FINAL REPORT

Title: **Effective Network Governance for Co-Management**

JFSP PROJECT ID: **17-1-06-14**

December 2021

PI Name: Branda Nowell

Affiliation: North Carolina State University

PI Name: Toddi Steelman

Affiliation: Duke University

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Government.

FIRESCIENCE.GOV

Research Supporting Sound Decisions

USGS

science for a changing world

TABLE OF CONTENTS

Abstract 3
Objectives 4
Background 5
Results and Discussion 9
What are areas of alignment and misalignment in risk perception on jurisdictionally complex wildfires? 9
What does co-management mean in the context of jurisdictionally complex wildfires? 12
What are the models of networks governance that effectively give voice to diverse jurisdictions on jurisdictionally complex wildfires? 16
What conversations do we need to be having right now to improve co-management on jurisdictionally complex wildfires? 21
How has the institutional complexity of wildfires changed nationally over the past 20 years? 26
Conclusions 29
Literature Cited 32
Appendix A: Contact Information for Key Project Personnel 35
Appendix B: List of Completed and Planned Publications and Science Delivery Products 36

Acknowledgements: We would like to thank our research team and collaborators: Dr. Anne-Lise Velez, Dr. Kate Albrecht, Ryan Scott, Shannon McGovern, Kate Jones, Elliot Nauert, Sarah Baines, Daisy Mills, and Honey Minkowitz. We would also like to thank the agency administrators, land managers, and incident command teams who participating in this research.

Keywords: co-management, network governance, cross-boundary, inter-jurisdictional complexity, risk perception, decision-making

LIST OF ABBREVIATIONS

Abbreviation	Meaning
209	Incident Command System Form 209, Incident Status Summary
AA	Agency Administrator
IC	Incident Commander
ICS	Incident Command System
IMT	Incident Management Team
NIFC	The National Interagency Fire Center
PL	The National Interagency Fire Center's National Preparedness Level
T1	Type 1 Incident
T2	Type 2 Incident
US NIMS	The United States National Incident Management System
WFDSS	Wildland Fire Decision Support System
WUI	Wildland-Urban Interface

ABSTRACT

A growing body of work has been focusing on how to govern and manage across jurisdictionally fragmented landscapes in an effort to promote more effective wildfire preparedness and response. We contribute to this worthy goal in the following five ways through the research undertaken in this project:

1) Human safety was identified as a common risk prioritization that has been instituitonalzed across all levels of government and the private sector. In contrast, differences in risk perception occurred along temporal dimensions. Stakeholders varied in the weight they placed on perceptions and management of immediate and tactical risk relative to incident-level potential risks and long term risks post incident. Minimizing risk in one temporal phase often necissitates acccepting greater risk in another phase.

2) Co-management, as defined by jurisdictional leaders on wildfires, is not monolithic. Broad definitions of co-management vary across a continuum of more idividualistic to more collecitvistic. Operationally, leaders subscribe to different mental models for undertaking co-management. These include cooperative assistance, negotiated order and collaborative singularity. The implication is that different leaders will enter into conversations about co-management with different expectations, preferences, and assumptions. Making these assumptions more explicit will be important to effectively manage interdependency in interjurisdcitional wildfire response.

3) Governance structures for co-managing mutliple jurisdictions on wildfires are varied and include ad hoc arrangements, unified command and delegations of authority. These structures are complemented by tools, technologies and forums that facilite formal and informal communication and relationship building. Ad hoc arrangements were most problematic for providing voice in decision making. Formal representation in the structure was associated with greater voice in decision making. New governance arrangements may be needed as fire organizations grow more complex over time with the growth of wildfire size and jurisdictional participation.

4) Lead agencies, federal and local jurisdictions tended to feel the best overall about the co-management outcomes on an incident. State and private jurisdictions were — as a group — significantly less satisfied across incidents. Facilitating better co-management outcomes was possible when two conditions were met: 1) Neighboring jurisdictions were involved in decision making and felt they had a voice and/or 2) Neighboring jurisdictions felt confident that the risk management process was appropriate and took their concerns into account. Under these conditions, neighboring jurisdictions tended to be supportive of the actions of their counterparts – even if they suffered significant loss during the wildfire.

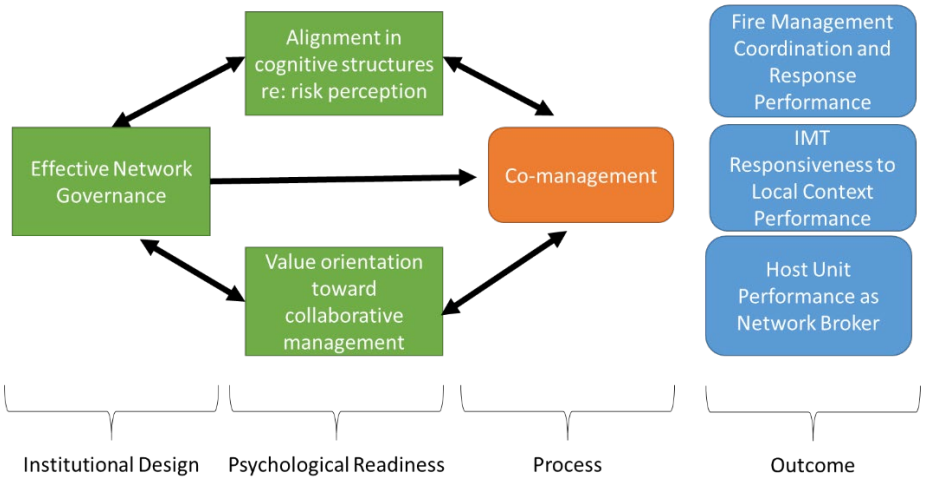
5) Type 1 and 2 wildfires in the United States have become more institutionally complex over the past 20 years in at least three ways: 1) larger fire perimeters, 2) greater number of incident days at PL 4 or 5, and 3) more jurisdictions across more levels of government affected on an average incident.

OBJECTIVES

The Joint Fire Science requested research on the Factors that Affect the Co-Management of Wildfire Risk. "The objective of this task statement is to advance our fundamental and applied understanding of the human dimensions that affect the co-management of wildland fire risk. Risk in this context may involve uncertainties and differences in stakeholder values that preclude a strictly probabilistic approach to risk management in its traditional sense. (pg. 14; JFSP Project Announcement No. FA-FON-17-0001).

Our project aimed to address the objectives of this task statement by using a mixed methods approach to empirically test a conceptual model of the co-management of wildfire risk. Specifically, our project sought to link the scholarly literature on network governance with psychological readiness to understand how these processes link to the outcomes of more effective co-management. We defined effective co-management through the lens of network governance.

Figure 1: Conceptual Model of Co-Management Processes, Structures, and Outcomes



Our initial research aims were to 1) identify the characteristics and practices of effective network governance for promoting co-management before and during a fire; and 2) develop and empirically test a network governance model of co-management. Through the execution of this project, we realized there was need for an additional research goal focused on gaining a better understanding of the changing institutional complexity of wildfire that is necessitating this focus on co-management.

BACKGROUND

Large wildfire management in the wildland urban interface (WUI) is inherently an exercise in co-management of fire risk because it involves an array of jurisdictions, management priorities, and interdependent tasks. Incident response is carried out by a menagerie of different agencies, organizations, and groups who are legally automous but functionally interdependent (Nowell & Steelman, 2013). This "network" is under the control of multiple jurisdictional authorities who can have divergent missions and foci thereby leading to conflict (Fleming et al., 2015), if governance mechanisms for effective co-management are not in place.

Network concepts have been growing in their use in disaster settings due to the challenges associated with how to accomplish a coordinated, coherent response among multiple organizations and agencies that become active during a response phase of a disaster (e.g., Comfort, 2007; Faas et al., 2015; Kapucu, 2006; Nowell & Steelman, 2013; 2014). Conceptual research relating to network-level governance activities, structures, and outcomes is more common than empirical research, leading to calls for greater empirical evidence to support conceptual claims (Magsino, 2009).

Complicating the clarity about the co-management of risk during a wildfire is the tight coupling of mitigation actions at the household, landscape, and operational response level that can be taken before a fire begins and that can have direct bearing on how risks are identified and shared during the fire (Ager et al., 2015; Carroll & Paveglio, 2016; Cohn et al., 2008; Fischer et al., 2012; Martin et al., 2008). Consequently, key drivers associated with effective wildfire co-management during a wildfire need to consider both actions taken before the wildfire occurred, as well as when the wildfire is active.

Effective Network Governance, Alignment of Risk Perception and Value Orientation Toward Collaborative Management

Network governance broadly refers to tools, forums, and practices that organize, shape (and constrain) social cognition, normative frameworks, and decision processes within networked settings (Fischer et al., 2012; Moynihan, 2009; Provan & Kenis, 2008). These tools, spaces, and practices are referred to in the network sciences as boundary objects of network governance because they facilitate a common operating picture, lateral patterns of exchange, the development of shared norms, understanding and expectations around mutual interests, and reciprocal lines of communication (Powell, 1990; Granovetter, 2005).

Network governance practices have been part of incident command systems for decades, our prior research suggests 1) they vary widely in *how* they are implemented and who participates (Nowell & Steelman, 2019), and 2) by themselves, the most commonly used tools may have limitations in supporting effective co-management within an expanded number of stakeholders (Nowell et al., under review). Research and theory suggests that network governance tools, forums, and practices put into practice both before and during a large scale wildfire event can both directly and indirectly influence co-management outcomes by contributing to two psychological factors -- better alignment of cognitive structures, such as risk perceptions during

the wildfire, as well as more positive value orientations toward collaborative management (Provan & Kenis, 2008; Comfort, 1990; 2007; Figure 1).

Our study hypothesized that co-management was facilitated when stakeholders shared an underlying cognitive framework of risk perception that served as the foundation for higher order attitudes, beliefs, and perceptions (Maitlis, 2005; Weick, 1995; Weick & Sutcliffe, 2001). Support for this hypothesis is found in research on sensemaking within multi-stakeholder settings (Comfort & Kapucu, 2006; Weick, Sutcliffe, & Obstfeld, 2005). For local level managers, what gets noticed and bracketed, and how it gets labeled and interpreted are guided by their schemata (e.g., Anderson, Spiro and Anderson, 1978; Brewer & Nakamura,1984; Harris, 1994) or mental models (Johnson-Laird, 1983; Gentner & Stevens, 1983; Jones, Ross, Lynam, Perez, and Leitch,) that have developed over time as a result of embeddedness in institutional and cultural settings and in response to work, training, and life experiences. Misalignment in cognitive structures, or risk perceptions, can lead to lack of agreement about action. A shared mental model of the situation, objectives, actions, and responsibilities, we hypothesized, was likely to lead to greater success in the management of the fire.

A key proposition in the literature is that collaborative management doesn't occur, in part, because historic emphasis on juridictional boundaries, and formal authority can pose challenges to collaborative management approaches (Weber & Khademian, 2008). In cases where signficant differences in risk perception exist, meaningful engagement with a range of stakeholders, including experts and non-experts, has been proffered as a means to overcome differences (Zaksek & Arvai, 2004; Gregory, 2000; Arvai et al., 2001; Winter et al., 2002;). Interactive processes or dialogue may help stakeholders understand the underlying reasons for a proposed action, thereby leading to greater support for management actions. Creating effective processes for risk communication and management has been consistently emphasized in the literature for decades (Slovic, 1986). Psychologically, a predisposition to engage in collaborative management before the fire can provide insight into the potential efficacy associated with co-management during the fire.

MATERIALS AND METHODS

To advance our project, we created and drew upon several data sets. These included 1) case studies of jurisdictionally complex wildfires; 2) surveys and key informant interviews of jurisdictional leaders and incident commanders; 3) field observations, and 4) data analytics of the institutional complexity of Type 1 and 2 wildfires from 1999-2019.

Case Studies of Jurisdictionally Complex Wildfires. To develop and empirically investigate a network governance model of co-management, we needed to identify a sample jurisdictionally complex Type 1 and Type incidents. In the late fall/winter of 2017, we used a key informant snowball sample approach, asking our network of Type 1 incident commanders to nominate what they saw were the most jurisdictionally complex incidents that occurred during the summer/late fall of 2017. We also conducted archival analysis of 209s for 69 different

wildfires, looking for indicators of complexity including the number of cooperators, values at risk and final size. This resulted in a final identification of 10 jurisdictionally complex incidents. In 2018, we sampled an additional 5 jurisdictionally complex incidents. These incidents were chosen because they involved a similar array of jurisdictions as impacted in our 2017 wildfires which created opportunity for investigating how repeated incidents impacted co-management dynamics.

Table 1. Breakdown of Key Informant Interviews of Jurisdictional Leaders in 2017

2017 Case Fires	Jurisdictions					
	Federal	**Local**	**Private/ Commercial**	**State**	**Tribal**	**Grand Total**
Grand Total	**34**	**11**	**16**	**25**	**2**	**88**

Table 2. Breakdown of Key Informant Interviews of Jurisdictional Leaders in 2018

	Jurisdictions					
2018 Case Fires	Federal	Local	Private/ Commercial	State	Tribal	Grand Total
Grand Total	**27**	**5**	**4**	**11**	**2**	**49**

Surveys and Key Informant Interviews of Jurisdictional Leaders and Incident Commanders. Our next step was to identify representatives from each of the jurisdictions that were threatened and/or affected by the wildfire for each incident. We included both public jurisdictions (national forests, national parks, state direct protection areas, county and municipal jurisdictions) as well as large private (e.g., commercial timber companies, ranches, private camps or recreational businesses), and nonprofit landowners (e.g. The Nature Conservancy) (see Table 1 and 2). The incident commander and liaison officer for each incident was our initial point of contact and from them we identified a preliminary list of jurisdictional/landowners as well as appropriate representatives. Representatives were identified as the highest-ranking individual representing that jurisdiction who was actively engaged in the incident. This list was verified and augmented by subsequent informants during the interview until we reached a point at which no new informants were identified. Interviews were conducted by phone and transcribed for analysis. In addition, interview participants were asked to complete a 10-question survey assessing the extent to which they felt the incident was effectively co-managed.

For the 2017 case study fires, we identified a total of 98 interviewees and completed 88 (90% response rate). For the 2018 case incidents, we identified a total of 64 key informants and conducted 49 interviews (77% response rate).

Field Observations. In addition to interviews and surveys, we shadowed incident commanders and agency administrators on three of our 2018 incidents. For this protocol, one of the members of our team shadowed either an agency administrator or the incident commander during active fire operations. Observations included a total of six observation days each for

incidents 1 and 2, and eight observation days for the third incident. During shadow observations, our team took notes on the interactions of jurisdictional leaders with each other and with the incident management team. Particular emphasis was placed on observations related to negotiating priorities and risk perception, the use of boundary objects and the evolving understanding of the network that needed to be managed. This allowed us to observe the co-management of risk and the role of network governance in real time as the incident unfolded.

Data Analytics of the Institutional Complexity of Type 1 and Type 2 Wildfires from 1999-2019. To understand the changing institutional complexity of wildfire, we set out to develop the first known national, longitudinal dataset of the jurisdictional make up of Type 1 and Type 2 wildfires. This is an ambitious endeavor that is on-going. Because there is no single national data source from which to create such a dataset, it was necessary to construct such a dataset using a number of different sources. These data sources included St. Denis et al.'s (2020) All-Hazards Data Set mined from the US NIMS system 1999-2014, Short's et al.'s (2020) Spatial Wildfire Occurrence data for the US 1992-2018 (Retrieved from: https://www.fs.usda.gov/rds/archive/Catalog/RDS-2013-0009.5), The Wildland Fire Decision Support System (WFDSS) Spatial Data (Retrieved from: https://wfdss.usgs.gov/wfdss/WFDSS_Data_Downloads.shtml o7247); NIFC's (2021) National Preparedness Level Data, as well as other geospatial demographic overlays depicting state and county boundaries. From these data sources, we created an incident level database of Type 1 and 2 wildfire incidents. We constructed a number of incident attributes reflecting the institutional complexity of the incident. These include: total acres burned, incident duration, jurisdictional make-up of the incident both in total numbers of jurisdictions threatened and affected, proportion of acres burned by jurisdiction, and total jurisdictional levels involved (e.g., federal, state, local, private, and tribal), number of structures damaged and destroyed, and number of incident days at national preparedness level 4 or 5. Data integration is still underway and awaiting the 2019 incidents. Data will be made publically available to support future research.

RESULTS AND DISCUSSION

WHAT ARE AREAS OF ALIGNMENT AND MISALIGNMENT IN RISK PERCEPTION ON JURISDICTIONALLY COMPLEX WILDFIRES?

In light of this more complex environment, it is critical we understand how to co-manage risk and create governance systems to respond effectively in jurisdictionally complex incidents. Before we could understand co-management of risk, we first needed to understand to what extent and in what ways there was alignment versus misalignment among jurisdictional leaders with regards to their perception and understanding of risk on complex wildfire incidents. During interviews with jurisdictional leaders and incident commanders, informants were asked to "tell the story" of the incident as it unfolded, with an emphasis on what they were most concerned about as the incident evolved. From these, we constructed risk narratives and qualitatively coded for variation across informants in terms of the concerns that were most salient.

Do different jurisdictional leaders fundamentally differ in their substantive perceptions of risk? Risk narratives were coded in terms of their substantive focus. Interviews revealed an array of concerns that fell into four broad categories of substantive risk: 1) human (firefighter and public) safety, 2) homes, built infrastructure, and communities, 3) eco-systems and the natural environment, and 4) social, political and economic risks. Human safety included risk to firefighter and public safety; built infrastructure included risk to homes, utility and transportation infrastructure, and communities; ecosystems and environmental risks included fire suppression impacts, threatened species, and threatened natural resources; and social, political, and economic risks included disruption of economies and effects on interagency relationships and public perceptions. Concern about these overarching areas of substantive risk during wildfire events were prevalent across interviewees regardless of stakeholder affiliation. In other words, actors representing agencies at different levels of government and private interests reported very similar substantive risk perceptions, with each of the substantive dimensions showing up in each group. Most informants – regardless of level of government or private versus public, identified human safety as their top priority/concern followed by built infrastructure and communities. There was more variation in the relative prioritization of concerns about the natural environment and social, political and economic risks, however, these were often viewed as entangled (e.g., economic concerns were linked to healthy forests). This is noteworthy as it suggests that differences in risk perception and prioritization, to the extent that they exist, are more nuanced.

KEY FINDING: Across incidents, there was considerable alignment among jurisdictional leaders, regardless of level of government or public/private affiliation, in terms of prioritization of human safety and protection of the built environment as top priorities.

There appears to be a relatively strong foundation of common risk prioritization that has been institutionalized across all levels of government as well as embraced by the private sector.

Do jurisdictional leaders fundamentally differ in their temporal perceptions of risk? Analysis of risk narratives revealed that the main difference across informants occurred in the temporal bounding of risk perception within substantive areas. Each substantive dimension comprised specific values or elements at risk that varied temporally according to the immediacy of threat. Specifically, we found temporal dimensions of risk varied in terms of whether perceptions of threats were tied to immediate and tactical elements of risk, the incident-level potential of risks, and the risk of long-term consequences that would endure after the incident was contained. Immediate and tactical risk comprised resources most at risk during the current operational period. Incident level risks comprised resources generally at risk across the temporal scope of the entire wildfire incident. Long term risks extended beyond the incident into the days and years after the event.

For example, risks to human safety could be expressed in terms of immediate and/or tactical risks such as concerns for firefighter safety as a result of a specific decision concerning where to put a fire line. It could also be expressed as risk to immediate public safety in relation to members of the public coming into contact with the fire at given point in time. At the incident level, human safety concerns could be expressed in terms of incident level duration of firefighter risk exposure and to public health from prolonged smoke exposure. Concerns about human safety in long-term/post incident risk included concerns such as heightened firefighter risks in future incidents due to increased number of snags. Perceived risks to ecosystems and the environment at the immediate and tactical level included suppression impacts on natural resources, at the incident level include threats to endangered species and habitat and destruction of natural resources such as timber and grazing lands, and in the long-term included ecological health, risk exposure for future incidents, and aesthetic and recreational values. All four substantive risk categories appeared across all three temporal dimensions of risk, with the exception of risk to homes, infrastructure, and communities, which was perceived to lie at the immediate/tactical and incident levels, (see Table 3). Differences in temporal prioritization of risk is important as interviews revealed that there are often tradeoffs such that minimizing risk in one temporal phase often requires accepting greater risk in another temporal phase. For example, minimizing the immediate tactical risk to firefighters may prolong an incident leading to greater total hours of firefighter risk exposure.

KEY FINDING: Jurisdictional leaders think differently about risk in terms of temporal emphasis: immediate/tactical risk, incident level risk, or long-term risk. Difference in risk perception were frequently expressed as differences in temporal prioritization rather than differences in the substantive risk prioritization

Table 3. Substantive and Temporal Dimensions of Risk			
Temporal dimension of risk:	**Immediate / tactical**	**Incident level**	**Long-term**
Substantive risk to: *Human safety*	Risks to fire fighter safety Immediate public safety	Firefighter risk exposure hours on long duration incident Community/public health risk from prolonged smoke exposure	Post-fire risks, mudslides, flooding, recovery
Houses, built infrastructure, and communities	Immediately threatened values	Fire potential to impact public infrastructure and communities	--
Ecosystems and environment	Fire suppression impacts on natural resource values	Threats to endangered species & habitat Destruction of natural resources (timber, grazing lands)	Ecological health of the wildland and associated risk exposure for more intense future wildfires Aesthetic and recreational value of the land
Social, political, and economic	Inter-agency coordination	Political risk and negative public perceptions Risks to cultural sites Cost (suppression dollars) Disruption of local economies	Long term impacts to local economies Public and political support of public lands

WHAT DOES CO-MANAGEMENT MEAN IN THE CONTEXT OF JURISDICTIONALLY COMPLEX WILDFIRES?[1]

Co-management is an abstract concept borrowed from natural resource management. Realizing the need to gain greater clarity, we wanted to understand what co-management meant to jurisdictional leaders in the context of a jurisdictionally complex incident and whether understanding of co-management varied across leaders. Specifically, we wanted to understand what jurisdictional leaders thought co-management looked like when it was going well. We also wanted to understand what leaders thought it looked like when an incident was not co-managed well.

When asked to describe what co-management meant to them in the context of a jurisdictionally complex wildfire incident, jurisdictional leaders offered varied descriptions of co-management. Descriptions addressed one or more of the following three major topics that we labeled as: 1) global orientation toward co-management, 2) models of co-management, and 3) the relationship of co-management to structures of network governance. These topics were not categorical or mutually exclusive. Rather, they illuminated the concept of co-management as one that is complex and can be thought about from a number of different angles. Altogether, the topics paint a picture of co-management during incidents that varies across a continuum of more individualistic to more collectivistic orientations and therefore is not confined to any one strategy (e.g., collaboration). Findings also illuminated that co-management is rooted in normative judgements of fairness and often takes place within, and is constrained and enabled by, institutional structures of network governance, but is not necessarily the same thing as network governance. In the following sections, we outline the major themes that emerged within each of these topic areas followed by a discussion of their implications for advancing both the theory and practice of co-management.

Strategic Orientation toward Co-Management. First, as outlined in Table 4, descriptions of co-management differed across jurisdictional leaders in terms of where they stood on a continuum anchored on one side as an emphasis on a collectivist orientation focused on creating unity versus a more individualist orientation focused on respecting differences and diversity among jurisdictions.

KEY FINDING: Jurisdictional leaders differ in their relative emphasis on the importance of unity (collectivism) versus respecting diversity (individualism) in their conceptions of co-management

[1] Findings under review with *International Journal of Wildland Fire*

Table 4: Global Orientations Toward Co-Management

Collectivistic Orientation	Individualistic orientation
Emphasis on Creating Unity	Emphasis on Respecting Diversity
You've got to agree. You know, you have one common goal, one common interest, one common set of objectives, and there has to be buy-in from all partners.	*[Co-management] It's about the respect. …. You don't have to agree philosophically with each other, but you've got to respect that they have a different mission.*
[Co-management] can go bad if we don't all agree on the best approach when we don't agree that we focused our resources on the highest probability of success even though it came at the expense of impacting a resource that may have been up under someone else's jurisdiction and we don't stand in locks sync with each other on those things.	*I think co-management means there's more than one interest there, and so consideration for multiple priorities is probably -- it becomes an issue*
	So I believe that part of co-management is looking at the mission for both departments. And our department missions are different, so those discussions have to be had.
[In co-management] We serve as one team, one plan, one mission and I'm bringing my resources and my objectives and maybe another agency as well. And we're aligning, setting priorities, setting expectations and be consistent as agency administrators of how our team are to employ those objectives or to do that.	*It means that you're bringing in multiple … organizations with different priorities and different requirements, and then joining them together to manage for the better of the good or the whole overall incident*

Models of Co-Management. A second key finding from this investigation was that jurisdictional leaders differed in terms of what effective co-management "looked" like. Specifically, descriptions of co-management revealed three distinct models: 1) cooperative assistance, 2) negotiated order, and 3) collaborative singularity (Figure 4). As shown in Figure 4a, cooperative assistance is distinguished from the other strategies in its emphasis on retaining jurisdictional autonomy while still addressing the need for communication, coordination and cooperative resource sharing between jurisdictions. In Figure 1, each of the colors represent a

different jurisdiction. Under cooperative assistance, a jurisdiction may lend aid to another jurisdiction as indicated by a colored circle, but the jurisdiction receiving aid still retains complete autonomy over all decisions and operations occurring on their jurisdiction. Strategy development and planning may remain fragmented among jurisdictions. The premise of cooperative assistance is that each jurisdiction has operational control of what occurs on their jurisdiction. Resources allocated to that jurisdiction from another will be used in a manner consistent with the objectives of the receiving jurisdiction's mission. In other words, this strategy expects that, when in Rome, everyone acts like Romans.

The second strategy, which we have termed negotiated order, had a similar emphasis on differing priorities and interests that each jurisdiction is trying to address. However, this co-management model differed from cooperative assistance in the sense that it placed greater emphasis on the recognition that these different priorities need to be negotiated into a single, coherent plan and that certain values or assets may need to be sacrificed to protect other values or assets given limited resources. Figure 4b shows that negotiated order is delineated by the integration of multiple jurisdictions into a single cohesive plan yet with a strong emphasis remaining on the individual jurisdictions that comprise this composite organization. The co-management emphasis here is on convincing other jurisdictions to take your interests, concerns, and objectives into consideration when operational plans are being developed, even if they run counter to another jurisdiction's interest, mission or direct objectives. Understanding interdependencies of actions and objectives is paramount.

KEY FINDING: Jurisdictional leaders differ in terms of their preferred models of co-management. Informants' preferences reflected three distinct models: cooperative assistance, negotiated order, and collaborative singularity.

The last strategic orientation to co-management we described as collaborative singularity. In this model, co-management was defined by the unification of all affected jurisdictions into a single organization guided by one mission and one set of objectives and priorities. What delineated this model from other models was the emphasis on the subordination of individual jurisdictional interests in pursuit of higher order, incident level, objectives that required the collective resources and efforts of all involved to accomplish the mission. Figure 4c shows the boundaries between individual jurisdictions can become blurred within a collaborative singularity as the collective aims become paramount. For some informants, this collaborative singularity was described as born out of negotiated order wherein affected jurisdictions weigh in on incident objectives at the onset.

Figure 4: Models of Co-Management

This model shows the three distinct models revealed by the descriptions of co-management.

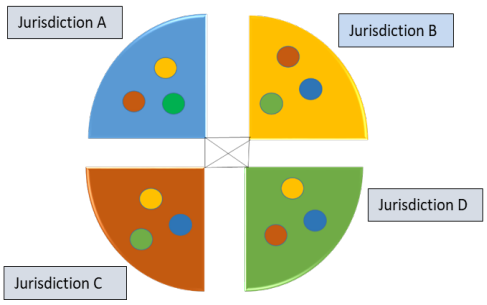


Figure 4a. Cooperative Assistance

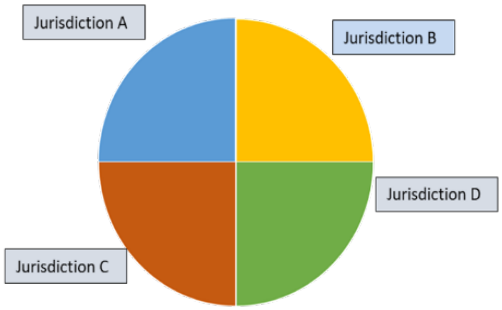


Figure 4b. Negotiated Order

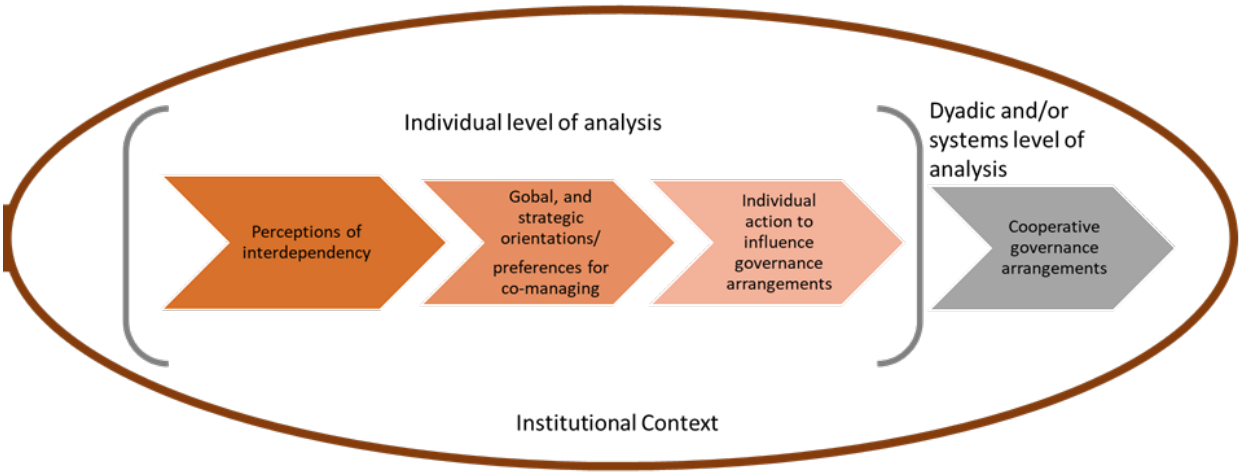
Figure 4c. Collaborative Singularity

A Multi-Level Theory of Co-Management on Jurisdictionally Complex Wildfires.

Collectively, this phase of analysis revealed a more nuanced model of what co-management means in the context of co-managing a jurisdictionally wildfire (see Figure 5). Put simply, findings indicate co-management means different things for different jurisdictional leaders which may prove problematic if leader are not aware, and thus unable to effectively navigate, these different expectations. These differences appear to be rooted in differing perceptions of the nature of interdependency with other jurisdictions and preferences for how to manage these interdependencies while still maintaining a comfortable level of jurisdictional autonomy. These perceptions drive different global and strategic orientations toward co-management.

Collectively, this model argues that it is the negotiation of these different preferences that shape and constrain the collaborative governance arrangement that emerges on an incident. Understanding this helps to explain variation in governance arrangements across incidents.

Figure 5: A Multi-Level Theory of Co-Management



WHAT ARE THE MODELS OF NETWORKS GOVERNANCE THAT EFFECTIVELY GIVE VOICE TO DIVERSE JURISDICTIONS ON JURISDICTIONALLY COMPLEX WILDFIRES?[2]

The previous analysis revealed considerable variation across jurisdictional leaders in their conceptions of what effective co-management looked like and how variation may shape the different governance arrangements that we observe. In this analysis, we investigated the efficacy of governance arrangements that were established to manage diverse jurisdictional interests on a sample of ten jurisdictionally complex incidents. We carried this work out in three phases bounded by two guiding questions and design principles: 1) What network governance structures allow for representation of diverse interests in a jurisdictionally complex incident (Phase 1); 2) To what extent does formal representation in network governance structures increase voice? Do we see variation in macro and micro structures when it comes to voice? (Phase 2); and 3) Design insights into governing conflicting contingencies in complex disasters (Phase 3).

Phase 1: ***What network governance structures allow for representation of diverse interests in a jurisdictionally complex incident?*** Our initial incident level analysis across our 10 case study incidents revealed that network governance on these incidents demonstrated considerable variability in how they structured network relations among jurisdictions. Network governance was further described as consisting of both macro and micro structures through which principals and their agents sought representation. *Macro structures* represent the principals and agents

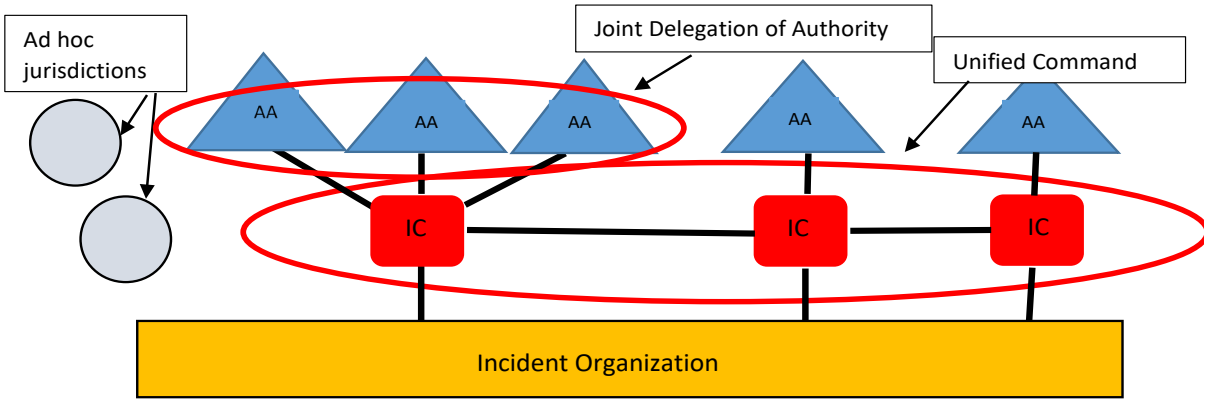
[2] Findings published in *Journal of Public Administration Research and Theory*, Volume 31, Issue 4, October 2021, Pages 723–739, https://doi.org/10.1093/jopart/muab004.

impacted by the incident and their formal relationships with one another. *Micro structures* are the tools, technologies, and forums through which formal and informal negotiated order is achieved.

Three macro structures were prevalent—ad hoc arrangements, unified command and delegations of authority. Eight of the 10 cases in this study typically employed some type of network governance design involving a combination of joint delegations of authority and unified command. In two cases, the entire incident lacked a formal network governance structure despite numerous jurisdictions being engaged. In other words, there was no joint delegation of authority or unified command structure formally linking any of the affected or threatened jurisdictions and coordination was carried out in an ad hoc arrangement. Seven incidents used unified command and eight used delegations of authority; these were used in combination on seven incidents. For example, Figure 6 represents the macro structure set up to govern an incident we will refer to as the Summit Fire. As shown, this network governance organization consisted of a joint delegation of authority between three federal agencies to a single incident commander who then was tasked to work in unified command with two other incident commanders representing a state and a county jurisdiction. Other jurisdictions involved in the incident were represented only through ad hoc arrangements, and existed outside of formal structural configurations.

Key Finding: Jurisdictional interests on complex incidents are governed through a combination joint delegations of authority, unified command, and ad hoc arrangements

Figure 6: Network Governance Organization for "Summit Fire"



Phase 2: ***To what extent does formal representation in network governance structures increase voice? Do we see variation in macro and micro structures when it comes to voice?***

We wanted to examine perceptions of voice among principals represented under different macro structural arrangements. To understand this, we first needed to categorize where individuals fell within the various macro structures. There were four different ways in which principals could be represented within the macro structure. First, they could be represented under a joint delegation

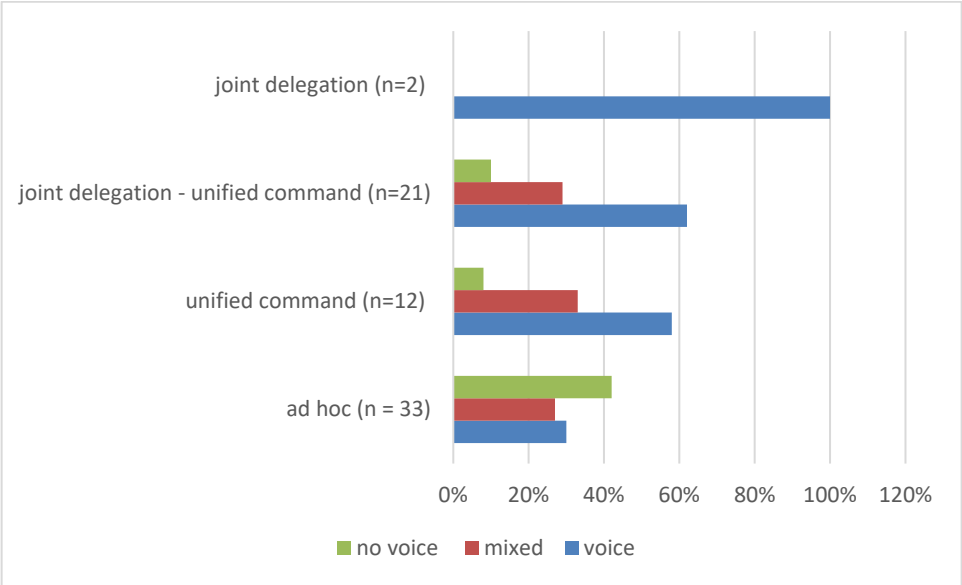
of authority in which multiple principals elected to mutually delegate authority to a single agent (i.e., incident commander) who managed their collective interest on their behalf. Only two of our principals met this criterion. Second, principals could be represented through unified command in which their interests were being represented by a dedicated agent, but that agent managed those interests in joint command with other agents who were likewise representing other jurisdictional interests. Twelve of our principals met this criterion. Third, principals could be represented through a combination of the first two. In these cases, a joint delegation with one or more jurisdictions to a single agent might be present along with a unified command structure with one or more agents representing additional jurisdictions. Twenty-one of our principals were represented in the macro structures under this arrangement. Last, principals could be represented ad hoc through informal coordination with other principals and their agents. Thirty-three of our principals were classified as ad hoc.

Second, we needed to understand who perceived who had voice in these structures and who did not. Our data indicated that 47% of the individuals in our sample expressed consistent sentiments of voice, 25% expressed consistent sentiments of having no voice, and 28% expressed mixed sentiments of voice, often expressing voice in one aspect of the incident but not in another or expressing differing sentiments during different time points as the incident unfolded.

The next question we posed was whether we would see variation in the expression of voice based on positionality within the macro structures. Our data indicated that all three macro structures and their combinations can effectively channel voice, although some appeared more problematic than others. 100% of those who were in joint delegation (n=2) and 58% in unified command (n=12) were perceived to have voice (Figure 7). 62% in a combination of joint delegation and unified command (n=21) were perceived to have voice. In contrast, only 30% of the principals in an ad hoc arrangement (n=33) perceived themselves to have voice. Among all of those who perceived to have no voice, 82% were under ad hoc arrangements, 12% were under a combination of joint delegation and unified command and 6% were under unified command. This pattern suggested core propositions that formal representation in the macro structure increased the likelihood of experiencing sentiments of having voice and that lack of formal representation increased the likelihood of experiencing sentiments of not having voice.

Key finding: Being formally represented in the incident organization through either joint delegation or unified command was associated with decreased risk that jurisdictional leaders experienced a lack of voice.

Figure 7: Perception of Voice by Jurisdictional Leaders under Different Network Structures



Phase 3: Design Insights into Governing Conflicting Contingencies in Complex Disasters

Our third phase consisted of a discrepancy analysis of cases in which formal representation did not lead to a perception of voice and cases in which those lacking formal representation still felt they had voice within the incident. This analysis revealed that micro structures were required to support macro governance elements.

Voice could be lost despite formal representation in the incident organization when organizational failures occurred. For example, direction issued from the top of the chain of command failed to translate down through ranks to the tactical level, often unraveling along historical and institutionalized differences in tactics and strategy associated with different agencies. This left individuals feeling that what had been agreed to was never executed on the ground and consequently their voice was not effectively translated into action. Second, six additional participants, who were formally represented but who expressed lack of voice, described being unclear about their role and/or feeling that their counterparts discounted their input. In the case of the latter, a strong technocratic theme was present. For example, if the other members of the macro structure did not perceive the agent to have the experience to offer an informed and realistic opinion, they could be discounted, thus revealing a hierarchy among equals. In other cases, conflicting ideas about risk and prioritization failed to be negotiated and certain agents' interests were perceived not to have been given priority. The chaos created during times of transitions appeared to be particularly susceptible to this type of dynamic.

The perception of having voice on the incident could be gained despite a lack of formal representation in the incident organization through micro-communication structures. In cases where those outside the formal incident organization still experienced voice, we noted compensatory patterns that essentially mimicked formal representation. All of these actions hinged on having pre-established relationships prior to the fire and/or leveraging micro structure communication and connection modalities during the incident. These included efforts to directly insert oneself into the formal organizational structure, leveraging pre-existing organizational relationships, and/or direct outreach by someone within the formal governance structure to the principal with an ad hoc arrangement. For instance, a number of participants leveraged existing relationships and previous experience to essentially create a quasi-formal representation, inserting themselves into the formal governance structure. In doing so, they mimicked the involvement of those formally represented, embedding themselves at the incident command post, attending daily briefings, connecting with the incident command and division supervisors, as well as obtaining phone numbers so they could contact key people within the formal structure as needed as issues arose.

Key Findings: Voice on an incident could be gained despite a lack of formal representation through micro-communication structures that mimicked quasi-formal representation

Last, we observed that in incidents like the Summit Fire, the organizational complexity of the fire organization was highly complex. Incident commanders reflected on the challenges of managing all the different agency administrators and private land interests that were invested in a jurisdictionally complex fire. Findings indicated that many fire organizations are potentially hitting limits in terms of how many jurisdictional interests can be knit together using existing structures of joint delegations and unified command. This suggests that the ability of fire organizations to allow some jurisdictional actors to experience voice despite a lack of formal representation may become increasingly important as fires continue to increase in jurisdictional complexity. It also suggests new governance arrangements may be needed. Collectively, these findings resulted in the following propositions concerning network governance of jurisdictionally complex wildfire.

> **Proposition 1:** *Direct representation of principals in the formal network governance structure increases the perception of voice.*
>
> **Proposition 2:** *Micro structural communication modalities can mitigate structural risks for having no voice that are associated with lack for formal representation.*
>
> **Proposition 3:** *Micro structural communication modalities will be less effective in mitigating structural risks when the formal structure is compromised.*
>
> **Proposition 4:** *Increasing institutional complexity in formal governance will hit a point of diminishing returns and governance through micro structures will be increasingly important*

WHAT CONVERSATIONS DO WE NEED TO BE HAVING RIGHT NOW TO IMPROVE CO-MANAGEMENT ON JURISDICTIONALLY COMPLEX WILDFIRES?[3]

The past 5 years, we've observed numerous wildfires move cross across the American landscape, many traversing three or more different jurisdictions. Co-management has been proposed as a guiding concept for operating effectively in what appears to be a new "inter-jurisdictional wildfire-world order." Sounds great, right? But how do we get there?

While ill-defined in policy, co-management in scholarship refers to power sharing of the decision space (Berkes, 2009). Scholars of change management have long recognized the challenges of retrofitting new concepts and ideas into existing systems (By, 2005). This begs two questions: Does our existing incident command system accommodate principles of co-management? And, what practices are being employed to retrofit the existing incident command practices to adapt to the demands of more complex multi-jurisdictional spaces?

How Are We Doing in Co-Managing Multi-Jurisdictional Fires?

Survey data indicate that lead agencies, federal and local jurisdictions tend to feel the best overall about the co-management outcomes on an incident. State and private jurisdictions were — as a group — significantly less satisfied across incidents.

While the challenges are considerable, incident commanders and agency administrators are rising to meet these challenges in creative ways. **Both the challenges and the solutions were markedly similar regardless of jurisdiction.** When jurisdictions perceived that their interests and concerns were not being given due consideration, both state and federal informants voiced frustration and concerns about risk transfer. At the same time, when co-management was perceived to have been effective, informants representing a variety of different jurisdictions tended to point to the same practices and dynamics at play.

Nature of the Beast: Jurisdictional Interdependency Meets Jurisdictional Autonomy

Interdependencies exist when the actions of one entity have consequences for another entity. Wildland fire response efforts are often jurisdictionally interdependent. This means that decisions and subsequent actions taken on one jurisdiction can have consequences for adjoining jurisdictions, both before, during and after the incident. However, different jurisdictions have different land and fire management objectives and currently, individual jurisdictions have the full authority to make unilateral decisions aimed at maximizing their own agency objectives when engaged in fire suppression efforts on their own land.

---

[3] Findings published https://fireadaptednetwork.org/co-managing-wildfire-conversations-you-need-to-have-right-now/ .

We have seen this equation in many environmental policy domains before (Figure 8). Situations characterized by jurisdictional interdependence and unilateral decision making, coupled with differing objectives create a powerful "conflict cocktail." Such conflict, if it occurs, frequently leads to on-going problems, making everyone less effective (Wondolleck & Yaffee, 2000).

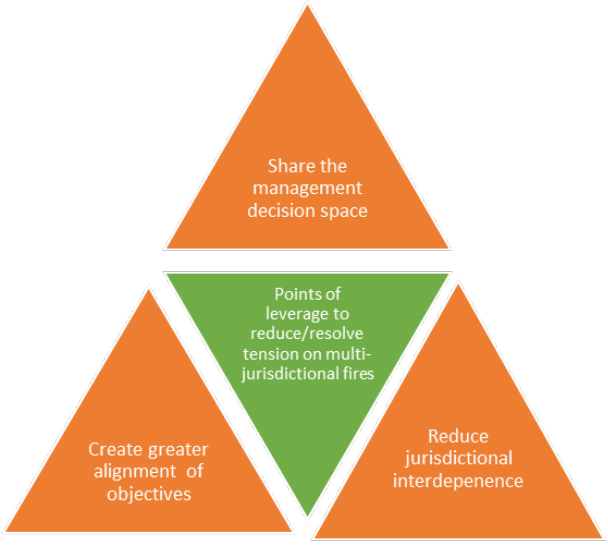
Figure 8: Recipe for the Conflict Cocktail

Interdependence **x** Competing Objectives **x** Unilateral Decision-Making = Conflict

Points of Leverage to Resolve Tensions in Multi-Jurisdictional Settings

The theoretical solution space is to lessen or eliminate one or more of the three elements on the left side of the above equation. Just like the fire triangle, when you remove any one of the elements, the conflict goes away. If you reduce jurisdictional interdependence by, for example, creating buffer zones between boundary properties so that it is difficult for a fire to transfer off of one property to another, the conflict is resolved. Alternatively, if there are spaces where land and fire management objectives can be brought into closer alignment across jurisdictions, then the tension is resolved. Last, if management actions are co-negotiated such that other jurisdictions believe their interests are represented in the decision space, the tension is again resolved.

Figure 9: Leverage Points for Co-Managing Conflict



Unfortunately, really only one of these three points of leverage is available to agency administrators and incident commanders during a wildfire. Finding opportunities where land/fire management objectives might align or establishing interjurisdictional buffers are complex planning efforts that must occur before the fire. These are not generally feasible options to work through during an active fire. This leaves one immediate option — creating more space for

consultation with and input from jurisdictions who will be directly impacted by the fire while it is happening.

The good news is that our interviews indicated that facilitating better co-management outcomes was possible when two conditions were met: **1) Neighboring jurisdictions were involved and felt they had a voice and/or 2) Neighboring jurisdictions felt confident that the risk management process was appropriate and took their concerns into account**. Under these conditions, neighboring jurisdictions tended to be supportive of the actions of their counterparts – even if they suffered significant loss during the wildfire.

Barriers to Co-Management

Three major barriers work against co-management. First, it is sometimes hard to predict whether a fire will become multi-jurisdictional until it starts making big runs toward other jurisdictions. By then, you're behind the curve. However, no jurisdiction wants to be sub-optimizing its own objectives out of consideration for another jurisdiction if there is no true interdependency present.

Second, jurisdictional authority is a critical element of our existing incident command system. In a wildfire response, clear objectives and lines of authority are key components that enable decisive action. But the more actors that are admitted to the decision space, the more difficult it is to communicate clear objectives. As more jurisdictions and objectives are added, the greater the challenge to effective co-management.

Third, and related to the second, tools for multi-jurisdictional command (e.g., joint delegations of authority, unified command, area command) generally make sense when a given jurisdiction is under imminent threat. Up until that time, potentially threatened but not yet affected jurisdictions do not have a clear role in ICS. For example, individuals showing up to the incident command post from threatened, but not yet affected, jurisdictions were jokingly described as "spies" in one interview.

Last, negotiating priorities and strategies across jurisdictions can be difficult, particularly if the relational groundwork has not been laid ahead of fire season. In total, we learned there are understandable reasons why jurisdictions might act unilaterally on fires.

Yet, there are even better reasons to change how we manage multijurisdictional fires. When co-management of multi-jurisdictional fires goes awry and jurisdictions feel they have been needlessly exposed to additional risk by their neighbor, the long term fall out to relationships can be substantial. Jurisdictions are structurally conjoined by their boundaries and the physical characteristics of the fireshed. This means the same set of actors will be brought together again and again, year after year, as fires and other natural hazards move through the area. No agency has the resources, expertise, networks or legitimacy to create more resilient landscapes, fire adapted communities or effective fire response working alone.

Our data highlighted several immediate actions that could have significant payoff for improving co-management outcomes. We learned that pre-season conversations are missing opportunities for building the foundation for effective co-management.

Conversations to Have Right Now:

1) **"Hi, my name is…"**

In some cases, agency administrators had never met one or more of their counterparts prior to the fire. These individuals often expressed regret at having not made that personal contact before they had to co-manage a fire together. Effective co-management often requires tough conversations and a willingness to give one another the benefit of the doubt. Numerous informants reflected on the value personal relationships offered when having to navigate tough conversations with their counterparts.

2) **"How and when are we going to communicate with each other about potential threats?"**

Themes related to mutual respect were also prominent in the interviews. Jurisdictions who receive fire from another jurisdiction look for signals suggesting that their concerns and interests were taken into account by the lead agency. One of the first places where this was repeatedly described as "getting off on the wrong foot" was when a receiving jurisdiction found out about a potential threat from a source other than the lead agency and had to go hunting for information. Conversely, both public and private land owners who ended up receiving a fire from another jurisdiction were appreciative when they were contacted early on by the lead agency. Knowing your jurisdictional counterparts and setting mutual expectations for when contact will be made about potential threats is a low cost/high return strategy to promote a climate of mutual respect. Sometimes this outreach was not as timely as it could have been because the lead agency did not anticipate what the fire ending up doing. In light of the increasingly unprecedented nature of fire behavior, erring on the side of over-communication may be wise — particularly late in the fire season when resources are scarce.

3) **"How do we communicate concerns and offer assistance when we perceive significant threat from a fire that is on your jurisdiction?"**

This one is tough. It is the grey area of the incident command system where a potentially threatened — but not yet impacted-jurisdiction has no formal standing within the lead fire organization. Offers to "help" were sometimes described as a cultural taboo within the fire community, communicating a lack of confidence in counterparts and their ability to handle things on their own.

A "don't worry, we got this" culture was also described as continuing to pervade the incident command world across multiple jurisdictions — likely an artifact from a previous era when fires were smaller and less active, and management objectives were less complex. Stories of

jurisdictional hand-wringing from the sidelines, “black ops” missions outside of command and control of the lead organization, sending “spies” into fire camps, and fire line negotiations with division sups were part of this broader narrative — all signals that there was lack of confidence in the command structure.

At the same time, our interviews were also filled with stories from individuals who innovated ways to break through these bureaucratic, institutional and cultural barriers toward more of a co-management approach (stay tuned for more on this). One of the most well-reviewed co-management tools we heard about was a **regularly scheduled agency administrator meeting**. This was a private meeting where current and/or prospective agency administrators met together with the incident commander to share concerns, vet strategies, offer suggestions and assistance, and be heard. These meetings too place outside of planning meetings and were described by incident commanders as useful because it forced agency administrators to work together to provide a shared set of objectives and priorities *for the incident* (not just for their jurisdiction) rather than require incident commanders to engage in shuttle diplomacy across jurisdictions. Agency administrators liked these meetings because it gave them a small decision forum to make sure their concerns were heard and considered in the strategy.

Multi-jurisdictional incidents will continue to be a key challenge within the wildfire community. The volatile combination of interdependencies, competing objectives, and unilateral decision processes help us understand the challenges, but it also helps identify points of leverage. Improving capacity for co-management among jurisdictions during an incident is only one point of leverage. More powerful opportunities may exist in the pre-season work aimed at reducing interdependency and/or increasing alignments of management objectives.

HOW HAS THE INSTITUTIONAL COMPLEXITY OF WILDFIRES CHANGED NATIONALLY OVER THE PAST 20 YEARS?

Our investigation into network governance that supports effective co-management of jurisdictionally complex wildfires presumes that the task environment of wildfire is changing and therefore required greater national capacity for co-management across jurisdictions. Our team investigated the extent to which and ways in which the task environment of Type 1 and Type 2 wildfires has changed over the past 20 years. While there is general acknowledgement that incident response to wildfire is increasingly complex, there is much we do not yet understand about how climate and human developments have changed the task and institutional environment of incident response. This phase of our investigation sought to generate greater empirical clarity and precision of understanding about changes in institutional complexity of large wildfire incident response over the past twenty years[4].

The first step in this process was to define institutional complexity of large wildfires. To narrow in on the most complex wildfires across the nation, we chose to focus solely on wildfires for which a Type 1 or Type 2 incident management team had been assigned between the years of 1999-2019. We then investigated changes over the past 20 years in six elements that reflected aspects of institutional complexity: 1) total acres burned, 2) # of fire perimeters, 3) # of incident days at Preparedness Level 4 or 5, 4) incident duration, 5) total number of jurisdictions, and 6) total number of jurisdictional levels (federal, state, local, private, tribal). To date, there is no national dataset available to serve as the definitive source of information about institutional complexity of wildfires. To create this dataset, our team has been compiling data sources from a number of different existing datasets (see pg. 7) – many of which are being updated themselves as new and better data are available. The creation of a national dataset of changing institutional complexity of wildfire has been a considerable task and is yet underway awaiting the 2019 and 2020 data. **As such, the time series analysis we present here is preliminary and should be interpreted with caution awaiting the finalized datasets.**

Change in final acres. Focusing just on the 1999-2018 Type 1 and Type 2 wildfires, preliminary time series analysis indicates that, on average, Type 1 and 2 wildfires nationally have increased in size by approximately 500 acres per year over the past 20 years. Larger fires generally require corresponding larger fire organizations in terms of the number of resources needed to manage the fire. Preliminary findings suggest that nationally, the greatest changes in the size of Type 1 and 2 wildfires is occurring in the Northwest and Northern California, the Great Basin, Rocky Mountain, Southwest and Southern Regions relative to the Eastern, Northern Rockies, Alaska, and Southern California.

---

[4] Focus on the past twenty years of wildfire is driven by two considerations. The first consideration was driven by limitations in data availability (See Short et al., 2020). The second consideration was the duration of time in which it takes to make significant institutional changes to complex bureaucracies. Changes within the past 20 years can be reasonably construed as "recent" from an institutional adaptation standpoint.

Change in # of days at PL 4 or 5. Analysis also revealed an upward trend of the number of days Type 1 and Type 2 incidents are being managed while national preparedness levels (PL) are at either 4 or 5. This is important as higher PL levels suggest that incident management teams are more likely to be restricted in the number of fire resources available and thus are more likely to have to adjust tactics, prioritizing certain values at risk over others given limited resources. Nationally, preliminary findings suggest the regions that have seen the greatest increase in Type 1 or 2 incident days at PL 4 or 5 are California, the Northwest, Northern Rockies, and Alaska.

Key Finding: Type 1 and 2 wildfires in the United States have become more institutionally complex over the past 20 years in at least three ways: 1) larger fire perimeters, 2) greater number of incident days at PL 4 or 5, and 3) more jurisdictions across more levels of government affected on an average incident

Jurisdictional Complexity. Jurisdictional complexity refers to the number of distinct jurisdictions that are impacted by a given wildfire incident and therefore must engage in the co-management of that wildfire. Preliminary time series analysis indicates a significant positive national trend in the jurisdictional complexity of Type 1 and Type 2 wildland fires (see Figure 2). This upward trend in increased jurisdictional complexity appears to be affecting every region in the United States with the exception of Southern California and Northern Rockies region.

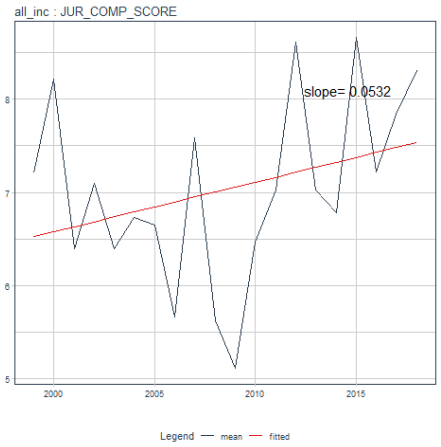


Figure 2: Jurisdictional Complexity Trend Line 1999-2018

Shows the positive national trend over time in the jurisdictional complexity of Type 1 and Type 2 wildland fires

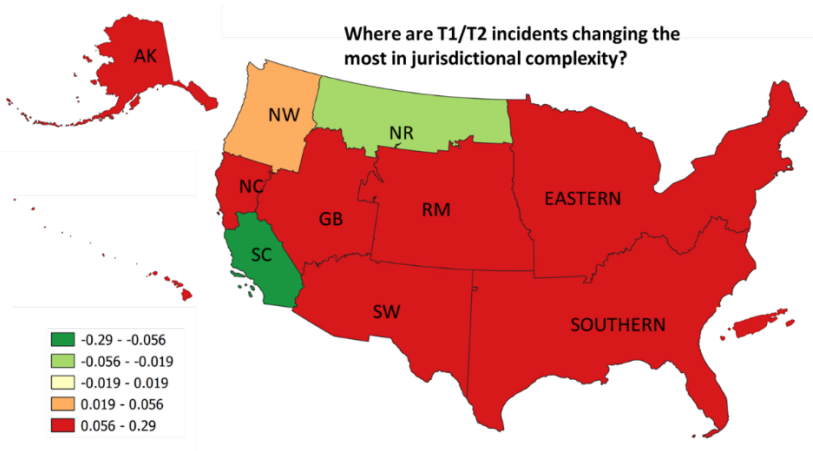


Figure 3. Change in Jurisdictional Complexity

Shows which regions are experiencing the most profound change in institutional complexity

Which regions are experiencing the most profound changes in institutional complexity? Preliminary analysis reveals the changing institutional environment is not uniform across the nation and that different regions are affected in different ways. In terms of the most profound effects, analysis suggests that **Northern California** is one of the most affected. Type 1 and Type 2 wildfires in North California are becoming significantly larger, more jurisdictionally complex, and are increasingly occurring over time periods when national response resources are at their lowest. This trend is reflected in the 1999-2018 data and undoubtedly will be more extreme based on the fire activity experienced in that region 2019-2021. However, the region with *greatest change* in Type 1 and 2 wildfire size and jurisdictional complexity over the past 20 years has been the **Southern Region.** This finding is particularly concerning as the Southern Region does not have the history of large, jurisdictionally complex wildfire that the Western regions have. This suggests that the Southern region may not have the same experience and institutional resources in place to respond to this changing task environment (Nowell & Stutler, 2020).

Key Finding: Changes in institutional complexity are **not** uniform across all regions. The Southern and Northern California regions have seen the greatest overall increase in complexity of Type 1 and 2 wildfires

CONCLUSIONS

Since the initiation of the National Cohesive Wildland Fire Management Strategy in the United States in 2010, co-management has emerged as an organizing concept in both policy and practice for considering the roles of federal, state, local, tribal and private landowners in preparing for and responding to jurisdictionally complex wildfires (e.g., Jacobson et al., 2021; Davis et al., 2021; Dunn et al., 2020; Schultz & Moseley, 2019; Steelman & Nowell, 2019). In this project, we set out to understand 1) some of the drivers for co-management, including the role of shared risk perceptions, 2) how wildfire participants defined co-management, 3) what structures allowed diverse participants in co-management to have a voice in decision making, 4) what kinds of conversations could improve co-management, and 5) whether and how the institutional complexity of wildfires has changed since 1999. In doing so, we build on the nascent social science research in this area.

Risk Perception and Co-management. We expected to find differences in risk prioritization among diverse stakeholders engaged in wildfire co-management. This was not what we found. There appears to be a relatively strong foundation of common risk prioritization that has been institutionalized across all levels of government as well as embraced by the private sector. Actors representing agencies at different levels of government and private interests reported very similar substantive risk perceptions, with each of the substantive dimensions showing up in each group. Most informants – regardless of level of government or private versus public-- identified human safety as their top priority/concern followed by built infrastructure and communities. This is noteworthy as it suggests that differences in risk perception and prioritization, to the extent that they exist, are more nuanced. There was more variation in the relative prioritization of concerns about the natural environment and social, political and economic risks, however, these were often viewed as entangled (e.g., economic concerns were linked to healthy forests). Further analysis of risk narratives revealed that the main difference across informants occurred in the temporal bounding of risk perception within substantive areas. We found temporal dimensions of risk varied in terms of whether perceptions of threats were tied to immediate and tactical elements of risk, the incident-level potential of risks, and/or the risk of long-term consequences that would endure after the incident was contained. Interviewees revealed that there are often tradeoffs such that minimizing risk in one temporal phase often requires accepting greater risk in another temporal phase. For example, minimizing the immediate tactical risk to firefighters may prolong an incident leading to greater total hours of firefighter risk exposure.

Co-management Definitions. Our findings indicated that co-management meant different things for different jurisdictional leaders. For instance, we found wildfire leaders carried different global definitions for co-management that varied across a continuum from more individualistic to more collectivistic orientations and therefore is not confined to any one global understanding (e.g., collaboration). Likewise, jurisdictional leaders differed in terms of what effective co-management "looked" like operationally. Specifically, descriptions of co-management revealed three distinct models: 1) cooperative assistance, 2) negotiated order, and 3) collaborative singularity. The implications that flow from these differences are that each leader carries a different global and operational orientation to co-management that might not be shared by others. These differences appear to be rooted in differing perceptions of the nature of interdependency

with other jurisdictions. Leaders have preferences for how to manage these interdependencies while still maintaining a comfortable level of jurisdictional autonomy.

Network Structures that Facilitate Voice in Co-Management. We identified significant variation in how network relations were structured among multiple jurisdictions engaged in co-managing wildfire. Three structures governed jurisdictional interests, these were ad hoc arrangements, unified command and delegations of authority. Tools, technologies, and forums enhanced these governance structures and allowed formal and informal relationships be negotiated. Nearly 50% of stakeholders sampled expressed they felt they had voice within these decision-making structures, 25% expressed having no voice and a little over 25% expressed mixed sentiments—they felt they had voice at some times but not others. Ad hoc governance arrangements were the most problematic for effectively channeling voice. Moreover, formal representation in the structure increased the likelihood of experiencing sentiments of having voice and lack of formal representation increased the likelihood of experiencing sentiments of not having voice. Finally, our findings indicated that many fire organizations are potentially hitting limits in terms of how many jurisdictional interests can be knit together using existing structures of joint delegations and unified command. This suggests that the ability of fire organizations to allow some jurisdictional actors to experience voice despite a lack of formal representation may become increasingly important as fires continue to increase in jurisdictional complexity. It also suggests new governance arrangements may be needed.

Improving Co-management. We conducted a survey to understand how various stakeholders perceived co-management outcomes on their incidents. Survey data indicated that lead agencies, federal and local jurisdictions tended to feel the best overall about the co-management outcomes on an incident. State and private jurisdictions were — as a group — significantly less satisfied across incidents. We asked about the challenges they faced and the solutions they identified. Both the challenges and the solutions were markedly similar regardless of jurisdiction. When jurisdictions perceived that their interests and concerns were not being given due consideration, both state and federal informants voiced frustration and concerns about risk transfer. At the same time, when co-management was perceived to have been effective, informants representing a variety of different jurisdictions tended to point to the same practices and dynamics at play. Frustration was born out of situations where expectations for jurisdictional interdependency met with jurisdictional autonomy and unilateral decision making, especially when differing objectives were present. The good news is that our interviews indicated that facilitating better co-management outcomes was possible when two conditions were met: 1) Neighboring jurisdictions were involved and felt they had a voice and/or 2) Neighboring jurisdictions felt confident that the risk management process was appropriate and took their concerns into account. Under these conditions, neighboring jurisdictions tended to be supportive of the actions of their counterparts – even if they suffered significant loss during the wildfire. Three major barriers work against co-management. First, it is sometimes hard to predict whether a fire will become multi-jurisdictional until it starts making big runs toward other jurisdictions. Second, jurisdictional authority is a critical element of our existing incident command system. In a wildfire response, clear objectives and lines of authority are key components that enable decisive action. But the more actors that

are admitted to the decision space, the more difficult it is to communicate clear objectives. As more jurisdictions and objectives are added, the greater the challenge to effective co-management. Third, and related to the second, tools for multi-jurisdictional command (e.g., joint delegations of authority, unified command, area command) generally make sense when a given jurisdiction is under imminent threat. Up until that time, potentially threatened but not yet affected jurisdictions do not have a clear role in ICS.

Institutional Complexity as a Driver of Co-Management. Our investigation into network governance that supports effective co-management of jurisdictionally complex wildfires presumed that the task environment of wildfire was changing and therefore required greater national capacity for co-management across jurisdictions. This assumption on our part was something that we wanted to investigate empirically, even though is was not part of our original proposal. Type 1 and 2 wildfires in the United States have become more institutionally complex over the past 20 years in at least three ways: 1) larger fire perimeters, 2) greater number of incident days at PL 4 or 5, and 3) more jurisdictions across more levels of government affected on an average incident. Further, preliminary findings suggest that nationally, the greatest changes in the size of Type 1 and 2 wildfires is occurring in the Northwest and Northern California, the Great Basin, Rocky Mountain, Southwest and Southern Regions relative to the Eastern, Northern Rockies, Alaska, and Southern California. Nationally, preliminary findings suggest the regions that have seen the greatest increase in Type 1 or 2 incident days at PL 4 or 5 are California, the Northwest, Northern Rockies, and Alaska.

In closing, we recommend that future work should continue to focus on how we work across jurisdictionally complex landscapes for more effective fire preparedness and management. Co-management, collaboration, boundary spanning, and other means for constructive collective action are needed to address the vexing challenges associated different actors' priorities, missions, incentives and cognitive biases. An innovative group of researchers is now focused on addressing these worthy challenges (e.g. Jacobson et al., 2021; Davis et al., 2021; Dunn et al., 2020; Schultz & Moseley, 2019; Kelly et al., 2019; Paveglio et al., 2018; 2019; Abrams et al., 2017). As wildfires grow more institutionally complex, we will need more tools in the toolkit to work toward viable, socially based solutions.

LITERATURE CITED

Abrams, J., Davis, E. J., & Wollstein, K. (2017). Rangeland fire protection associations in Great Basin rangelands: A model for adaptive community relationships with wildfire?. *Human Ecology*, *45*(6), 773-785.

Ager, A.A., Kline, J.D., & Fischer, A.P. (2015). Coupling the biophysical and social dimensions of wildfire risk to improve wildfire mitigation planning. *Risk Analysis, 35*(8), 1393-1406.

Anderson, R. C., Spiro, R. J., & Anderson, M. C. (1978). Schemata as scaffolding for the representation of information in connected discourse. *American Educational Research Journal*, *15*(3), 433-440.

Arvai, J.L., Gregory, R & McDaniels, T. (2001). Testing a structured decision approach: Value-focused thinking for deliberative risk communication. *Risk Analysis, 21*, 1065-1076.

Berkes, F. (2009). Evolution of co-management: role of knowledge generation, bridging organizations and social learning. *Journal of Environmental Management*, *90*(5), 1692-1702.

Brewer, W. F., & Nakamura, G. V. (1984). The nature and functions of schemas. *Center for the Study of Reading Technical Report; no. 325*.

Carroll, M., & Paveglio, T. (2016). Using community archetypes to better understand differential community adaptation to wildfire risk. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1696), 1-7.

Cohn, P. J., Williams, D. R., & Carroll, M. S. (2008). Wildland-urban interface resident's views on risk and attribution. *In: Martin, Wade E.; Raish, Carol; Kent, Brian, eds. Wildfire risk: Human perceptions and management implications. Washington, DC: Resources for the Future, RFF Press. p. 23-43.*

Comfort, L. K. (1990). Turning conflict into cooperation: Organizational designs for community response in disasters. *International Journal of Mental Health*, *19*(1), 89-108.

Comfort, L. K. (2007). Crisis management in hindsight: Cognition, communication, coordination, and control. *Public Administration Review*, *67*(s1), 189-197.

Comfort, L. K., & Kapucu, N. (2006). Interorganizational coordination in extreme events: The World Trade Center attacks, September 11, 2001. *Natural Hazards*, *39*, 309–327.

Davis, E. J., Huber-Stearns, H., Cheng, A. S., & Jacobson, M. (2021). Transcending parallel play: Boundary spanning for collective action in wildfire management. *Fire*, *4*(3), 41.

Dunn, C. J., D O'Connor, C., Abrams, J., Thompson, M. P., Calkin, D. E., Johnston, J. D., ... & Gilbertson-Day, J. (2020). Wildfire risk science facilitates adaptation of fire-prone social-ecological systems to the new fire reality. *Environmental Research Letters*, *15*(2), 025001.

Faas, A. J., Jones, E. C., Tobin, G. A., Whiteford, L. M., & Murphy, A. D. (2015). Critical aspects of social networks in a resettlement setting. *Development in Practice*, *25*(2), 221-233.

Fischer, A.P., Kline, J.D., Charnley, S., & Olsen, C. (2012). Identifying policy target groups with qualitative and quantitative methods: The case of wildfire risk on nonindustrial private forest lands. *Forest Policy and Economics, 25*, 62-71.

Fleming, C.J., McCartha, E.B. & Steelman, T.A. (2015). Conflict and collaboration in wildfire management: the role of mission alignment. *Public Administration Review*, *75*(3), 445-454.

Granovetter, M. (2005). The impact of social structure on economic outcomes. *Journal of economic perspectives*, *19*(1), 33-50.

Gregory, R. (2000). Using stakeholder values to make smarter environmental decisions. *Environment*, *42*, 34-44.

Harris, S. G. (1994). Organizational culture and individual sensemaking: A schema-based perspective. *Organization science*, *5*(3), 309-321.

Jacobson, M., Smith, H., Huber-Stearns, H. R., Davis, E. J., Cheng, A. S., & Deak, A. (2021). Comparing social constructions of wildfire risk across media, government, and participatory discourse in a Colorado fireshed. *Journal of Risk Research*, 1-18.

Jones, N. A., Ross, H., Lynam, T., Perez, P., & Leitch, A. (2011). Mental models: an interdisciplinary synthesis of theory and methods. *Ecology and Society*, *16*(1).

Kapucu, N. (2006). Interagency communication networks during emergencies boundary spanners in multiagency coordination. *The American Review of Public Administration*, *36*(2), 207-225.

Kelly, E. C., Charnley, S., & Pixley, J. T. (2019). Polycentric systems for wildfire governance in the Western United States. *Land Use Policy*, *89*, 104214.

Magsino, S. L. (2009). *Workshop summary: Applications of social network analysis for building community disaster resilience*. Washington, DC: National Academies Press.

Maitlis, S. (2005). The social processes of organizational sensemaking. *Academy of management journal*, *48*(1), 21-49.

Martin, W. E., Martin, I. M., & Kent, B. (2009). The role of risk perceptions in the risk mitigation process: The case of wildfire in high risk communities. *Journal of Environmental Management, 91*(2), 489-498.

Moynihan, D. (2009). The network governance of crisis response: Case studies of incident command systems. *Journal of Public Administration Theory and Research, 19*, 895–915.

Nowell, B., & Steelman, T. (2013). The role of responder networks in promoting community resilience: toward a measurement framework of network capacity. In *Disaster Resiliency* (pp. 254-279). Routledge.

Nowell, B., Steelman, T., Velez, A. L. K., & Yang, Z. (2018). The structure of effective governance of disaster response networks: Insights from the field. *The American Review of Public Administration*, *48*(7), 699-715.

Nowell, B. and Steelman, T. (2019). Beyond ICS: How should we govern complex disasters? *The Journal of Homeland Security and Emergency Management, 16(2):*

Nowell, B., & Stutler, J. (2020). Public Management in an Era of the Unprecedented: Dominant Institutional Logics as a Barrier to Organizational Sensemaking. *Perspectives on Public Management and Governance*, *3*(2), 125-139.

Paveglio, T. B., Carroll, M. S., Stasiewicz, A. M., & Edgeley, C. M. (2019). Social fragmentation and wildfire management: Exploring the scale of adaptive action. *International Journal of Disaster Risk Reduction*, *33*, 131-141.

Paveglio, T. B., Carroll, M. S., Stasiewicz, A. M., Williams, D. R., & Becker, D. R. (2018). Incorporating social diversity into wildfire management: Proposing "pathways" for fire adaptation. *Forest Science*, *64*(5), 515-532.

Powell Walter, W. (1990). Neither market nor hierarchy: network forms of organization. *Research in organizational behavior*, *12*(2), 295-336.

Provan, K. G., & Kenis, P. (2008). Modes of network governance: Structure, management, and effectiveness. *Journal of Public Administration r\Research and Theory*, *18*(2), 229-252.

Schultz, C. A., & Moseley, C. (2019). Collaborations and capacities to transform fire management. *Science*, *366*(6461), 38-40.

Slovic, P. (1986). Informing and educating the public about risk. *Risk analysis*, *6*(4), 403-415.

Steelman, T., & Nowell, B. (2019). Evidence of effectiveness in the Cohesive Strategy: measuring and improving wildfire response. *International Journal of Wildland Fire*, *28*(4), 267-274.

Valenta, A. L., & Wigger, U. (1997). Q-methodology: definition and application in health care informatics. *Journal of the American Medical Informatics Association*, *4*(6), 501-510.

Weber, E. P., & Khademian, A. M. (2008). Wicked problems, knowledge challenges, and collaborative capacity builders in network settings. *Public administration review*, *68*(2), 334-349.

Weick, K.E., Sutcliffe, K. M., & Obstfeld, D. (2005). Organizing and the process of sensemaking. *Organization Science*, *16*, 409-421.

Weick, K. E. (1995). *Sensemaking in organizations* (Vol. 3). Sage.

Weick, K. E., & Sutcliffe, K. M. (2001). *Managing the unexpected* (Vol. 9). San Francisco: Jossey-Bass.

Winter, G. J., Vogt, C., & Fried, J. S. (2002). Fuel treatments at the Wildland-Urban Interface: Common concerns in diverse regions. *Journal of Forestry, 100*(1); 15-21.

Wondolleck, J. M., & Yaffee, S. L. (2000). *Making collaboration work: Lessons from innovation in natural resource management*. Island Press.

Zaksek, M., & Arvai, J.L. (2004). Toward improved communication about wildland fire: Mental models research to identify information needs for natural resource management. *Risk Analysis, 24*(6).

APPENDIX A: CONTACT INFORMATION FOR KEY PROJECT PERSONNEL

Branda Nowell, PhD
Professor – School of Public and International Affairs
North Carolina State University
Branda_nowell @ncsu.edu

Toddi Steelman, PhD
Stanback Dean - Nicholas School of the Environment
Duke University
Toddi.Steelman@ncsu.edu

APPENDIX B: LIST OF COMPLETED AND PLANNED PUBLICATIONS AND SCIENCE DELIVERY PRODUCTS

Publications

1. Nowell, B. Steelman, T. Velez, A. and Albrecht, K (under review): Co-Management During Crisis: Insights from Jurisdictionally Complex Wildfires. Manuscript under review with *International Journal of Wildland Fire*

2. Steelman, T., Nowell, B., Velez, A. L., & Scott, R. (2021). Pathways of Representation in Network Governance: Evidence from Multi-Jurisdictional Disasters. *Journal of Public Administration Research and Theory, 31*(4), 723-739. https://doi.org/10.1093/jopart/muab004

3. Nowell, B., Steelman, T., Velez, A. L. K., Albrecht, K., Baines, S., McGovern, S., Minkowitz, H., Nauert, E., & Scott, R. (2020). Knowing what we're up against: A profile of jurisdictional complexity of wildfire. *Wildfire*, 29(1), 16-21. https://www.iawfonline.org/article/2020-01-profile-jurisdictional-complexity-wildfire/

4. Nowell, B., Velez, A, and Steelman, T. (2019). Co-managing Wildfire: Conversations You Need to Have Right Now. Research Synthesis published by Fire Adapted Communities Learning Network; retrieved 12/09/21 https://fireadaptednetwork.org/co-managing-wildfire-conversations-you-need-to-have-right-now/

Papers in Preparation

1. Nowell, B., McGovern, S., & Jones, K. (in preparation). 20 Years of Wildfire: Investigating Changing Jurisdictional Complexity over Time. Manuscript in preparation for submission to *Nature*.

2. Nowell, B., Jones, K. and McGovern (in preparation). Advancing a Method for Defining Firesheds from a Socio-Ecological Perspective manuscript in preparation for publication in *Ecology and Society*.

3. Nowell, B (in preparation) Network Cognition in Co-Managing Complex Incidents. Manuscript in preparation for publication in *Journal of Public Administration Research and Theory*

Science Delivery

1. Nowell, B. (2021). 20 Years of Wildfire: Investigating Changing Jurisdictional Complexity Over Time. Paper presented at 4th Annual National Cohesive Wildland Fire Management Strategy Workshop, October 4-7th, delivered virtually due to COVID-19.

2. McGovern, S., Jones, K., & Nowell, B. (2021). To lump or split? Mapping jurisdictional complexity in the context of wildfires. Paper presented at the University of Colorado – Boulder Natural Hazards Center's 46th Annual Natural Hazards Research and Application Workshop, July 15-16th, delivered virtually due to COVID-19.

3. Steelman, T. and B. Nowell. 2021. Representation and Voice in Disaster and Network Governance. Public Management Research Conference 202, Honolulu, HI, United States, June 23-26, 2021.

4. McGovern, S., & Nauert, E. (2020). Co-management of today's complex wildland fires. Invited presentation at the Southeast Climate Adaptation Science Center's Global Change Seminar Series, February 6th, Raleigh, NC.

5. Nowell, B. and Steelman, T. 2020. Moving from Incident Management to Incident Governance: Research insights on Co-Managing Jurisdictionally Complex Wildfires. 2020 Incident Command Advisory Council & Area Command Meeting. Boise, ID. February 23

6. Nowell, B. (2019). Governing Firesheds: Co-managing the new era of wildfire in the US. Presentation at the 8th International Fire Ecology and Management Congress. November 18-22nd, Washington, D.C.

7. Nowell, B. (2019). Complex Multi-Jurisdictional Fires: Understanding and Mitigating Perceptions of Risk Transfer. Presentation at the 8th International Fire Ecology and Management Congress. November 18-22nd, Tucson, AZ.

8. Nowell, B., Steelman, T., and Velez, A. (2019) . Not your father's fire organization: Jurisdictional complexity in the new era of wildfire. Presentation to the 3rd Annual Cohesive Strategy Workshop. Oct 21-24th, Plymouth, MA.

9. Steelman, T. Nowell, B., and Velez, A. (2019) . Preparing for jurisdictionally complex wildfire: Are the right actors having the right conversations? Presentation to the 3rd Annual Cohesive Strategy Workshop. Oct 21-24th, Plymouth, MA.

10. Velez, A., Nowell, B. and Steelman, T. (2019). Models of Co-management Presentation to the 3rd Annual Cohesive Strategy Workshop. Oct 21-24th, Plymouth, MA.

11. Nowell, B., and Nauert, E. (2019) The role of Boundary Objects in Network Cognition. Paper presented at the Public Management Research Conference, June 11-14th, Chapel Hill, NC.

12. Nowell, B., Steelman, T and Ryan Scott. (2019) Network Governance of Multi-Jurisdictional Disasters: Is ICS Enough? Paper presented at the Public Management Research Conference, June 11-14th, Chapel Hill, NC.

13. Velez, Anne-Lise, McGovern, S., & Minkowitz, H. (2019). Federalism meets social cognition: Temporal and substantive variation in risk perception across levels of government. Paper presented at the Public Management Research Conference, June 11-14th, Chapel Hill, NC.

14. McGovern, S. (2019). The new normal of jurisdictional complexity in wildfire incidents. Poster presented at the Risk, capacity, and resilience: Preparing the next generation of public service leaders, NASPAA Emergency Management Education Conference, June 3-4th, San Juan, Puerto Rico.

15. Nowell, B. (2019). Governing the "New Normal": The Evolution of Network Management of Wildfires in an Era of Climate Change. Presentation at the American Society for Public Administration, March 8-12th, Washington, DC

16. Nowell, B., Steelman, T., Velez, A., and Albrecht, K. (2018). Network Cognition in Co-Managing Complex Incidents. Paper presented to the Human Dimensions of Wildfire conference, December 10-14th, Asheville, NC.

17. Nowell, B., and Stutler, J. (2018) Public management in the era of the unprecedented. Invited paper presented to the University of Arizona Workshop on Organizational Theory, Nov 30-Dec 1st, Tucson, AZ.

18. Nowell, B., Steelman, T., and Velez, A. (2018) Risk co-management on interjurisdictional lands. Fire Continuum Conference, May 21-24th, Missoula, MT.

19. Steelman, T., Nowell, B., and Velez, A. (2018) Risk co-management on the 2017 wildfires. Paper presented at the National Cohesive Wildland Fire Management Strategy. April 25-27th, Reno, NV.

20. Nowell, B., and Steelman, T. (2018) Social Resilience and Wildfires: Effective Network Structures and Performance Metrics. Paper presented at the American Association for the Advancement of Science. Feb 15-19th, Austin, TX

Tools

Institutional Analysis of Co-Management Framework – Available for download at https://research.cnr.ncsu.edu/blogs/firechasers/resource/tools/)