way to visualize the connections between people and groups in a certain location or working on a certain problem, like wildfire resilience. Social networks are comprised of nodes, representing individual people or sometimes organizations, and edges, which are the connections between nodes. In the context of wildfire, edges usually represent working ties, demonstrating who works together on wildfire management. The structure of social networks can have important implications for what collaboration looks like and may even suggest how adaptive a community will be to disturbance. Bodin et al. (2006) discuss how many factors impact a network's ability to manage adaptively, and

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any feature can simultaneously be beneficial and detrimental to the network. For example, modularity is a measure of how many cohesive sub-groups are contained in a larger social network. This can be a useful feature, since these sub-groups may have distinct ways of knowing or acting, and this diversity can make the network as a whole more adaptive to environmental change. However, networks that rely too heavily on connections to people in their own organizations or modules–at the exclusion of cross-boundary relationships–risk limiting themselves and hindering their receptivity and access to new ideas, practices, or collaborative opportunities (Newman and Dale 2005). People or organizations that connect these sub-groups–sometimes called brokers or bridgers–are therefore extremely important for networks (Bodin et al. 2006, Burt 2000, Newman and Dale 2005). Their position enables them to have more diverse informational inputs, often learning new things early and synthesizing multiple viewpoints or information. Betweenness centrality is the term used to describe to what extent a person acts as a bridger and can be calculated from social network maps. Bodin et al. (2006) propose that one optimal network structure is a network where there are multiple separate groups with high internal trust and moderate external trust, linked together by broker organizations or people who initiate and facilitate adaptive co-management. The more proactively a social network fosters both strong in-group connections (bonding social capital) and between-group connections (bridging social capital), the more adaptive they can be when a disturbance does occur (Newman and Dale 2005).

A person's or organization's location in the social network can have a huge impact on their influence and power. Because social networks are usually informal and spontaneous, not something that people are actively constructing or thinking about, people may serve key bridging roles without even realizing it (Huber-Stearns et al. 2021). Even if they are unaware of their network position, it still affects the impact they can have (Bodin and Crona 2009), and so a community that is aware of the network dynamics at play can potentially work towards creating a network that is better equipped to foster innovation and collaborative action (Newman and Dale 2005).

Other personal factors will also play a role in the impact that different people can have on their network and may contribute to measures of social capital such as betweenness centrality and/or affect their ability to participate in collaborative projects. For instance, a person's role (i.e., Fire Chief) may make them an important contact for many people, thereby increasing their betweenness centrality. People who work at a hyper-local scale, on the other hand, may have fewer contacts and thus lower betweenness centrality. Additionally, factors such as role, scale of work, and gender may impact managers' ability to contribute to collaborative projects, independent of betweenness centrality. For instance, research indicates that collaborative projects in natural resources are often led by women (Westermann et al 2005, Westburg and Powell 2015), but that women also face discrimination in natural resource fields. Either or both of these dynamics could affect the participation of women in collaborative wildfire management actions.

1.4 Research objectives

In this study, I investigated how wildfire managers' position in their social network, as well as their gender, scale and focus of work, and roles, affect their collaborative behavior. I specifically asked these questions in the context of wildfire management in Northwestern Wyoming. Using chain referral sampling and survey methodology, I elicited a map of the social network of wildfire managers in this region, details about participants' understanding of their role in this network, and their participation in several different collaborative actions related to wildfire. I then constructed 5 generalized linear models (GLMs) to understand the influence of social network position and personal factors on collaborative behavior.

In Model 1, I assess the influence of betweenness centrality on collaboration. I hypothesize that people with higher betweenness centrality will participate in more cross-boundary collaborative actions due to their connections to multiple sub-groups in the management network. In Model 2, I analyze the impact of gender on cross-boundary collaboration. I separate this variable from other personal factors because gender could be implicit in the other variables (role, betweenness, and job description), and so analyzing it by itself avoids the influence of gender being covered up by these other variables. In Model 3 I assess the impact of focus and scale, which are attributes of the jobs managers hold, hypothesizing that a specific emphasis on wildfire (as opposed to a peripheral focus) and operating at a multi-community or multi-jurisdictional scale would increase collaboration. In Model 4 I look at self-identified roles that people play in wildfire

management. These roles could both be tied to job description and related to people's personalities or strengths. In Model 5, I combine all variables into a single model to understand their combined influence on collaboration. In a field where collaboration is essential, understanding what factors allow managers to effectively collaborate across boundaries could inform hiring practices, job descriptions, and even changes to workplace culture.

2. METHODS

2.1 Survey

This study used a survey that was based on previous surveys administered in WA and UT by co-author Nielsen-Pincus (among others). One goal of the survey was to build a network map that illustrates the working connections between professionals whose work involves wildfire. To that end, we included a nomination portion of the survey where we asked participants to list people with whom they had collaborated for wildfire risk mitigation and response. To measure collaboration, we asked participants to select which collaborative actions they had engaged in with people from outside their own organization in the past two years. The actions included in the survey were derived from Neilsen-Pincus et al. (in progress) and were selected to represent a range of activities that managers may collaborate on that require varying degrees of time and energy investment. The actions are displayed in Table 1.

Table 1. Description of collaborative actions that participants selected from in the survey. Prompt: What collaborative actions have you taken with people outside of your organization in the past two years?

Collaborative Action	Description
Collab1	Shared information pertinent to wildfire with members of another organization.
Collab2	Participated in inter-agency meetings for wildfire planning.
Collab3	Collaborated on at least one joint grant or funding proposal related to wildfire with personnel from another organization.
Collab4	Collaborated to implement a project related to planning, wildfire education and awareness, fuels mitigation, or emergency response to wildfire with personnel from another organization.
Collab5	Participated in a wildfire-related interagency task force or partnership.
Collab6	Established or improved communication/collaboration mechanisms with other organizations working on wildfire.
Collab7	Contributed to writing or updating a community wildfire protection plan with other organizations.
Collab8	Signed a memorandum of understanding or agreement with other organizations regarding planning, implementation of risk reduction, emergency response, or other wildfire activities.
Collaborative Score (CS)	Number of selected actions / 8

Participants also supplied their gender, scale and focus of work, and roles with respect to wildfire. We formatted and distributed the survey using Qualtrics online (Qualtrics, Provo, Utah).

2.2 Distribution

The survey was distributed using chain referral sampling, which allowed us to elicit the connections that participants considered most important. Prior to distributing the survey, we researched organizations in the region that dealt specifically with fire and selected 15

people to be our initial survey participants and to take part in individual, informal stakeholder meetings over Zoom (Zoom.us, San Jose, California). Our goal was to select people from diverse parts of the expected network, both geographically (within the study area) and organizationally. In previous iterations of the study (WA and UT), a single focus group was held, and there were not any Tribal members present for it. We thought that this could have contributed to the low response rate from Tribal fire managers in the survey section of the project. By reaching out to and meeting with people from multiple areas and organizations individually, we hoped to create a more personal connection with people who may be on the periphery of the wildfire management network and therefore elicit responses from people who may have otherwise been overlooked by the chain referral sampling method. We were able to meet with one Tribal member and one person who works closely with a reservation in the study area, but ultimately neither participated in the survey. We also tried to minimize people with overlapping job descriptions or jurisdictions, since the initial stakeholder group could influence the segments of the network that end up being represented in the survey. In total, we held 11 meetings and met with 15 people, representing 12 different organizations.

The goal of the stakeholder meetings was for us to build an understanding of the local context and also to introduce ourselves to managers in the area to build trust. We briefly presented findings from the Utah and Washington iterations of the survey (Nielsen-Pincus and Evers n.d., Nielsen-Pincus, Jacobs, and Evers n.d). We then invited attendees to share their thoughts on the strengths of fire policy/management in the region, the challenges they face in their jobs, how collaboration factors into their work, and any

priorities they had for research on the topic. At the conclusion of the stakeholder meetings, participants were asked to take the survey as our initial seeding group. In addition to these informal stakeholder meetings, we also invited additional people throughout the region to participate in the survey as part of the seeding group, although without a prior meeting. The purpose of this additional seeding was to elicit responses from as many parts of the potential network as possible. Due to time and personnel constraints, it was not possible to have stakeholder meetings with all of the people that we wanted to, so instead we contacted them through email with detailed, but succinct, information about the project and an invitation to participate in the survey.

The stakeholder meeting attendees were the first people to take the survey, followed by the additional identified seeding participants. In their responses to the survey, we asked them to nominate people that they worked with on wildfire, and we then invited those nominees to participate in the next round of the survey. The responses from these individuals populated the next round of participants who were invited to take the survey. This chain referral sampling continued until saturation (where few new individuals were nominated in each sampling round), which for us occurred at 12 rounds. Nominated participants were not told who nominated them, and all personally identifying information has been removed from figures and publicly facing summaries. We asked a total of 187 people to take the survey; of that, 135 people responded (72%), and created a roster of 199 managers (nodes) in a network of 710 working relationships (edges).

2.3 Data

We downloaded the completed surveys from Qualtrics as CSV files and cleaned them

using a combination of R (R Core Team 2021) and Google Sheets (Google.com,

Mountain View, California). Some responses were incomplete, but still usable for our

research question; others that were not sufficiently complete to include in our analysis

were removed. I imported the nodes and edges list into R, where I constructed a network

map (**Figure 1**) and obtained centrality scores for each individual node in the network.

For use in my analysis, I pruned the network to only include those nodes who had also

returned a completed survey, and further pruned to eliminate nodes that had either not

nominated any other nodes or had not been nominated by any other nodes. The final

network size after this pruning was 73 nodes. For use in producing other figures, where

betweenness was not relevant, I used all survey responses (n=135).

For my dependent variable, collaboration, I found the sum of collaborative actions that

each survey participant reported taking over the past two years. These Collaborative

Sums (CS) were between 0 and 8. I converted these scores to proportions (between 0 and

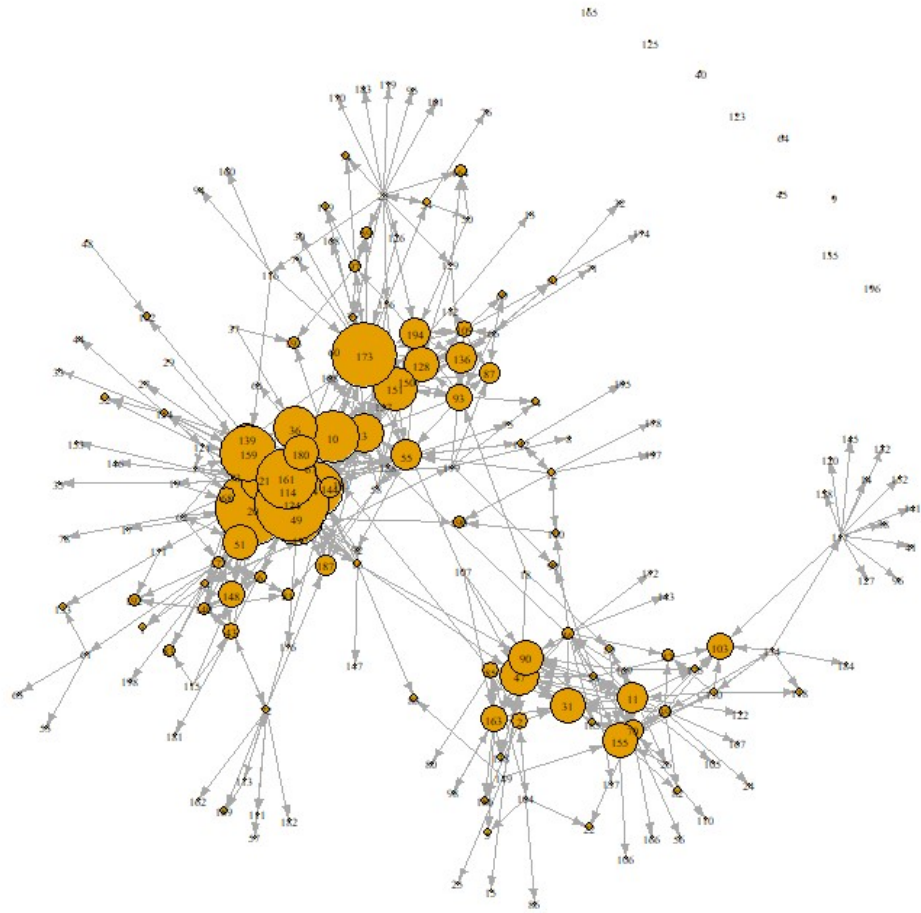1). A list of the dependent variables is included below in Table 2.

Figure 1. Network of wildfire managers working in NW Wyoming as identified via chain

referral sampling. (n=199)

Table 2. Model variables and descriptions.

Variable	Description
Collaborative Score (CS)	Proportion of 8 collaborative actions participants reported taking with people outside their organization within the past 2 years (between 0 and 1).
Betweenness Centrality (betweenness)	Score indicating how many shortest paths between nodes in the network pass through a specific node.
Gender	Female (1), male (0)
Focus	how focused participants' work is on wildfire (3 categories)
Scale	At what geographic scale participants do most of their work (5 categories)
Planning	planning fire adapted communities
Convening	convening diverse stakeholders Yes (1), no (0)
Coordinating	coordinating across jurisdictions or interests Yes (1), no (0)
Authorizing	providing leadership or authority to address fire risk Yes (1), no (0)
Engaging	engaging with landowners or homeowners about fire Yes (1), no (0)
Implementing	implementing projects designed to reduce fire risk Yes (1), no (0)
Assessing	Assessing fire risk and hazard conditions Yes (1), no (0)
Responding	Responding to emergencies when called Yes (1), no (0)

2.4 Analysis

I first evaluated the distribution of all variables visually and mathematically by making

plots and running the Shapiro-Wilk test. None of the variables were normally distributed

and transformations did not fix this problem. However, betweenness was skewed to the

right and so I used a log transformation to draw the data in more tightly, first adding 1 to

all betweenness values to account for individuals with betweenness=0. I ran five different generalized linear models (GLM) with CS as the dependent variable, using the "quasibinomial" family to account for CS being a proportion. Model 1 only includes betweenness centrality; Model 2 only contains gender; Model 3 contains focus of work and scale of work; Model 4 contains all eight role variables to describe what responsibilities managers see themselves having; and Model 5 contains all of the above variables together. I used an alpha value of 0.1 to determine the significance of the variables. Variables gender, scale, and focus were categorical and so used one category as a reference variable, meaning that the coefficients for the remaining categories are in relation to the reference variable. I used the deviance residuals, McFadden's R^2, and the chi-squared test to determine the usefulness of the model when compared to a null model. The goal of this model is not to predict collaboration, but rather to describe how these factors may influence a manager's ability to participate in multiple forms of collaboration, and to what extent.

3. RESULTS

Descriptive Results

A total of 135 people participated in the survey and identified a total of 199 people involved in wildfire management in the study region. Of the people who took the survey, about three-quarters identified as male and one-quarter as female. Approximately one-half worked for Federal agencies such as USFS, BLM, or NPS. About 20% were from local agencies, 13% each from fire-specific agencies and state agencies, and 5% from

other groups. Over half of all respondents had been working in the wildfire field for over 20 years. These proportions were roughly the same for the pruned network. Table 3 shows the proportion of respondents who agreed with the survey questions that make up the variables used in the models.

Table 3. Proportion of respondents that selected each variable (n=135 unless otherwise stated)

Category	Variable	% Agree
Collaborative Actions (n=135)	Shared information pertinent to wildfire	85.2
	Participated in inter-agency meetings for wildfire planning	79.3
	Collaborated on joint grant or funding proposal related to wildfire	58.5
	Collaborated to implement a project related to wildfire	77.8
	Participated in a wildfire-related interagency task force or partnership	60.0
	Established or improved communication/collaboration mechanisms	58.5
	Contributed to writing/updating a community wildfire protection plan (CWPP)	39.3
	Signed a memorandum of understanding (MOU) or agreement related to wildfire	34.1
	Mean Collaborative Score (Interquartile Range) = 5.1 (4 - 7)	
Gender (n=127)	Female	23.6
	Male	76.4
Focus (n=134)	Fire is a main focus of my work	18.7

	Fire is one of a number of issues in my work	63.4
	Fire is pertinent but not a major issue in my work	15.7
	Wildfire risk management is not related to my work	2.2
Scale (n=130)	Single community	10.0
	Several Communities	15.4
	Single jurisdiction	33.1
	Multiple jurisdictions	31.5
	Not focused in NW WY, but I do interact with NW WY on wildfire	7.7
	No interaction in NW WY	2.3
Planning Role	Planning fire-adapted communities	40.0
Convening role	Convening diverse stakeholders	53.3
Coordinating Role	Coordinating across jurisdictions or interests	73.3
Authorizing Role	Providing leadership or authority to address fire risk	60.0
Engaging Role	Engaging with landowners or homeowners about fire	60.7
Implementing Role	Implementing projects designed to reduce fire risk	67.4
Assessing Role	Assessing fire risk and hazard conditions	59.3
Responding Role	Responding to emergencies	65.2
–	no roles selected	5.2

The results of all four models are shown in Table 4. Model 1 shows the relationship between the betweenness centrality scores (logged) and the collaborative scores (CS) of participating managers. The coefficient is highly significant, the chi-squared test indicates

Table 4. Results of 5 GLMs predicting influence of variables on Collaborative Score (CS). Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '†' 0.1 ' ' 1. *Rv* = reference variable.

Variable	Description	Model 1	Model 2	Model 3	Model 4	Model 5
Betweenness centrality	log(betweenness+1)	0.29***	–	–	–	0.11
Gender (*rv: male*)	female	–	-0.75*	–	–	-0.16
Focus (*rv: Fire is a main focus of my work*)	Fire is one of a number of issues in my work	–	–	0.06	–	<-0.00
	Fire is pertinent but not a major issue in my work	–	–	-1.41**	–	-0.21
Scale (*rv: Single community or jurisdiction*)	Multiple community or jurisdiction	–	–	0.97***	–	0.55†
	Not focused in NW WY	–	–	0.07	–	0.58
planning role	Planning fire-adapted communities	–	–	–	0.26	0.43
convening role	Convening diverse stakeholders	–	–	–	0.21	0.06
coordinating role	Coordinating across jurisdictions or interests	–	–	–	1.03**	0.71†
authorizing role	Providing leadership or authority to address fire risk	–	–	–	0.71*	0.49
engaging role	Engaging with landowners or homeowners about fire	–	–	–	0.69**	0.72**
implementing role	Implementing projects to reduce fire risk	–	–	–	-0.09	-0.17
assessing role	Assessing fire risk and hazard conditions	–	–	–	0.25	0.01
responding role	Responding to emergencies	–	–	–	0.50†	0.66*
McFadden's R^2	—	0.21	0.07	0.31	0.57	0.62
Chi-Squared Test	—	6.36 *	2.05	9.23†	17.13*	18.69

that the model has significant predictive power compared to a null model, and the

McFadden's R^2 of 0.21 is reasonable for a single variable model. The model suggests that

higher betweenness centrality can lead to greater collaboration. Table 5 shows Model 1's

prediction of the marginal difference in CS for individuals at different quartiles of

betweenness score. According to Model 1, an individual with a betweenness score at Q1

is predicted to participate in only a quarter of collaborative actions, while someone at Q2

is predicted to participate in more than 60% of collaborative actions. The model's

predictions for individuals with a betweenness score at Q2 through Q5 are much closer

together than Q1 is to Q2, with the highest scoring individual predicted to participate in

80% of collaborative actions.

Table 5. Model 1 output using quartiles of log(betweenness + 1) data.

Quartiles of log(betweenness)	log(betweenness + 1)	Model output (CS)
Q1 (0%)	0.00	0.26
Q2 (25%)	5.09	0.61
Q3 (50%)	6.17	0.68
Q4 (75%)	7.02	0.73
Q5 (100%)	8.36	0.80

Model 2 (**Table 4**) describes the influence of gender on CS. Although the chi-squared test

and McFadden's R^2 indicate that this model is not the best explanation of the variation in

CS, the coefficient is highly significant and is worth exploring. The coefficient is

negative, meaning that identifying as female had the effect of lowering managers' CS.

The respondents to this survey were approximately three-quarters male, and I was curious

if this gender imbalance could have impacted the results, so I looked at the nomination data for the survey and organized it by the gender of the source manager (who took the survey) and the target manager (who was nominated by the source manager using the survey). These values are shown in Table 6. Men were much more likely to nominate other men than they were to nominate women: over 80% of their nominations were for other men. Women were also more likely to nominate men than women, but the ratio is much closer to equal, and they were much more likely to nominate women than men were.

Table 6. Nomination count and percentage according to gender. Taken from the full edge list minus those who did not report their gender (n=568). For reference, men comprised 76.4% of participants and women comprised 23.6%.

Direction of nomination	Number of nominations	Percent nominations from source gender	Percent nominations out of total
Male to male	360	81.6	63.4
Male to female	81	18.4	14.3
Female to male	76	59.8	13.4
Female to female	51	40.2	8.9

Model 3 (**Table 4**) shows the impact of job focus and scale of work on CS. The McFadden's R^2 (0.31) and significant chi-squared test indicate this model explains the variation in CS moderately well. The model predicts, unsurprisingly, that managers who report that fire is not a major issue in their work have a lower CS than those who report it as the main focus of their work. Further, it predicts that managers who work at the scale

of multiple communities or jurisdictions have a higher CS than those who work at the level of single communities or jurisdictions.

Model 4 (**Table 4**) shows the influence of various roles on managers' CS. Four roles were significant, the high McFadden's R^2 suggests the model is a good fit for the data, and the chi-squared test indicates that the model does has good predictive power. Coordinating, authorizing, engaging, and responding were the three significant roles, all of which served to increase managers' CS.

Model 5 (**Table 4**) collects all of the previously discussed variables into a single model. It has the highest McFadden's R^2 (0.62) of the four models, indicating that it explains the most variation in the data, although the chi-squared test indicates that it does not have good predictive power. This is likely because of the high number of variables included in the model. Scale of work, coordinating role, engaging role, and responding role remained significant in this full model, basically maintaining the same impacts on CS that they had in the previous models.

4. DISCUSSION

4.1 Network position and collaborative behavior

Model 1 indicates that a manager's position in the social network may impact their collaborative behavior. Higher betweenness centrality, indicating a position which

bridges a gap between two social sub-groups in the wildfire network, can positively impact that manager's ability to participate in multiple collaborative actions. This agrees with the literature that suggests bridgers/brokers are positioned at the cutting edge of information sharing and relationship building (Bodin et al 2006, Burt 2000) and provides empirical support to that literature. A change in betweenness centrality from the lowest to just the first quartile (Q1 to Q2) resulted in the largest marginal change in collaboration. This suggests that even a small additional effort in relationship building across boundaries can impactfully change a manager's ability to engage collaboratively. Networking and relationship building require time and energy, but these data indicate that small investments in relationship building may pay off without overburdening managers.

4.2 Gender and collaborative behavior

Model 2 shows collaboration was negatively impacted if the manager identified as female compared to if they identified as male. This finding was counter to my expectations given some research that suggests greater collaborative behavior between women in natural resource contexts (Westermann et al. 2005) and that collaborative natural resource projects are often led by women and described with feminizing language (Westburg and Powell 2015). However, Westburg and Powell point out that the feminization of collaborative projects is sometimes both a result and a cause of undervaluing female workers and collaborative work. Women also face discrimination and underrepresentation in the wildfire (Reimer et al 2018), conservation (Jones and Solomon 2019), and federal workforces (Hsieh and Winslow 2006), which could undermine their ability to participate in collaboration for wildfire resilience. One type of discrimination

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women often experience is not being recognized for the work they do (Jones and Solomon 2019), which could have directly impacted my results due to the nature of chain referral sampling. Since it relies on participants to nominate other people that they work with, women who are doing good work but who aren't being recognized for it may have been excluded from the study due to the conscious and unconscious bias of their coworkers. Table 5 reveals a notable difference in how frequently men and women were nominated by their coworkers. One limitation is that we only have gender data for people who took the survey, not necessarily for every person that participants nominated, and so there are edges that aren't accounted for in this table.

4.3 Roles and collaborative behavior

Three of the roles that were significant influences on collaboration were the same in Model 3 as in Model 4: coordinating, engaging, and responding. The authorizing role was significant in Model 4, but not Model 5. The coordinating role (coordinating across jurisdictions or interests) implies working in a cross-boundary manner as a function of one's job, and it is therefore unsurprising that working in this role would correlate with increased collaboration.

The engaging role was the most significant variable in the multivariate model. This is striking because this role measures engaging with landowners, not other managers, and therefore suggests that landowner engagement is potentially an issue that galvanizes people to collaborate. A lot of literature focuses on how much private land contributes to cross-boundary fire risk (Ager et al. 2017, Downing et al. 2022, Palaiologou et al. 2019),

on landowner participation as a key component of collective action around wildfire, and on how difficult it can be to elicit that participation (Charnley et al. 2020, Paveglio et al. 2015). It therefore makes sense that people engaging with landowners would reach out to others to collaborate on an issue that has been proven both important and difficult.

The responding role comprised people who are engaged in emergency or wildfire response. The collaborative actions that participants were asked to select from in the survey were more preparation/mitigation focused than response focused, however people involved in response were still highly engaged in these actions. The significance of the role to collaboration could be related to the Holley and Gunningham (2011) assertion that collaboration works best when there is a crisis. The focus of response personnel on the crisis-side of wildfire may help them to collaborate more effectively.

Although the authorizing role was not significant in the last model, it was in Model 3. This role indicates managers that have a leadership role in their organization or on their projects, suggesting that they would have the decision-making power needed to participate in some of the collaborative actions. One mitigating factor for authority is that in some cases, collaboration can be a way for managers to work around their own lack of authority in a given area (Steen-Adams et al. 2021, Hamilton et al. 2021).

The role of authority in collaboration may reveal a limit to how much betweenness may be able to facilitate a manager's collaborative actions. If they have high betweenness, but are in a position that isn't able to participate in certain actions that require authority (i.e.,

CWPPs or MOUs), betweenness will not change that fact. Conversely, high betweenness in some cases may in fact be the result of a manager's authoritative position; I built the social network map based on who participants said they worked most with, and some may have nominated people they report to or who otherwise have authority in the network. Other literature discusses betweenness as something that actors may be able to exert influence over, purposefully identifying, creating, and/or bridging gaps with more autonomy than they may be able to exert in their formal roles (Burt 2000, Hamilton et al. 2021). However, there is undoubtedly an overlap in role and betweenness.

4.4 Factors with significant influence on collaborative behavior

Model 4 suggests that a manager's position in the social network, alone, does not dictate how many collaborative actions they are able to take on. When other variables are added to the model, betweenness drops out of significance, and scale of work and role proved most significant. Specifically, the model suggests that if managers work at the scale of multiple communities or jurisdictions, the number of collaborative actions they participate in will be larger than if they worked in a single community or jurisdiction. Collaboration is particularly useful when confronting a problem whose scale outstrips the capacity of one entity to confront (Steen-Adams et al. 2021, Charnley et al. 2020), so managers whose jurisdiction is larger may rely on collaboration to supplement their capacity to act at the scale they need to. This finding may contradict previous research that suggests there are transaction costs associated with collaboration at large scales (Hamilton and Lubell 2018) which prevent collaboration at these scales from being beneficial. These transaction costs stem from less place-based knowledge, less

homogenous preference between potential collaborators, and less frequent interaction between managers at larger spatial scales, all of which can erode the effectiveness of collaboration. In this model, however, working at multiple communities or jurisdictions both have a more positive impact on collaboration than working at a single community or single jurisdiction scale.

5. CONCLUSION

In this study, I demonstrated that managers who act as bridgers in Northwestern Wyoming's wildfire management networks are more collaborative than those who play less of a bridging role. I also showed that even small increases in betweenness centrality relative to other people in the management network may increase managers' collaboration. However, managers' position in the network is one of many factors that affect their ability to participate in collaborative actions. Female managers were less engaged in collaboration than their male colleagues, possibly due to the discrimination that women face in the natural resource and wildfire fields. Managers' job focus and the geographic scale at which they worked significantly impacted collaboration, with more collaborative actions seen in people with a specific focus on wildfire and fewer collaborative actions in people who focus only on a single community or jurisdiction. Managers' roles were also impactful, with greater collaboration seen in managers who performed coordinating, engaging, responding, and authorizing roles. When all factors, both personal and positional, were combined in a single model, scale of work and role

(coordinating, engaging, and responding) were most significant in their effect on collaboration.

As managers work to address wildfire across boundaries, these data may help illuminate what factors facilitate managers' ability to participate in important cross-boundary collaborative efforts. Training and hiring practices may benefit from emphasizing coordinating and engaging roles to promote more collaboration, as well as designing and hiring for positions that specifically focus on wildfire collaboration. Managers should address gender biases in their workplaces that prevent women from participating in collaborative actions and should ensure that women are adequately recognized for their contributions to wildfire management and have access to career advancements and roles that facilitate collaboration. Cross-boundary networking and relationship building should be encouraged and facilitated, but managers should also feel empowered to acknowledge their time and energy constraints with regard to this aspect of their job, since these data demonstrate that even small efforts impact collaboration. Organizations may also consider hiring for positions that specifically focus on cross-boundary collaboration. Future research should investigate these dynamics in other regions to understand how collaboration may be impacted by other cultures and ecologies. The impact of gender on collaboration in wildfire management also requires further study, as does the impact of gender bias on chain referral sampling methods.

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6. ACKNOWLEDGEMENTS

CHAPTER 4: Conclusion

With this research, I wanted to better understand what factors make cross-boundary collaboration on wildfire management effective. I expected to find something relatively prescriptive, emphasizing the importance of collaboration and formal collaborative organizations, affirming the importance of highly networked people in achieving collaborative goals. These results are far more nuanced than that. I found that managers had a practical approach to collaboration on wildfire management, treating it as one tool among many for achieving the healthy landscapes and adaptive communities they all genuinely strive towards. Their reservations about collaborative work were not based on distrust of other organizations or reticence to relinquish control, but rather on a realistic assessment of their time, resources, and the needs of their communities. In addition, in some cases their conception of who they could collaborate with was more expansive than I expected, including non-human entities and future generations as well as other organizations and existing community members. Some of my quantitative results were intuitive, such as the relationship between job focus and multi-jurisdiction or multi-community scale work increasing collaboration. On the other hand, the results on gender were surprising and fascinating to me, and I hope to see more work in the future that specifically investigates how gender bias impacts collaboration in wildfire management. Similarly, while my research affirmed the positive impact of betweenness centrality on collaboration, I was surprised to find that betweenness was most impactful in the first and second quartiles, meaning it was most impactful not for the highly connected people in the network, but for those in the middle.

In Chapter 2, I described four overarching ways that managers approach collaboration in wildfire management to maximize both collective and individual organizational benefit. The first theme, deciding when collaboration is and isn't the right tool, agreed with both the literature acknowledging the constraints of collaboration (Koontz and Thomas 2006, Lubell et al. 2017, Lubell 2004), as well as the literature affirming its necessity (Charnley et al. 2020, Davis et al. 2021). Managers used collaboration as one of several tools at their disposal and stressed that it was not the solution to every wildfire management problem. However, they also saw it as a necessity, both to address capacity and funding restrictions and to improve the public perception of controversial projects.

The second theme, utilizing jurisdictional and organizational differences, also builds on literature that describes collaboration in natural resources using differences to benefit each other (Kelly et al. 2019, Steen-Adams et al. 2021). Managers were highly aware of collaborators' different tools, reputations, and capacities, and relied on each other to fill in gaps in wildfire management that they themselves could not fill. This was particularly relevant when communicating with different communities predisposed to think better of one organization or another. Managers recognized the unique context of the communities they worked in and adjusted collaborative behavior to better work within those communities (Paveglio et al. 2012, Paveglio et al. 2015).

The third theme, finding or designing multi-benefit projects, draws on literature that discusses the transaction costs of collaborative relationships (Lubell et al 2017, Hamilton and Lubell 2018) and the importance of compensating collaborators adequately for their

participation. Holley and Gunningham (2011) suggest that funding can help collaborators overcome transaction costs, but so can "in-kind support", which is more similar to what I heard in my research. One manager I interviewed used the phrase "collaborative benefits" to describe how prescribed fire for fuels reduction can also produce beneficial wildlife habitat, and therefore is a good collaborative project for fuels and wildlife-focused managers. This sentiment was echoed by other managers about other benefits.

In the fourth theme, choosing collaborators and building relationships, managers described the need to find people with whom they could work effectively to accomplish their goals. People also reflected on the fact that they had to invest in their collaborative relationships even when they hadn't had the opportunity to choose those collaborators, and discussed the effort that went into aligning personalities, goals and interests. The discussion of positionality in collaborative projects by Cheng and Randall-Parker (2017) is relevant here. In addition, managers discussed the importance of investing in relationships early and often, even when no collaboration was imminent, as this built trust that would be necessary in a later crisis. This agrees with Steelman and McCaffrey's (2013) finding that relationships built prior to a crisis were part of best practices for wildfire risk networks. Interestingly, managers also discussed non-humans, such as "Mother Nature" and lightning, in similar terms to other collaborators, indicating that these actors have agency and sway in management decisions (Youatt 2017).

In Chapter 3, I further explored the personal factors that influence collaborative behavior, as well as the impact of high betweenness centrality on collaboration. I found that higher

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betweenness centrality did result in more cross-boundary collaboration. When comparing people in different quartiles of betweenness centrality, the largest increase in collaboration occurred between quartile 1 and quartile 2. In subsequent quartiles, collaboration continued to increase but with a smaller marginal increase. This suggests that cross-boundary collaboration requires a certain threshold of betweenness, or connectivity across boundaries, beyond which the advantages of betweenness drop off. This finding relates to previous theoretical work that suggests most measures of social capital in networks are beneficial in moderation. For example, Bodin et al. (2006) assert that excessive betweenness can damage the adaptivity of a social network by decreasing modularity and leading to a more homogenous network. Newman and Dale (2005) emphasize the importance of bridging roles but caution they should be balanced with in-group (bonding) connections.

My findings on scale and focus of work demonstrate that managers with a specific focus on wildfire (rather than a peripheral focus) and who work at a multi-community or multi-jurisdictional scale are more engaged in cross-boundary collaboration. Other research has suggested that some wildfire risk planning does not match the geographic scale of wildfire (Ager et al. 2017), and that larger-scale projects can be challenging to manage collaboratively (Hamilton and Lubell 2018, Holley and Gunningham 2011). However, there is also research that shows landscape-scale crises can galvanize effective cross-boundary collaboration (Steen-Adams et al. 2021).

These data also demonstrated that gender bias may have an impact on collaboration. The impact of managers identifying as female was to lower their collaborative score. This may be due to the discrimination that women face in many fields, including natural resources (Hsieh and Winslow 2006, Jones and Solomon 2019, Reimer et al 2018), which could undermine their ability to participate collaboratively. Although gender explained a relatively small amount of the variation in collaborative score, it is also likely that gender is implicit in some of the other variables, such as the roles they play in fire. Further, I demonstrated that male managers were more likely to nominate other managers who were also men than managers who were women in the survey. This suggests that the sampling method I used (chain-referral survey distribution) may amplify gender biases against women, producing data that does not accurately reflect the contributions that women make in wildfire management. Other research has shown that a common type of discrimination that women face in the workforce is not being recognized for the work they do (Jones and Solomon 2019).

Wildfire managers often play multiple roles in their work, and this research identifies four that are particularly important in collaboration: coordinating across jurisdictions, providing authority, engaging with landowners, and responding during emergencies. I discussed an interviewee who noted that decision-making authority was part of what makes someone a good collaborator, because they could follow through on project ideas and directly take action. I also discussed how many interview participants felt frustration when working with private landowners. These roles appeared in both the qualitative and

quantitative results, further emphasizing their importance in collaboration in the study

area.

This thesis contributes to the literature by providing both qualitative and quantitative

analysis of managers' ways of navigating collaboration in wildfire management, which

could potentially serve as the groundwork for best practices in collaboration. It also

provides empirical data on the positive impact of betweenness centrality on collaborative

action, demonstrates the impact of gender bias on collaboration and chain referral

sampling methods, and shows that some roles are more likely to engage in cross-

boundary collaboration in wildfire, which could inform hiring and training practices.

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APPENDICES

Interview Guide

Goals

The main purpose of these interviews is to qualitatively assess how the informal wildfire management network in Wyoming functions, drawing both from pre-survey interviews, the recently completed survey, and the framework of polycentric governance. Much research has been conducted on wildfire response networks, which are often hierarchical in nature because of that structure's ability to facilitate quick emergency response. In this interview, the goal is to focus more on mitigation/preparedness networks where possible (some people will work primarily in response, and in those cases it may be necessary to pivot to response more quickly). Specifically, the goals are:

1. To understand wildfire governance dynamics from the perspectives of highly central actors from multiple parts of the network, and compare them to polycentric governance dynamics.
2. To understand the capacity and barriers that individuals have in initiating and maintaining collaborative relationships.

Final Products

1. Create a narrative describing the features of wildfire management in Wyoming that function via polycentric governance and those that function hierarchically, with an understanding of why based on local context.
   a. Kelly, E. C., Charnley, S., & Pixley, J. T. (2019). Polycentric systems for wildfire governance in the Western United States. Land Use Policy, 89, 104214. https://doi.org/10.1016/j.landusepol.2019.104214
   b. Andersson, K. P., & Ostrom, E. (2008). Analyzing decentralized resource regimes from a polycentric perspective. Policy Sciences, 41(1), 71–93. https://doi.org/10.1007/s11077-007-9055-6
2. Develop a conceptual diagram of collaboration as a function of transaction costs and social capital using social exchange theory as a model.

Interview Guide

The interview guide asks about collaboration, focusing on the elements of polycentric governance outlined in Kelly et al. 2019.
- There are multiple actors at multiple scales
- Overlapping jurisdictions and/or organizational redundancy
- There is interaction between actors
- There is a guiding set of rules for all organizations

- The actors are able to influence each other

It also asks about transaction costs, and attempts to explore how highly connected people navigate maintaining collaborative relationships with limited time and resources.

Numbered questions will be asked to every participant. Bulleted questions are "probes" that can be used to both determine whether the participant has covered the topics of interest in their response, and as invitations for further discussion if the response to the initial question is not sufficiently detailed.

I: Introduction
- Thank you for your willingness to continue helping with this research. Just to recap, the purpose of this project is to get a sense of who is working on wildfire in Wyoming, what kinds of work they are doing, and how and where they are collaborating with other people in their work. The survey that you took was the first step in that process, and gives us one way to visualize some of the relationships that people rely on in wildfire management in Wyoming [show network map]. What we want to do with these interviews is get a better sense of how this network of people functions in reality. I'm especially interested in your personal perspective relating to what collaboration and action look like when there **isn't** an active fire, but I expect we will talk about fire response as well.
- Do you have any questions for me about the survey or the interview before we begin?
- If at any point you wish to stop the interview, you are free to do so, or if there are any questions that you would prefer not to answer, please let me know. I'll use your responses in my thesis and probably other written reports about this project, but nothing will be attributed to you or your organization, this is all confidential.
- I would like to record this interview so I can focus on listening rather than taking notes. Are you comfortable with that?

1. To start, could you tell me a bit more about your day to day work, especially your roles in managing wildfire risk?
   a. Job title?
   b. Major responsibilities?
   c. What are the main ways you address those responsibilities?
   d. Where is most of your work focused?
   e. What are some recent important projects you have worked on?
   f. Be specific to mitigation, education, and pre-fire planning, but allow for discussion of response too.

2. A lot of what I'm trying to learn about is collaboration in the process of wildfire mitigation work. Can you talk about the relationships you have with folks outside of your organization?
   a. What other organizations do you work with to address northwestern Wyoming's wildfire risks?
   b. Where did those relationships start?
      i. An event?
      ii. A mutual connection?
      iii. A strategy?
   c. How does your affiliation with [name of organization] influence those relationships?
      i. Legitimacy? Trust? Resources? Capacity?
      ii. Is collaboration supported or just tolerated?
3. How do you decide which organizations are most worth your time to collaborate with?
   a. Especially when short on time or money
   b. How much capacity do you have for new collaborations?
   c. What impacts your capacity to collaborate?
4. We heard from some people that the wildfire community in Wyoming can be a small world, and that personal relationships can heavily impact collaboration. Do you agree? Could you describe how personal relationships impact your work?
   a. Are there instances where the relationship is more about the organization than about the personal relationship?
   b. Turnover
   c. Culture
   d. How do you get past differences or difficult relationships when collaboration is necessary?
   e. Trust
5. How effective do you think collaboration has been for managing wildfire risk in northwestern Wyoming? And what influences when collaboration works?
   a. In your experience, how useful is it to have a variety of people who work at different scales involved in collaboration? Or is it more useful to have people all focused at the same scale?
      i. Vertical and horizontal bridging
      ii. Power differentials
      iii. Culture, reciprocity, and trust
   b. How much do overlapping jurisdictions or organizational redundancies matter, if there are any?
      i. Competition and cooperation

      ii.   Power differentials
  c. What about formal and informal agreements? What kinds of examples do you see in your work and how do they influence collaborative outcomes?
      i.   Informal
      ii.   Mandated
      iii.   Co-management
      iv.   Bottom-up vs top-down
  d. Can you think of examples where you or your organization has been influenced by others you collaborate with on wildfire risk, or the other way around?

6. What keeps people on the same page when working together on wildfire mitigation? Or divides them? Is there a key ingredient that you've experienced?
  a. Legitimacy
  b. Trust
  c. Resources
  d. Outcomes
  e. What about personal relationships, how do they help or hinder the process?
  f. Has COVID influenced your capacity to maintain collaborative relationships?

7. How does northwestern Wyoming's wildfire management community compare to other places you've worked?
  a. What has happened here that you can't imagine happening without collaboration?
  b. Is the landscape different today than it was in the past in ways that you imagine are attributable to collaborating on wildfire risk management?
  c. Has collaboration changed wildfire risk in northwestern Wyoming? Why or why not?

8. As you think about the future in northwestern Wyoming, with respect to wildfire risk, what still needs to happen? What would you prioritize?
  a. Collaboration
  b. Fuels
  c. Prescribed fire
  d. Defensible space
  e. Development
  f. Community engagement

9. Is there anything else I should be asking about to understand how collaboration plays a role in managing northwestern Wyoming's wildfire risk?

Thank you so much for your participation.

APPENDIX B

Managing Wildfire Risk in Northwest Wyoming

A Survey of the Network of
Wildfire Risk Managers in Northwest Wyoming

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Summer 2022

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Executive Summary

Northwest Wyoming is one of twenty wildfire risk hotspots in the western US, areas where wildfire risk has challenged residents, officials, and land managers to rethink how wildfire risk should be managed. Towards that end, stakeholders in community wildfire risk management have invested in developing strategies such as the Teton Area Wildfire Protection Coalition and similar collaborative organizations to foster learning and engagement across communities in the region. At the state and federal levels, the National Cohesive Wildland Fire Management Strategy has convened a diversity of stakeholders from different agencies, jurisdictions, organizations, and interests to envision a new future for wildland fire.

To understand how these investments are shaping the region's wildfire risk management system, Portland State University, as part of the US Forest Service (USFS) Co-Management of Fire Risk Transmission project (CoMFRT; Williams & Essen 2018), conducted a survey of wildfire risk management professionals aimed at identifying who is part of the wildfire management system in Northwest Wyoming, what their roles are, where they work, and how they are connected to each other. This report describes the results derived from the 135 individuals who participated in the survey.

Key highlights from our work include:

1. **The wildfire management system in Northwest Wyoming is diverse and includes professionals spanning governmental and non-governmental boundaries across many scales.** Professionals in wildfire risk management included government employees operating at the federal, state, and local levels, as well as people in the private sector, non-governmental organizations (NGO), Tribal nations, and others. This diversity and the collaborative capacity of the region is in part the result of past investments in efforts like the Teton Area Wildfire Protection Coalition and the Alpine Area Wildfire Protection Coalition. Although the majority of professionals indicated they have a local jurisdictional focus (e.g., a fire protection district or national forest), others work with specific communities or more broadly at a regional scale. Collectively, wildfire risk management practitioners in Northwest Wyoming have extensive experience, with almost 80% of participants reporting more than a decade of experience with wildfire, and broad networks of relationships with others. **Nearly 20% of those we surveyed indicated wildfire was the main focus of their job, while over 60% reported that wildfire was one of several major issues in their jobs.** Relevant positions included fire management officer, fire chief and

warden, district ranger, and wildlife and habitat biologist, as well as public information officer, fuels specialist, and emergency management, among others.

2. **Collaborative relationships within Wyoming's wildfire network may be more strongly influenced by geography than we have seen in other study areas.** Preliminary analysis suggests three main subgroups within the network that are more closely related to each other than to the rest of the network. These groups appear to correspond with three loose geographic areas: 1) Teton County and the surrounding area, 2) Sublette and Lincoln Counties and surrounding areas, and 3) areas east of Teton County. The groups also appear to correspond roughly with the Geographic Area Coordination Center (GACC) boundaries in the region. Differences in the population, land use, wealth, and other factors in these subregions may contribute to the formation of subgroups of fire professionals who can address local fire concerns with local expertise. Despite this modularity, there were still many significant relationships that crossed between subgroups.

3. **Practitioners in Northwest Wyoming have a wide array of relationships with people in other organizations, yet some organizational affiliations tend to foster more diverse relationships than others.** The 199 professionals identified as part of the Northwest Wyoming wildfire management system were affiliated with federal agencies (47%, including 30% with the US Forest Service, 10% with BLM, and 8% with NPS), local agencies (22%), fire departments/EMS (13%), state agencies (11%), and other groups including private companies or landowners (3%), universities and research organizations (2%), Tribes (1%), and NGOs (1%). Of those 199 professionals, 135 responded to the survey (68%), and of those, 82 (41% of total respondents) nominated individuals that they worked with. Over 60% of those 82 respondents identified 5 or more people, and nearly all of them identified people from organization types other than their own. Over 55% of individuals in the network were identified multiple times. Twenty-one individuals were nominated 10 times or more, making them highly central to the wildfire management system. Relationships within and between affiliations varied across affiliation. Federal agencies had the most representation in our survey, were most likely to be nominated by other groups, and also had the highest rate of self-nomination. State agencies were most likely to nominate people from outside their own organizational affiliation, and people from Private, Research, NPS, and NGOs were most likely to nominate individuals from fire-specific organizations.

4. **Some people in the network play an outsized role in bridging boundaries between the many individuals who play a role in wildfire risk management.** At

the individual level, some respondents also emerged as particularly important for spanning boundaries between organizational affiliations (see network maps below). Boundary spanning individuals are commonly described as influencers or bridgers because their position in the network allows them to combine different perspectives, transfer ideas between groups, make introductions, and negotiate between different interests. These qualities give boundary spanners important leverage and power in a network. The top 2 boundary spanning individuals were affiliated with USFS Forest Districts, and of the top 20 boundary spanners, 8 were from Forest Districts and 5 were from Fire Districts or Emergency Management. Boundary spanners may be in a good position to bridge collaborative work with the USFS, other federal agencies, state and local agencies, tribes, non-governmental organizations and the private sector, when and where laws and policies allow.
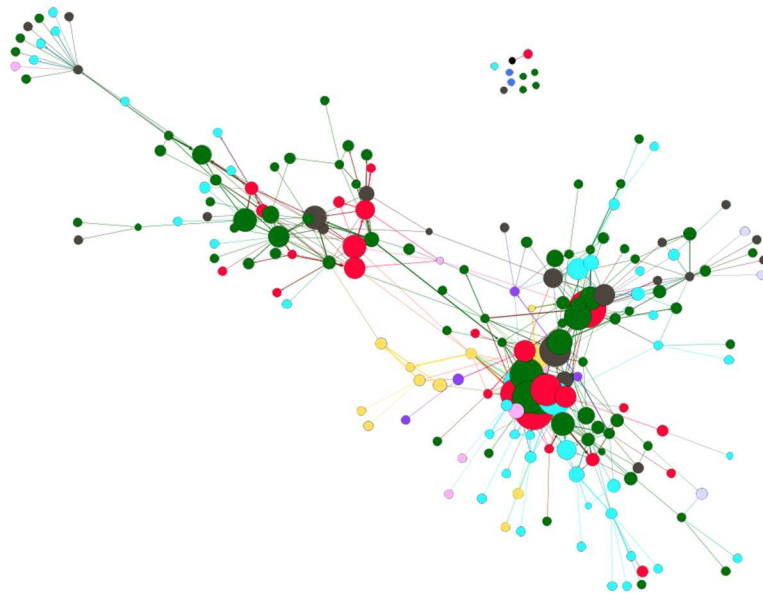

Figure i. *Network map depicting individual to individual connections. Colors correspond to affiliation: federal=green, local=light blue, fire=red, state=black, nps=yellow, private=pink, science=purple, tribes=dark blue, ngo=gray.*
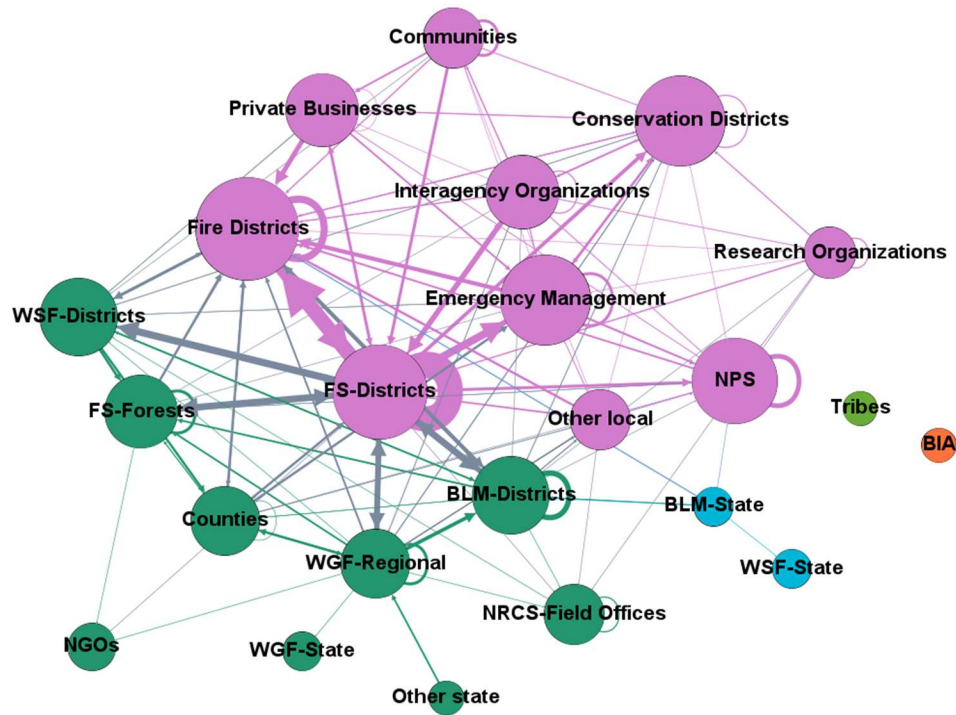
Figure ii. Network map depicting connections between organizational units. Nodes with the same color are more likely to be connected to each other than nodes of different colors.

Recommendations

Our findings paint a picture of a well-developed and relatively diverse set of professionals working across boundaries of the wildfire management system in Northwest Wyoming. Nonetheless, those involved in the network expressed the need for continued improvement. Furthermore, whether the wildfire management system in Northwest Wyoming is representative of other hotspots of wildfire risk in the western US is unknown. Towards these ends we make the following recommendations:

1. **Develop shared stories about wildfire and celebrate successes in wildfire risk management across jurisdictional boundaries.** Northwest Wyoming contains many

different communities whose priorities and resources don't always align, but creating a shared narrative to help both decision makers and homeowners think about fire as a collective responsibility throughout the region can help facilitate effective, landscape scale management. Publicly celebrating successful actions taken by outside organizations can also help build public confidence in the network of people managing wildfire risk in the region, and could encourage participation in future actions.

2. **Plan for a collaborative network that can adapt to change.** Over half of the respondents in this survey indicated that they have been working in the field for 20+ years, meaning that a large number of folks may be retiring in the coming years. It will be important to find new people to step into these roles who can maintain collaborative relationships that have been built over long careers, as well as spark new ones where needed. Existing and incoming wildfire risk managers also need to be prepared for wildfire conditions and goals to change, and adapt their practices collaboratively when they do.

3. **Invest in boundary spanners to increase the connections and collaborative engagement between otherwise disconnected parts of the network.** The position occupied by boundary spanners gives these individuals and organizations important leverage and power in the wildfire management system by allowing them to combine perspectives, transfer ideas between groups, and negotiate between interests. Building trust and investing in these individuals and the organizations that support them may be critical to maintaining collaborative engagement and strategic alignment of goals, programs, and actions across jurisdictions. If the outsized role these individuals and organizations play becomes a burden to their limited capacity, future investments in wildfire risk management in Northwest Wyoming may be less likely to establish and maintain fire-adapted communities, resilient landscapes, or safe and effective incident management.

4. **Prioritize high-value collaborations.** Formal collaboratives can be an effective way to bring people together around shared goals, but simply having collaborative meetings is not the goal. Organizations need to make sure that people who participate in collaborative activities are receiving as much support as they are providing. Determining jurisdictions and geographies where collaborative identities can lead to effective collaborative actions will help people make the most of limited capacity.

Next Steps

This report concludes Phase 1 of Portland State University's work on the CoMFRT project in Northwest Wyoming and helps launch Phase 2. The Phase 1 research asked about who makes up the wildfire management system in Northwest Wyoming, what their roles are, where they work on the landscape, and how they are connected to each other. The report provides a summary of the respondents, mapping, and networks of the 135 professionals in wildfire risk management in Northwest Wyoming who graciously volunteered their time and perspectives to this research. It also draws occasionally on 12 interviews with central individuals, who agreed to describe their jobs and experiences in more depth.

As we transition to Phase 2, it is important to note that Phase 2 will rely on participants from Phase 1 to volunteer their time again (less than 30 minutes on average), and some participants may be asked to participate in a separate voluntary interview to describe what motivates their collaborative behaviors.

Phase 2 of our research will ask a set of questions that couldn't be asked until we knew answers to the questions asked in Phase 1. The questions include:

1. Why are some people and organizations more focused on boundary spanning than others?
2. Why are some people and organizations more engaged in collaboration than others?
3. Why are some managers' understandings of wildfire risk different from others?

Answers to these questions are important for encouraging the collaborative engagement needed to ensure that across organizations wildfire management goals are strategically and programmatically aligned. These questions can also help us test hypotheses that organizational missions, job descriptions, and personality can influence boundary spanning behaviors and the success of collaborative efforts toward adapting to wildfire risks in Northwest Wyoming (Kilduff and Krackhardt 2008). If supported, these findings would show that adaptive governance of wildfire risks can be successfully designed through organizational processes as well as selected for through recruitment and employment processes.

Finally, in collaboration with the CoMFRT Project, Portland State University has initiated similar research in the Wasatch and Cache Valley region in Northern Utah, and the North Central region of Washington. Results from these areas will be compared with those from Northwest Wyoming and will help provide a more general understanding of wildfire risk management systems in the United States and how they vary. We hope our

research will be useful both for the regions in which we are working and for decision-makers at the state and national scales who are trying to understand how best to support and encourage local initiatives to be prepared for future wildfire risks.

1. Introduction

Northwest Wyoming (NWWY) is a national hotspot of wildfire risk, due in part to the potential for transmission of wildfire from federal lands to adjacent communities and infrastructure. Recent analyses funded by the USDA Forest Service (USFS) identified National Forest System lands in NWWY as one of 20 core firesheds across the western United States. Collectively, the 20 hotspots account for nearly 80% of the fire predicted to be transmitted between USFS lands and nearby communities in the western US (USDA Forest Service 2018).

NWWY is also a hotspot of innovation for wildfire risk management. Due to the present wildfire risk in the region, managers, policy-makers, and practitioners have begun work to implement the resilient landscapes, fire-adapted communities, and safe and effective response goals of the National Cohesive Wildland Fire Management Strategy (hereafter, the Cohesive Strategy; USDA-USDOI 2014). To do so, the Cohesive Strategy calls for the following:

- Strategic alignment of goals, programs, and actions across jurisdictions
- Collaborative engagement on issues including governance, sharing of information and resources, communications, and monitoring and accountability
- Programmatic alignment of individual agency/organization objectives with Cohesive Strategy goals.

Towards these ends, leaders in the Jackson Hole wildfire risk management community developed the Teton Area Wildfire Protection Coalition (TAWPC) to encourage collective risk management, provide support for cross-boundary mitigation projects, and provide education to residents of Jackson and other nearby communities. Similarly, wildfire managers in Alpine, south of Jackson, have created the Alpine Area Wildfire Protection Coalition (AAWPC). Others from the region are involved in forest collaboratives, Firewise neighborhood programs, and informal groups working towards wildfire risk mitigation in their communities. These efforts and others like them at the local and state levels around the country are evidence of initiatives to adapt the interface between communities and infrastructure and western US forests and other wildlands to the increasing risks of wildland fire as called for by a number of recent scientific publications, policy reports, and the popular media.

The USFS Rocky Mountain Research Station wanted to better understand what strategies and innovations are allowing people and institutions to work successfully together across jurisdictional, agency, organizational, and interest boundaries. To do this, they coordinated the Co-Management of Fire Risk Transmission (CoMFRT) partnership to identify local approaches to co-managing risk in fire-prone landscapes; highlight ways to improve capacity in different social and geographic conditions; and provide science-based recommendations for investments to improve the wildland fire system, sustain fire-adapted communities, and conserve the land.
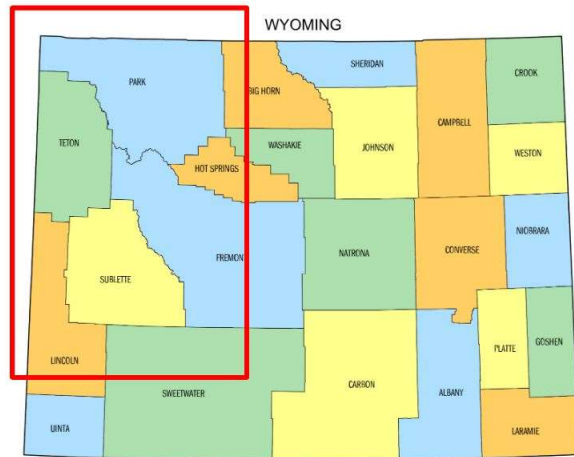
As part of the CoMFRT research project, the Portland State University (PSU) team is working to describe the network of wildland fire risk management actors and institutions working in core USFS firesheds, their relationships with each other, and where they coordinate and collaborate on wildfire risk management. This report describes the results of the PSU team's initial online questionnaire of wildfire risk managers in the NWWY fireshed. The objectives of the PSU survey were to:

1. Describe the diversity of the wildfire risk managers and organizations (i.e., actors) operating in the NWWY hotspot, including
   a. what they consider to be their contributions to wildfire risk management,
   b. where they are working, and
   c. who they are working with and the qualities of their working and influential relationships.
2. Characterize wildfire risk management system network in the NWWY hotspot.

This report provides a brief overview of the NWWY hotspot and methods for data collection. The results of the questionnaire are described from the perspectives of those who responded to the survey and at the scale of the wildfire management system in NWWY. The report ends with a brief discussion of implications and conclusions.

1.1. Northwest Wyoming

Northwest Wyoming is a region generally characterized by a low-frequency, high-severity fire regime and relatively sparse population. Within this region, there are a number of geographically variable subregions such as the high elevation forests of Yellowstone, the more fire-prone forests of the Bridger-Teton, Bighorn, and Shoshone National Forests, and the dryer rangelands east of the Bridger-Teton National Forest. Wildfire in the study region tends to be infrequent and stand-replacing, and urban growth and increased tourism in the area have led to expanded WUI development, putting firefighters, residents, businesses and others at higher risk from wildfire. While recent wildfires have not caused significant damage to structures or human life, the high severity fire regime of the area and continued human development into forested areas mean that when a wildfire does occur, there will be high risk to the residents and tourists of the area. People in the area have made significant efforts to organize for risk mitigation, as evident in the development of the Teton Area Wildfire Protection Coalition and the Alpine Area Wildfire Protection Coalition, among other formal and informal organizations.

The largest communities of the NWWY hotspot are located near Jackson, which is situated just southeast of the Grand Teton Mountain Range. There are many smaller communities south and east of Jackson that face significant wildfire risk as well. Most of the participants identified from our survey focused on wildfire in Teton, Lincoln, Sublette, Fremont, and Park counties. Precipitation, elevation, wealth, and values can vary considerably between subregions, and collaboration in fire management may reflect those differences. In other words, collaborating on wildfire management can boost an area's capacity to mitigate, respond to, and recover from a wildfire, but collaboration between some areas or entities may be more effort than it is worth. However, cross-boundary collaboration often still exists within a given area and is vital for local wildfire risk mitigation.

2. Methods

2.1. Sampling

We used chain referral sampling to distribute this survey and collect our data. This involved identifying an initial seeding group of between 10 and 15 people who we asked to take the survey. In their responses to the survey, we asked them to nominate people that they work with on wildfire, and we then invited those nominees to participate in the next round of the survey. We first researched organizations in the region that deal specifically with fire and selected between 10 and 15 people to be our initial survey participants and to take part in informal stakeholder meetings. Our goal was to select people from diverse parts of the expected network. In previous iterations of the study (WA and UT), there were not any Tribal representatives present for the focus group, and we thought that this could have contributed to the low response rate from Tribal fire managers in the survey section of the project. We also tried to minimize people with overlapping job descriptions or jurisdictions, since the initial stakeholder group could influence the segments of the network that end up being represented in the survey. In total, we met with 15 people, representing 12 different organizations.

The goal of the stakeholder meetings was for us to build an understanding of the local context and also to introduce ourselves to managers in the area to build trust. We briefly presented findings from Utah and Washington and background on the CoMFRT project. We then invited attendees to share their thoughts on the strengths of fire policy/management in the region, the challenges they face in their jobs, how collaboration factors into their work, and any priorities they had for research on the topic. At the conclusion of the stakeholder meetings, participants were asked to take the survey as our initial seeding group.

In addition to these informal stakeholder meetings, we also invited additional people throughout the region to participate in the survey as part of the seeding group, although without a prior meeting. The purpose of this additional seeding was to elicit responses from as many parts of the potential network as possible. Due to time and personnel constraints, it was not possible to have stakeholder meetings with all of the people that we wanted to seed the survey, so instead we contacted them through email with detailed, but succinct, information about the project and an invitation to participate in the survey.

2.2. Questionnaire

The survey was based on previous surveys administered in WA and UT, and the main questions asked who works on wildfire in Northwest Wyoming, what organizations work together, what collaborative activities participants engage in across boundaries, what

attitudes participants hold about wildfire, and how jurisdictional and geographic boundaries impact collaboration. We formatted and distributed the survey using Qualtrics online (Qualtrics, Provo, Utah). The stakeholder meeting attendees were the first people to take the survey, followed by the additional identified seeding participants, and the responses from these individuals populated the next round of participants who were invited to take the survey. This chain referral sampling continued for 12 rounds. Nominated participants were not told who nominated them, and all personally identifying information has been removed from figures and publicly facing summaries.

2.3 Interviews

As we approached the end of survey data collection, we used the nomination section of the survey to construct preliminary network diagrams and calculate betweenness centrality– which indicates to what extent an actor is engaged in connecting otherwise disconnected parts of the network–for all of the actors in the network. We then identified people with high betweenness centrality and requested the opportunity to interview 17 of them about their role in wildfire risk management. These people were those that had the highest betweenness centrality, unless we had already selected a person within the same organization and location, in which case we passed to the person with the next highest betweenness centrality. In this way we were able to create a roster of people from different organizations and geographic locations within the study region, hopefully giving us a more representative sample of interviewees. We were able to conduct our semi-structured interview with 12 of these 17 people (70% of those asked; 6% of the total identified network). These interviews were recorded and transcribed for analysis.

2.4 Analysis

We used R to summarize responses to each of the questions in the survey. We most often organized responses according to broad organizational affiliation (Federal, State, Local, Fire, and Other) for ease of reporting. The Other category comprises NGOs, Tribes, universities and research organizations, and private companies or landowners, which together amount to 7% of the individuals identified in the survey. We used Gephi to construct network maps depicting connections between individuals and organizations working on wildfire in the study region. Further analysis of the interviews will be forthcoming, but we occasionally use insights from the interviews to contextualize the survey results.

3. Results

The following results are derived from responses to the survey we deployed in the spring and summer of 2022. We contacted a total of 187 people and asked them to take the survey; of that, 135 people responded to the survey (72%). In the nomination portion of the survey, respondents identified a total of 206 individuals, but 7 of these nominations were incomplete and were therefore removed. The final network consists of 199 people.

In the following results, the *n* is different depending on the question being answered, and this could be for several reasons. In some sections, we use the total number of respondents, which was 135. However, not every respondent answered every single question in the survey, so some sections report a smaller *n*. In other sections, we used the total identified people in the wildfire risk network, which was 199. This number applies to sections that report on affiliation, job description, or similar information that was obtained from the nominations or was publicly available. In some cases, this number may be smaller due to our inability to find certain information on an individual.

3.1. Demographic data

Tables 1 and 2 summarize the organizational affiliations and some demographic information about the people identified as part of the Northwest Wyoming fire management network.

Table 1: *Organizational affiliation and gender of survey respondents (n=133)*

	Federal	State	Local	Fire	Other	All
Male	49 (80%)	13 (76%)	16 (55%)	14 (78%)	5 (63%)	97 (73%)
Female	9 (15%)	4 (24%)	10 (35%)	4 (22%)	3 (38%)	30 (23%)
Not specified	3 (5%)	0 (0%)	3 (10%)	0 (0%)	0 (0%)	6 (4%)
Affiliation Total	61	17	29	18	8	133

Most survey participants were men, which is consistent with other regions of the Western US. Federal, State, and Fire positions had particularly high representation from men, whereas local positions had more representation from women. These results indicate that women are not well represented in wildfire management collaboration relationships in NWWY.

Of the people identified as part of the wildfire risk management network, most (47%) were affiliated with Federal agencies, with a total of 30% affiliated with the US Forest

Service alone. The positions held by Forest Service respondents, however, were quite diverse. Our survey contained perspectives from district rangers, forest supervisors, forest deputies, wildlife and habitat specialists, timber managers, fire management officers, public affairs officers, and GIS specialists, among many others. Local fire departments and ecosystems specialists as well as Wyoming state employees were also well represented in the network. Numerous fire chiefs, WY Game and Fish employees, and conservation district leaders were identified as important actors in the wildfire management network. Based on our results, fire practitioners ranging from the local to the federal level play essential roles in mitigating wildfire risk in the NWWY area, indicating that wildfire management at multiple scales is important for coordinating landscape level wildfire risk reduction.

Table 2: *Experience (years) in wildfire risk management for survey respondents (n=131)*

How many years has your work involved wildfire?	**Federal**	**State**	**Local**	**Fire**	**Other**	**All**
< 1 year	0	0	2	0	1	3
	(0%)	(0%)	(7%)	(0%)	(13%)	(2%)
1-5 years	4	1	6	0	0	11
	(7%)	(6%)	(21%)	(0%)	(0%)	(8%)
6-10 years	2	4	4	1	0	11
	(3%)	(24%)	(14%)	(6%)	(0%)	(8%)
11-20 years	17	4	8	4	2	35
	(28%)	(24%)	(28%)	(22%)	(25%)	(26%)
> 20 years	37	8	8	13	5	71
	(61%)	(47%)	(28%)	(72%)	(63%)	(53%)
Affiliation total (n):	60	17	28	18	8	131

The results of our survey show that a large majority of wildfire practitioners in NWWY

have been working in wildfire for a decade or more, indicating that most practitioners represented in the survey have a wealth of wildfire experience. This makes sense, as practitioners who have worked in wildfire for longer periods of time have had more time to forge and strengthen collaborative relationships, and so may have been more likely to be nominated to the study. While the level of experience among wildfire practitioners in NWWY reflects the expertise of practitioners in the region, it also means that turnover could leave a large rift in any given organization and, more broadly, the regional wildfire management network.

3.2. The types of work involved in wildfire risk management

We identified a total of 199 people involved in wildfire management in Northwest Wyoming, 195 for whom we could find a position title. There were a total of 130 different specific position titles. We simplified these to 84 general positions (for example, we combined the Zone FMO title with the Regional FMO title under the simplified title of FMO). FMO was the most common position held (15%), followed by Fire Chief or Warden (11%), District Ranger (5%), and Wildlife or Habitat Biologist (4%). The remaining positions all comprised less than 4% of respondents. Table 3 below shows a list of the most frequently held positions in the network.

Table 3. Frequency of positions within the wildfire risk management network in NWWY. This table shows the top 13 positions, each of which is performed by 3 or more people.

Positions	Frequency
FMO	31
Fire Chief/Warden	21
District Ranger	10
Wildlife Biologist	7
Habitat Biologist	5
Fire Management Specialist	
Supervisor	3
Public Information Officer	3
Public Affairs Officer	3

Fuels Specialist	3
Forest Supervisor	3
Emergency Management Coordinator	3
District Forester	3
Conservationist	3

The prevalence of the FMO and Fire Chief or Warden position makes sense in the context of our understanding of the network and conversations with participants. A significant portion of the study area is USFS land, and local Fire Districts were highly central in the network. Wildlife related positions seemed to be located on the periphery of the network, but through our interviews with participants, it became apparent that the Wyoming Game and Fish department is extremely important to prescribed fire projects. Public Information Officer was another position that interview participants specifically called out as vital to wildfire risk management projects.

3.3. How focused is your work on wildfire risk management?

This question was used to understand whether managers focused solely on fire or whether it was one of many issues that they worked on. Interestingly, two participants were nominated who said they did not work in wildfire at all. Most respondents (64%) indicated that wildfire was one of a number of issues that they work on, and 16% said it was pertinent but not major to their work. Only 19% of respondents claimed wildfire was the main focus of their work.

***Table 4:** Pertinence of wildfire risk management to survey respondents according to affiliation (n=132)*

How relevant is wildfire to your work in general?	Federal	State	Local	Fire	Other	All
Main focus	17	2	1	4	1	25
	(28%)	(12%)	(4%)	(22%)	(13%)	(19%)
One of a number of issues	39	12	15	14	5	85
	(64%)	(71%)	(54%)	(78%)	(63%)	(64%)
Pertinent but not major	5	3	11	0	2	21
	(8%)	(18%)	(39%)	(0%)	(25%)	(16%)
Not relevant	0	0	1	0	0	1
	(0%)	(0%)	(4%)	(0%)	(0%)	(1%)
Affiliation Total	61	17	28	18	8	132

These results suggest that many wildfire practitioners are also specialists in an adjacent field and that a majority of survey respondents have experience working across disciplines. This is encouraging, as the wildfire management network that we observed with our survey contains interdisciplinary specialists that bring diverse perspectives to the table when planning projects.

3.4 What roles are involved in managing wildfire risk?

This question asked respondents to select which of 8 fire-specific roles they play within the network. Participants could select as many rolls from the list as they liked. Almost three-quarters of respondents indicated that they were involved in coordinating across jurisdictions or interests, and the second most common role was that of implementing projects to reduce fire risk (68%).

Table 5: *Self-identified responsibilities of survey participants. Participants (n= 133) could select more than one role.*

What roles do you play with respect to wildfire? Select all that apply.	Federal	State	Local	Fire	Other	All

Planning Fire Adapted Communities	31 (50.8%)	5 (29.4%)	8 (27.6%)	8 (44.4%)	2 (25.0%)	54 (41%)
Convening Diverse Stakeholders	42 (68.9%)	8 (47.0%)	11 (37.9%)	8 (44.4%)	3 (37.5%)	72 (54%)
Coordinating across jurisdictions or interests	53 (86.9%)	14 (82.4%)	15 (51.7%)	13 (72.2%)	4 (50%)	99 (74%)
Providing leadership or authority to address fire risk	48 (78.7%)	7 (41.2%)	10 (34.5%)	13 (72.2%)	3 (37.5%)	81 (61%)
Engaging with landowners or homeowners about fire	35 (57.4%)	9 (53.0%)	18 (62.1%)	14 (77.8%)	6 (75%)	72 (54%)
Implementing projects designed to reduce fire risk	48 (78.7%)	15 (88.2%)	14 (48.3%)	12 (66.7%)	2 (25%)	91 (68%)
Assessing fire risk and hazard conditions	48 (78.7%)	7 (41.2%)	8 (27.6%)	13 (72.2%)	4 (50%)	80 (60%)
Responding to emergencies when called	50 (82.0%)	10 (58.8%)	11 (37.9%)	14 (77.8%)	3 (37.5%)	88 (66%)
Affiliation Total	61	17	29	18	8	133

3.5 Collaborative actions in wildfire management

This question asked participants to select the collaborative actions that they had recently engaged in with colleagues from other organizations in the context of wildfire. The collaborative actions were modified from Lubell (2004) and informed by previous research by Nielsen-Pincus et al (2017).
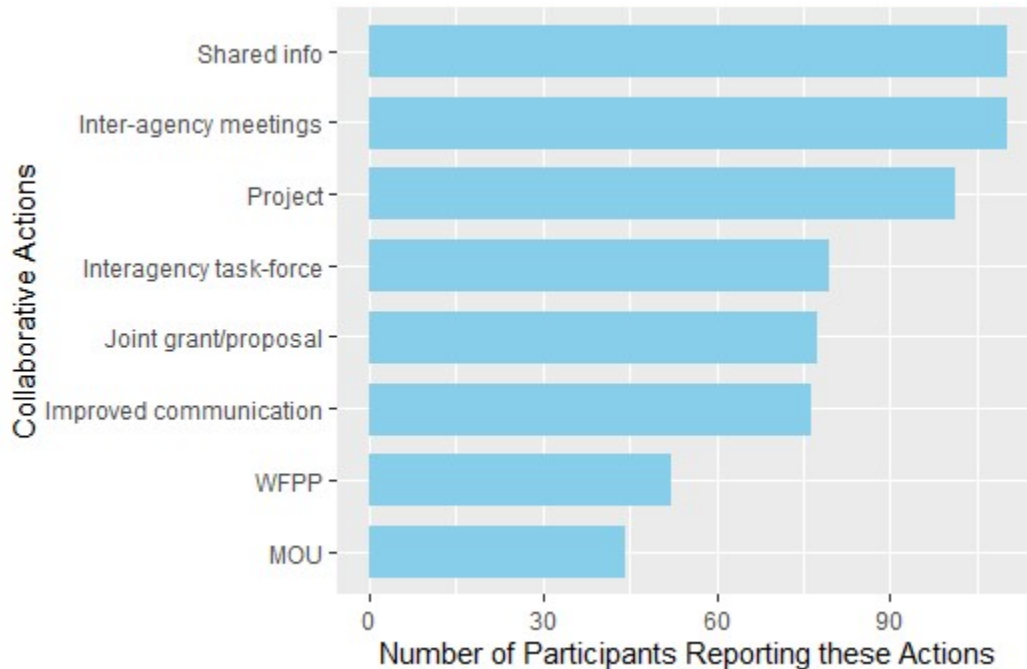
Figure 7. Self-identified collaborative actions that participants play in the context of wildfire management over the past two years. Participants (n= 133) could select more than one collaborative action.

The most commonly practiced collaborative actions were sharing info, inter-agency meetings, and joint projects. Less common were memorandums of understanding (MOUs) and Community Wildfire Protection Plans (CWPPs), actions which are both more time and energy intensive as well as less frequently necessary, so this is perhaps intuitive. However, Figure 8 shows how there are differences in which actions are undertaken by members of different organizations. Respondents from NGOs reportedly did only two of the collaborative activities, sharing information and improving communication. Privately affiliated respondents did not participate in MOUs, and Research affiliated respondents were not involved in interagency task forces, join grants/proposals, or interagency meetings. However, Research affiliated respondents were the most likely to participate in MOUs, while Local entities were least likely.
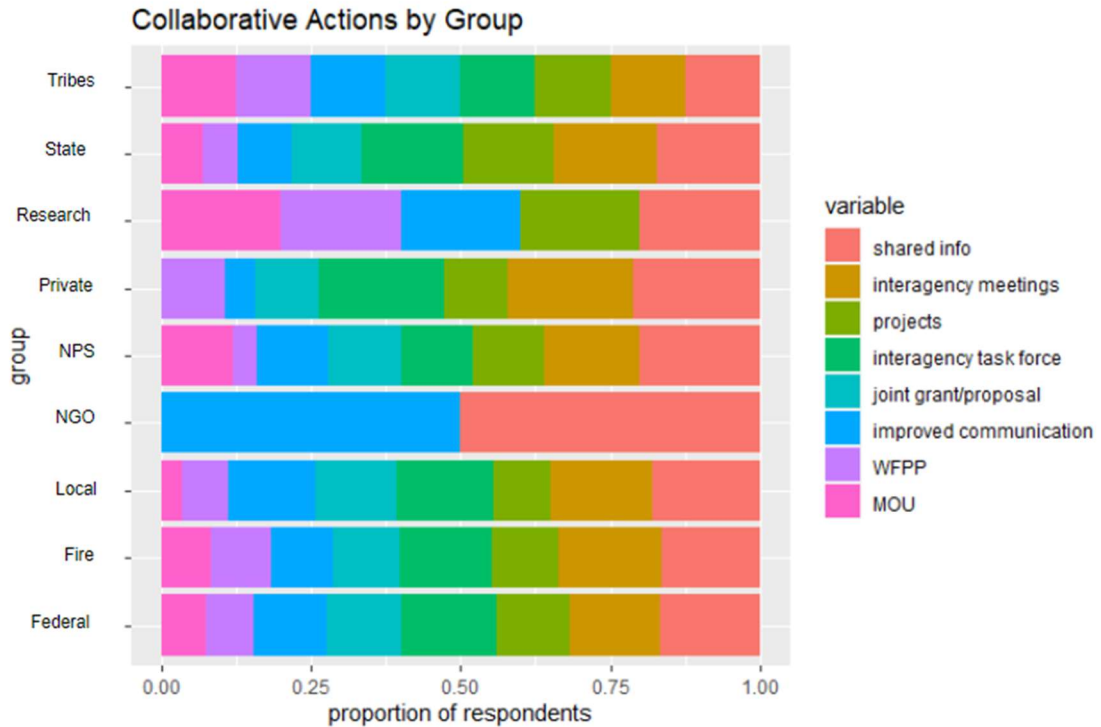
Figure 8. *Self-identified collaborative actions that participants took in the context of wildfire management within the past two years, separated by jurisdictional group. Participants (n=133) could select more than one collaborative action.*

3.6 Geographic scale of work addressing wildfire risk

Respondents indicated at what scale they usually worked in a wildfire context, whether primarily at the local scale, regional scale, or larger scales. After this, participants were shown a mapping exercise where they could select specific areas in which they had worked. Approximately 60% of respondents worked between the "single community" and "single jurisdictions" (i.e., county, National Forest, etc.) scale, with State actors predictably contributing the most to work at a broader scale. Interestingly, 10% of respondents said they did not work directly–or at all–within NWWY, however their presence within the network indicates that they still contribute some sort of influence or support to actors who do work in the region.

Table 6: *Geographic scale of wildfire work reported by survey respondents. Percentages refer to percent of each column (n=130).*

What scale is the majority of your wildfire work focused on?	**Federal**	**State**	**Local**	**Fire**	**Other**	**All**
Single community	1	0	8	2	2	13
	(2%)	(0%)	(30%)	(11%)	(25%)	(10%)
Several communities	12	1	3	3	1	21
	(20%)	(6%)	(11%)	(17%)	(13%)	(16%)
Single jurisdiction in NWWY	20	3	11	9	0	46
	(33%)	(18%)	(41%)	(50%)	(0%)	(34%)
Broadly across NWWY	21	10	3	4	3	42
	(35%)	(59%)	(11%)	(22%)	(38%)	(31%)
Not focused in NWWY, but do interact with NWWY	5	3	2	0	0	10
	(8%)	(18%)	(7%)	(0%)	(0%)	(7%)
No interaction with NWWY	1	0	0	0%	2	3
	(2%)	(0%)	(0%)	(0%)	(25%)	(2%)
Affiliation Total	60	17	27	18	8	130

3.7 The professional network of wildfire risk management

We used the nominations of each participant to visualize connections between wildfire managers in Northwest Wyoming, creating a network map of wildfire risk management. The connections between individuals allowed us to calculate the "betweenness centrality" of each individual in the network, or the degree to which an individual connected otherwise disconnected parts of this network. People with high betweenness centrality may have significant influence in the network and can help information flow between different groups in an area. In Figure 9, these "bridgers" can be seen linking the three clusters of individuals that make up this network. Without the bridgers, these subregions of the network might not be able to share information or resources.
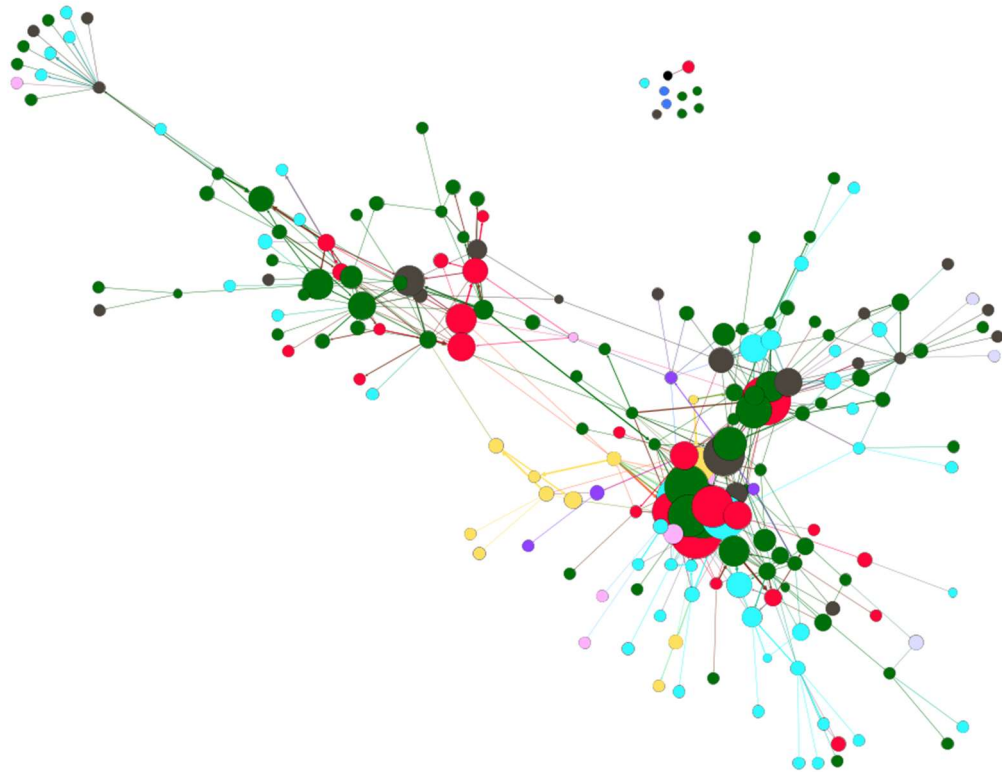
Figure 9. Network map depicting individual to individual connections (199 nodes, 529 edges). Size indicates in-degree. Federal=green, local=light blue, fire=red, state=black, nps=yellow, private=pink, science=purple, tribes=dark blue, ngo=gray.

Figure 10 depicts the same individual to individual network as Figure 9, but is color coded according to the Geographic Area Coordination Center (GACC) that an individual's office is most likely to associate with based on location. Information for some individuals had not been found by the time of this writing. Those individuals are represented by black dots. Based on this network map, it appears that at least two of the clusters in the network may have strong associations with different GACCs. Bridgers within the network may therefore be engaged in collaboration over organizational, administrative, and geographic lines.
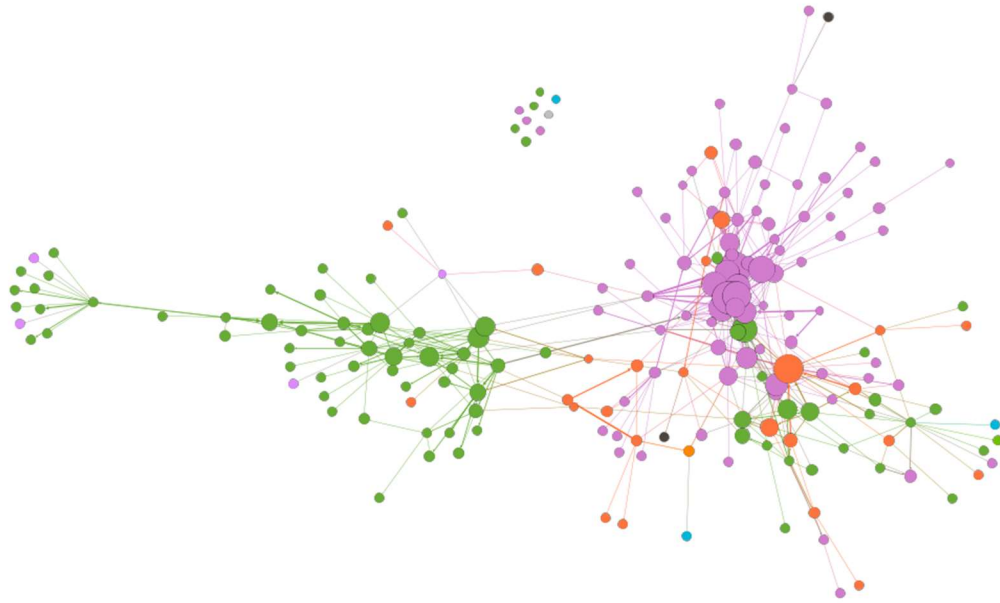
Figure 10. Network map depicting individual to individual connections (199 nodes, 529 edges). Colors correspond to the Geographic Area Coordination Center (GACC) that individuals fall into: green=Rocky Mountain, pink=Great Basin, blue=Northern Rockies, orange=multiple, and gray=undetermined.

We also aggregated individuals within the same or similar organization types and created a network map showing organization to organization connections, seen in Figure 11. The colors of the nodes in this map indicate clusters of organizations that are more likely to be connected to each other than to nodes of different colors. This helps us to see which organizations generally may have significant influence on the network. It is important to note that this is just one way to visualize connections between people and organizations in Northwest Wyoming and could look slightly different depending on which people had the time and capacity to participate in the survey or on how long we sampled for.
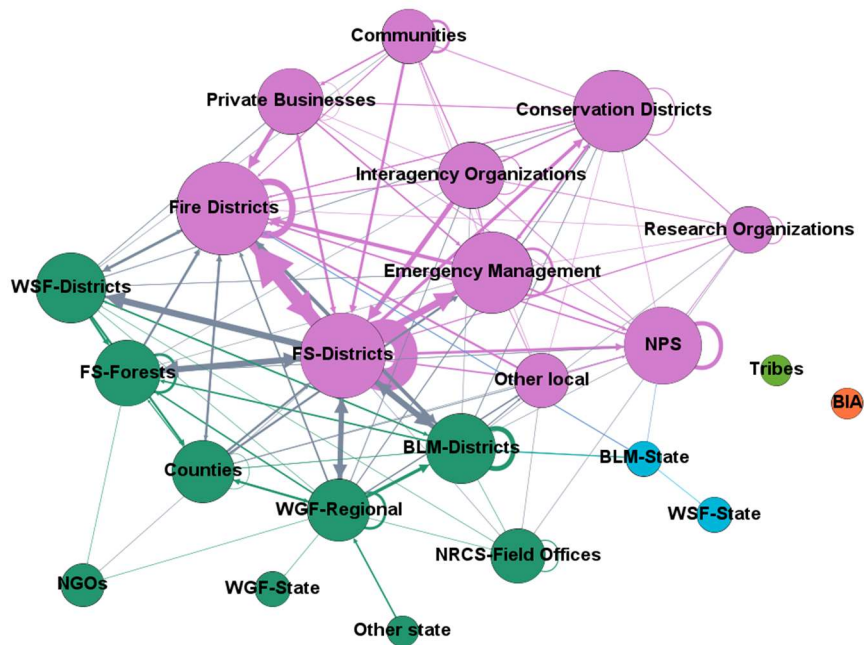
Figure 11. *Network map depicting connections between organizational units. Nodes with the same color are more likely to be connected to each other than nodes of different colors.*

3.8 Network ties and their reported frequency

We identified 199 individuals connected to wildfire risk management in Northwest Wyoming, with a total of 529 ties between people. As discussed earlier, many people were nominated more than once, and others served important roles connecting different parts of the network. Federal agencies had the most representation in our survey, were most likely to be nominated by other groups, and also had the highest rate of self-nomination. State agencies were most likely to nominate people from outside their own organizational affiliation, and people from Private, Research, NPS, and NGOs were most likely to nominate individuals from fire-specific organizations.

Table 7. *Number of times people from different organizational affiliations nominated each other. Sources on the top, targets on the left. Percentages reflect the percent of total nominations for an affiliation that went to a target category.*

	Federal	State	Local	Fire	Other
Federal	108 (48%)	31 (46%)	24 (25%)	37 (43%)	12 (22%)
State	29 (13%)	12 (18%)	7 (7%)	8 (9%)	2 (4%)
Local	26 (12%)	13 (19%)	31 (32%)	15 (17%)	8 (15%)
Fire	46 (20%)	8 (12%)	25 (26%)	20 (23%)	17 (31%)
Other	16 (7%)	3 (4%)	10 (10%)	6 (7%)	15 (28%)
Affiliation Total	225	67	97	86	54

3.9 Wildfire perceptions

We designed a set of questions with the goal of better understanding the different ways in which wildfire managers frame the issue of wildfire. Inspired by previous qualitative research from Michal Russo and Paige Fischer, this question set is the first attempt to quantitatively measure wildfire "framing". We define framing as the individual perception of a given problem and the associated implications for response to the problem. Regarding problems that require collective action, differences in framing may impact consensus building and strategy coordination, as indicated by Fischer and Russo (2022).

This section of the survey contained 19 questions designed to measure six ways in which fire practitioners may frame the narrative around wildfire. Participants indicated how strongly they agreed or disagreed with each statement in this section. The six frames were:

- ***Restore***: wildfire management should prioritize fuels management and ecosystem restoration. Example survey item: "We need to increase the pace and scale of fuel reduction activities."
- ***Life***: wildfire is a part of my family and/or community history. Example survey item: "For generations, fire has been a vital part of life in my community."
- ***Equity***: wildfire management should prioritize alleviation of environmental injustices for marginalized peoples. Example survey item: "Wildfire has affected some groups of people more than others."
- ***Climate***: wildfire management should center action on the relationship between climate change and wildfire. Example survey item: "Increased drought in the future will lead to more catastrophic fire."
- ***Hazard***: wildfire management should prioritize protecting human values, such as buildings and homes from wildfire. Example survey item: "Wildfire is a threat to human development that needs to be suppressed."
- ***Wild***: wildfire management should allow wildfire to act as it does naturally. Example survey item: "We should let wildfires burn where they naturally occur."

While these perspectives are unique from each other, they are not mutually exclusive (ex: a wildfire manager might frame wildfire from both the *Climate* and *Equity* lens). If our question set reveals differences in framing tendencies between fire managers, it could be used to test relationships between framing and collaborative actions in future projects.

Based on the survey results, wildfire managers in NW Wyoming tend to frame the issue of wildfire differently. There was a general consensus among participants around the *Restore* (general agreement) and *Hazard* (general disagreement) perspectives, but there was dissensus around the *Life, Equity, Climate, and Wild* perspectives. These results indicate that fire practitioners in the area have multifaceted perspectives on wildfire, but their perspectives often contain different priorities and values. Therefore, we should not assume that any two fire managers operate in the same ideological framework, as differences in education, training, past experience, and culture likely influence their narratives around the issue. Going forward, there may be utility in testing how these differences in perspective differ across organizational boundaries, how they impact the likeliness of collaboration, and how they generally affect the management of a region.
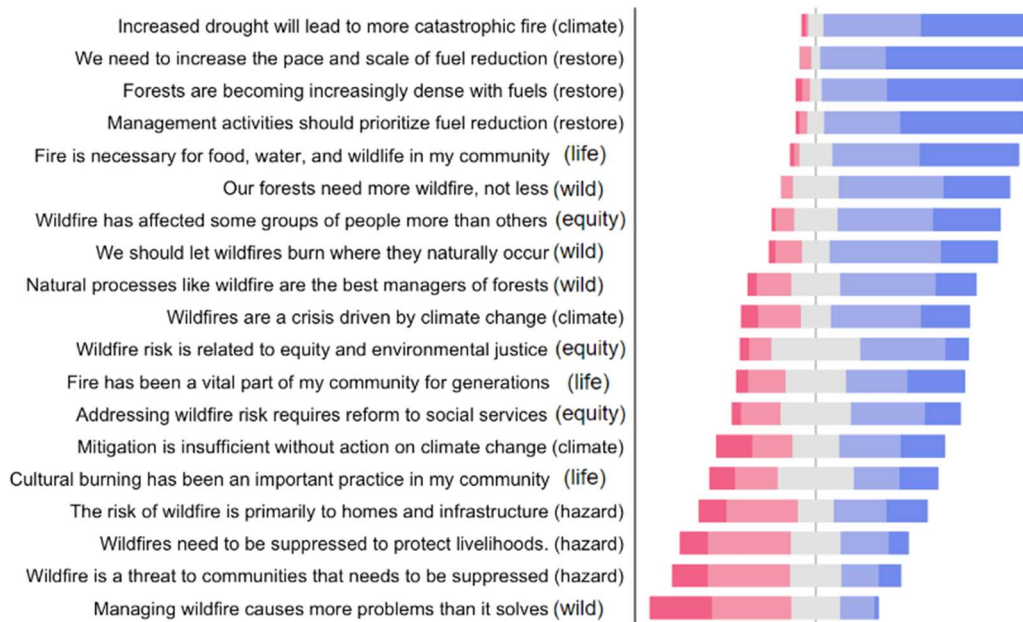
Figure 12: *Likert response ranges for each wildfire framing survey item. The category of framing is shown in parentheses, and the bars indicate the number of participants who disagreed with the item (shown in red) and who agreed with the item (shown in blue).*

4. On Tribal Collaboration

Many Indigenous communities in the Western United States have used fire for landscape management, cultural celebrations, spiritual ceremonies, and food generation among many other purposes since time immemorial. Since the colonization of North America, however, fire suppression policies have largely outlawed Indigenous fire practices. More recently the Cohesive Strategy and the USDA Equity Action plan have called for more inclusion, leadership, and collaboration with Tribal communities despite past marginalization. However, in the study regions of Northwest Wyoming, North Central Washington, Central Oregon, and Northeast Utah, our network analysis has indicated that Tribal nations are not well represented in regional wildfire management networks. Figure 9 (replicated to the right to emphasize Tribes) illustrates the lack of connections between the Tribes in Wyoming and the rest of the wildfire management network. One of our goals was to examine the factors influencing Tribal collaboration within our mapped wildfire management network. In a number of pre-survey conversations, we asked both tribal and non-tribal fire practitioners about the extent to which the Tribes were involved in collaborative wildfire management. Following the survey, we conducted a series of interviews focused explicitly on tribal collaboration to better understand the lack of connectivity between the tribes and the rest of the wildfire management network. We were able to consolidate the following information:

A. **Wildfire collaboration with the Eastern Shoshone and Northern Arapaho tribes was very limited outside of wildfire response.** Throughout all 12 rounds of survey nominations, nobody representing the Eastern Shoshone, the Northern Arapaho, or any other tribe was nominated outside of our initial selection process. Therefore, Indigenous perspectives are not well-represented in our survey.
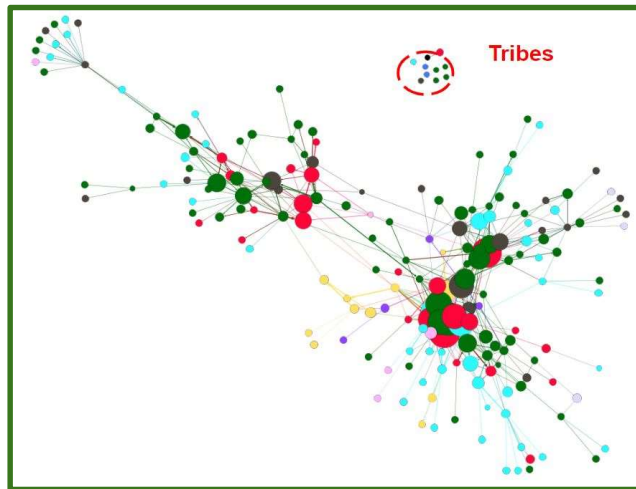
B. **The lack of collaboration between the tribes and the rest of the state reflected in our survey is, in part, due to geographic separation and differences in wildfire risk.** Our survey found that the majority of wildfire practitioners worked in the Jackson Hole area, which is over 100 miles from the Wind River Reservation. Additionally, Central Wyoming is significantly less forested than the northwestern part of the state and appears less prone to catastrophic wildfire. Consequently, cross-boundary coordination around fuels planning, prescribed fire, effective response, and post-fire recovery may be less necessary than in other regions of the state.

C. **Capacity for collaboration within the tribes is limited outside of wildfire response.** With the Fire Management Officer and Assistant Fire Management Officer positions at the Wind River Reservation currently vacant, the number of strong ties between Indigenous and non-Indigenous fire practitioners are scarce. However, our interviews indicated that existing collaboration with the Tribes on the Wind River Reservation is centered around wildfire response.

D. **Most wildfire collaboration requires participation in Western organizations and frameworks.** Most meetings to build consensus around future fire management strategies, public outreach, policy advocacy, and funding occur in non-Indigenous land management organizations. This may present both geographic and ideological barriers to Tribal participation.

5. Recommendations, Limitations and Next Steps

Recommendations

Our findings paint a picture of a well-developed and relatively diverse set of professionals working across boundaries of the wildfire management system in Northwest Wyoming. Nonetheless, those involved in the network expressed the need for continued improvement. Furthermore, whether the wildfire management system in Northwest Wyoming is representative of other hotspots of wildfire risk in the western US is unknown. Towards these ends we make the following recommendations:

5. **Develop shared stories about wildfire and celebrate successes in wildfire risk management across jurisdictional boundaries.** Northwest Wyoming contains many different communities whose priorities and resources don't always align, but creating a shared narrative to help both decision makers and homeowners think about fire as a collective responsibility throughout the region can help facilitate effective, landscape scale management. Publicly celebrating successful actions taken by outside organizations can also help build public confidence in the network of people managing wildfire risk in the region, and could encourage participation in future actions.

6. **Plan for a collaborative network that can adapt to change.** Over half of the respondents in this survey indicated that they have been working in the field for 20+ years, meaning that a large number of folks may be retiring in the coming years. It will be important to find new people to step into these roles who can maintain collaborative relationships that have been built over long careers, as well as spark new ones where needed. Existing and incoming wildfire risk managers also need to be prepared for wildfire conditions and goals to change, and adapt their practices collaboratively when they do.

7. **Invest in boundary spanners to increase the connections and collaborative engagement between otherwise disconnected parts of the network.** The position occupied by boundary spanners gives these individuals and organizations important leverage and power in the wildfire management system by allowing them to combine perspectives, transfer ideas between groups, and negotiate between interests. Building trust and investing in these individuals and the organizations that support them may be critical to maintaining collaborative engagement and strategic alignment of goals, programs, and actions across jurisdictions. If the outsized role these individuals and organizations play becomes a burden to their limited capacity, future investments in wildfire risk management in Northwest Wyoming may be less likely to establish and maintain fire-adapted communities, resilient landscapes, or safe and effective incident management.

8. **Prioritize high-value collaborations.** Formal collaboratives can be an effective way to bring people together around shared goals, but simply having collaborative meetings is not the goal. Organizations need to make sure that people who participate in collaborative activities are receiving as much support as they are providing. Determining jurisdictions and geographies where collaborative identities can lead to effective collaborative actions will help people make the most of limited capacity.

Limitations

We encountered several challenges, some of which were brought to our attention by participants who left comments at the end of the survey or sent us emails. One consistent snag was with the nomination process. Some people were concerned about invading their colleagues' privacy by providing names and contact information, while others pointed out that positions are more stable than individual people, and so naming individuals could be difficult. This meant that some people nominated an organization or general job description, which disrupted the chain referral sampling process, but also indicated that we did not adequately explain our methods. Another drawback was the timing of the survey's implementation, which coincided with many of our participants' organizations onboarding seasonal staff and preparing for fire season. The designation of our study area as "Northwest Wyoming" confused some people and may have discouraged participation from some folks we would like to have heard from. Lastly, many folks felt that the wildfire perceptions questions at the end of the survey were inadequately nuanced or misleading, indicating that the questions either need additional work or that our survey should have included a more comprehensive discussion of the purpose of the questions.

Next Steps

This report concludes Phase 1 of Portland State University's work on the CoMFRT project in Northwest Wyoming and will help launch Phase 2. The Phase 1 research asked questions including: who is part of the wildfire management system in Northwest Wyoming, what are their roles, where do they work on the landscape, and how are they connected to each other?

Phase 2 of our research will ask a set of questions that couldn't be asked until we knew answers to the questions asked in Phase 1. It is important to note that Phase 2 will rely on participants from Phase 1 to volunteer their time again (less than 30 minutes on average), and some participants may be asked to participate in a voluntary interview to describe what motivates their collaborative behaviors.

The questions in the Phase 2 survey will include:

1. Why are some people and organizations more focused on boundary spanning than others?
2. Why are some people and organizations more engaged in collaboration than others?
3. Why are some managers' understandings of wildfire risk different from others?

Answers to these questions are important for encouraging the collaborative engagement needed to ensure that across organizations wildfire management goals are strategically and programmatically aligned. These questions will also help us test hypotheses that organizational missions, job descriptions, and personality can influence boundary spanning behaviors and the success of collaborative efforts toward adapting to wildfire risks in Northwest Wyoming (Kilduff and Krackhardt 2008). If supported, these findings would show that adaptive governance of wildfire risks can be successfully designed through organizational processes as well as selected for through recruitment and employment processes.

Finally, in collaboration with the CoMFRT Project, Portland State University has initiated similar research in the Wasatch and Cache Valley region in Northern Utah, the North Central region of Washington, and the Eastern Cascades region of Central Oregon. Results from these areas will be compared with those from Northwest Wyoming and will help provide a more general understanding of wildfire risk management systems in the United States and how they vary. We hope our research will be useful not only for the regions in which we are working, but also for decision-makers at the state and national scales who are trying to understand how best to support and encourage local initiatives to be prepared for future wildfire risks.

6. Works Cited

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