12-2020

Collaboration and Reflexivity in Wildland Fire Risk Governance in the Western United States

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COLLABORATION AND REFLEXIVITY ON WILDLAND FIRE RISK

GOVERNANCE IN THE WESTERN UNITED STATES

by

Brett Alan Miller

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

of

DOCTOR OF PHILOSOPHY

in

Sociology

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2020

ABSTRACT

Collaboration and Reflexivity in Wildland Fire Risk Governance

in the Western United States

by

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Public lands in the western United States are experiencing more frequent and higher severity wildland fires due to even-aged forest growth after years of timber extraction, a legacy of aggressive fire suppression, climate change trends, and increasing human development in the wildland-urban interface; this development contributes to the transboundary nature of wildland fire risk and transmission since wildfire moves across boundaries, entangling a diverse array of actors in complex governance systems. For all of these reasons, actors involved in wildland fire risk governance need to explore alternative management strategies that leverage individual and institutional collaborative capacities that account for both the biophysical and social aspects of conjointly constituted wildland fire risk.

This dissertation presents participatory, post-normal mixed-methods research examining collaborative governance of conjointly constituted wildland fire risk and alternative management strategies in transboundary social-ecological systems through

Reflexive Sociology. This research is organized around four independent chapters. First, a general technical report, which is a co-produced problem analysis of wildland fire risk in transboundary landscapes, outlines the Co-Management of Fire Risk Transmission partnership.

The second chapter is a qualitative analysis of twenty semi-structured interviews conducted with members of a wildfire governance social network in northcentral Washington. In these interviews, participants described structural opportunities and barriers as well as personal characteristics that facilitate collaboration. The third chapter is a mixed-methods analysis of a proposal to fund forest restoration through carbon offsets. This research included a regression analysis of potential carbon benefits and qualitative analysis of public and peer-reviewed comments on the proposal. Results demonstrated carbon benefits but also illuminated barriers to registering these reductions as carbon offsets. And finally, the fourth chapter is an autoethnographic reflexive essay on this research and my experiences.

Taken together, these chapters cumulatively address different aspects of wildland fire risk governance as a single complex topic. These findings offer insight for improving the collaborative governance of wildland fire risk in this and similar social-ecological systems. Although far from comprehensive, the transdisciplinary nature of this post-normal research provides theoretical and methodological insights into the governance of wildland fire risk in transboundary settings in the face of an uncertain future.

(312 pages)

PUBLIC ABSTRACT

Collaboration and Reflexivity in Wildland Fire Risk Governance

in the Western United States

Brett Alan Miller

This dissertation presents both quantitative and qualitative analysis on different aspects of wildland fire risk management in the western United States. Each of these chapters is framed by and examines the sociological concept of reflexivity, which describes a process of individual and/or collective reflection. This reflexivity is needed to identify and enact alternative management strategies that contend with the expected increases in the number and severity of wildland fires in the future due to the combined effects of even-aged forest growth after years of timber extraction, a legacy of fire suppression, climate change, and increasing human development in the wildland-urban interface.

The first chapter in this dissertation is a general technical report that outlines theories and methods about the social dynamics of wildland fire risk management. The second chapter is a qualitative analysis of twenty semi-structured interviews conducted with members of a wildland fire management social network in northcentral Washington. In these interviews, participants described both opportunities and barriers to collaboration. The third chapter of this dissertation is a mixed-methods analysis of a proposal to fund restoration of northern Arizona ponderosa pine forests through registered carbon offsets. Results demonstrate potential carbon benefits from restoration but also illuminate administrative, technical, and theoretical barriers to registering these benefits as carbon offsets. And finally, the fourth chapter is an autoethnographic essay.

These findings are important since wildland fire management will need to be even more collaborative in the future due to expected increases in the number and severity of wildland fires, which will also exacerbate the need for increased funding for forest restoration. Moreover, these results speak to the complex and contested nature of human values at risk in these fire-prone landscapes, which will also need to be incorporated into wildland fire risk management in order to achieve better outcomes in the face of an uncertain future.

DEDICATION

This dissertation is dedicated to my son, Corvid Aldo Miller, who was born less than a year before I submitted my final revisions. In the short time you have been alive, you have completely changed my life. I am so glad that you got to be a part of this journey with me, even though it was an added challenge, at times. Having you with me as I wrote up each of these chapters, or trying to finish editing them while you napped, are memories I will cherish forever.

As I have been meeting deadlines towards publication, you have been skipping (i.e., crawling) past milestones, exceeding your own accomplishments every single day; you inspire me to engage each new challenge in my life as a new opportunity to surpass my limitations. I am amazed at how much of a scientist you already are, exploring and interacting with the world around you with determined curiosity. Whether you decide to follow this path and write your own dissertation someday, or whether you take a completely different path, I will be so proud of you; I already am.

ACKNOWLEDGMENTS

This research was supported by the National Science Foundation, under Grant Number 1633756, awarded to me as part of my fellowship in the Climate Adaptation Science program. Without this opportunity, this dissertation and my Ph.D. program would have been very different. I also want to acknowledge the support of the USFS, Rocky Mountain Research Station in Fort Collins, Colorado and the Co-Management of Fire Risk Transmission Project. As a project partner, this research was supported by the United States Department of Agriculture – Forest Service Award ID: 202266-00001, entitled "Investigating the Social Dimensions of Cross-Boundary Fire Risk Mitigation."

I need to acknowledge the tireless support of my advisor, Courtney Flint. Thank you for always pushing me to be a better scholar and helping me identify opportunities, encouraging me to pursue them, and never letting me give up on them, or myself. You have forever shaped who I am as a scholar, researcher, and teacher.

I want to thank my committee members: Rick Krannich, I am extremely proud to be the last student to have you on my committee. I will always think of you and your enduring legacy when I reflect on my education, training, and involvement in IASNR. Speaking of legacies, thank you Steve Daniels, for always holding me to a higher standard. Jennifer Givens, I have benefited from your guidance as a teacher and mentor, and you have forever shaped my identity as an environmental sociologist. Will Pearse, when we connected about board games I had no idea what an influence you would have on my scholastic journey. Thank you for the single best statistics class I have ever taken, and for all your time, support, and patience. And finally, I owe Dan Williams a great deal of gratitude. I remember when we first met and I was just an M.S. student, I thought you were so intimidating. Now that I know you and what a kind and encouraging person and mentor you are, it's hard to imagine I ever felt that way. Thank you for all the opportunities you have given me and for always treating me like I deserved them.

I also need to recognize so many other mentors: Nancy Huntly, thank you for all your support and kindness. Patrick Belmont, you challenged me when I needed to be challenged, but always treated me with respect. Derric Jacobs, without you, Chapter II would not exist. Shawn Olson-Hazboun, you have been more of an inspiration than you probably know. Spencer Plumb, you have been a research partner, mentor, and friend. I owe much of my development as a scholar to you and our innumerable brilliant ideas.

I want to give special thanks to my friends for their encouragement, moral support, and patience. To single out a few: Jyoti Jennewein, my academic sibling, for all your love and support throughout this next phase in our parallel journeys. Sierra Nevada Sampson, for organizing my office. Claire Deters, for your help in copyediting the final drafts of this thing. Lainie Brice, for all your help making that infamous figure for Chapter IV. And Michael Briscoe, for being my confidant (and for all the distractions!).

I could not have done this without my family. Especially, Sam and Teressa Leggett, thank you for your love and encouragement (and free childcare), and my wife and partner in life, Kailie, 'these are the days we live for!' Thank you for all you have done and endured during this journey. I love you. And finally, Gitsey, I can't imagine having done this without you, my constant companion.

Brett Alan Miller

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CHAPTER I

INTRODUCTION

Year after year, increasingly severe wildfire seasons across the globe draw international attention to the fact that many landscapes face a future of more frequent and higher intensity wildfires (Devisscher et al., 2016). Forests in the western United States (U.S.) of America are no exception (Polley et al., 2013; Prudencio et al., 2018; Schoennagel et al., 2017). Even-aged forest growth after years of timber extraction, paired with aggressive fire suppression (USFS, 2018), has led to the build-up of volatile fuels in many forests in the western U.S., increasing wildland fire risk complexity (Houtman et al., 2013; Moritz et al., 2014; Abatzoglou & Williams, 2016; Ager et al., 2017). This biophysical reality is compounded by climate change trends in conjunction with increasing human development proximate to wildlands prone to fire, referred to as the wildland-urban interface (WUI) (Kramer et al., 2018; Radeloff et al., 2018).

Development in the WUI contributes to the cross-boundary nature of wildland fire risk and transmission since fire moves across boundaries, from one parcel governed by one land tenure type or jurisdiction to another (e.g., private lands to a national forest or vice versa), which entangles a diverse array of actors in a complex governance system (Ager et al., 2019; Fischer & Charnley, 2012). Successful governance of this cross-boundary fire transmission requires transboundary fire risk governance strategies coordinated among different federal, state, tribal, and private actors and institutions across institutional boundaries as well as geographic ones (Palaiologou et al., 2018). Thus, transboundary landscapes are cross-boundary landscapes where institutional differences between different adjacent landowners creates a vertical (i.e., institutional) dimension that necessitates careful coordination and collaboration on the horizontal (i.e., geographic) dimensions of wildfire transmission (Palaiologou et al., 2019). These collaborative governance strategies may be supported or restricted by the structure of the governance system (Abrams et al., 2016; Dupéy & Smith, 2018; Schultz et al., 2018).

For all of these reasons, actors involved in wildland fire risk governance increasingly need to consider alternative management strategies that leverage individual and institutional collaborative capacities, since no *one* institution or actor can *effectively* manage cross-boundary wildland fire risk in these transboundary landscapes (Paveglio et al., 2011; Fischer & Jasny, 2017; Palaiologou et al., 2018). These alternative management strategies will need to account for both the biophysical and social aspects of wildland fire risk in order to engage diverse actors with different perspectives and values (Ager et al., 2015; Prudencio et al., 2018; Tedim et al., 2016).

Not only is wildland fire risk governance complicated by biophysical complexity and uncertainties (Calkin et al., 2011), but different actors in these transboundary landscapes have different values and priorities at risk (Paveglio et al., 2015). Through those values, priorities, and interactions with select other actors in the system, actors socially construct different perceptions of wildland fire risk realities (Dickinson et al., 2015; Newman et al., 2014; Paveglio et al., 2011). Those perceptions lead to management actions that actually change the biophysical reality of the landscape (Thompson et al., 2018). Thus, wildland fire risk is conjointly constituted between social and biophysical factors (Champ et al., 2012, Paveglio et al., 2016), which is consistent with the increasing recognition that wildlands that experience fire are social-ecological systems (SES) (Steelman, 2016).

Achieving alternative management of conjointly constituted wildland fire risk in SES requires active reflexivity, i.e., individual and collective reflection on how the social construction of wildland fire leads to management outcomes, in order to identify how different ideas could lead to different, potentially better, governance strategies (Cheng & Randall-Parker, 2017). One idea that is receiving increased attention is the recognition of the utility of collaborative governance strategies (Abrams et al., 2016; Brooks et al., 2006; Toman et al., 2013). For instance, in the summer of 2018, the United States Forest Service (USFS) released: "Toward Shared Stewardship Across Landscapes: An Outcome-Based Investment Strategy," which recognized the increasingly complex and contested conjoint constitution of wildland fire risk governance and articulated a mandate for increasing collaboration as a solution (USFS, 2018).[1]

The "shared stewardship" document expanded the still current "all lands – all hands" mandate (Fischer & Charnley, 2012; Charnley et al., 2017), which encourages wildland fire risk managers to work across federal, state, tribal, and municipal boundaries (Paveglio et al., 2018). This institutional emphasis on an "all hands – all lands" approach to the "shared stewardship" of fire prone SES is an elaboration on the National Cohesive Wildland Fire Management Strategy (NCS) vision: "to safely and effectively extinguish fire when needed; use fire where allowable; manage our natural resources; and as a nation, to live with wildland fire" (Lee et al., 2011).

[1] Although this document did not use the term 'conjoint constitution' it does explain how perceptions about wildfire risk led to too much fire suppression, which increased fire risk, and how this remains a challenge.

The NCS is structured around three major goals as pillars supporting this vision: 1) restoring and maintaining resilient landscapes, 2) creating fire-adapted communities, and 3) safe and effective wildfire response (Lee et al., 2011). See Figure 1.1 for a

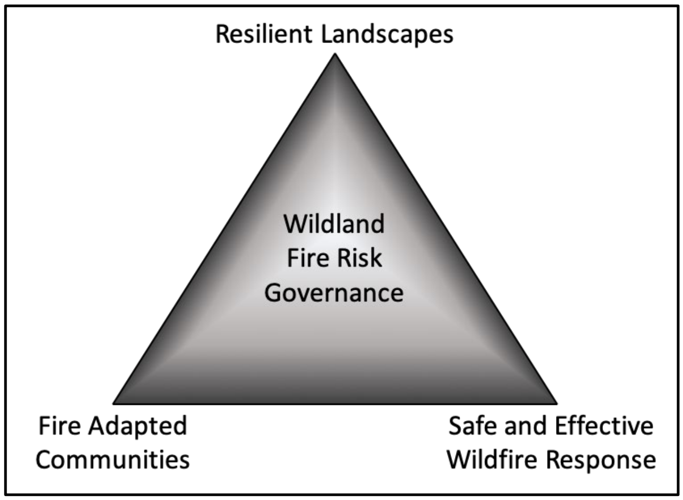

Fig. 1.1 The three pillars of the National Cohesive Wildland Fire Management Strategy.

visualization. These three goals also inform the normative goals that guide the post-normal research presented in this dissertation. Normative, post-normal science is appropriate when exploring complex problems where inquiry is beyond the capacity of basic science (Funtowicz & Ravetz, 1993; Gidley et al., 2009; Wilkinson & Eidinow, 2008), such as the governance of wildland fire risk in transboundary settings (Williams, 2018).

This dissertation presents post-normal research methods aimed at addressing different aspects of conjointly constituted wildland fire risk in transboundary SES by examining collaborative governance and other alternative management strategies. Since collaborative governance, alternative management strategies, and post-normal research methods all require active reflexivity, the guiding theoretical framework for this dissertation is the construct of “reflexivity.” Specifically, I use Reflexive Sociology (Bourdieu & Wacquant, 1992) to interpret and organize results of this post-normal research into useful and actionable products. These methods are also participatory and iterative, i.e., sequentially building towards understanding by reflecting on and refining previous insights in collaboration with others (Ebi et al., 2014).

Consistent with Reflexive Sociology theory and practice (Bourdieu & Wacquant, 1992), my position as the primary researcher is not neutral, but rather is an inseparable aspect of my participation in several collaborative research partnerships; just as successful wildland fire risk governance in transboundary landscapes involves collaboration among a variety of different institutions and actors, research on the topic must be similarly collaborative (Champ et al., 2012). Collaborative research and governance of complex systems requires active “reflexivity” since collaboration relies on navigating and aligning different mental models of these complex systems, which are unavoidably incomplete and potentially incompatible (Daniels & Walker, 2012). This is often the case in systems that produce so-called “wicked problems” (Freeman, 2000; Head & Xiang, 2016), where solutions present inherent and inescapable trade-offs between competing values, such as are inherent in wildland fire risk (Levin et al., 2012; Smith et al., 2016).

Acknowledgment of My Positionality as Primary Researcher

Although I am the primary researcher and author throughout this dissertation, this research is facilitated by my collaboration with other researchers, practitioners, and other stakeholders. Specifically, I am a member of the Co-Management of Fire Risk Transmission (CoMFRT) research team, which is a partnership between the U.S. Forest Service (USFS) Research and Development, Rocky Mountain Research Station, several universities, and state and federal wildland fire risk managers and policy-makers. My role on the CoMFRT project was facilitated by my involvement in the National Science Foundation funded and transdisciplinary Climate Adaptation Science program at Utah State University, which led to my being a research intern with the Rocky Mountain Research Station and CoMFRT project.

My involvement in CoMFRT led to my role as a founding member on the advisory committee for the Prescribed Fire Council of Utah, which is a voluntary collaboration between private, state, and federal actors interested in increasing and improving the use of prescribed fire as a forest management strategy in Utah. And finally, I am part of the Southwestern Forest Restoration (SFR) research project aimed at reducing emissions from wildfires through forest restoration practices, including prescribed fire, which is a partnership with the National Forest Foundation, USFS, and researchers at Northern Arizona University.

The general technical report (GTR) presented in Chapter II is co-produced through my involvement with the CoMFRT project and collaborations among researchers, managers and other stakeholders. This GTR serves as a problem analysis and theoretical explanation for the CoMFRT project and participatory research methods on assessing collaborative wildfire risk governance strategies in transboundary landscapes.

The CoMFRT project is comprised of several research packages including a social network analysis of actors engaged in wildland fire risk governance.

As a CoMFRT team member working on this social network work package, I conducted interviews with actors in an identified social network in order to understand how those participants conceive of collaboration. Results from that qualitative analysis are presented in Chapter III. Likewise, my involvement with the SFR research project led to the conception and execution of the transformative mixed-methods analysis presented in Chapter IV assessing the possibility of restoring northern Arizona ponderosa pine forests as a climate change adaptation strategy. Each of these research partnerships were iterative, post-normal, and participatory research projects.

Post-Normal Reflexive Sociology on Wildland Fire Risk Governance

The "challenges of policy issues of risk and the environment" (such as wildland fire risk governance) require post-normal science (Funtowicz & Ravetz, 1993, p. 739). Although the term "post-normal science," was coined by Funtowicz and Ravetz (1993), the increasing emergence and recognition of "wicked" problems in research has led to the emergence of several different approaches to post-normal science (Williams, 2018), such as "adaptive, participatory, [and] transdisciplinary science" (Head & Xiang, 2016). Transdisciplinary research denotes empirical efforts that go beyond academic interdisciplinarity to include managers and other relevant stakeholders (Qin & Flint, 2009).

Post-normal research addresses the oft-noted gap between theory and practice in natural resource management (Wiek et al., 2012). Frame, Brown and Newton explain that, “post-normal science shows why stakeholder engagement in sustainability (and other scientific) issues is critical for the legitimacy and quality of decisions and the admission of complexity in decision-making” (2008, p. 2). Post-normal science methods facilitate this participation between stakeholders in order to co-produce knowledge about the system in question (Frame et al., 2008), i.e., co-produce shared mental models of that system (Vervoort et al., 2015) that facilitate reflexive praxis (Frame et al., 2008). This reflexive praxis actively changes the pathways and mechanisms of the system through the application of shared mental models and reflexivity (Gurtner et al., 2007).

Reflexivity has become a prevalent term used comfortably by sociologists and other social scientists who don’t always specifically define it (Adams, 2006), while other scholars have defined slightly different meanings for the same term (Lumsden, 2019). For instance, Ulrich Beck’s well-known concept of a Risk Society is a materialist and linear explanation of reflexive modernity as the inevitable product of anthropogenic risk and uncertainty (Elliott, 2002; Irwin, 2013). In contrast, Bourdieu’s “reflexivity” is not a product of “modernity” or any other materialist and/or linear process since reflexivity describes the way that all systems are understood and thereby changed (Bourdieu, 1998)

Bourdieu (1984) distinguishes “reflexivity” from “habitus,” an equally important aspect of systems thinking (Costa et al., 2019). Habitus describes the unconscious or unexamined actions that define most of everyday reality (Bourdieu, 1984). Far from a pejorative, the majority of human actions necessarily take place via habitus because constant reflexive engagement would be practically paralyzing (Bourdieu, 1988). Reflexive actions are carefully examined as they occur since these actions are either something outside of a person's normal routine or a new elaboration on that routine (Adams, 2006). This applies to wildland fire risk governance as managers employ "best practices" (i.e., habitus) or appeal to precedent because utilizing established practices confers legitimacy (McLennan & Eburn, 2015), but new challenges in these complex systems necessitate alternative management (i.e., reflexivity) (Prudencio et al., 2018; Rodríguez et al., 2018).

When complex problems make established practices problematic and/or ineffective, then wildland fire risk managers and researchers need to turn reflexively inward and question those practices (Prudencio et al., 2018). Bourdieu & Wacquant (1992) explain that although all attempts to understand reality will fail, insights are gained and both the accurate and inaccurate insights and understanding garnered from this process has material consequences that will inevitably change reality (Bourdieu & Wacquant, 1992). For instance, traditional wildfire management practices have led to undesirable outcomes such as the build-up of volatile forest fuels through predominant wildfire suppression (Brown et al., 2004; USFS, 2018). According to Bourdieu (1990), acknowledging this dynamic is not a critique of attempts at understanding (e.g., science), but rather, recognizing these limitations presents an opportunity to improve those attempts and/or implement more nuanced concepts that account for a wider range of perspectives. For example, trying to understand the conjoint constitution of wildland fire risk reveals that this seemingly simple concept is actually a highly contested idea (Brenkert-Smith et al., 2017; Champ et al., 2012; Evers et al., 2019; Flint & Luloff, 2005; Paveglio et al., 2015; Thompson et al., 2018).

Although wildfire is widely acknowledged to pose risks (Calkin et al., 2010), ‘wildfire risk’ is a term that has different meaning for different people across groups and the precise definition of that risk varies (Hill et al., 2015). Governmental agencies, private landowners, and even biophysical and social science researchers may construct unique, value-laden or otherwise subjective definitions of risk (Devisscher et al., 2016). This further complicates governance at different scales of fire risk transmission according to different types of institutions and authority; also, although often ignored by managers, the relative level of power and authority of different stakeholders dramatically affects collaborative governance outcomes (Orth & Cheng, 2018).

The two most prominent organizations that manage wildfire risk in the U.S. are the USFS and Bureau of Land Management (BLM) (Kemp et al., 2015). Not only are these agencies organized into two different federal departments, leading to low administrative overlap, these agencies are very decentralized and have great deal of administrative authority at a landscape (or district) scale, leading to differences in management strategies and priorities (Loomis, 2002). While federal public land is managed by federal agencies and policies, state lands are governed by state agencies who often pursue different long-term and short-term strategies at different scales (Fischer et al., 2016). And finally, municipal property is managed by municipal level institutions such as local fire districts. Fortunately, although contested, the shared recognition of wildfire risk can serve as an anchor point for collaboration, bringing different stakeholders together to reconcile their conflicting mental models to identify and achieve collective action (Morisette et al., 2017).

Conjoint Constitution of Social-Ecological Systems and Wildland Fire Risk

In response to the expensive, contested, and transboundary problem of wildland fire risk, more and more researchers and practitioners are coming together to reflexively negotiate their understanding of wildland fire risk (McCaffrey & Olsen, 2012). Increasingly, these efforts recognize that wildland fires occur in SES (Steelman, 2016). The term SES refers to the fact that human systems and natural systems are reciprocally related (Anderies et al., 2004), see Figure 1.2.

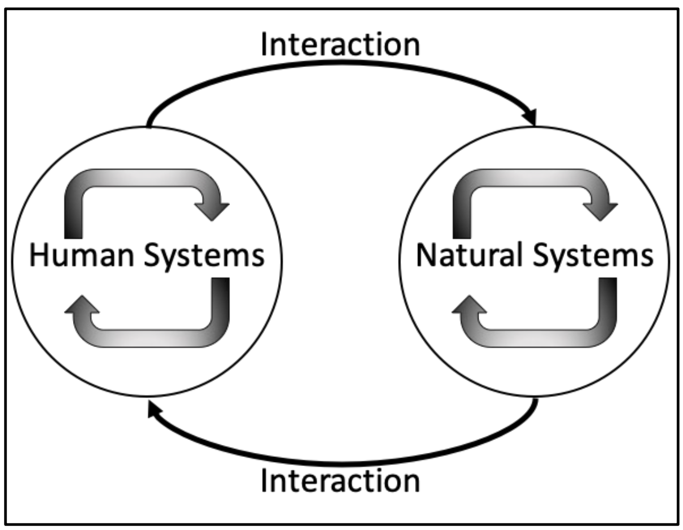

Fig. 1.2 Model of a social-ecological system (SES).

The concept of SES also recognizes the broader observation in the literature that "places are neither totally material nor completely mental; they are combinations of the material and mental and cannot be reduced to either" (Cresswell, 1996, p. 13). Freudenburg et al., (1995) coined the term "conjoint constitution" to address this dialectic in their influential article, "Beyond the nature/society divide: learning to think about a mountain" where these authors demonstrated the interaction between constructed meaning and structural reality over time. This concept has been proven to be highly influential in environmental sociology (Gramling & Freudenburg, 1996). Therefore, in this dissertation SES are considered to be conjointly constituted. This process is driven through habitus and/or reflexivity. See Figure 1.3.

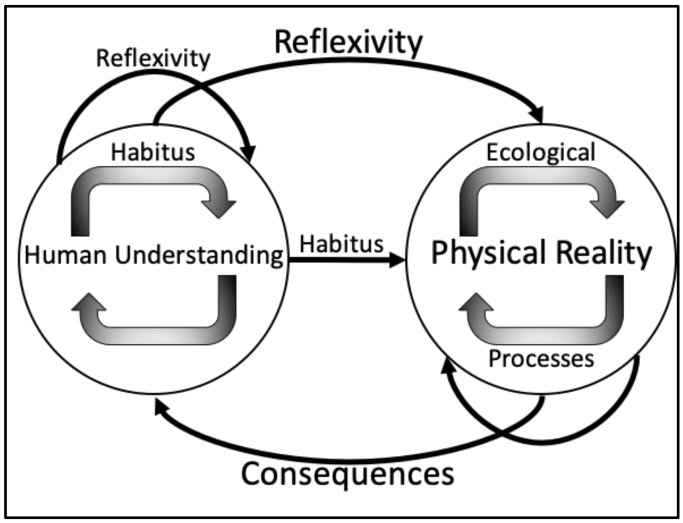

Fig. 1.3 Model of a SES with processes and consequences of reflexivity and habitus highlighted.

Freudenburg (1993) utilized a Weberian[2] explanation of the relationship between humans and the environment, noting both the social and material aspects of this conjoint constitution. For instance, risk research that concentrates on the construction of risks and hazards by specific people/communities provides important insights into the material consequences for those people/communities (Flint & Luloff, 2005; Paveglio et al., 2017). For example, Paveglio et al. (2016) examined how residents' wellbeing after 25 different wildfires was a function of different social constructions of the environment; since

[2] Weber defined technology as ideas made manifest; compared to contemporaries such as Marx, who treated technology as material, and Durkheim, who defined technology as ideas, Weber recognized that technology (and by extension, society) required both an ideological and material aspect (Weber, 1947).

landscapes are socially constructed (Greider & Garkovich, 1994), when wildfire events occurred, the impact on individuals differs based on the biophysical reality of that event as well as different their social constructions (Paveglio et al., 2016).

Similarly, Meldrum et al. (2015) examined four different communities in Delta County, Colorado and found significant differences in attitudes about wildfire and those attitudes correlated with different perceptions of how effectively wildfire could be controlled. Furthermore, stakeholder perceptions of wildfire risk probability are also socially constructed (Reid & Beilin, 2014). For instance, Brenkert-Smith et al. (2013) utilized survey data from two Colorado counties to explore how information sources affected perceived probability and consequences of a wildfire and management legitimacy.

Conversely, critical social science research on the human dimensions of the environment looking for material evidence of something similar to Beck's Risk Society and reflexive modernization based on a more materialist and deterministic relationship between people and the environment (Beck et al., 2003; Elliott, 2002), find evidence to support those theories (Malin & Petrzelka, 2010). This provides equally useful insight into wildland fire risk management. For instance, a critical lens applied to wildland fire risk governance reveals how a set of complex and problematic interactions in SES create wildfire as a socioecological pathology (Fischer et al., 2016). So, while *risk* itself is a calculable probability of something happening multiplied by the consequence of that thing happening measured in an ostensibly objective way (e.g., monetary cost), risk perception is a social construction based on individual or group expectations, values (beyond monetary values), and perceived control (Flint et al., 2012).

Similar to wildfire risk, landscape and community resilience is determined by biophysical calculations (Bestelmeyer et al., 2009; Hornborg, 2009) and social constructions (Folke et al., 2017). For instance, Smith et al. (2016) examined different fire prone landscapes to understand how resiliency goals were achieved, and they found that each solution was unique to each SES. Similarly, Luce et al. (2012) demonstrated that increases in wildland fire risk frequency and intensity due to climate change is going to affect and be affected by physical processes and biological interactions as well as management decisions and social systems. Likewise, Glicksman (2009) examined guidelines to reduce forest density and preserve forest function and resilience in the face of climate change and found that adaptive management based on both biophysical and social factors was key to successful implementation. Both of these factors can also limit managements options. For instance, Evers et al. (2019) explored wildland fire management constraints in five different communities and found that management options were limited by both biophysical and social conditions.

Individuals assess wildland fire risk and SES resilience based on their personal experience and biophysical evidence as well as local culture (Newman et al., 2014). Thus, reality is actually better understood as both a biophysical and a social *process* rather than merely an outcome (Freudenburg et al., 1995):

> When the nature of human interaction with the environment is understood more clearly, it is possible to see that that the greater need may be to resist the temptation to separate the social and the environmental, and to realize

> that the interpenetrating influences are often so extensive that the relevant factors can be considered 'socioenvironmental' (p. 370).

Therefore, despite biophysical factors that determine the probability of wildfire frequency and intensity (Calkin et al., 2010) and SES resilience (Higuera et al., 2019), wildfire risk and landscape resilience are the product of social structures and interactions that inform management choices (Brenkert-Smith et al., 2017). Applying the concept of reflexivity and habitus to this process, normal or established management choices are the product of habitus, whereas alternative management choices that intend to change either wildland fire risk or governance are manifestations of reflexivity. See Figure 1.4.

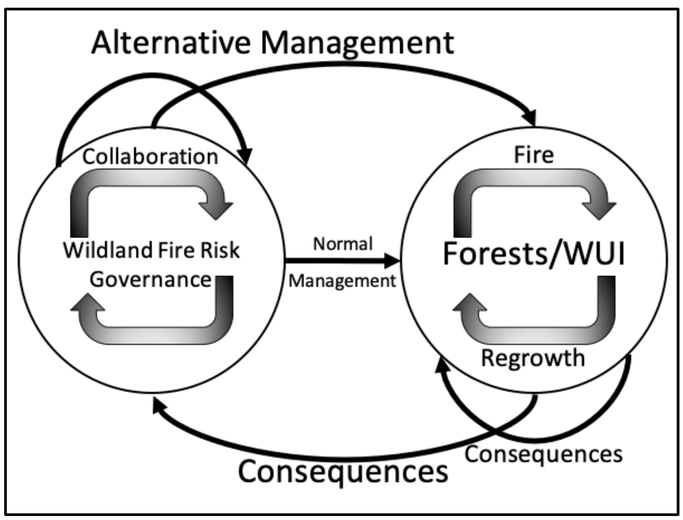

Fig. 1.4 Normal and alternative management of wildland fire risk in SES through the processes of habitus and reflexivity.

In short, SES are the product of biophysical reality as well as social constructions (Stedman, 2003), referred to as conjoint constitution (Fisher, 2006). Understanding these dynamics is instrumental to understanding the conjoint constitution of fire adapted communities, resilient landscapes, and ultimately collaborative governance of wildland fire risk in transboundary SES. Due to the collaborative nature of wildland fire risk governance in these SES, collaborative (e.g., participatory), post-normal research is necessary. The research presented in this dissertation engages in participatory, post-normal research aimed at examining collaborative governance and alternative management strategies of wildland fire risk in different conjointly constituted SES. This participatory, mixed-method research utilizes Reflexive Sociology as the unifying theoretical framework of this transdisciplinary research.

Research Design and Audiences

This research is organized around four independent chapters. These chapters include a general technical report (GTR), which is a problem analysis of wildland fire risk and governance in transboundary SES that outlines theories and methods for the study of the social dynamics of wildland fire risk (Chapter II). The second substantive chapter of this dissertation is a qualitative analysis on collaboration and collaborative wildland fire risk governance (Chapter III). The third substantive chapter of this dissertation is a mixed-methods analysis of a proposal to fund forest restoration through carbon offsets (Chapter IV). And finally, the fourth substantive chapter of this dissertation is a reflexive autoethnographic essay about this process (Chapter V).

These research products are facilitated by my participation in the CoMFRT and SFR research partnerships. Specifically, the GTR (Chapter II), is co-produced through my participation in CoMFRT meetings and workshops with CoMFRT partners and other stakeholders, which began in the summer of 2018 and is ongoing. These workshops were facilitated via a Theory of Change, which is both a product and iterative process that informs the implementation and evaluation of co-production initiatives (Funnell & Rogers, 2011; Weiss, 1995; Vogel, 2012).[3] Implementing a Theory of Change is a participatory and reflexive approach to program and research design (Vogel, 2012).

A Theory of Change begins by defining the desired change or future state (sometimes called a 'north star') that researchers would like to achieve (Reisman & Gienapp, 2004), and then participants work backwards to identify steps required to realize that goal (Connell & Kubisch, 1998). In the case of the CoMFRT research project, the goal is the improvement of wildfire risk governance in transboundary SES in order to achieve the goals and vision of the NCS. After identifying this goal through these participatory workshops, the CoMFRT team and participants identified sub-goals, resulting in the creation of six research packages.

Workshops included a facilitated workshop with wildland fire managers and policy-makers at the Northern Utah Interagency Fire Center in the fall of 2018 where CoMFRT project partners and participating stakeholders engaged in active reflexivity examining the major challenges to effective governance of wildland fire. With project partners, I helped plan, design, organize, and run three subsequent workshops with stakeholders in Logan, Salt Lake City, and Heber, Utah in the spring of 2019.

In a week-long team meeting in the summer of 2019 in Portland, Oregon, CoMFRT team members presented their ongoing research, reevaluated the mission and

[3] For some, a Theory of Change is simply a tool that improves the chance of designing and implementing a successful project (Stein & Valters, 2012; Taplin et al., 2013). Others emphasize the participatory nature of a Theory of Change (Archibald et al., 2016; Stein & Valters, 2012; Vogel, 2012), and the ways in which the approach can be used to co-produce a shared mental model of the context in which an intervention will be implemented to gain legitimacy (Stein & Valters, 2012; Archibald et al., 2016).

direction of the CoMFRT research project, reflected on our research insights, and (re)constructed a shared mental model of wildland fire risk governance. Finally, we held a workshop in Wenatchee, Washington where we presented research findings to project partners and research participants in October, 2019. Insights from these workshops and CoMFRT meetings as well as project documents led to the organization and structure of the GTR that serves as Chapter II.[4]

The version of the GTR reproduced in Chapter II was completed in March, 2020, and presented to the CoMFRT team. This draft has since been revised and will be resubmitted to the CoMFRT team for additional team member contributions and revision in September of 2020. After these revisions and additional contributions are completed and compiled into the GTR, it will be submitted for internal peer-review by USFS Rocky Mountain Research Station employees and eventually published as a Rocky Mountain Research Station GTR available to the public.

Although it is a bit unusual to include a GTR as a chapter in a dissertation, given the transdisciplinary nature of this topic, a GTR is in important and appropriate output. Internally peer-reviewed, GTRs are publicly available to researchers, policy-makers, managers, and other stakeholders. As such, GTRs serve an important function for researchers who focus on natural resource management broadly (Murphy et al., 2015), and/or wildland fire risk management, specifically (Brooks et al., 2006). These GTRs are also useful to policy-makers and managers who are interested in gaining a better

[4] Chapter II as composed for this dissertation is written primarily by me, based on ideas generated in these meetings and workshops. Brief sections outlining CoMFRT work packages were submitted to me by CoMFRT partners. These sections were substantially altered or rewritten to fit into this document.

understanding of science to inform policy and management. Thus, GTRs support academic and federal researchers, policy-makers, and managers looking to improve their research and/or management of wildland fire risk (Graham et al., 2004).

The primary audience for this GTR (Chapter II) is social science researchers, both academic researchers as well as those employed by land management agencies such as at the USFS, Rocky Mountain Research Station. Public land and wildland fire risk management policy-makers are also a primary audience for this GTR, and in particular the recommendations outlined therein. Meanwhile public land and wildland fire risk managers are a secondary audience for this GTR; although many managers may find this GTR to be too theoretical, a small but important cadre of highly collaboration-oriented managers (such as those who are CoMFRT partners) will be interested in this problem analysis and overview.

As part of my participation in the CoMFRT partnership, I also conducted interviews that I analyzed for the research presented in Chapter III examining the perceptions of collaborative governance by identified members of a wildland fire risk governance social network in Washington State. This social network is also a CoMFRT project output, completed by different CoMFRT research partners. Thus, Chapter III is a product of a larger, iterative research design, and this chapter led, in turn, to changes in future CoMFRT research protocols. Therefore, this research improves CoMFRT researchers' understanding of collaborative wildland fire risk governance by providing details that are not captured by quantitative social network analysis (Bodin et al., 2016). More broadly, this work is designed to better understand the aspects of governance structure and personal characteristics that facilitate more collaborative governance and thus promote the NCS goal of safe and effective wildfire response.

The primary audience for this research (Chapter III) is other wildland fire risk researchers, and in particular social scientists, although there are also insights and implications for public land and wildland fire risk policy-makers and managers. Since social science researchers interested in collaborative governance of wildland fire risk comprise the primary audience, this chapter will be submitted to a social science of natural resources journal such as *Society & Natural Resources*. However, insights from this research have also been added to CoMFRT project documents and reports for wildland fire risk policy-makers and managers as a secondary audience. Biophysical wildland fire researchers interested in understanding the social dynamics of wildland fire risk governance are another secondary audience for this research.

Chapter IV examines a novel funding mechanism for forest restoration in northern Arizona and the opinion of subject matter experts on that methodology, developed by other SFR partners. This transformative mixed-methods research employs a regression analysis to evaluate net benefits in surface carbon over time from this forest restoration methodology as well as a content analysis of comments on and reviews of the methodology in order to explore the potential utility of this innovative forest management strategy aimed at changing the frequency and intensity of wildland fires in specific contexts. By potentially improving the ecological function of these forests, this chapter relates directly to the NCS goal of more resilient landscapes.

Although my involvement in the SFR project began after this restoration methodology was developed and submitted for review by a carbon registry, the research presented in this chapter emerged from my participation in this collaborative research project. Thus, this analysis is also an iterative engagement that reflexively examines why this methodology was rejected as a carbon offset project and how to improve upon those limitations. Moreover, reflexivity is utilized to unpack the relationship between constructed knowledge and structural reality at a landscape scale in regard to the SFR methodology.

The primary audience for Chapter IV is researchers who are interested in forest restoration, carbon modelling, and ecosystem service valuation. This research is of particular interest to researchers concerned with wildland fire management and the relationship between forest restoration and wildland fire frequency and intensity. As such, this research will be prepared for publication in an interdisciplinary wildland fire science journal such as the *International Journal of Wildland Fire*, which is read by social scientists, biophysical scientists, and public land management agency employees, including researchers, policy-makers, and managers. As with the previous chapters, wildland fire policy-makers and, to a lesser extent, managers comprise a secondary audience for this research. In this case, this is because these policy-makers and managers are interested in exploring ways to fund more restoration on public wildlands.

Finally, Chapter V is a reflexive essay that employs an autoethnographic examination of my involvement in these research partnerships. In this essay I reflect on my positionality in these projects, the experience of doing this research, and the implications for these research findings. I also critically examine my experiences with, and lessons learned about, engaging in post-normal research. The primary audience for this chapter is anyone who has elected to read part of, or all of, this dissertation as it provides more details and insights that supplement the other chapters.

As a reflexive document written in a more expository manner, with only select citations, this chapter could be of interest to a lay audience. I reflect on the difficulty of communicating science to the general public (despite the necessity to do so) in Chapter V. With this dilemma in mind, I intend to use parts of this chapter in an editorial submitted for publication in a less academic periodical with a western focus, such as *High Country News.* This would be consistent with an emerging recognition that scientists need to communicate outside of peer-reviewed journals (Bolsen & Shapiro, 2018) as well as the tenets of Reflexive Sociology, which implore sociologists to reengage the larger cultural dialogue (Bourdieu & Wacquant, 1992).

Taken together, these chapters build on the theoretical framework, presented above, with elaborations to answer more specific research questions. While these chapters are each in preparation as standalone products, by being presented together in this dissertation these chapters cumulatively address different aspects of wildland fire risk governance as a single complex topic. Although far from comprehensive, the transdisciplinary nature of this post-normal research provides theoretical and methodological insights into the governance of wildland fire risk in transboundary settings in the face of an uncertain future.

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CHAPTER II

CO-MANAGING FIRE RISK TRANSMISSION IN TRANSBOUNDARY LANDSCAPES: A GENERAL TECHNICAL REPORT

Abstract

Due to the current conditions leading to increased wildland fire frequency and intensity and conflict over wildland fire risk management in the United States, the U.S. Forest Service and other federal natural resource agencies need to employ more collaborative governance of wildland fire risk in transboundary wildland-urban interface settings that promotes resilience, adaptability, and ultimately promotes the National Cohesive Wildland Fire Management Strategy. Broadly speaking, governance is a *process*; focusing on process rather than products leads to greater management success and stakeholder support in transboundary landscapes by identifying pathways that promote landscape resilience and allow communities to better live with wildland fire. In order to achieve this, the definition of both "transboundary," as well as "collaborative governance" needs to be critically considered along with other relevant concepts in the context of the current literature on the management of wildfire risk in complex social-ecological systems. This general technical report examines these concepts theoretically in the context of a comprehensive problem analysis on wildland fire risk management in transboundary landscapes and then outlines the utility of these concepts in practice for the Co-management of Fire Risk Transmission (CoMFRT) partnership.

Keywords: post-normal research; transboundary; wildland fire; risk; collaborative governance; co-management

1. Introduction to Transboundary Wildland Fire Risk

Agencies that manage public land in North America face a steadily worsening regime of increased wildland fire risk due to exacerbated drivers of wildfire (Calkin et al., 2010), more constrained institutional budgets (Forest Service, 2015), increased conflict over the values at risk (Edgeley et al., 2020), and the inherent trade-offs presented by different management strategies (Carroll et al., 2006; Paveglio et al., 2016). *Wildfire fuels* on wildlands have accumulated due to a history of extraction followed by unmanaged, even-aged regrowth and an enduring legacy of aggressive fire suppression (Abatzoglou & Williams, 2016; Ager et al., 2017; Houtman et al., 2013; Moritz et al., 2014). When combined with climate change trends that are expected to decrease fuel moisture levels and increase the average heat index (Hanberry, 2020), these conditions will increase *wildfire intensity* and *severity*.[5]

Meanwhile, substantial increases in residential development proximate to wildlands at risk of wildfire also increases wildfire severity by increasing the amount of human values at risk and contributing to the *cross-boundary* consideration of wildland fire (Calkin et al., 2015; Olsen et al., 2017; Paveglio et al., 2017). Development in these fire-prone landscapes, referred to as the *wildland-urban interface* (WUI), includes houses, businesses, infrastructure such as powerlines, and, increasingly, community buildings such as schools (Radeloff et al., 2018). More than just the built environment, the WUI consists of neighborhoods and communities of people whose lifestyles are shaped by their understanding and attachment to these landscapes (Williams et al., 2016).

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[5] Definitions for key terms such as "wildfire intensity" and "wildfire severity" are included in a glossary in Appendix 2.1. Included terms are italicized the first time they are used in the text.

The expansion of the WUI in the path of potential wildfires complicates institutional efforts to reduce wildfire risk frequency and intensity (Stidham et al., 2014; Ager et al., 2016; 2017): many of the necessary approaches to dealing with the *biophysical* drivers of wildfire (e.g., prescribed fires) present trade-offs for WUI residents, especially those with respiratory health concerns (Fish et al., 2017; Wilson et al., 2017), and are considered unacceptable or political impossible by mangers and government officials (Charnley et al., 2015). Furthermore, despite a common proximity, these WUI areas are quite different from one another (Meldrum et al., 2018), necessitating an adaptive approach to both wildfire risk mitigation and response over time as well as across territory (Alexandre et al., 2016; Carroll & Paveglio, 2016; Meldrum et al., 2015; Paveglio et al., 2009). Although people who live in the WUI can take steps to protect against wildfire risk themselves, these communities typically lack the resources required to contain a large wildland fire or mitigate future fires without state and/or federal agency coordination and resources (Otero et al., 2018).

In response to this "new normal" (Kroepsch et al., 2018), this General Technical Report (GTR) outlines a problem analysis of *transboundary* wildland fire risk and presents an overview of theories and methods pertinent to a collaborative, iterative research project entitled the Co-Management of Fire Risk Transmission (CoMFRT)[6]

[6] The CoMFRT team includes researchers, policy-makers, and managers: Hannah Brenkert-Smith (University of Colorado at Boulder), William H. Butler (Florida State University), Matt Carroll (Washington State University), Patty Champ (Rocky Mountain Research Station), Linda Chappell (USFS – Region 4), Catrin Edgeley (Northern Arizona University), Maureen Essen (Rocky Mountain Research Station), Cody Evers (Portland State University), Benjamin Gray (University of Montana), Patrick Haggerty (Cascadia Conservation District), Jennifer Hansen (USFS, Uinta-Wasatch-Cache National Forest), Derric Jacobs (Portland State University), Brett Alan Miller (Utah State University), Max Nielsen-Pincus (Portland State University), Travis Paveglio (University of Idaho), Jon Riley (Chelan County Fire

(Williams & Essen, n.d.), which is aimed at achieving a better understanding of collaborative wildland fire risk *governance* in these transboundary WUI areas. In this GTR, transboundary areas are cross-boundary landscapes where different public and private institutions and individuals manage adjacent parcels of land. This assemblage of different adjacent landowners has a vertical (i.e., institutional) dimension that necessitates careful coordination and collaboration on the horizontal (i.e., geographic) dimensions of wildfire transmission (Palaiologou et al., 2019). Thus, the CoMFRT research partnership directly addresses two of the major goals of The National Cohesive Wildland Fire Management Strategy: more resilient landscapes and more fire adapted communities.[7]

The National Cohesive Wildland Fire Management Strategy

The *National Cohesive Wildland Fire Management Strategy* (NCS) is an interagency strategy document that presents three major goals related to wildland fire risk: 1) restoring and maintaining resilient landscapes, 2) creating fire-adapted communities, and 3) safe and effective wildfire response (Lee et al., 2011). The NCS is the culmination of a three-phased, interagency collaborative that was initiated in 2009 (The Wildland Fire Leadership Council, 2014). Building on the NCS, in 2018, the USDA, Forest Service released: "Toward Shared Stewardship Across Landscapes: An

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District 1), Annie Schmidt (Fire Adapted Communities Learning Network), Tyler Thompson (Utah DNR), Brad Washa (Utah BLM), Dan R. Williams (Rocky Mountain Research Station), Carina Wyborn (University of Montana), and Laurie Yung (University of Montana).

[7] This report is co-produced with varying amounts of input from CoMFRT project partners. These partners include, but are not limited to, the list presented in footnote 6, above. Although I am the primary author who wrote or substantially revised every line of this draft, I was only able to accomplish this by participating in CoMFRT project meetings and workshops and with direct input from project partners. After more input from project partners, a final draft report will be submitted for publication as a Rocky Mountain Research Station GTR with additional co-authors.

Outcome-Based Investment Strategy," which recognized the increasing complexity of wildland fire risk governance and presented a mandate for increasing collaboration between actors in the wildland fire risk governance system in order to meet NCS goals (USFS, 2018). The "Shared Stewardship" document and corresponding directive expands on the previous "all lands – all hands" mandate (Fischer & Charnley, 2012; Charnley et al., 2017) that encourages managers to work across federal, state, and municipal agencies (Devisscher et al., 2016), and with the communities proximate to public lands that are susceptible to wildfire risk transmission (Stasiewicz & Paveglio, 2018).

This institutional emphasis on an all hands – all lands, *shared stewardship* approach to managing fire prone landscapes is an elaboration on the NCS vision "to live with wildland fire" (Lee et al., 2011). The NCS is the explicit mission statement of the Wildland Fire Leadership Council, which was established in 2002 by the Secretaries of Agriculture and the Interior in response a series of high severity turn-of-the-century wildfires (A cooperative effort of the United States Department of the Interior (DOI), the United States Department of Agriculture (USDA), their land management agencies, and their partners., n.d.). At this same time, Burning Questions: A Social Science Research Plan for Federal Wildland Fire Management was published, which was a report to National Wildfire Coordinated Group (Machlis et al., 2002). This group was formed from representatives from the United States Forest Service, the Bureau of Land Management, the National Park Service, the Bureau of Indian Affairs, the U.S. Fish and Wildlife Service, and the National Association of State Foresters in 1970 in response to a high severity wildfire season in 1970. Thus, arriving at interagency collaboration on wildland fire risk governance has a long legacy, and need for incorporating more social science insights into this collaboration has been recognized for at least two decades (Daniel et al., 2007).

However, gaps persist between biophysical and social science on wildland fire risk as well as between the (biophysical and social) scientific assessment of wildfire systems and interagency management (Ager et al., 2015). Although research on the social dynamics of wildfire risk has expanded in recent years, insights from these research findings are often difficult to integrate into the current governance structure of wildland fire risk management (Steelman, 2016; Thompson et al., 2016). Therefore, managers, researchers, and other stakeholders need to understand the social dynamics of wildland fire risk governance and the ways that collaborative governance is already occurring in order to identify ways to improve this process. After identifying these possibilities, investing in the social dynamics of wildfire will lead to better wildland fire risk governance outcomes.

Investing in the Co-Management of Transboundary Fire Risk Transmission

Since wildfire processes and costs are transmitted and shared across a complex geographic network of co-dependent stakeholders and land tenure types, investing in the shared stewardship of landscape scale wildland fire risk is needed (Fischer & Charnley, 2012; Charnley et al., 2017). Understanding effective, on-the-ground collaborative governance of wildland fire risk will likely facilitate investment in better fire management outcomes in transboundary settings. With these insights, it may be possible to identify ways to invest in more collaborative wildland fire risk governance between different stakeholders, such as agencies, communities, and individuals.

Similar to investing in biophysical risk reduction, investing in more adaptive and collaborative social systems requires a systematic approach that begins with understanding existing social systems and builds on that knowledge in order to inform future investment strategies and associated wildfire risk mitigation activities (McCaffrey, 2015). These strategies need to involve multiple stakeholders, not just public land managers, in order to execute management-relevant, place-specific, and politically-feasible solutions (Cacciapaglia et al., 2011). This is the ultimate goal of the Co-Management of First Risk Transmission (CoMFRT) Partnership.

Co-Management of Fire Risk Transmission and Post-Normal Science

The CoMFRT Partnership that informs and inspired this GTR is a collaborative, post-normal research project. The idea of *post-normal science* has gained traction in the last few decades as a strategy for dealing with complex adaptive *social-ecological systems* (Colloff et al., 2017). Post-normal research adopts more adaptive, participatory, and *transdisciplinary* methods *co-produced* by different types of researchers, managers and other stakeholders (Head & Xiang, 2016; Lemos et al., 2018; Miller & Wyborn, 2018). Post-normal science is appropriate when exploring complex problems where solutions are beyond the capacity of more traditional approaches (Funtowicz & Ravetz, 1993; Gidley et al., 2009; Wilkinson & Eidinow, 2008). Thus, this GTR serves as an outline of the CoMFRT partnership and problem analysis of transboundary wildland fire as well as a potential guide to conducting collaborative post-normal research on the social dynamics of wildfire risk more broadly.

While many GTRs exist that provide guidance for conducting biophysical assessments of wildland fire risk (see Calkin et al., 2010; Graham et al., 2004; Thompson et al., 2016), and several other GTRs synthesize relevant social science research on wildland fire risk (Mccaffrey & Olsen, 2012; Toman et al., 2013), to date no GTR serves explicitly as a problem analysis of wildland fire risk governance in transboundary landscapes. Also, although the observation that integrating social science more explicitly into wildland fire risk management goes back at least twenty years (see Daniel et al., 2007; Machlis et al., 2002), this integration has yet to be achieved. More than a list of topics or an anthology of project reports, this GTR connects relevant literature and theoretical insights to actual research methods that have already been implemented to understand collaborative wildland fire risk governance in specific landscapes and provide management and policy recommendations.

Goals and Outline of this General Technical Report

This GTR is the product of an iterative problem analysis and *collaborative research* program aimed at identifying and diversifying opportunities for investments across landscape boundaries driven by locally informed approaches and innovations to wildland fire governance strategies.[8] The ultimate goal of this GTR is to improve

[8] This GTR was co-produced with input from CoMFRT project partners through synthesized participatory research and workshops on wildland fire risk governance in the Intermountain West, scaffolded by a Theory of Change framework, which is both a process and a product, used to unearth and then document the assumptions underpinning connections between activities and intended outcomes (Funnell & Rogers, 2011; Weiss, 1995; Vogel, 2012).

understanding of public and private collaboration on wildland fire risk in order to increase ecological and social resilience to wildfire (Abrams et al., 2015; Paveglio et al., 2016). *Resilience* refers to the capacity for a system to experience a change or shock and continue to function (Folke, 2006).

However, inflexibility in the wildland fire management system (Fischer et al., 2016) and trade-offs faced by communities and stakeholders in the WUI continue to constrain the ability of wildland fire risk managers to achieve more collaborative governance strategies (McLennan & Eburn, 2015). This report reveals some of those challenges in specific landscapes and identifies potential recommendations to overcome these barriers theoretically as well as in practice. This report is separated into different sections for different audiences.

Part One of this report provides important background on the complexity of wildland fire risk governance in transboundary contexts. This is helpful to anyone who wants a high-level overview of CoMFRT and transboundary wildland fire risk governance, such as policy-makers at the USFS Washington Office. Part Two is a problem analysis and review of relevant literature and theoretical concepts that should inform research efforts aimed at understanding the complexity of this topic. This is useful to academic and agency researchers who want to incorporate more participatory research into their practice. This section could also be useful to select managers who want to better understand the social dynamics of transboundary landscapes.

Part Three presents an overview of CoMFRT project work packages based on this problem analysis and expands on the various ways that the CoMFRT partnership has been co-produced through partnerships and workshops in collaboration with actors at different scales within the wildland fire risk governance system as it exists in different fire-prone landscapes. This section provides recommendations for policy-makers and/or managers. This is also useful to researchers and managers who want to find ways to coordinate their efforts in order to procure more funding partners. Finally, Part Four is a conclusion that provides a synthesis of the key insights from the literature, practice, and implications for continuous learning and iterative engagement. In this section I provide a selection of recommendations for policy-makers and managers aimed at improving transboundary wildland fire risk governance at a variety of scales.

2. Theoretical Understanding of Wildland Fire Risk Governance

Reducing the negative consequences of wildland fire risk to lives, property, and landscapes is among the most intractable and expensive problems facing public land management agencies (Forest Service, 2015). Interagency investment has grown to nearly $400 million annually by 2018 (USFS, 2018). These investments tend to favor biophysical fuel reduction treatments and advanced modeling of wildland fire behavior (Stephens et al., 2009; Vaillant et al., 2009; Martinson & Omi, 2013; Kalies & Yocom Kent, 2016). Although these latter (advanced modeling) investments have led to better understanding of fire behavior and movement, annual expenditures on fire suppression continue to climb (Forest Service, 2015) and wildland firefighter and residential fire-related injuries and deaths remain largely unchanged (North et al., 2015). These costs and consequences are more complex in transboundary settings where different individuals and institutions manage adjacent parcels (Palaiologou et al., 2018).

Similar to the biophysical systems that experience wildfire, which are often described as “patchy” (Olsen et al., 2017), social systems are also patchy. For instance, adjacent communities are often very different (Carroll & Paveglio, 2016), and within communities different neighborhoods and households have different amounts of capital and/or *adaptive capacity* (Paveglio et al., 2015), which describes different abilities to react to and manage change, increasing resilience (Abrams et al., 2015). Additionally, wildland fire risk exists at different scales than the scales at which human solutions are traditionally organized (Ager et al., 2019). By better understanding these patchy social landscapes and the complex systems that embed them it may be possible to improve our understanding of social resilience to biophysical wildland fire risk in order to identify potential pathways to more collaborative wildland fire risk governance strategies.

The Inherent Complexity of Wildland Fire Risk Governance

The wildland fire risk governance system in the US includes important social components such as formal programs, policies, and institutions (e.g., Hazardous Fuel Program and the USFS, respectively) operating at a variety of scales and in conjunction with informal social systems. This system also includes a variety of fuel types, topography, climate, weather and other biophysical components. Both the social and biophysical components are arranged in a variety of complex ways in different places, reflecting the unique characteristics of specific fire-prone landscapes, both ecologically and socially. This variety produces emergent and uncertain characteristics that do not hold to linear cause-effect relationships, making trade-offs difficult to analyze and manage through distributed authority in a hierarchal structure (Grêt-Regamey et al., 2013; Wyborn et al., 2015). Which is to say, due to diverse institutional objectives and governance structures, it's difficult to manage this complex issue.

Uncertainty also makes it difficult to achieve more resilient systems (Adger et al., 2005; Folke, 2006), and complicates efforts to promote adaptive capacity (Murphy et al., 2016; Wyborn et al., 2019). However, this uncertainty makes promoting resilient systems and building adaptive capacity through collaborative fire risk governance even more important (Barron et al., 2012). The complexity of the wildland fire risk governance system is increasingly recognized by wildfire professionals (Ager et al., 2015; Ager et al., 2016; Champ et al., 2013; Fischer et al., 2016; Paveglio et al., 2009; Thompson et al., 2018). By contending with the complexity of the wildland fire risk governance system, managers and researchers can identify pathways that if pursued will lead to better social and biophysical structures.

Actively changing the pathway and mechanisms of the system is an example of active *reflexivity*. "Reflexivity" describes a process of examining one's own understanding of a system in order to come up with new insights about that system (Rodríguez et al., 2018). Reflexive actions are often outside of a person's normal routine or a new elaboration on that routine (Ruane, 2019). For instance, reexamining wildfire risk governance systems in order to improve them requires carefully reconsidering current and potential future processes (Fischer et al., 2016; Thompson et al., 2018). Thus, collaborative governance is inherently reflexive governance (Iñiguez Gallardo et al., 2013). Although reflexivity and collaborative governance are effective in addressing wicked problems (Freeman, 2000), if researchers and practitioners are not careful, the process can potentially alienate and disenfranchise stakeholders (Urgenson, et al., 2017).

Conjoint Constitution of Wildland Fire Risk in Social-Ecological Systems

Due to the complex and intractable nature of wildland fire risk in transboundary landscapes, managing wildland fire risk collaboratively is like a complex board game without a clear win condition where the patchy landscape is controlled by different jurisdictions on the board, and the wildland governance system defines the rules of the game, which are incomplete, evolving, and often contested by players (Brenkert-Smith et al., 2017). Changes to the rules manifests as changes to the structure and function of both human and natural systems in social-ecological systems. Although this comparison may seem to trivialize the importance and difficultly of wildland fire risk governance, games continually prove to be a fruitful metaphor for understanding the complex relationship between socially constructed and biophysically emergent realities (Bourdieu, 1977). Metaphorically, the decisions made by relevant players (stakeholders) change the game state (reality), which in turn changes the future choices for players. This is also described as "conjoint constitution" (Freudenburg et al., 1995). See Appendix 2.1.

Conjoint constitution refers to the reciprocal relationship between social construction and biophysical conditions that co-creates specific landscapes (Vickery et al., 2020). Which is to say, the metaphorical board game (e.g., wildfire risk management) requires players (e.g., actors in the governance system), a board (e.g., a fire-prone landscape), and rules (e.g., formal and informal governance), and those three things interact to establish reality at any given time. In the context of wildland fire risk, this is the recognition that both fire risk and fire risk management strategies are the product human understanding and actions as well as the biophysical conditions that contribute to wildland fire risk frequency and intensity (Champ et al., 2012, Paveglio et al., 2016).

The concept of conjoint constitution is compatible with the theoretical concept of social-ecological systems. The term social-ecological systems (SES) is simply the recognition that human systems and biophysical systems are reciprocally related (Anderies et al., 2004). Thus, understanding SES requires analysis of the relationships between human systems and natural systems (Salerno et al., 2010). The fire management system is an example of a complex SES (Thompson et al., 2018; Steelman, 2016; Fischer et al., 2016a) requiring consideration of unique components, complexities, uncertainties (Champ et al., 2012) and multiple forms of knowledge (Williams et al., 2009), at different scales (see Figure 2.1).

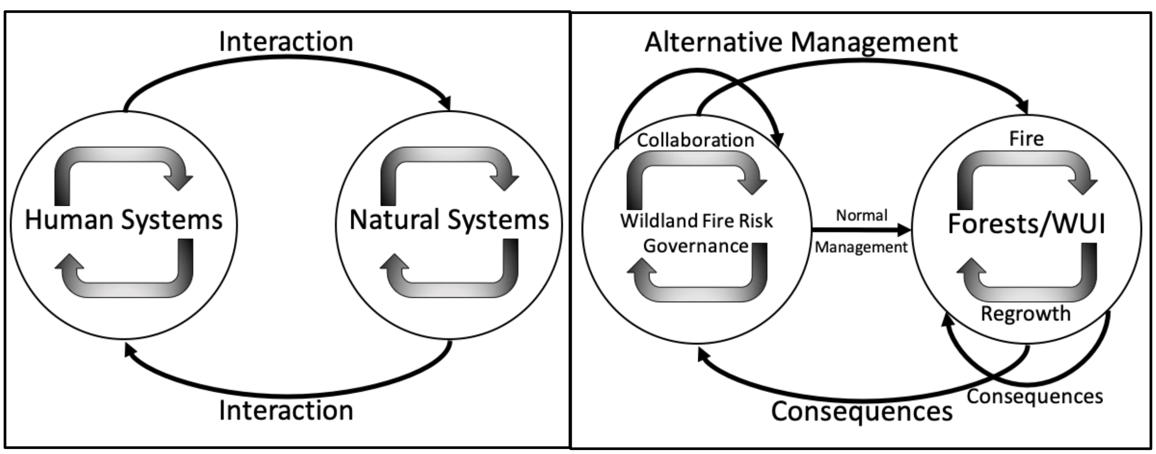

Fig. 2.1 Conjoint constitution of social-ecological systems and wildfire risk management.

SES that experience wildland fires are made even more complex by the scalar "nestedness" of both the biophysical conditions and the management of those resources at various scales (Beckley, 1998; Dietz et al., 2003; Berardi et al., 2015). Similarly, a complicating factor in the mitigation of wildland fire risk is often that the scale at which community planning is done (e.g., Community Wildfire Protection Plans: CWPPs) is finer than the scale of most biophysical processes that drive wildland fire risks (Ager et al., 2017a). Since fire risk exists at multiple scales in nested SES, those different scales need to be critically considered before different governance strategies can be evaluated.

Furthermore, in transboundary settings with different property ownership arrangements, public land interventions have consequences on private land and vice versa in complex, inter-scaler ways (Cash, 2003; Cash et al., 2006; Iñiguez Gallardo et al., 2013; Johnson & Becker, 2015). Landscapes are nested and linked to management actions at a variety of scales, from federal to state, to community, to individual stakeholders (Beckley, 1998). Similarly, while wildfires vary in size, the individual human cost of these events is immediate and personal such as a lost home (Brenkert-Smith et al., 2017), while effective management must involve large scale treatments to reduce wildfire risk severity or involve extensive interagency collaboration in response to wildfire events (Reinhardt et al., 2008).

This highlights the importance of understanding scales and boundaries in wildfire risk governance. Which is to say, we need to understand the board, the rules of the game, and the motivation of the players. It also necessitates a critical understanding of what managers and stakeholders actually consider to be wildfire risk.

Wildland Fire Risk and Resilience

In any conversation about changing wildfire risk governance it's tempting to frame that conversation around ways to reduce wildfire risk. However, as Calkin et al.,

(2010) have discussed, 'reduced risk' is an imprecise way to describe wildfire. While the word risk presents a negative connotation, the probability of wildfire is not inherently negative (Thompson et al., 2016). From an analytical standpoint, wildfire has potential benefits to valued assets such as ecological health and, more importantly, some fire prevents future, higher intensity fires (Calkin et al., 2010). Moreover, without the presence of valued human assets, even large and/or high intensity wildfires are not bad, because 'good' and 'bad' are based on human values. Far from an esoteric aside, understanding the social construction of risk for stakeholders in conjointly constituted SES is necessary for understanding more effective wildfire risk governance (Champ, 2017), especially in transboundary settings (Palaiologou et al., 2019).

The social construction of risk is inherently contextual, affected by both biophysical conditions (Newman et al., 2014) as well as social dynamics (Reid & Beilin, 2014). Wildfire severity is determined by the fire size, intensity, and the value placed on the assets affected by the fire (Calkin et al., 2010). Thus, a high-intensity fire is only a high-severity fire if it burns something that someone cares about (Graham et al., 2004). Stakeholders, communities, and wildfire risk managers need to prepare for high intensity wildfires and invest in strategies that protect stakeholders and their valued assets. However, this proves to be difficult in transboundary areas due to the complexity of governance across different institutions, especially when values are not agreed upon. And yet, it's possible, and in fact common for multiple agencies and other stakeholders to have productive conversations about wildfire risk because the concept of 'wildfire risk,' without being as critically considered as it is here, serves as a *boundary object*.

Boundary objects are significant symbols that operate as translators between social worlds (Star & Griesemer, 1989). This occurs because boundary objects are plastic enough to adapt to specific people and contexts but robust enough to maintain a common identity (Steger et al., 2018). Thus, boundary objects facilitate different forms of knowledge coming together to create meaning and creates opportunities for discussion (Rawluk et al., 2017). For instance, the universal recognition of the need to address wildfire risk allows different agencies and stakeholders to come together to negotiate differing ideas of proper forest management and navigate contested issues such as the distribution of financial and political authority.

Fire risk as a boundary object offers an opportunity for researchers and managers to discuss ways to work across the boundaries that define transboundary settings since it offers an anchor point for consensus and action (Morisette et al., 2017). These conversations can lead to identifying strategies to achieve resilience (Devisscher et al., 2016). However, those conversations will fail to materialize until managers and other stakeholders confront the fact that wildfire represents something different to different people (Hill et al., 2015; Paveglio et al., 2016). Although more regular, lower intensity fires lead to more resilient landscapes and lower fire intensity (Spies et al., 2018), but allowing any fire is considered unacceptable to many stakeholders (Fischer & Charnley, 2012). Thus, the concept of resilience is yet another boundary object where different stakeholders agree on the concept in principle, but may define it differently.

Another term often employed without a careful definition, resilience refers to the capacity for a system to experience a change or shock and continue to function (see

Anderies et al., 2013; Bestelmeyer et al., 2009; Folke et al., 2017; Hornborg, 2009). In the context of managing wildfire, biophysical assessment is often more prevalent than social assessment in determining resilience (Toman et al., 2013). However, both aspects need to be understood to actually understand the conjoint constitution of SES resilience (Evers et al., 2019; Smith et al., 2016). This dialectic is important since the social construction of these biophysical conditions directly determines what alternative management will be implemented (Luce et al., 2012). This is especially important in transboundary SES where unilateral governance is impossible. Thus, achieving the third goal of the NCS of safe and effective response to fire in transboundary SES is impossible without also understanding the composition of fire adapted communities and the social construction of resilient landscapes.

Some researchers have suggested the inclusion of homeowners into these efforts (Fairbrother et al., 2013; Stasiewicz & Paveglio, 2018). Towards this aim, the national interagency wildland fire risk governance system has engaged in several attempts to incorporate local stakeholders and community members into participatory wildfire governance (Lee et al., 2011). Therefore, managing landscapes for more regular instances of lower intensity wildfires requires collaboration between different individuals and institutions. This is where fruitful conversations can lead to managerial stagnation. Despite a common identification of the problem of high severity wildfire theoretically, management decisions rely on normative valuations and assumptions that may be contested and difficult to achieve due to incompatible institutional structures and values in transboundary settings.

Wildland Fire Risk Severity and Transmission in Transboundary Settings

Accumulative development in the WUI means that wildland fire risk transmission is increasingly transboundary. Although sometimes used as a synonym for cross-boundary, which describes spatial contexts where different landownerships abut (Fischer et al., 2018; Kark et al., 2015), in this GTR "transboundary" specifically denotes a cross-boundary setting where different levels of authority within and between the different institutions responsible for those adjacent land ownerships add a vertical dimension to effective wildland management. Transboundary landscapes complicate the collaboration necessary to manage wildland fire risk effectively (Berardi et al., 2015; Dietz et al., 2003; Iñiguez Gallardo et al., 2013; Roos et al., 2016). Which is to say, cross-boundary landscapes with different land tenure types and jurisdictional authorities are transboundary due to scalar and institutional dimensions (Iñiguez Gallardo et al., 2013).

In transboundary landscapes, stakeholders are distributed horizontally (based on institutional position and personal power) as well as vertically (based on community and geographic position) at different levels of authority and at different spatial scales (Berardi et al., 2015). Due to these complexities, spatially cross-boundary fire risk transmission requires transboundary governance solutions. Therefore, in transboundary SES, governance is nested at different scales, and state and municipal perceptions and incentives need to be incorporated into long term management (Beckley, 1998). To promote interagency collaboration the NCS was developed to serve as a cohesive wildfire risk strategy (Lee et al., 2011).

Although there is an overall movement towards a single cohesive fire management strategy, different institutional incentives can hinder effective collaboration. For instance, state and municipal agencies often favor suppression more highly than federal agencies (Abrams et al., 2018); while federal agencies try to take a longer view and tend to manage larger areas of land, state and municipal agencies are responsible for protecting stakeholders and assets from wildfire danger in the short run and at more immediate scales (North et al., 2015).

Risk of wildfire spreading from federal land to state, municipal, and/or private lands land also compels federal agencies to suppress wildfires that may be too difficult to contain (Abrams et al., 2015; Charnley et al., 2015; Fischer et al., 2016a). Unfortunately, more vigorous fire suppression leads to fuel build-up and eventually to larger and/or higher-intensity fires in the future that are more difficult to suppress or contain (Graham et al., 2004). These large and/or high intensity fires can move quickly and threaten multiple lands that are managed by different institutions/authorities (Nowell & Steelman, 2015). In the event of a larger or high intensity fire, the incident command system responds quickly. On the other hand, that system often circumvents more localized management strategies and priorities (Williams et al., 2012). Furthermore, it is often much more difficult to organize proactive approaches to wildfire risk mitigation across these multiple landscapes within the current wildfire risk governance structure.

Therefore, managing wildland fire risk is more difficult, but also even more necessary in transboundary landscapes where adjacent parcels of land are managed by different political authorities (Fischer et al., 2018; Palaiologou et al., 2018). Wildfires burn across landscapes, transmitting fire from one land tenure to another and land use decisions affect if and how wildfires burn within and between jurisdictions (Ager et al., 2017b). Consequently, efforts that change or understand wildfire risk must work across individual, local, community, and institutional scales and jurisdictions (Palaiologou et al., 2018).

Cultural Consensus Theory can be applied to understand if these different actors at different institutional scales currently construct wildland fire risk and resilience the same way (Allen, 2010). Cultural Consensus Theory is based on the proposition that culture is based on information that is learned and shared among its members and that the "culturally correct" answer to a given question can be inferred from consensus agreement (Garro, 2000). Cultural Consensus Theory also recognizes that individuals within a group are likely to vary with regard to how much knowledge about a topic they possess (Williams, 2017). This is just one potential framework that can be utilized in order to understand how different people think about boundary objects such as wildland fire risk and their own role in wildland fire risk governance at and across different scales.

Understanding Wildland Fire Risk Governance System at Different Scales

Due to a scalar mismatch between values and risk and management strategies, perspectives at each nested scale need to be examined and compared. Here, relevant literature and theories of wildfire at those scales are presented, starting at the household scale. Then the community scale is considered, followed by an examination of social networks at a regional scale. Finally, a governance scale is considered where the nested nature of these systems is considered across scales from local to national.

The Household Scale

In wildland fire risk governance, encouraging more active participation by households increases the success of wildfire management in transboundary settings (Abrams et al., 2016; Ager et al., 2017b). Understanding the realities for households at risk to fire transmission in cross-boundary settings reveals important insights for governance strategies aimed at promoting more successful household strategies in response to fire risk (Champ & Brenkert-Smith, 2016). This can be complicated by the fact that perception of wildfire risk differs from household to household and those perceptions are often divergent from the perspectives of managers and other actors in the governance system (Champ & Brenkert-Smith, 2016). Those divergent perceptions help determine potential wildfire management practices and adaptive capacity (Miller et al., 2013).

Action on the private lands that are adjacent to public lands constitutes one important piece in the successful collaborative governance of wildfire risk across boundaries. Wildfire social science and the broader hazards literature consistently indicate that action on private lands requires more than just a high level of risk perception or the so-called ‘appropriate’ level of understanding. The provision of parcel-specific information, engagement with trusted local sources of information, and engagement with neighbors are key social factors that are associated with owners taking more action on their parcels to reduce wildfire risk (Brenkert-Smith et al., 2015).

However, promoting fire adapted communities requires consideration of community level variables, which is more than an amalgamation of individual household perceptions and behaviors (Paveglio et al., 2017; Theodori et al., 2015). Paveglio et al., (2018) revealed that aggregate assessments of demographic indicators and/or individual risk perceptions were poor indicators of social vulnerability to wildfire risk; although sociodemographic variables and individual-level attitudes and perceptions influence household wildfire mitigations, significant variation in that relationship across different communities indicates that community dynamics moderate that relationship.

The Community Scale

Community is a more elusive and complex construct than locality alone (Flint et al., 2008). Community is a foundational concept in the social sciences broadly (Calhoun et al., 2012); and yet, the construct of community is often misused as a self-evident thing that needs no theoretical or operational consideration (Bender, 1978; Effrat, 1974; Hummon, 1990; Kumar, 2005). More than a place on the map or the sum of its members, communities are social systems for community members who interact in social fields defined by shared identity (Wilkinson, 1972). Community attachment affects resident perceptions of the local landscapes (Brehm et al., 2006).

Similarly, the way that community members think about their landscapes affects their understanding of their community (Trentelman, 2009). In terms of the NCS goal of promoting fire adapted communities, different communities possess different levels of adaptive capacity, which describes the characteristics of a community that enable or promote their ability to acclimate to change (Murphy et al., 2015; Williams et al., 2016). Also, wildfire management offers potential implications for more vulnerable members of particular communities and community members (Paveglio et al., 2018).

More nuanced understanding of the composition of different community structures reveal potentially differentiated strategies for fire governance for different communities (Paveglio et al., 2018). For instance, Fairbrother et al., (2013) open their examination of the Community Fireguard program by recognizing the contested nature of community. This recognition is crucial to two related conclusions: 1) that 'community' has become an amorphous and yet politically loaded term that is overused but poorly understood/operationalized and, 2) that so-called "community building" programs do not "directly 'create' or 'build' community but rather that a self-reported sense of community seems to be built by increasing social networking within a very limited geographical area" (Fairbrother et al., 2013, pg. 205). Similarly, Paveglio et al., (2015) compared eighteen case studies of WUI communities in order to understand community adaptive capacity. Their results refined a framework for delineating community archetypes based on social networks, construction of place, perception and trust of government, and perceptions of forest health and overall esthetic (Paveglio et al., 2015).

Based on these community archetypes, some communities are more successfully incorporated into collaborative governance whereas others are more responsive to top-down directives (Paveglio et al., 2018). For example, in working landscapes stakeholders commonly want to be consulted whereas those in amenity communities are more likely to trust and want more institutional guidance (Carroll & Paveglio, 2016). Understanding differences across communities is important for calibrating wildfire risk adaptation strategies (Paveglio & Edgeley, 2017; Toman et al., 2013). In an analysis of the development of Community Wildfire Protection Plans (CWPP), Williams et al., (2009) emphasized the role of understanding and drawing upon communities' local knowledge and local networks. Communities are the product of biophysical landscape legacies as well (Brooks et al., 2006). For instance, many communities in the WUI are the product of the legacy of economic activities (such as logging) that contribute to the materiality of the environment (Carroll & Paveglio, 2016). These landscape legacies are one of the criteria for different community archetypes (Carroll & Paveglio, 2016).

Social Networks at Regional Scales

Community members and stakeholders affected by wildfire risk and/or engaged in wildfire risk governance are also distributed in social networks that are themselves multi-scaler (Fischer et al., 2016b). Which is to say, stakeholders are simultaneously situated within different neighborhoods, landscapes, agencies and institutions at multiple scales. One approach to better understand social interactions at various scales is to study the connections among actors and systematically describe or explain the basis for these interactions (Jones et al., 1997). Accordingly, it is important to identify actors (both as individuals and members of different institutions) that interact in the wildland fire risk governance system in order to paint a picture of that system (Dominguez & Hollstein, 2014). This picture can explain, for example, the relative importance of specific actors in a network and how closely they are connected as well as provide opportunities to examine why specific actors hold particular roles or positions in the network (Long et al., 2013).

Insights into the social network may provide opportunities to understand how wildfire governance is situated in a specific geography (Fischer et al., 2016b). Previous research has shown that connections in social networks can be the product of both the social structure and/or the agency of actors in the network. For instance, homophily leads some actors to form connections with other actors similar to themselves (McPherson et al., 2001). Homophily can be age homophily (people associate with people in the same age cohort), gender homophily (males associate with other males and vice versa), institutional/organizational homophily (people in the USFS chose to and prefer to only interact with other USFS people) or based on another identity, e.g., firefighter homophily (people who work directly with wildfire suppression like to interact with similar others regardless of organizational affiliations) (McPherson et al., 2001).

Homophily is different from social foci, which have been shown to affect connections in social networks via similar cleavages, but these are the product of institutional or societal structures more than personal preference (Feld, 1981). Homophilia and social foci are two examples of a broader body of work that has tackled sameness, differences, and the ties in between. This recognition has an important legacy in many relevant scientific fields, including community literature (Chalmers Thomas et al., 2012; Fischer & Stueve, 1977). The importance of social capital (Fey et al., 2006; Flora et al., 2004) and social ties (Granovetter, 1978) emerges periodically on the importance of communities as local societies (Hamilton et al., 2014; Putnam, 2000) and natural resource management (Bodin & Prell, 2011; Yung et al., 2010).

In recent decades the topic of network mapping is increasingly linked to concepts of governance. Therefore, understanding social networks is important for understanding both the formal and informal governance of natural resource systems (Leahy &

Anderson, 2010; Mollinga, 2008). Network governance has made its way into the complex systems around socio-ecological problems involving governance and collaborations (Bodin & Prell, 2011; Goldsmith & Kettl, 2009). Network governance has been used to study and understand complex socio-ecological systems in fisheries (Ramirez-Sanchez, 2011: Sandström, 2011), agriculture and water governance (Lubell et al., 2014; Rathwell & Peterson, 2012), forest management (Harshaw & Tindall, 2005) and climate change (Rabe, 2009; Jaja et al., 2017). Thus, understanding social networks is important for understanding both the formal and informal governance of natural resource systems (Chang et al., 2012; Leahy & Anderson, 2010; Mollinga, 2008).

Governance Scales

Wildland fire risk management actions occur within a larger governance structure defined by who or what institution has the authority to take specific actions; this governance context determines what management practices are possible (Cheng et al., 2011). Governance includes formal and informal institutions and their actors, laws, rules, policies, and social norms involved in making decisions. Which is to say, governance involves processes and structures shaping individual or collective action (Young, 1997) solidified through formal and informal norms and rules (Lebel et al., 2006); governance is not just the rules and regulations promulgated by government agencies, but the many formal and informal ways we manage shared interests, in this case wildfire risk, across governmental and non-governmental entities.

Wildland fire risk management involves unavoidable trade-offs between competing values and perspectives that add to the complexity of governance (McLennan

& Eburn, 2015; Spies et al., 2018); not only do different stakeholders have different perspectives and understanding of the system, but even when stakeholders agree on how the system works, different values and priorities lead to potential conflict (Petty et al., 2015; Moskwa et al., 2018; Urgenson et al., 2018). The contested complexity of these systems means that institutions with the authority and resources to invest in different potential management solutions need to consider these trade-offs when evaluating ways to invest in collaborative governance and should also consider investing in alterative conceptions of wildland fire risk (Olsen et al., 2014; Spies et al., 2014; Stasiewicz & Paveglio, 2018).

In transboundary landscapes, effective wildland fire risk management requires collaborative governance that may be supported or restricted by the structure of the governance system (Abrams et al., 2016; Dupéy & Smith, 2018; Schultz et al., 2018). Collaboration governance allows diverse public agencies and local stakeholders affected by both wildfire risk as well as potential management solutions to explore more appropriate management options. Different actors and stakeholders in that system have different perceptions of the system and wildfire risk, which is constructed through social interactions within the system (Paveglio et al., 2010; Newman et al., 2014; Dickinson et al., 2015). Adaptive and collaborative governance, in particular, have received substantial attention within wildfire research literature.

Collaborative governance is a form of *participatory governance* (Biermann, 2007). Participatory governance incorporates stakeholders into the process of governance (Wampler, 2012). Participatory governance is an inherently transdisciplinary effort

(Evers et al., 2016), which recognizes multiple types of authority and types of expertise related to a topic (Fry, 2001; Heilmann & Pundt, 2017). Highly participatory governance such as collaborative governance requires that participants are involved in the process of governance from the very beginning when goals are established (Bodin et al., 2006). Prior to implementing collaborative governance, collaborative research with different stakeholders reveals what priorities and considerations different stakeholders have of the system.

Collaborative Research Methods

In more complex SES, engaging multiple actors through collaborative research methods can reveal opportunities for collaborative governance (Bosch et al., 2007; Cundill et al., 2012; Miller & Wyborn, 2018). This is due, in part, to the fact that resilience in complex SES often requires the active collaboration of multiple stakeholders (Lyon & Parkins, 2013). Also, managing complex systems effectively requires multiple forms of knowledge rather than one type of expertise (Prell et al., 2007; Wyborn et al., 2015). Collaborative research is a type of post-normal research where participation ranges from minor involvement of stakeholders to the extensive involvement from the beginning, in defining the problem, throughout the process, and finally in evaluating success (Allen, 2016). “Knowledge co-production” describes highly participatory research with high involvement from diverse stakeholders.

This approach is appropriate when approaching complex and contested topics such as wildland fire risk where co-producing shared solutions is necessary for successful collaborative governance. For instance, as has been established in this report, wildfire risk in transboundary contexts is too complex for traditional research to adequately assess the complexity of the social dynamics of those systems (Daniels & Walker, 2012; Freeman, 2000; Paveglio et al., 2015; Paveglio et al., 2009; Smith et al., 2016).

Co-Producing Shared Solutions to Complex Problems

The scientific community is increasingly turning to “knowledge co-production” as a process to generate solutions to complex problems (Nel et al., 2016). Engagement aims to develop knowledge that is not only credible, but also salient and legitimate to multiple stakeholders (Cash et al., 2003), while ensuring knowledge can and will be used in a specific context (Clark et al., 2016). It thus accepts that choices about questions, methods, and focus of research are inherently driven by values (Wyborn, 2015).

Co-production is sometimes referred to as “actionable science” reflecting literatures from action research, transdisciplinarity, science policy, and science and technology studies (see Beier et al., 2017; Cook et al., 2013; Nel et al., 2016). Calls for knowledge co-production assume that “better outcomes” for natural resource management will be realized through collaborative processes with diverse stakeholders who co-produce knowledge to be applied in specific decision-making contexts (Mauser et al., 2013, van der Hel, 2016). Co-production is a process that is promoted to generate knowledge to address challenges where there are high stakes, diverging values, and substantial systems or scientific complexity (Reyers et al., 2010), such as wildfire governance in transboundary areas.

Common themes are apparent across discussions of co-production: dialogue and exchange improve shared learning, research, and decision-making (Jolibert & Wesselink, 2012; Lauber et al., 2011; Nel et al., 2016). Others stress the importance of inclusive and iterative processes (Kirchhoff et al., 2013; Sarkki et al., 2015). Some suggest that socio-cultural contexts and power relations influence the success of participation processes (Schuttenberg & Guth, 2015), while others argue that co-production can contribute long-term capacity building within scientific and policy networks in spite of these dynamics (Armitage et al., 2011). Either way, in order to be successful, co-production must go beyond collectively defining research questions to support deep engagement between research, policy, and practice that builds knowledge and capacity to use in decision-making (Van Kerkhoff & Lebel, 2015).

The co-production of science and co-management of a natural resource systems requires the identification of relevant stakeholders and the social dynamics of specific SES (Cash et al., 2006). Co-produced post-normal research identifies shared and contested goals, produces knowledge, and implements actions in order to achieve goals and manage trade-offs and uncertainties (Bennett et al., 2015). In the space of contested values, knowledge, and multiple possible responses to complexity, successful co-production requires an examination of the assumptions underpinning knowledge production and products and how these are intended to make change in the world (Williams, 2004). This can be more successfully achieved by engaging stakeholders through place-specific understandings (Williams & Stewart, 1998).

The Co-Production of CoMFRT

Since wildfire risk cannot be managed by any one actor or institution in isolation (Reid & Beilin, 2014), multiple actors and institutions need to be involved in co-producing solutions and insights to collaborative governance (Williams et al., 2009). In transboundary contexts, wildland fire risk managers need to explore management strategies that include other agencies as well as other relevant stakeholders (Brooks et al., 2006; Stasiewicz & Paveglio, 2018; Williams et al., 2009). Although this "shared stewardship" approach to the NCS has been identified as a goal (USFS, 2018), it's not yet clear how to actualize this goal. Thus, collaborative, iterative post-normal research is needed and forms the basis of the creation of the CoMFRT research partnership. True to participatory research, CoMFRT began with a workshop where researchers conceptualized the challenge of wildland fire risk transmission in transboundary areas. Through this workshop, researchers and managers co-produced the goal of promoting more collaborative governance of wildland fire risk. From here, research objectives were identified based on four core guiding principles:

1. Using transdisciplinary approaches to understanding wildland fire risk
2. Sensitivity to the scalar realities of wildland fire
3. Meaningful inclusion of local place-based knowledge
4. Making continuous opportunities for collaboration across scales

These guiding principles are based on the relevant literature and theoretical foundations outlined above. Below is a more detailed description of the CoMFRT partnership goals, research questions, history, and methodology.

3. CoMFRT Objectives and Research Methodology

In late 2016, after yet another intense and expensive wildfire season in the western U.S., USFS managers (specifically those in State and Private Forestry, Fire and Aviation Management Office of Landscapes and Partnerships) asked researchers at the

Rocky Mountain Research Station, USFS, to identify the communities in the U.S. that are most threatened by wildfires in order to better inform USFS investments aimed at managing wildfire risk via the Hazardous Fuels program. What began as an effort to spatially calculate and locate wildland fire risk for communities quickly became more complex by a further request to better understand the characteristics of these communities. This additional request underscored the need for researchers with expertise in the social sciences to address these management questions. This agency-led and management-oriented mission became the CoMFRT partnership (see Figure 2.2).

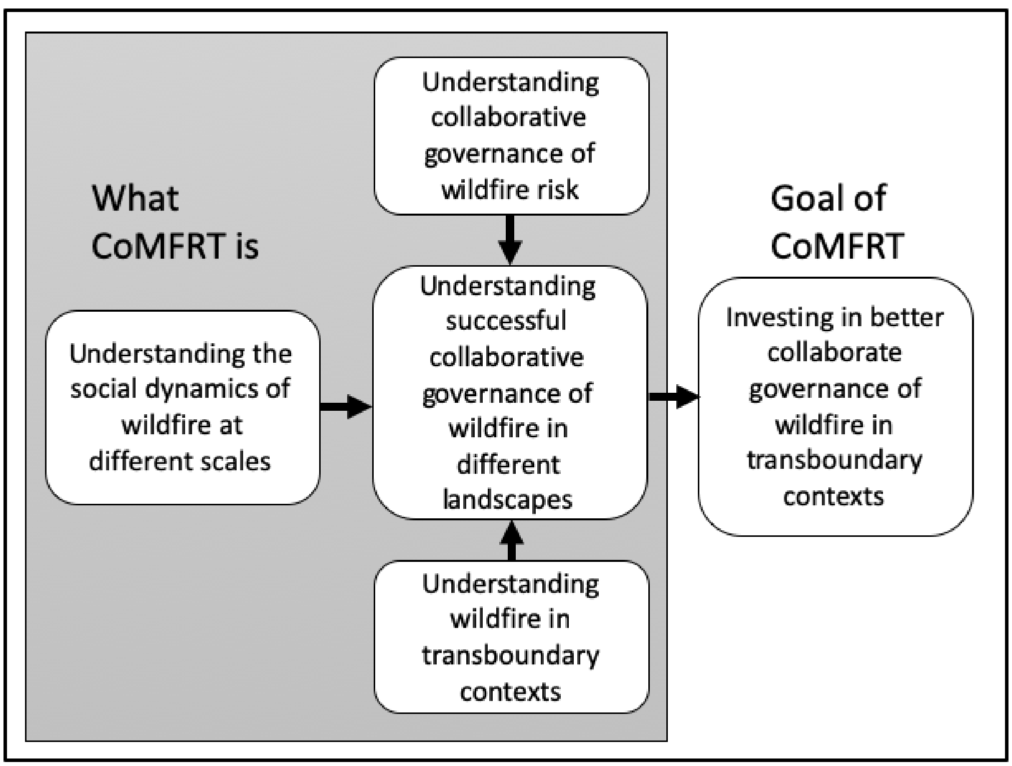

Fig. 2.2 Methods and ultimate goal of the CoMFRT project partnership.

The CoMFRT project partnership is designed to address wildfire as a transboundary, multi-jurisdictional problem, with an explicit focus on identifying place-specific and politically-feasible solutions that promote collaborative governance. As such, CoMFRT partnership research is a coordinated, transdisciplinary effort, co-produced by a number of different actors including CoMFRT researchers, community stakeholders, local managers, and project administrators (Williams & Essen, n.d.); interactions among these wildfire researchers, state, tribal, private, and federal managers and fire-prone community members facilitate research work packages on wildfire risk governance, adaptation, and resilience at different frequencies and intervals throughout the life of the project. This process results in the co-production of knowledge and practice pertinent to NCS goals.

CoMFRT Partnership Goals

The CoMFRT partnership offers the potential to make significant contributions to collaborative wildland fire risk governance by identifying opportunities for strategic investment that promotes the shared stewardship of different landscapes. By taking a systems approach (i.e., looking at wildfire, wildfire governance, and communities as systems), the CoMFRT partnership is aimed at better understanding the interconnectedness of the different parts of the wildland fire system in selected landscapes in the western U.S. CoMFRT is a long-term, iterative, and process-oriented research project that examines the social dynamics of wildland fire systems in that context. In certain transboundary contexts, developing effective long-term strategies for managing wildfire risk increasingly depends on cooperatively co-managing risks across landscapes that often encompass multiple communities, public and private stakeholders, individuals, and local organizations.

The CoMFRT partnership targets selected communities in the western U.S. in wildfire risk 'hotspots' where there is an especially high likelihood of fire risk transmission from forests managed by the USFS to other federal, state, or tribal land and/or private homes and property. To date, the landscapes under study by the CoMFRT project partnership are northcentral Washington, northern Utah, and northcentral Wyoming. In these landscapes, a series of work packages document the social characteristics of households, neighborhoods, communities, and the wildland fire governance social network.

These work packages also aim to understand the wildland fire risk governance system currently addressing wildland fire risk. Finally, the cumulative goal of the synthesized findings of these separate work packages is to identify actionable recommendations for managers and policy-makers to increase collaborative governance in these landscapes in order to meet the goals of the NCS. In summary, the goals of the CoMFRT partnership include 1) identifying efforts that support and enable successful adaptation to the wildfire threat among different land ownerships and jurisdictions in fire-prone landscapes; and 2) identifying recommendations to share with fire managers and policy-makers to further support relevant solutions designed for and with communities.

CoMFRT Partnership Structure and Design

The CoMFRT project partnership is comprised of many different researchers, managers, and stakeholders working together to co-produce collaborative research organized into seven research work packages. Each of these research packages addresses different research questions. Since the goal of these methods is to improve the actual management of wildland fire risk, the aim of the CoMFRT partnership is to identify recommendations for how fire management agencies can further support locally relevant solutions designed for and with communities. Working in identified areas of high wildfire risk transmission, referred to as *hotspots*,[9] the CoMFRT partnership is ultimately aimed at better understanding how to invest in collaborative governance that supports local solutions designed for and with communities.

Thus, together, project partners examine what people and organizations can do and/or have done in specific fire-prone landscapes to better live with wildfire across land ownerships and jurisdictions across different scales. In sum, the CoMFRT partnership provides research to support fire risk mitigation planning and coordination through a portfolio that is organized into seven work packages with associated outcomes. These work packages are explained in greater detail below. At the end of each work package description recommendations for policy and management are listed.

Research Work Packages and Findings

Each of the seven CoMFRT research work packages addresses different aspects of collaborative wildfire risk governance in specific transboundary landscapes. These work packages are aimed at addressing the household, community, social network, and governance scales of collaborative wildland fire risk governance. Broadly speaking, these work packages are aimed at investigating the social systems and governance properties of

[9] These regional-scale geographic units map wildfire exposure across ownerships. These are based on firesheds and were the first product to result from the original request to identify the communities most at risk to wildland fire risk exposure. For more detail on how these hotspots and firesheds are calculated, see the "spatial pattern of wildfire risk work package" below.

identified regional wildfire risk hotspots, based on smaller scale *firesheds* (Ager 2019), in order to understand how they vary from place to place across geographic scales (household, neighborhood, community, county and state).

Specifically, these packages examine the ways that residents, stakeholders and institutional actors are coordinating, collaborating, and co-managing fire risk mitigation and whether this generates collective action that can occur across different scales to promote wildfire adaptation. Also, these work packages identify local innovations that may work across boundaries and scales to support collaborative governance.

The results of these work packages can also be used to identify ways to monitor social systems in order to assess the long-term effectiveness of transboundary collaborative governance and agency efforts to improve it. Monitoring these systems through network studies, for instance, can quantitatively express how much connectivity there is between different elements of the system that need to be coordinated at local, state, and federal scales. Ultimately, these work packages are meant to identify what types of resources might strategically improve adaptive and collaborative governance strategies and the implementation of social science. Each of these work packages results in published peer-reviewed research outputs that provide more details on these methods.

Literature Review and Problem Analysis Work Package

The literature review and problem analysis work package assesses the state-of-knowledge on the co-management of natural hazards, including wildfire, and develops a detailed problem analysis intended to guide the CoMFRT research program. Outcomes of this work package include developing and delivering a comprehensive assessment of existing knowledge on wildland fire risk governance, including factors that promote and/or limit alternative management strategies that could mitigate wildfire risk across land ownerships and jurisdictions.[10] This work package also identifies knowledge gaps and complexities involved in addressing and adapting to wildland fire risk in a variety of social-ecological settings in order to deliver frameworks that guide future research. Based on these insights, CoMFRT partners provide advice to USFS leadership about effective strategies for targeting investments in adaptive capacity informed by a wealth of existing research.

The outputs of this work package mirror the frameworks associated with complex risk where one-size-fits-all approaches aren't effective. Contending with transboundary social complexity and heterogeneity requires a focus on formal and informal governance processes at multiple scales. By focusing on process rather than specific targeted outputs (e.g., acres treated), this strategy leads to greater management success and stakeholder support in transboundary landscapes. Thus, beyond the problem analysis that examines these complexities, and the comprehensive assessment described above, work package outputs are iterative and context and policy dependent.

Work Package Recommendations for Policy and Management:

- Directly engage with differences in perspectives and definitions. These differences do not need to be resolved, but discussion can lead to shared learning that identify new and innovative approaches to address challenges across boundaries and increase collaborative capacity.

[10] This GTR is a product of this work package and is the comprehensive assessment described.

- Conduct on-the-ground, longitudinal participatory research that engages with diverse stakeholders to identify, understand, and monitor conditions and practices that facilitate and/or challenge wildfire adaptation in a variety of fire-prone landscapes, and implement and monitor co-produced recommendations.

Spatial Patterns of Wildfire Risk Work Package

The spatial patterns of wildfire risk and governance work package assesses the spatial arrangement and distribution of mitigation actions associated with wildfire risk governance in CoMFRT study sites and their relationship to a variety of ecological and social features at multiple scales. This work package builds from the Landscape Dynamics and Scenario Planning element of the National Fire Decision Support Center (NFDSC) (RMRS, n.d), which led (in part) to the conception of the CoMFRT research project; CoMFRT relies on large-scale spatial analysis output of that program in order to identify potential study areas with relatively higher likelihood of wildfire transmission from USFS lands to communities. These areas are called firesheds. Landscapes identified in this analysis, together with input from researchers, USFS staff, and project partners, guides the selection of CoMFRT project study sites and boundaries.

Outcomes of this work package integrate NFDSC spatial analysis findings with other CoMFRT work packages in order to identify specific cross-boundary wildfire transmission hotspots and associated firesheds. Also, this work package develops and applies methods to identify past forest treatments across broad landscapes using existing and available imagery. This results in the co-development of a fine-scaled database of past forest treatments developed with and for local managers. This allows for analysis of historical land management actions in CoMFRT study sites for evidence of cross or near cross-boundary treatments. Finally, this work package identifies the social vulnerabilities, values at risk, and governance characteristics of communities and their geographic proximity to these past forest treatments using U.S. Census data.

Work Package Recommendations for Policy and Management:

- Consider increasing the use of Hazardous Fuels funds to target private lands in the wildland-urban interface, in addition to federal acres as private lands account for the bulk of structure exposure for more socially vulnerable areas.
- Follow up simulation analyses with detailed field-based studies, especially in areas shown to be more vulnerable.
- Identify locations where high wildfire risk conditions coincide with vulnerable groups and emphasize pre-fire, site-specific coordination in those areas.

Household and Parcel Analysis Work Package

The household and parcel analysis work package engages the Wildfire Research (or WiRē) Center[11] to assess residential participation in wildfire preparedness and household-level risk mitigation. Identifying variation among different residents in fire-prone communities in a shared landscape highlights the importance of collecting and using local data to ensure programs focused on bolstering activities on private properties

[11] WiRē is a partnership between wildfire practitioners and researcher with a focus on household scale mitigations supported by the U.S. interagency National Fire Plan, the Joint Fire Science Program, and several academic institutions (RMRS, n.d.).

are guided by locally relevant evidence. Efficiency and efficacy in engaging fire-prone communities requires investment in locally relevant data in order to support evidence-based decision-making at the local level.

Outcomes of this work package include: developing tools and support for parcel-level wildfire risk assessments; delivery of empirical assessments of fire risk mitigation practices among parcel owners in CoMFRT study sites; identification of mitigation factors such as reported mitigation activities, barriers, and openness to potential incentives to mitigate, expectations about the likely outcomes of future wildfires, and different wildfire information sources, and testing ‘nudges’ to increase household mitigation efforts.

Results of this work package demonstrate that residents across the Squilchuck drainage community in northcentral Washington, for instance, have similar attitudes toward wildfire and strongly support fuel treatments on nearby public lands. However, there are measurable differences among residents in the adjacent neighborhoods related to: parcel-level and community-level wildfire risk; community capacity to engage with programs and/or opportunities that support risk mitigation (e.g., language barriers); preparedness factors such as roads for access/egress, plans for evacuation, and sign-ups with emergency notification systems; mitigation factors such as reported mitigation activities, barriers and/or openness to potential incentives to mitigate; expectations about the likely outcomes of a future wildfire; and the source of wildfire information for residents. These findings are consistent with the NCS assertion that there is “no one size fits all solution" to wildfire risk. These results also support the assertion that social heterogeneity across the landscape is a barrier to effective collaborative governance.

Work Package Recommendations for Policy and Management:

- Encourage individual parcel owners to complete risk mitigation activities on private land.
- Invest in local organizations that already engage with private landowners.
- Provide wildfire risk information that residents find most useful as compared to other sources.
- Collect parcel-level information to ensure locally relevant and applicable wildfire risk information is provided to individuals by organizations.

Pathways to Community Capacity Work Package

The pathways to community capacity work package assesses local capacities, relationships, and available tools to formulate tailored pathways for collectively building fire adapted communities among socially diverse (i.e., heterogeneous), fire-prone human populations. This effort recognizes that community boundaries do not necessarily follow existing administrative or so-called 'fireshed' boundaries and thus communities can help or hinder the shared responsibility for wildfire management across landscape boundaries.

Outcomes of this work package document how elements of local social context, including interactions among locals and agency professionals, combine to influence planning and adaptation actions promoted by different human populations across landscapes. Also, this work package draws lessons about the development of community capacity within and outside of CoMFRT study sites to inform the development of tailored strategies for promoting fire adapted communities. This work package also develops and administers community-led co-management assessment processes that identify unique community influences, such as, experiences with past wildfire events and/or the importance of recreation and/or timber access across the landscape. These processes match communities with tailored strategies for fire adaptation informed by empirical research and local management practitioners. As such, this work package co-designs monitoring benchmarks with practical utility to stakeholders at various scales.

Results of this work package highlight the need to be flexible in implementing innovative co-management at scales far more fine-grained than the view from the USFS office in Washington D.C., referred to as the 'Washington Office.' These results also highlight the importance of thinking about community across scales (i.e., communities are heterogeneous in both vertical and horizontal dimensions). Collectively, this research across the northcentral Washington, northern Utah, and northcentral Wyoming research study sites suggest that each study area features specific, fine-grain patterns of community emergence and/or community fragmentation. These patterns are recognized and articulated by stakeholders interviewed in each region and help explain past as well as possible future fire adaptation strategies.

Results indicate that community emergence across the landscape does not necessarily follow existing administrative boundaries, and community fragmentation refers to increasingly divergent human values, perspectives, skills, and relationships with area resources that occur among individual landowners in a region (see Paveglio et al., 2019). The opposing forces of social fragmentation versus community emergence (or change) influence the scale, patterns and occurrence of collective action surrounding fire in a broader landscape. Given this, it is important to focus on fire adapted communities as emergent, variable units in order to advance processes of fire adaptation at broader scales.

Professionals, residents, and partners in all three research sites studied (and other locations being studied) indicate that coordinated fire risk management should first occur at these smaller scales (where action can occur most readily) and then actions can be aggregated to larger scales. Developing fire adapted communities can also serve as a co-management process when they are conceived of as a set of inductive, interactive steps that articulate unique community influences across a landscape, match each community with tailored pathway components gleaned from ongoing practice, and there are co-designed monitoring benchmarks with practical utility to local stakeholders (see Paveglio & Edgeley, 2020, a direct CoMFRT output).

Work Package Recommendations for Policy and Management:

- Work with communities to identify appropriate pathways for fire adaptation and offer policy tools to support different pathways.
- Develop guides, materials, and processes that help key stakeholders develop capacity to work with diverse groups of people across fire-prone landscapes and to facilitate adaptation strategies that are sensitive to local conditions.
- Create repositories of outreach materials that professionals, residents, and planners can tailor to community needs.

- Create a monitoring and data collection framework to enable communities to monitor their progress toward fire adaptation.

Fire Adaptation Social Network Mapping Work Package

The fire adaptation social network mapping work package identifies key wildfire mitigation actors operating in CoMFRT study sites across a range of local, state, federal, and other jurisdictions. The network mapping effort describes interrelationships among wildfire risk management professionals and organizational affiliations, describes their relationships to the landscape, and pinpoints key characteristics of each network, including factors that enhance and constrain the network's ability to adapt to changing wildfire risk.

Outcomes of this work package include developing and delivering network maps of individual and institutional actors engaged in all-lands wildfire risk management within CoMFRT study sites, including descriptions of the roles different actors play in managing wildfire risk, where different actors work in the landscape, and how they are connected to each other. Also, this work package pinpoints highly connected network actors and their roles in the wildfire adaptation management network. For instance, network maps in Utah and Washington demonstrate that a small number of people play outsized roles, which can be linked to the idea of community readiness. In the state of Washington, non-governmental actors play a significant role whereas in Utah this role is less pronounced. In Utah, state Department of Natural Resources employees and state WUI coordinators are among those highly connected individuals with outsized roles seeking opportunities to coordinate.

Based on this research it is possible to identify regional opportunities for shared stewardship based on overlaps in where different actors work in the landscape, as well as overlaps and gaps between NFDSC spatial analysis findings and network adaptive capacity in areas of high fire risk transmission. These outcomes also identify key evidence-based factors for encouraging transboundary collaborative engagement to strategically and programmatically align organizations as called for by the NCS.

These findings suggest monitoring the wildland fire governance system in order to understand where network boundary-spanning capacity lies. This involves developing a way to track the impact of investments in the adaptive capacity of identified networks over time in order to improve the ability of communities to live with and manage wildfire risk. With this monitoring in place, these results could reveal opportunities to invest in boundary-spanning actors and activities that increase the connections and collaborative engagement between otherwise disconnected parts of the network. Recommendations based on these results include the impetus to act on opportunities for shared stewardship between the federal government, the state, and other elements of the wildfire management system with a focus on areas of existing capacity.

Work Package Recommendations for Policy and Management:

- Monitor regional wildfire management networks over time to understand USFS and other stakeholders' capacity to engage with each other.
- Identify where boundary-spanning capacity lies and how it changes over time.
- Evaluate whether specific sectors (e.g., development and land use planning) are missing from networks and engage them.

- Invest in improving capacity to build effective interagency partnerships, and act on opportunities for shared stewardship between federal government agencies and other managers in the wildfire management network.

Governance Systems Structures and Levers Work Package

The governance system structures and levers work package identifies the policies, tools, and strategies that enable or constrain cross-jurisdictional and cross-scale co-management of wildfire risk. This effort includes research on formal mechanisms (e.g., agency missions, planning processes, etc.) and informal factors (e.g., trust, legitimacy, and organizational culture) that interact to shape mitigation and adaptation work. The focus of this work package is understanding how the wildfire governance system operates at a landscape scale and how that understanding can help researchers and/or managers address barriers, improve investments, and achieve better outcomes for future wildfire risk governance.

Outcomes of this work package include identifying potential governance innovations that enable mitigation work across jurisdictional boundaries and across scales (e.g., mechanisms that enable new types of partnerships or build capacity in new ways) and recommending opportunities to scale-up innovations while accounting for local context. These outputs provide recommendations for improving agency investments to address key barriers to developing and implementing landscape-scale risk reduction activities. These recommendations also identify planning processes that enable risk governance that effectively accounts for the ways that wildfire risk is changing due to climate change and other biophysical factors. Ultimately, this work package pinpoints how science and risk assessments interact with decision-making processes across scales in order to develop recommendations to improve integration of scientific products into the governance process.

For example, the results of this work package reveal transboundary patterns of fuel treatments in the state of Washington due to increased interagency collaboration in recent years. These results also indicate that governance perceptions and practices differ across institutions and geographies. Navigating these differences in the governance system requires cultural consensus and translation via social learning processes (Collins, 2014). The idea of translation is used in social science to provide a framework for understanding how stakeholder groups coalesce around an issue. In this work package, translation is viewed as a process where stakeholders in a governance network develop a shared understanding of a problem and mobilize strategies to address that problem, or don't. Thus, this research provides insights into how governance networks are formed, and how stakeholders position themselves relative to that problem. This work package also identifies pathways for improving governance structures.

Work Package Recommendations for Policy and Management:

- Invest directly in partnerships, collaborations, and effective public engagement at all scales. At the local level, this can be done by using forest treatment funds to support agreements with local partners.
- Establish relationships for collaboration outside of treating acres and/or managing wildfire incidents.

- Outline different pathways for translating the National Cohesive Strategy to state and local scales, providing exemplars for agencies and other stakeholders to utilize as they move toward shared stewardship in specific landscapes.
- Pursue organization changes to enhance continuity and reduce staff turnover, develop and promote relevant training, and adjust job descriptions and evaluation processes to prioritize partnership activities. When hiring wildfire managers, look for willingness to collaborate.
- Attend collaborations initiated by local partners even if it is not yet clear how the USFS can get involved on the project and/or benefit.
- Avoid using the process of collaboration simply to manufacture buy-in or get permission to take action from local actors.

Co-Production and Integration Work Package

The co-production and integration work package brings together local stakeholders, CoMFRT team members, and other fire management actors to interconnect CoMFRT research and management findings with the lived experience of stakeholders in order to generate actionable recommendations for more comprehensive community-based wildfire adaption outcomes. This work package convenes groups of both researchers and managers in workshops in order to identify lessons learned and recommendations for future efforts to support wildfire adaptation. Outcomes of this work package include co-produced, actionable research synthesis findings and policy recommendations developed with and for wildland fire risk managers at a variety of scales. The insights that follow emerged from the synthesis effort of this work package.

Although every stakeholder group or individual is concerned about the loss of life and property to wildfires, it cannot be assumed that shared concerns are enough to animate a coordinated response that contributes to landscape-scale risk mitigation. Thus, examining the NCS through a translation or cultural consensus theoretical framework provides a concept map that can help all stakeholder groups, not only the federal government, make the process of negotiating the NCS's goals explicit, thereby enhancing each group's ability to negotiate their position. For instance, the state of Utah is a case of successful translation, where the state has integrated the NCS's three main goals into its fire legislation and is using federal policy tools to mitigate cross-boundary wildfire risk. From this case, it is possible see how political projects related to state or federal control of public lands illustrate the push and pull between different extant political agendas within this policy framework.

Insights from research in Utah reveal that new policies do not roll out on a blank slate, but are infused by existing relationships and power dynamics. Because Utah is a particular socio-ecological context, the lessons from this successful translation cannot be transported as a piece to other states and/or regions and assumed to be effective. However, this case does identify starting points and possibilities for the negotiations that must occur in other cases. Based on these findings, CoMFRT researchers used Cultural Consensus Theory to test for consensus of knowledge (propositions about wildfire risk factors in this case) among members of the wildfire governance system in northcentral

Washington that had participated in the fire adaptation social network mapping work package's social network survey.

Because governance literature emphasizes challenges in coordination that can occur when different stakeholders do not agree on the causes of a problem, it is important to know if members of the wildfire governance system agree amongst themselves on wildfire risk factors. Results of this analysis reveal that there is a consensus about wildfire risk factors in the sampled group, which suggests that difficulty in interagency coordination is not likely due to members having different sets of knowledge about wildland fire risk or governance. This research is also being used to explore how knowledge might vary within different segments of the network (USFS compared to NGOs for example) and whether individuals with more interactions in the network possess more knowledge.

CoMFRT research partners are also examining variation among residents in fire-prone communities in shared landscapes by combining household and parcel analysis work package results with pathways to community capacity work package results. This synthesis reveals the importance of collecting and using local data to derive insights to ensure programs focused on bolstering activities on private properties are guided by locally relevant evidence. Also, current deficits have been identified including limited extant data to enable evidence-based programs and to identify what kinds of support differently positioned communities may require to successfully engage with private landowners.

CoMFRT research work packages have also identified long standing relationships, tensions, and barriers that shape land management options and choices in the western U.S. that co-constitute the conjoint constitution of the wildfire governance system. For instance, relationships between state and federal actors, different ideologies and conflicting views about land management and the appropriate roles of actors at different scales, and inability to keep up with current vegetation loads are stymieing the ability of managers to cope with the increase in high intensity wildfire events. Without intervention, these issues are not going to go away, and they are making it very difficult to conceptualize what a more anticipatory governance system might look like.

Work Package Recommendations for Policy and Management:

- Invest in pre-fire planning and mitigation activities.
- Foster engagement among different social groups to build a sense of community through interactions designed to overcome social fragmentation.
- Conduct stakeholder-oriented sense making, co-production workshops in specific local landscapes with agencies and others stakeholders.
- Develop, fund, and hire a social science advisor to Fire and Aviation Management within USFS with training and expertise in collective action, collaborative governance, wicked problems, adaptive capacity, and resilience.

CoMFRT Workshop Findings and Recommendations

The following co-produced workshop findings and recommendation emerged from a series of workshops in Washington, Utah, and Oregon. In these workshops, CoMFRT researchers briefly present their current research findings and then solicit stakeholder input, at which point researchers attempt to listen to stakeholder input. Thus, the following workshop recommendations represent how participating stakeholders understand wildland fire risk in transboundary settings.

Two major themes identified in these workshops were: 1) Community readiness or adaptive capacity to do cross-boundary co-management, and 2) Coordination deficit between among and communities. These deficits are not well-addressed by top down solutions. For instance, previous to the launch of the National Risk Map (USFS, n.d.), neither state, private, nor federal managers working in either Utah or Washington communicated the need for more technical risk maps or similar products. Indeed, workshop participants indicate that this product adds more administrative burden than it alleviates.

Workshop participants also indicated that risk management activities concentrate around the WUI and identified opportunities for shared stewardship. For instance, practitioners in northcentral Washington have a wide array of relationships with people in other organizations, yet some organizational affiliations tend to foster more diverse relationships than others (Nielsen-Pincus, n.d.). Whereas, in Utah where the state plays a bigger role in the shared stewardship of wildfire risk and federal agencies are highly coordinated across a large geographic area, there is a disconnect between federal actors and other actors at smaller scales, and coordination is concentrated in three distinct regions in Cache Valley, Salt Lake Valley, and the Wasatch back.

Insights gathered in these workshops are also integrated into each of the CoMFRT work packages and co-produced insights influenced the development of this GTR. For more outputs from these workshops, refer to the numerous workshop reports produced by the CoMFRT project.[12]

Synthesis of CoMFRT Research Findings and Recommendations

Selected findings thus far from work in northcentral Washington and northern Utah include the observation that wildfire risk across jurisdictional boundaries is managed by a diverse set of networked actors, from local to national scales, and a small number of different players play outsized roles. For instance, in Washington, non-profit organizations and other local actors are key among a set of over 700 networked individuals, whereas in Utah, State Department of Natural Resource employees and state WUI coordinators are the key actors.

Also, not all fire-prone communities are the same. As a result, there is no one-size-fits-all solution. Instead, CoMFRT research partners see that different communities, and the residents and organizations within them, devise different pathways to more effectively participate in shared stewardship and increase their ability to better live with wildland fire. Consequently, at this point, preliminary recommendations include investing in locally-based capacity to coordinate networks across all levels of fire risk managers (e.g., the Fire Learning Network or regional based approaches such as the Washington State Fire Adapted Communities Learning Network and Kittitas Fire Adapted Communities Learning Network). Also, based on this problem analysis and research

[12] When this GTR is published, this footnote will provide a URL where these reports can be found.

findings, the CoMFRT partnership recommends working directly with communities and state and local managers to craft national-level investment strategies to address wildfire risk challenges from the perspectives of communities.

Understanding the opportunities and barriers to implementing mitigation at landscape scales can help focus interventions and investments. For instance, through integrated work package research, CoMFRT partners have found that policy documents (such as the NCS), and workshop and research participants often focus on the following dilemmas: 1) the need for more money to treat more acres, more ways to share resources across agencies to treat more acres, and mechanisms to enable the states to treat federal acres; 2) streamlining perceived policy barriers (e.g., National Environmental Policy Act commonly referred to as NEPA) and limiting litigation; and 3) educating the public to help them understand what the agencies know about wildfire and fuels.

CoMFRT research findings indicate that there are other barriers that are not highlighted as much that suggest a different set of solutions. These barriers include: 1) agency missions and approaches are different, which makes it difficult to work across boundaries; 2) agencies need to invest time and effort into navigating these differences and building partnerships and trust, but they don't have the capacity to do so; and 3) staff turnover limits the ability of agencies to navigate these differences and build effective working relationships and collaboratives.

These findings suggest that investments in agency capacity for building partnerships and organizational changes that reduce turnover could lead to more on-the-ground work as compared to the same funds being simply allocated to 'acres treated.'

Further, NEPA processes and litigation provide avenues for members of the public to contest proposed fuel treatments and where conflicting views on how to reduce wildfire risk (or how navigate risk tradeoffs) emerge to prevent treatment. However, streamlining NEPA and limiting litigation won't build public support and could backfire by creating more animosity toward agencies. Conversely, investing in collaboratives and effective public engagement (e.g., pre-NEPA engagement) that build a shared understanding of fire, forest management, and smoke could reduce litigation and build trust to get more projects implemented (and thus ultimately leading to more acres treated).

4. Conclusion

Taken together, this report offers readers the theoretical basis for understanding collaborative wildland fire risk governance in transboundary settings with explicit details of ongoing research efforts aimed at addressing these aspects. Due to the complex, multi-scaler nature of shared wildland fire risk in transboundary landscapes, collaborative governance of wildland fire risk is needed to pursue more resilient landscapes and more fire adapted communities. This GTR expands on those concepts, theoretically, and at different scales, in order to complete a problem analysis of this complex topic. Afterward, the history and methods of the CoMFRT research partnership were presented. Selected results demonstrate the potential utility of participatory approaches to research on shared wildland fire risk. Finally, in this conclusion, CoMFRT partnership recommendations are reiterated, with reflections on possible future directions for research, policy, and governance.

Key findings from the pathways to community capacity work package reveal that that there needs to be flexibility to implement co-management activities at scales far below the Washington Office purview. Thus, it is not the Washington Office’s responsibility to impose, suggest, or roll-out another program or risk map stakeholders are expected to use. Which is to say, the current model might need to be flipped so that locally-oriented projects provide alternative strategies for monitoring or experimentation. Ironically, these findings support the NCS recognition that there is no-one-size-fits-all approach, and yet, by definition, the NCS articulates a cohesive strategy that dictates wildfire risk governance nationally. For instance, page 11 of the NCS states: "It is important that linkages exist between each level from a top-down as well as a bottom-up perspective... Local values and risks influence regional and national values and risks. Likewise, national values and risks influence regional and local values and risks" (Lee et al., 2011).

If recognition of this is a cornerstone of the NCS, this problem analysis, in conjunction with CoMFRT research outputs, presents alternatives to the current business-as-usual approach of crafting national-level investments to solve context-specific dilemmas. CoMFRT research has identified ways that the Washington Office can be supportive of locally-derived programs rather than dictating them. Rather, if a small portion of national funds were directed to local organizations and partnerships, context specific adaptive capacity and resilience would be promoted at local, regional, and national scales. Other CoMFRT Recommendations for Policy and Management include:

- Coordinate with local fire districts before wildland fire events.

- Make year-round fire prevention and community liaison positions at the local level.
- When promoting local-scale home-hardening, set appropriate expectations about the reality of wildland fire risk.
- Pursue actions that would make it safer for wildland fire fighters to protect homes (e.g., multiple entrances/egresses) with home owners associations and developers.
- Use agreements and/or contracts with local governmental and/or non-governmental organizations to get acres treated, even on federal or state land, because these agreements result in a double-benefit of 1) treating acres, and 2) establishing and/or bolstering relationships with local organizations, which builds collaborative capacity, supports these local organizations financially, and improves their skills and/or knowledge.
- Move beyond acres treated as a metric; alternative metrics should incorporate factors related to a range of social, economic, and community variables.
- Communicate with communities about current wildfire realities including but not limited to fuel loads, funding shortages and smoke, before wildfires occur.
- Determine how much smoke the community can tolerate and communicate about the reality of wildfire and smoke.
- When messaging about smoke in local communities, it is advisable to explain, in order, 1) that more wildland fire smoke is to be expected in the future due

> to fuel buildup, and then 2) that prescribed fire and/or managed natural fires that produce some smoke now will reduce the amount of smoke that those acres produce in the future by reducing the chance of those acres experiencing a high-intensity wildfire. However, 3) do not suggest that these treatments will definitely result less smoke in the future as yearly smoke may still increase due to exasperated drivers of wildfire, the amount of wildland acres currently untreated, and the variability of wind patterns.

In sum, investing in collaborative governance of wildland fire risk will be most effective by recognizing that systems are configured in different ways in different fire-prone landscapes and thus investment must be target at these different systems and scales. Towards this initiative, this GTR outlines factors that contribute to social-ecological complexity related to wildland fire risk governance, which need to be as critically considered as biophysical factors when making policy decisions. Additionally, gaps persist in the state of knowledge on these social-ecological factors due to this complexity, which necessitate iterative and participatory research. In this GTR, participatory research methods were discussed theoretically, and examples from the CoMFRT project were presented as examples of participatory research practice. Finally, recommendations for management and policy were made based on CoMFRT research findings.

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Appendix 2.1: Glossary of Key Terms

Adaptive Capacity: Describes the ability to react to and manage change, increasing resilience.

Biophysical: Describes the environmental or non-human aspects of social-ecological systems. These factors include biotic aspects, such as plants and animals, as well as abiotic factors such as topography and climate.

Boundary Objects: Significant symbols that operate as translators between social worlds because boundary objects are plastic enough to adapt to specific people and contexts but robust enough to maintain a common identity.

Collaborative Research: A type of post-normal research where participation ranges from minor involvement of stakeholders to the extensive involvement from the beginning and throughout the process, and in evaluating success.

Conjoint Constitution: Refers to the reciprocal relationship between social construction and biophysical conditions that co-creates specific landscapes.

Co-produced: A process where a multitude of relevant stakeholders work together to define the scope of a product or project and complete it collaboratively.

Cross-boundary: Describes spatial contexts where different landownerships abut.

Fireshed: Geographic unit mapping fire exposure across land ownerships at landscape a scale.

Governance: A process that includes formal and informal institutions, their actors, laws, rules, policies, and social norms that shape individual and/or collective action.

Hotspots: Regional-scale geographic units mapping wildfire exposure across ownerships where communities are most at risk to wildland fire risk exposure.

National Cohesive Wildland Fire Management Strategy: An interagency strategy document resulting from a three-phased, interagency collaborative that was initiated in 2009, which is structured around three major goals as pillars supporting this management vision: 1) more resilient landscapes, 2) fire adapted communities, and 3) safe and effective wildfire response.

Post-Normal Science: Research exploring complex problems where inquiry is beyond the capacity of basic science. The increasing emergence and recognition of wicked problems in research has led to the emergence of several different approaches to post-normal science.

Participatory Governance: Incorporating stakeholders into the process of governance.

Reflexivity: Describes a process of examining one's own understanding of a system in order to come up with new insights about that system. This can be individual and/or collective reflection. Reflexive actions are carefully examined as they occur since these actions are either something outside of a person's normal routine or a new elaboration on that routine.

Resilience: Refers to the capacity for a system to experience a change or shock and continue to function.

Shared Stewardship: Interagency recognition and agreement to manage landscapes across jurisdictional boundaries.

Social-ecological systems: A theoretical model for landscapes based on the recognition that human systems and biophysical systems are reciprocally related.

Transboundary: Cross-boundary landscapes where institutional differences between different adjacent landowners creates a vertical (i.e., institutional) dimension that necessitates careful coordination and collaboration on the horizontal (i.e., geographic) dimensions of landscape management.

Transdisciplinary: Denotes empirical efforts that go beyond academic interdisciplinarity to include managers and other relevant stakeholders.

Wildfire Fuel: Composition, amount, structure, and moisture content of dead and live vegetation and detritus.

Wildfire Intensity: the rate at which fire is producing thermal energy in the fuel-climate environment, most often measured in terms of temperature and heat yield.

Wildfire Severity: The effect the fire has on vegetation, soil, buildings, watersheds and other valued assets and systems.

Wildland-Urban Interface: includes houses, businesses, infrastructure such as powerlines, and, increasingly, community buildings such as schools. More than just the built environment, the WUI is comprised of neighborhoods and communities of people whose lifestyles are shaped by their understanding and attachment to these landscapes.

CHAPTER III

REFLEXIVITY AND PERCEPTIONS OF COLLABORATION BY MEMBERS OF A WILDLAND FIRE RISK GOVERNANCE SOCIAL NETWORK

Abstract

In the western United States, wildland fires burn across landscapes, through different land tenure types managed by different institutions and individuals. Thus, wildland fire risk must be managed through collaborative governance. This collaborative governance is the product of biophysical and social systems, as well as social networks. In these networks and governance systems, active reflexivity allows actors to reexamine current management practices in order to identify alternative management strategies and collaborative governance opportunities. With these dynamics in mind, this qualitative research presents insights garnered from twenty semi-structured interviews, conducted with identified members of a wildland fire risk governance social network in northcentral Washington in the western United States. Participants described organizational and biophysical structural barriers to collaboration as well as potential opportunities, such as creating more institutional incentives and positions and pursuing collaborative restoration projections. Participants also described the characteristics that make effective collaborators, such as personal passion. Finally, these data demonstrate the importance of reflexivity for wildland fire risk managers when assessing and adopting collaborative governance strategies. These findings offer insight for improving the collaborative governance of wildland fire risk in this and similar social-ecological systems.

Keywords: transboundary; wildland fire; risk; governance; reflexivity; collaboration; social network

1. Introduction

Wildland fire risk is not bound by social, political, or economic boundaries: wildfires burn across landscapes, transmitting fire from one land tenure to another (e.g., private lands to public and vice versa), and affect landscapes in complex and context-specific ways (Fischer et al., 2016a; Roos et al., 2016). As a result, wildland fire risk in transboundary social-ecological systems (SES) is governed by a variety of state, federal, and local public agencies and private individuals and organizations with diverse missions, visions, and actors (Steelman, 2016). In this context, SES are landscapes comprised of both human systems and biophysical systems that are reciprocally related (Anderies et al., 2004). Moreover, in transboundary SES, where cross-boundary wildland fire risk threatens physically adjacent land tenure types governed by different individuals and institutions, different public and private actors must collaborate in order to successfully govern wildland fire risk (Bodin & Nohrestedt, 2016; Fischer et al., 2018).

For these reasons, wildfire, and the associated risks it poses in specific SES, cannot be managed effectively by any one actor or institution in isolation and efforts to manage wildfire risk must be coordinated across individual, local, community, state, and federal scales and jurisdictions in order to be successful (Palaiologou et al., 2018); which is to say, actors across these different institutions need to collaborate (Brooks et al., 2006; Floress et al., 2011; Johnson & Becker, 2015). Successful collaboration is affected by social network structures as well as the specific types of actors that actively create and maintain connections in that network (Bodin & Prell, 2011). This process is, in part, the product of “reflexivity” (Rodríguez et al., 2018).

Reflexivity describes a process of examining cause and effect whereby an individual reflects on and reexamines their understanding of complex systems (Bourdieu & Wacquant, 1992). Which is to say, reflexivity is how people think about how they think. Thus, reflexivity often prompts wildland fire managers to reconsider their wildfire risk management options (Ruane, 2019), including increasing their collaborations across institutional boundaries (Cheng & Randall-Parker, 2017), which in turn leads to identifying new management ideas and innovations generated by sharing knowledge (Sol et al., 2018). These innovations increase the institutional capacity of these agencies to managed wildland fire risk effectively (Butler et al., 2015). This collaboration also serves to bolster more localized governance and fills missing capacity in existing management (Margerum, 2007).

This paper presents qualitative research aimed at understanding this collaboration and actor reflexivity in a specific wildland fire risk governance social network centered in northcentral Washington. This region is experiencing more frequent and higher severity wildfires in an increasingly transboundary wildland-urban interface setting (Ager et al., 2017). By interviewing identified members of this social network about their experience with and opinions on collaboration, these data reveal more nuanced details about the different drivers of relational ties between actors in a social network aimed at transboundary wildfire risk governance. In order to differentiate between different possible factors that may facilitate or present barriers for collaboration, this work is focused on examining structure (i.e., factors outside of an actor's control such as the organization and distribution of connections in the network, official job/institutional responsibilities, and/or biophysical realities) and agency (i.e., factors within an actor's control such as how they chose to interact with others in the network).

The objectives of this research are two-fold: 1) to explore how and why actors take particular roles/actions in a wildland fire risk governance social network and 2) to better understand advantageous and disadvantageous network, institutional, role, and/or actor characteristics according to network actors. In this context, actors are considered to be people identified as part of the social network, whereas 'roles' refer to that actor's role in the social network and/or their role in their institution(s). This qualitative research addresses the following research questions:

Research Questions

1) What do actors identify as promoting or limiting collaboration on wildland fire risk governance?
    a. How do actors discuss biophysical and/or social network structure?
    b. How do actors discuss the importance of personal agency?
2) How does reflexivity emerge in discussion of collaborative governance?

2. Relevant Literature and Theoretical Framework

Previous research has shown that connections in social networks can be the product of social structures and/or the agency of actors (Bodin & Prell, 2011; Yung et al., 2010). In some SES, structure and/or personal agency may be more or less consequential to effective governance (Cheng & Randall-Parker, 2017). This depends on both the social and biophysical aspects of the SES in question (Steelman, 2016). These SES and corresponding wildland fire risk are conjointly constituted (Vickery et el., 2020) by a relationship between biophysical and social systems (Huntington et al., 2006). Thus, wildland fire risk and wildland fire risk governance strategies cannot be completely generalized to all contexts (Fischer et al., 2016a). However, with proper contextualization, these results can inform researchers and managers looking to understand and achieve better wildland fire risk governance.

This research examines personal, institutional, and network characteristics that facilitate more effective and reflexive collaborative governance of wildland fire risk. Achieving more effective wildland fire risk governance ultimately serves to promote the National Cohesive Wildland Fire Management Strategy (NCS) goals of more resilient landscapes and fire adapted communities (Lee et al., 2011). In order to achieve these goals in pursuit of the NCS vision to better "live with fire," stakeholders need to collaborate across different individual, community, and institutional scales (including non-profit organizations as well as local, state, and federal agencies) (Brenkert-Smith et al., 2017; Roos et al., 2016; Williams et al., 2012). More than a synonym for cooperation, true collaboration is a process of joint decision-making by different "stakeholders in a problem domain directed towards the future of that domain" (Bouwen & Taillieu, 2004, p. 141).

The problem domain in this context is shared wildland fire risk (McCaffrey, 2015), where the stakeholders are situated across different agencies and institutions (Fischer et al., 2016b). In complex systems, such as transboundary SES that experience wildfire (Higuera et al., 2019), multiple stakeholders engaged in collaboration can enact more successful management strategies (Margerum, 2007). This collaboration can be facilitated by encouraging active engagement and communication between actors in order to achieve more complete conceptions of the system (Daniels & Walker, 2012). In order to achieve this level of collaboration, governance systems need to move away from "top-down planning-implementation" towards "active and responsible membership [from stakeholders] across levels" (Bouwen & Taillieu, 2004, p. 144). This will lead to innovation in wildland fire risk management strategies and increases insitutiuonal capacity in wildfire risk govervance structures (Butler et al., 2015). These structures (e.g., top-down and/or distributed authority), will be reflected in the social network of stakeholders (Bodin & Prell, 2011).

2.1. Social Network Theory

Social network analysis is based on the idea that cultural, political, and economic facts are relational in nature rather than an aggregate of individual actions (Bodin and Prell, 2011). The social structure of these relationships presents emergent properties (Bodin et al., 2006). Social network analysis is now applied throughout a diverse range of scientific disciplines (Knoke & Yang, 2019).

Understanding social networks is important for understanding both the formal and informal governance of natural resource systems (Chang et al., 2012; Leahy & Anderson, 2010; Prell et al., 2010). Interviewing members of a social network reveals important insights about the social network and, by extension, the wildfire governance system situated in a specific geography (Fischer et al., 2016b). For instance, Spies et al., (2018) performed a social network analysis of fire-prone landscapes in Oregon, revealing that the social network is split into fire protection and fire restoration “subnetworks” bridged by a few key organizations that collaborate.

The structure of a social network is defined by quantity and distribution of connections between actors as well as the position of actors in the social network. Actors in social networks make connections for instrumental reasons (i.e., in order to achieve something) (Bixler et al., 2016), and due to similarity in personality and/or institutional objective (McPherson et al., 2001). In network theory, some people tend to play critical roles in collaboration (Scott & Thomas, 2017). The structure of these actors between otherwise disparate groups of individuals is a construct referred to as “betweenness” or “betweenness centrality” (Everett & Walente, 2016). Thus, social network structure as well as specific members of social networks are important for successful collaborative governance because they foster collaboration and social learning among actors (Folke, 2006) and promote adaptive management that increases resilience (Folke et al., 2017). This social learning and collaboration leads to shared mental models of the system between actors (Daniels & Walker, 2012).

What is not clearly understood is what the personal, institutional, and network characteristics and different mental models of the network are that lead to actors taking specific roles or actions in a social network (Dominguez & Hollstein, 2014). Also, to what extent are these factors a function of a specific biophysical landscape? Since wildland fire risk is conjointly constituted by both biophysical and social systems in specific SES, understanding wildland fire risk governance social networks needs to consider this dialectic dynamic (Fischer et al., 2016a, 2016b).

2.2. Conjoint Constitution and the Role of Reflexivity in Social Networks

Understanding fire risk and effective fire risk governance in transboundary settings also requires an understanding of the conjoint constitution of wildland fire risk (Paveglio et al., 2017; Vickery et al., 2020). Conjoint constitution refers to the socioenvironmental co-creation of environmental systems in a reciprocal relationship between social construction and biophysical conditions (Freudenburg et al., 1995). The product of this process is referred to as SES. In these SES, governance actions in human systems and interaction with natural systems such as wildland forests begets subsequent decisions and biophysical dynamics in natural systems, which affect both natural systems and human systems.

In the context of wildland fire risk, this is the recognition that fire risk management strategies are socially constructed by stakeholders in social networks in response to the undeniable material reality to the conditions that contribute to wildland fire risk frequency and intensity (Champ et al., 2012; Paveglio et al., 2016). With these insights in mind, management decisions based on human understanding affect both biophysical wildland fire risk realities as well as the structure of the wildland fire risk governance social network. See Figure 3.1.

The complexity of these systems means that members of wildland fire governance social networks engage in active reflexivity in order to reconsider their understanding of the system and facilitate cooperation within their networks, change the social network, and produce different outcomes, which is the focus of this paper. See Figure 3.2.

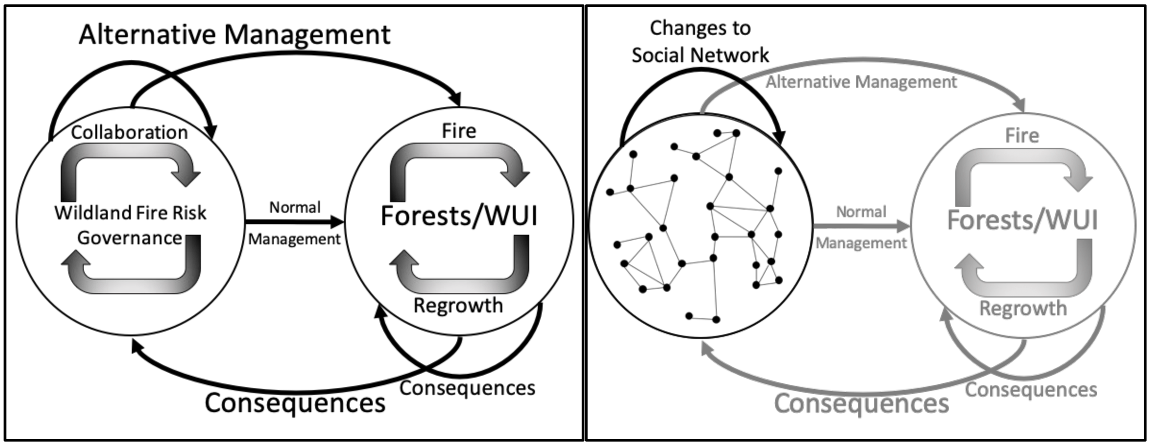

Fig. 3.1 Normal and alternative management of wildland fire risk on the left and the same model on the right with the position of a social network in the model highlighted.

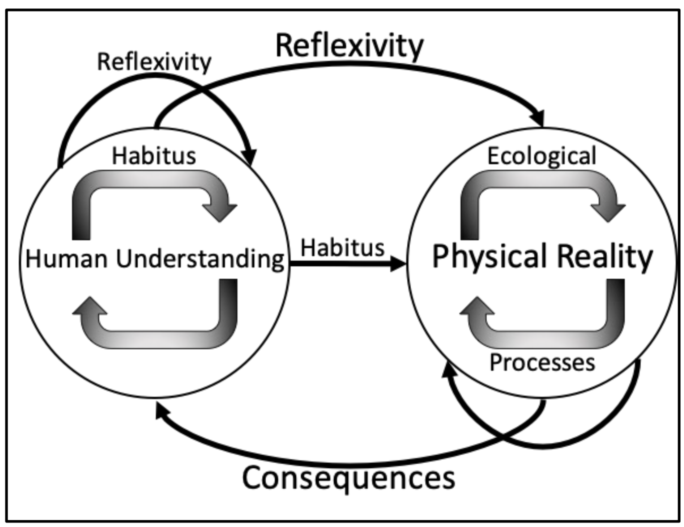

Fig. 3.2 The function of reflexivity and habitus in the management of natural systems.

Reflexivity is individual and collective reflection on the construction of knowledge in order to reconsider actor understanding of the system, which leads to innovation (Cheng & Randall-Parker, 2017). Reflexive wildland fire risk management is, therefore, innovatively aimed at intentionally transforming these systems in order to achieve different outcomes.

Conversely, habitus describes the automatic or unquestioned actions of managers and other stakeholders in the system that reiterate the structure of the system (Costa et al., 2019). Habitus is not necessarily inferior to reflexivity. In fact, many aspects of wildland fire risk governance work well as the product of habitus, such as the incident command system that is activated to manage wildfires, seamlessly resulting in a clear and recognized chain of command (Paveglio et al., 2015). However, the impacts of climate change and other biophysical stressors to the biophysical system have consequences that will force managers in wildfire risk governance and other relevant stakeholders to reconsider current management practices (habitus). Thus, alternative management strategies such as prescribed burning, forest restoration, and increased collaboration may need to be pursued (reflexivity).

By utilizing reflexivity to assess actor perceptions, more nuanced categories of actors may emerge. Reflexivity is useful in examining the perceptions and mental models of actors (Jacobson et al., 2009; Rodríguez et al., 2018). Understanding the mental models of actors in a social network may reveal ways that those mental models can alter the effectiveness of social networks (Senge et al., 2007). Mental models refer to the ways that individual actors conceive of complex systems and shared mental models occur when actors conceive of the system similarly (Champ et al., 2012).

Successful collaboration will also produce shared mental models (Daniels & Walker, 2012). Reflexivity also serves as a reminder that actor perceptions about collaboration and the social network are not completely accurate (Bourdieu, 1998; Long et al., 2013), but those perceptions will actually alter systems and networks in order to conform to actor perceptions (Bourdieu, 1984). Given this, not all actors have equal influence on the social network (Bodin & Crona, 2009; Matous & Wang, 2019). Therefore, it is important to understand the perceptions and reflexivity of those identified as occupying a structurally important place in the network.

3. Methods

Although this research is informed by the results of a social network analysis conducted by researchers at Portland State University (PSU) (Nielsen-Pincus et al., 2019), the methods employed in this analysis should not be misconstrued to be social network analysis. Rather, this is a qualitative analysis based on twenty semi-structured interviews with members of a wildland fire risk governance social network who were identified by a social network analysis conducted by PSU researchers. Respondents to a social network survey conducted by researchers at PSU were used as the sampling frame. These survey data identify the structural positions of actors based on their position in an institution as well as based on the number and distribution of their connections within the network.

A semi-structured interview guide was developed collaboratively with PSU researchers (Appendix 3.1). Semi-structured interviews were conducted in-person and were audio recorded and then transcribed. In these interviews, participant mapping of a social network was used as a reflexive activity to spur discussion. Transcripts of each interview were analyzed for emergent themes related to the main research questions. Interview data was analyzed through reflexive thematic analysis.[13]

3.1. Study Area

The wildfire risk governance social network being studied is centered in northcentral Washington. Although members of the network reside in and/or work across the state of Washington, the Pacific Northwest, and/or the Intermountain West, actor inclusion was based on involvement in wildfire risk governance in northcentral Washington, specifically. This centrality was achieved via the social network analysis methods employed by researchers at PSU, who initiated their survey protocol with a workshop in Wenatchee, Washington. State, federal, local, and non-governmental actors were invited to participate in the workshop and given a survey. These institutions included the U.S. Forest Service (USFS), the U.S. Bureau of Land Management (BLM), the National Oceanic and Atmospheric Administration (NOAA), Washington State Department of Natural Resources (DNR), and Non-Governmental Organizations (NGO). From here, a chain referral method was used to recruit other members of the network.

3.2. Sampling

Respondents who completed the PSU social network survey comprised the sampling frame for this study. From this sampling frame, a stratified random sampling

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[13] This research protocol was submitted and approved by Utah State University's Institutional Review Board. Participants were provided with a Letter of Information (Appendix 3.4). Participants were informed of the study goals and objectives and they were informed that they could decline to participate at any time by notifying researchers via email, verbally, or any other method of their choosing to withdraw their consent. Digital audio files and transcriptions of the audio files were kept in a secure password protected folder along with other digital files. Physical files were kept in a locked filing cabinet. Any names mentioned in the interviews were deleted during transcription of the audio recordings.

was implemented based on participant institution and number and distribution of their connections within the network, which is called “betweenness centrality” (Wasserman and Faust, 1994) or “betweenness” (Everett & Walente, 2016). This stratified random sampling was employed in order to make sure that the sample included actors with very low, low, medium, and high betweenness scores across five institutional strata (i.e., Washington State, NGO, local or municipal institutions, USFS, and other federal agencies), see Table 3.1.

Table 3.1 Number and distribution of participants in sample separated by strata.

	Betweenness Scores			
Institution	**0.000 – 0.001**	**0.001 – 0.005**	**0.005 – 0.01**	**0.01 – 0.022**
State	2	2	3 (out of 9)	3 (out of 5)
NGO	2	2	0	3 (out of 3)
Local	2	2	3 (out of 3)	3 (out of 7)
USFS	2	2	3 (out of 3)	0
Other Federal	2	2	1 (out of 1)	1 (out of 1)

Participants were given a betweenness score between 0 and 0.022 based on the number of otherwise not connected participants in the network. Most participants had a betweenness score lower than 0.005. For participants with a betweenness score below 0.005, two participants were randomly chosen, stratified based on their institution. Above 0.005, three participants were contacted. Based on this threshold and the institutional alignment of actors, forty individuals were contacted. Participants were contacted via e-mail (Appendix 3.3). A follow up e-mail was sent after one week.

Of the forty actors contacted, a total of twenty participants responded, agreed to participate, and were able to make time for the semi-structured interview while I was in their area, see Table 3.2. I conducted these interviews across the state of Washington,

Table 3.2 Participant number and type.

Participant Number	*Institutional Type*
Participant 1	NGO
Participant 2	NGO
Participant 3	Local Politician
Participant 4	BLM
Participant 5	DNR
Participant 6	Local Fire District
Participant 7	DNR
Participant 8	NGO
Participant 9	BLM
Participant 10	Local Fire District
Participant 11	DNR
Participant 12	NOAA
Participant 13	Local Fire District
Participant 14	NGO
Participant 15	USFS FMO
Participant 16	Local Fire District
Participant 17	NGO
Participant 18	DNR
Participant 19	NGO
Participant 20	DNR

from Olympia to Spokane.[14] Interviews were conducted between June 1st and August 15th 2019. One of the difficulties of conducting interviews during this timeframe was the fact that this timeframe comprises a significant portion of the wildfire season in northcentral Washington. Since this was a constraint for all the actors contacted, I do not believe this led to a non-response bias. After completing these twenty interviews, new participants were not contacted because content saturation had been reached.

[14] These interviews included: one USFS Forest Fire Management Officer (FMO), one local politician (city mayor), four Washington DNR employees (two in Olympia), two BLM employees, four local fire district employees (three fire district chiefs), five NGO employees (across four different organizations), one NOAA employee, and finally, two conservation district employees.

3.3. Interview Protocol

Through semi-structured interviews, participants explained their mental model of the wildland fire governance system and social network by describing collaboration and their role in wildland fire risk governance. Participants who agreed to an interview chose the time and place to conduct interviews. In this research protocol, certain questions were always asked, which were intended to refer specifically to research questions about the importance of structure and agency. These questions are in bold in the interview protocol (Appendix 3.1). Midway through the interview, participant mapping was also utilized to further elicit participant mental models. Although I knew the participant's institution, I did not know the participant's betweenness score during interviews or analysis in order to reduce influence on the interpretation of interviews.

Participant mapping has been utilized as a valuable tool for understanding social networks and individuals' roles in those networks (Cascavilla et al., 2015; McCann et al., 2016; Wilson & McDonald, 2018). In these interviews, participants were given a piece of paper with a blank diagram on it (see Appendix 3.2) and asked to write the names of people and institutions they collaborate with. They were then asked to draw the connections between these people and institutions. After participants finished drawing their networks, they were asked to delve deeper into their mental models through more probing questions. This participant mapping process facilitated the co-creation of interview data, but the models themselves were not actually utilized as research data. Rather, this process served as a catalyst for further elaboration of participant perspectives during the interviews.

3.4. Analysis

I used a modified reflexive thematic analysis was utilized based on the approach outlined by Braun and Clark (2012, 2019; Braun et al., 2018). This process was adapted to suit this research question and theoretical framework, consistent with the reflexive theoretical engagement prioritized by this method (Braun et al., 2018). More than a recipe or step-by-step process, reflexive thematic analysis describes the active and reflexive process of developing codes by a researcher who constantly and knowingly “bends back” or reexamines their production of themes (Braun & Clarke, 2019).

This reflexive thematic analysis began during the process of conducting interviews through notes recorded on emergent themes. Although the interview protocol did not change based on these emergent themes, the interviewer continued to note whether emergent themes were repeated in subsequent interview and/or if new themes emerged. These emergent themes and answer categories served as the first round of thematic coding.

Before full reflexive thematic coding and analysis could begin, the interviews were transcribed. The interviews were then uploaded into the qualitative research program NVivo 12. Afterwards, each interview was reread for initial codes and new themes were identified related to the two main research question about collaboration and reflexivity. Also, sub-themes related to network structure, biophysical structure, and actor agency were identified and categorized within the larger theme of collaboration. The context of these themes was examined in order to determine the topics and portions of the interview where these themes emerged.

Thus, themes were associated with specific questions and/or topics. For instance, in order to identify responses related to collaboration, quotes and themes were selected based on when they came up in the interview (e.g., was it in response to collaboration specific questions?) and/or based on the response itself (e.g., was the participant clearly talking about collaboration and/or using the words “collaborative,” “coordinate,” etc.?). Responses and themes related to structure and agency were similarly identified. Identified themes were then recoded based on evidence of reflexivity. Any response that revealed awareness that wildland fire risk is actively constructed, contested, and changing according to actor understanding and subsequent governance systems was categorized as reflexive.

For each theme, exemplary quotes were selected and compiled into a document structured according to themes and specific interview questions. These quotes were identified according to the portion of the interview where they emerged (e.g., during participant mapping). Lastly, the text search function in NVivo 12 was utilized to search the entire dataset for text exemplars related to each theme and exemplary quotes and results were then also coded accordingly. Additional exemplarily quotes were added to the master list of themes and exemplary quotes. With this list as a guide, the results of these interviews were written and organized according to research questions. Quotes were selected that demonstrated the themes and observations being described.

4. Results and Discussion

Qualitative results and corresponding themes are presented with discussion, organized by research question. Themes are identified with italicized headings in each section. Section 4.1. provides results and discussion that address the first research question. Subsection 4.1.a. addresses network and biophysical structures whereas subsection 4.1.b. addresses the importance of actor agency. Although reflexivity emerges throughout these results, section 4.2. addresses the second research question about reflexivity in participant responses. Section 4.3. provides a list of explicitly reflexive governance strategies. Finally, section 4.4. addresses the importance of agreements.

Interviews with members of this wildland fire risk governance social network reaffirm the importance of biophysical and network structures for enabling or limiting collaboration. Participants also attributed a great deal of importance to personal initiative and agency. When asked whether institutional and/or network structure or personal agency is more important for promoting collaboration, the answer is often: “it’s both. You can’t work outside your authority. And it has to be about [your personality]” (Participant 7). This dialectic between structure and agency is consistent with previous literature on collaborative natural resource management (Margerum, 2007), social networks (Bouwen & Taillieu, 2004), and adaptive wildland fire risk management (Cheng & Randall-Parker, 2017; Rutherford & Schultz, 2019), particularly in transboundary landscapes (Palaiologou et al., 2018).

Reflexivity is identified by participants as instrumental to collaboration. Through reflexive examination of their own roles and collaboration activities, participants discussed gaining insights into the overall structure of the network and their role in it, consistent with network theory (Bodin, 2017). This allows actors to reexamine their mental model of the system and expand them to account for more complexity (Daniels &

Walker, 2012). Participants also identified specific actions, projects, policies, structures, and positions that were reflexively aimed at changing wildland fire management.

4.1. Factors Promoting and Limiting Collaboration

Participants identified institutional structures and objectives as well as biophysical factors, such as forest fuels and the issue of smoke, as structural factors affecting collaboration. Participants also identified personal passion, flexibility, and willingness to work towards other actor's objectives as key themes that enable successful collaboration.

Importance of Personal Passion

One theme that often prompts actors to take collaborative initiative is personal passion about wildland fire governance more than a natural tendency to associate:

> I wouldn't say that collaboration is my strength, necessarily, or what I'm super interested in. That said, in order for the organization that I lead, which I care passionately about, for us to go out and safely operate in this interagency environment, it requires that we have good collaborative relationships and thus, in my position, I'm shirking my duties if I don't create those relationships (Participant 15).

Many participants spoke of effective collaboration with and support from other institutions. A BLM employee explained that, "we've gotten to treat all the land the same regardless of ownership… we need to treat it all the same… everybody agreed to it… we're all running on the same template" (Participant 9). This level of collaboration was described as having improved in recent years:

> I feel like the state has stepped up. They finally have gotten it. I mean, the state and [the] Forest Service didn't work together hardly at all five years ago. And now that's dramatically changed" (Participant 17).

Collaborative Wildfire Incident Response as Habitus

When asked about collaboration, many participants highlighted wildfire incident response. For instance, the USFS FMO explained that:

> The other major part of my job is… building an organization that's effective at fire suppression and that weaves in all of our cooperators, local fire districts, Department of Natural Resources, BLM fire organization, North Cascades fire … and how we interact and work together to protect our communities (Participant 15).

This is the direct result of a decision to combine the wildland fire Incident Command (IC) teams into interagency teams:

> Ten years ago they inter-combined the [IC] teams… On my team, I have DNR. I have local government. I have Homeland Security. I have retirees. We're all mixed, and all the teams up here in Washington are that way (Participant 9).

According to this participant, as a result of this decision "there's just been a lot more collaboration and coordination and willingness to work together up here."

Wildfire response follows the IC system (Paveglio et al., 2015), which is extremely automated and "there are very clear rules, organization, and nobody questions it" (Participant 11), which is habitus rather than reflexivity (Costa et al., 2019). Thus, habitus promoting collaborative wildfire response is a theme. But participants indicated that collaboration before and after a wildfire incident requires a different approach.

Need for Reflexive Collaboration Before and After Wildfire

Another theme is the assertion that collaborative mitigation prior to a wildfire event and/or collaborative adaptation after a wildfire event are difficult to achieve due to the very rules that promote effective and collaborative wildfire incident response:

> Before or after [a wildfire]… managing a forest, whether it's the Forest Service or [the state]… that operational mindset of 'follow the rules, do what you're told, don't ask questions,' [makes] collaboration very difficult. Ingenuity and creative thinking are very difficult because it's not in the box (Participant 11).

Thus, inflexibility within and between institutions in meeting different institutional objectives and a lack of reflexivity in navigating institutional bureaucracies is limiting collaboration before and after wildfire incidents:

> The local forest service does not engage local practitioners. For us, it's been a consistent pattern of them not showing up to whatever planning meetings [or] to homeowner collaborative meetings. We just don't see it. That doesn't mean it's not happening. And it doesn't mean that our priorities and [our] objectives meet theirs to where they should be at the table. But when asked, we often get no response (Participant 10).

Reflexivity is required to overcome these barriers (Ruane, 2019).

Reflexivity is a collective process (Sol et al., 2018), driven by highly engaged individuals (Cheng & Randall-Parker, 2017). For instance, multiple participants identified the new Washington State Commissioner of Public Lands, Hillary Franz, as a one of these engaged individuals, who is working to increase collaboration across institutions:

> It was a complete 180 switch to get to someone who is now a cheerleader. I mean, Hillary is just all about collaboration and working across lines. We've signed [the] Good Neighbor Authority, which means we can go on to Forest Service lands to do timber harvests. That money will then go in a pot to be reinvested in forest health treatments (Participant 11).

Another participant discussed how they had once played a similar role in the creation of interagency IC teams:

> There was a great deal of conflict between the Washington DNR and the [Forest Service]. Okay? And the DNR decided to pull out of any relationship with Forest Service. Okay? I had a lot of dealings with DNR. And the fire staff here, at the time, a fellow named [redacted], asked me if

> I'd be willing to be a DNR IC [incident commander} with Forest Service, working for the Forest Service (Participant 1).

However, despite the undoubtable importance of specific actors, one participant warned that “no endeavor should be one charismatic person away from failure” (Participant 2).

‘Collaboration’ vs Collaboration

Another theme is the distinction between official collaborations and the actual act of collaborating. Unlike collaborations that emerge organically from the efforts of motivated individuals (Bouwen & Taillieu, 2004), many official collaboratives are comprised of actors based on official role rather than personal passion: “Forest Service people use ‘collaboration’ and ‘a collaborative.’ I'm talking about informal [collaboration]” (Participant 2). Many participants distinguished between official collaborations or collaboratives as a noun and the actual act of collaboration as a verb; not all official collaborations are truly collaborative. As one participant whose job entails increasing collaboration between communities and state and federal managers expressed:

> You go into a lot of collaboratives, you come in, you talk about the projects, and sometimes I'm like, ‘Who is this for?’ Is this just to get the okay to move on?... That doesn't feel collaborative. It just feels like you're voting (Participant 8).

Which is to say, true collaboration requires more than just showing up. As one Washington State employee described: “I've collaborated… where these other people want to collaborate… for their objectives, and to hell with mine… But it has to be a two-way collaboration” (Participant 5). This distinction serves as a reminder that collaboration “is a tool that you can use but it's only an appropriate tool when you have sort of a more leveled playing field” (Participant 17). Therefore, collaborative governance is not always the most appropriate management strategy for addressing wildfire risk (Carroll & Paveglio, 2016).

Federal and state agencies should be careful not to use collaboration as a means of establishing social license to take actions only in line with their own institutional objectives (Fleming et al., 2015), without considering power dynamics (Orth & Cheng, 2018): “In some watersheds, the Forest Service is the 800-pound gorilla in that collaborative. And in others, they're just one of many and it might be industry, Department of Natural Resources, Tribes…” (Participant 20). Another participant described:

> I've been a part of several different collaboratives, and every time everybody goes around the room and they say their title first instead of why they're there… they're asserting power… And so all of the attention turns to that power. Where's the funding? Where's the resources? Who has pull in policy? Who has pull in making decisions? Instead of it being a truly collaborative nature (Participant 8).

However, these roles also promote collaboration.

Actors Wearing a Lot of Hats (Having Multiple Roles)

Many participants talked about engaging in collaboration from multiple roles as another theme. For instance, when asked if they remembered how they identified themselves in the PSU survey, one participant indicated that:

> I don't even remember what I marked. Because I have several hats. So my background, I've been a first responder… I've been in the community as a business owner for a long time… I have a lot of community connections, and that's what, in turn, led me to be the director of the long-term recovery group (Participant 3).

Also, when participants identified other actors they saw as key collaborators, these multiple roles were used as a criterion. For example, a NOAA employee indicated that they saw another actor as a key collaborator because:

> [They are] connected with the stuff happening at the top level in the country in fire and postfire and kind of that NGO world, and I never would have even known that stuff was happening if it wasn't for [redacted]… because she has worn a lot of hats, she just sees how things can operate (Participant 12).

However, multiple roles also served as a potential barrier to collaboration. Another participant indicated that “it's tricky, because you have all these partners engaged all across Washington state who are [pause] – [omitted 1] wears a lot of hats, and they're all big hats. [Omitted 2] wears a lot of hats, big hats” (Participant 3).

Tired of Talk – All About Action

Although having many roles can facilitate collaboration, it can also be a barrier to action and implementation. When one of the participants who identified themselves as wearing multiple hats was asked about how they see themselves as a collaborator, they simply stated:

> It's a combination… it depends on the reception. It depends on how far I think I can get with them, who can actually deliver something. I'm about results… and I want to see – I am so tired of talk, and I am all about action (Participant 3).

Although collaboration evokes the idea of communication, and, simply put, talking, many participants expressed frustration that sometimes these discussions take time away from implementing management activities (Schultz et al., 2018). As another participant stated that, “I think we get this disconnect where we all collaborate really well on these ideas. But it's getting the work on the ground that's the disconnect” (Participant 10).

4.1.a. The Function of Structure on Collaboration

Consistent with other research on wildland fire management (Murphy et al., 2016), participants talked about both the social and biophysical rules of wildfire in these conjointly-constituted social-ecological systems; wildland fire risk and fire risk management strategies are socially constructed by stakeholders in social networks in combination with the material reality of the conditions that contribute to wildland fire risk frequency and intensity (Champ et al., 2012; Paveglio et al., 2016). Wildland fire risk perceptions are socially constructed as well (Reid & Beilin, 2014), and lead to different governance structures (Rawluk et al., 2017). Thus, governance structures as well as biophysical realities change the biophysical probability of wildfire frequency and intensity in specific landscapes (Fischer et al., 2016a).

Network Structure is Necessary, But Not Sufficient

As a theme, state and federal employees expressed that although they wanted to collaborate more, they felt as though their official job description, which affords them administrative authority, limits their ability to truly collaborate. As one Washington state employee explained: “It's not in their job description… the position description is basically what Wildfire Division needs the job to do. But then… when [that employee] shows up… [collaboration] is what I actually want [that employee] to do” (Participant 11). This added responsibility adds to stakeholder burden. In their interview, the local politician indicated that they were “working on getting four hours of sleep” because “this work comes at a cost” (Participant 3).

Collaborative Burden

Participants identified this burden as potentially leading to actors leaving institutions and, by extension, the network. This theme of attrition is identified as a real threat to governance since it takes actors some time and experience to learn the biophysical reality of wildfire in these landscapes, specifically. One DNR employee expounded, “the challenges we have with retention – keeping trained, qualified people here… [we’re] losing institutional knowledge at every level” (Participant 18). Reflexively, participants recognized that this was the product of the current governance system, which is inflexible and overburdens collaborators. Although wildland fire risk collaborations are important (Ager et al., 2016), overburdening collaborators can undermine effective governance and waste actor’s and institution’s time and energy (Fleming et al., 2015).

The Paradox of Inflexibility Due to Maturing Collaborative Capacity

Many participants indicated an ironic theme that when collaboratives and partnerships matured and gained more monetary and political capital, the flexibility of actors in the network is reduced. One participant explained their decision to leave a partnership they helped create by stating that they felt that as the organization matured, opportunities to innovate became more difficult, and they “felt constrained, and that’s why I left” (Participant 2). To some degree, this may be inevitable (Eriksen & Selboe, 2012). But flexibility is an important feature of effective natural resource governance systems, especially when there is a high degree of uncertainty (Chapin et al., 2007; Cheng et al., 2015). Thus, the biophysical structure also affects collaborative capacity.

Needing 100 Years to Solve a Problem 100 Years in the Making

Collaborative wildfire governance is partially a product of the biophysical reality of wildland fire risk in these landscapes that affects “relationships… just because of the way fires move here” (Participant 18). This is due in part to a long history of fire suppression (Ager et al., 2016), which has led to the built up of fuels in even-aged forests that are more susceptible to high intensity wildfire events (Houtman et al., 2013). Many participants reflexively acknowledged the theme that the current biophysical reality of wildland fire is the product of previous conceptions of wildland fire risk that led to management activities that in turn created current biophysical conditions:

> We spent over 100 hundred years creating this problem with really, really good fire suppression which completely changed the fuel profile. So it's going to take maybe that long to unwind this thing, right? And some major investment on all of our parts - private landowners included - to make that happen (Participant 18).

This ‘unwinding’ of the current state of these forests requires collaboration, and alternative management strategies such as managed low-intensity and prescribed fire (Thompson et al., 2018).

Where There Could be Smoke, There Isn’t (Prescribed) Fire

As a theme, concerns about smoke prevent the implementation of these alternative management strategies. Out of twenty interviews, concerns about smoke came up in eleven of them. One NGO employee and member of several forest collaborations expressed frustration over the difficulty of getting prescribed fire on the landscape:

> The only way we can increase our prescribed fire is to expand the way that we – expand money into it but expand in the way we have to live with some smoke during the spring and fall... And we can't lobby state

> government, which is really frustrating. The developers can and they do (Participant 17).

This is a well-documented problem in wildfire risk management (Engebretson et al., 2016). Ironically, however, suppressing low intensity fires and allowing fuels to build up increases the possibility of future, higher intensity wildfires that can’t be suppressed as effectively and which will release significant amounts of smoke (Houtman et al., 2013).

A USFS FMO explained his decision to suppress a recent wildfire that he felt could have been allowed to burn safely and, more importantly, should have been allowed to burn because it would effectively treat several acres of forest with built-up fuels. He made the call to suppress the fire because:

> This community has a very low tolerance for smoke, and the reason they have a low tolerance for smoke is that when there is smoke in the air, tourists from the west side [of the state] do not come here… the entire tourist economy grinds to almost a halt, and [in] the short period of time that these businesses have to make money, that really makes them mad (Participant 15).

As the forest FMO, this participant could have allowed the fire to burn, but altered his decision due to his connection to the community. Similarly, a DNR employee stated:

> I'm a community member here. I'm definitely invested in what this community does and how we are able to address wildfire… Last year we were under a level one evacuation which I helped inform and tell the law enforcement to put in place. So, it's kind like, oh, yeah that's right. My house is in that area, so [laughter] (Participant 18).

Thus, community is an important structural factor. This finding is consistent with a wealth of literature on natural resource management broadly (Bennett et al., 2017; Brehm et al., 2006; Flint & Luloff, 2007; Theodori, 2005), and wildfire specifically (Abrams et al., 2016; Nielsen-Pincus et al., 2018; Paveglio et al., 2009; Williams et al., 2012). Those findings are echoed here, where actor roles within the community lead to more successful collaborative governance outcomes. This indicates that an active community field is facilitating interaction among individuals (Wilkinson, 1979). For instance, some participants identified collaboration with community members and other stakeholders as a potential solution, as one Conservation District employee described:

> A group called the Okanogan River Airshed Partnership [which is] focused on air quality issues of which wildfire smoke is one. And so some of the stuff we've been working on has been smoke-ready communities as a concept and sort of preparing people for wildfire smoke and how to handle that and how to protect themselves (Participant 14).

Trying to Lose Less (i.e., Adjusting Expectations for a New Normal)

Some participants described trepidation that state and federal agencies may not be completely realistic about the potential efficacy of collaborative and/or alternative management given the current reality of wildfire risk. One NGO employee explained that:

> Right now, we have a pretty progressive commissioner of public lands [Hillary Franz], and she's still making a pretty significant mistake. She is kind of alluding - would be the word that I would use - to the fact that if we do… more prescribed fire, more fuels treatment, more home hardening - our suppression costs are going to decrease. I don't think that's true, and I don't think the data we have… reinforce that link to the degree that they are alluding (Participant 2).

Due to the size and scope of current biophysical conditions, which are exacerbated by a warming, drying climate, and a rapidly expanding wildland-urban interface (Littell et al., 2018), an extended period of increased fire frequency and intensity may be inevitable (Moritz et al., 2014). Instead this participant offered:

> My goal is not to win all the time. I'd love that, but that's not very realistic. I want to lose less, and I want to lose better. I want to bounce back faster. I

> want to be more prepared for the loss. I want to avoid the loss, if at all possible, but there are going to be bad days. The bad days are coming. It is hot here right now. That wind starts ripping, the climate's warming, our population's exploding. Bad days are coming and we're going to lose. And so the question is how do we lose less? And lawmakers, policymakers, that is a really unattractive proposition because it requires acknowledging loss (Participant 2).

This participant is concerned that putting time, money, and effort into these strategies and policies based on unrealistic expectations may ultimately undermine collaborative governance efforts.

As a theme, investment in new wildland fire management strategies presents inherent trade-offs (Spies et al., 2018). Even with properly adjusted expectations, the biophysical and institutional realities of this conjointly constituted problem require that stakeholders constantly reevaluate their strategies (Vickery & Brenkert-Smith, 2020). Indeed, participants expressed an awareness that the biophysical condition of forests in northcentral Washington will necessitate that managers and other stakeholders have to adjust to some unavoidable realities. In the face of these realities, effective collaborative governance potentially offers better outcomes, but collaborative governance is not a promise for perfect or lossless solutions (Bodin, 2017), and indeed many negative outcomes may be unfortunately unavoidable (Littell et al., 2018).

4.1.b. Actor Agency and Successful Collaboration According to Participants

Participants felt that it was up to individuals to take the initiative to collaborate according to their personal strengths. One participant explained that "you have to identify your strengths. And then try and cater to that role with that job description, right?" (Participant 3). So, while the need to collaborate is perhaps a product of the system

(Daniels & Walker, 2012), actors need to take it upon themselves to do the work of collaboration (Cheng & Randall-Parker, 2017). Therefore, institutionalizing collaboration as a part of one's job description is important, but not sufficient. As one local fire district chief succinctly summarized: "it's my role and personality" (Participant 6).

Importance of Personality and Personal Relationships

Regardless of job description, another theme emerged that, ultimately, it's the individual in the role who chooses how to do their job in a way that plays to their strengths. With this in mind, collaboration between those who respond to fire and those who manage forests and/or communities in the long-term can be complicated by divergent personalities and goals between actors. One participant explained that:

> There's a different mindset to first responders, and that kind of preparedness and response mindset or mantra doesn't always jive with what the rest of the organization in the Forest Service has going, who are, perhaps biologists who are managing a piece of ground for that particular interest, that particular program (Participant 15).

This speaks to the difficulty in merging wildland fire response with longer-term governance aimed at improved adaptation and mitigation, which requires actors to work hard to build and maintain relationships with specific individuals in different positions in the network; a key to this collaboration is building trust because "collaboration moves at the speed of trust" (Participant 19). This trust leads to collaborative capacity (Brooks et al., 2006). Building trust is often the product of building close personal relationships:

> There's definitely that blend of where those personalities just mesh, right, where you're like, yeah, let's go have some beers, right? Let's talk about things at a different level and in a lot of times those don't necessarily even need to be work-related, so. Yeah. There's overlap (Participant 18).

Many participants felt that personal relationships facilitated collaboration, but could also complicate things: “Your professional relationships and your personal relationships are often the same, and that's what enables a lot of progress on the professional scale, but it also creates a mess” (Participant 8). So, again, it takes the right kind of person who can work with a lot of different kinds of people, build personal relationships, utilize that social capital without overburdening those relationships and somehow maintain a separation between personal and professional aspects of the same relationship. Acknowledging the high bar this sets for actors, one participant even described the necessary type of person as “a unicorn” (Participant 2).

Contradicting Importance of Personality

While participants identify individual agency as necessary for achieving collaborative governance solutions, another theme involved many participants admitting that this was not their personal style or natural tendency but simply the most successful way to achieve their goals:

> I think if you read my job description, collaborating with others is something that is encouraged, but I think-- I don't know-- with my personality or whatever, I'd sometimes probably take that collaboration maybe in a little different direction that wasn't envisioned, or take it further than it might be spelled out. For example, the state parks [collaboration], I don't think that was on anybody's radar screen (Participant 20).

Rather, personal passion and dedication are among the most important traits identified for collaboration. This finding provides elaboration on previous findings that highlight the importance of individual collaborators in adaptive wildland fire governance (Cheng & Randall-Parker, 2017).

Regardless of motivation, the creation of meaningful relationships built on trust are crucial for effective collaborative governance, consistent with similar research (Brooks et al., 2006). These relationships are the product of both institutional (e.g., USDA Forest Service, BLM, Washington DNR) and societal structures (e.g., community) where both professional and personal connections define network structure. For instance, reflexively examining the smoke management plan and relationship between the state DNR and USFS led to improvements in collaborative governance:

> I would just articulate that with the meetings we've gotten with the Forest Service. It's, 'what is it that the Smoke Management Plan is keeping you from doing?'… They said that, well, they have trained themselves to only ask for small burns because they know we will always say 'no' to a big burn. [But] that's not in the Smoke Management Plan anywhere. So why have we done that?... Obviously, it's going to be more difficult because that's more smoke but we can make accommodations to get that done. So to me, that's collaboration right there, it's learning why they did that. And it was because we basically trained them to do that. So how do we gain that trust back? (Participant 11).

Professional and Non-Professional Connections Built on Trust

Informal social ties were identified as a very important theme for collaboration since meaningful relationships built on trust is the key to successful collaboration (Stern & Coleman, 2015). Participants described the process of building trust as a slow process, built out of a series of successes where actors fulfilled their obligations, consistent with other collaborative networks (Fischer & Jasny, 2017). Thus, collaborative capacity takes time and effort to achieve (Cyphers & Schultz, 2019), but could be undone much more quickly (Schultz et al., 2019), due to the loss of specific actors or changes in institutional structure (Sol et al., 2018), which was identified by participants as a potential threat to collaborative governance. Also, actors in federal and state agencies face structural barriers to collaboration (Fischer et al., 2016a). On the other hand, efforts to institutionalize collaboration can potentially erode true collaboration by replacing personal passion and responsibility with professional responsibility.

Therefore, creating official collaboration positions such as liaisons and/or including collaboration in job descriptions is a necessary but not sufficient condition for collaboration. Furthermore, merely adding ‘collaboration’ to job descriptions or creating collaborative positions without filling those positions with the right people and allowing for the time it takes to build trust could actually undermine collaborative capacity (Brooks et al., 2006). Organizations need to allow their members the leeway to collaborate (Cheng & Randall-Parker, 2017), and they also need to encourage and reward it in practice (Williams et al., 2009). There are other structural aspects of the network that may be necessary as well. For instance, the structure of the communities themselves and the integration of actors in multiple institutions and fields promotes collaborative capacity (Williams et al., 2009).

4.2. Reflexivity in Collaborative Wildland Fire Risk Governance

By acknowledging the difficulty of collaboration and attempting to explain the complexity of the network, participants engaged in active reflexivity. Participant responses often centered on an explicit recognition that how actors think about wildfire risk and institutional responsibility in turn creates wildfire risk realities. Reflexive participant responses also included an awareness of how the network was structured prior to a series of key wildfire events that lead to the current composition of wildland fire risk governance systems.

Reflexive Dialectic Relationship Between Structure and Agency

Interviews revealed a theme where actors felt they needed to game the system. Put one way, by an NGO employee: "we have to play the institutional game – and right now all of these collaborations [take time]" (Participant 2). Poignantly reminiscent of Pierre Bourdieu's famous illustration of reflexivity as a player's understanding of the rules of a game (LiPuma, 1993), participants often utilized metaphorical game terms such as "rules," "positions," and "objectives." Participants reflexively understood that they are bound by these rules and their positions on the field (i.e., network, institutional, and literal position in the landscape). But, they articulated a desire to change the rules of the game in order improve governance outcomes, which is reflexivity (Sinclair et al., 2017).

These data reveal that when tensions emerge in this dialectic, reflexivity allows participants to change their understanding of the system and/or identify ways to change the system in order to align more closely with potential collaborative governance strategies (Cheng et al., 2015). Understanding this dynamic helps reveal opportunities and threats to improving collaborative governance of wildland fire risk (Rutherford & Schultz, 2019), allowing actors and institutions to overcome barriers while maintaining flexibility (Steger et al., 2018).

Trial by Fire – Having the Right People in the Right Places at the Right Time

One remarkable aspect of the wildland fire risk governance social network in northcentral Washington is the amount of collaborative capacity that exists compared to other regions in the western United States (Nielsen-Pincus et al., 2019). When asked why the wildland fire risk governance system in northcentral Washington is this way, several participants pointed to that the fact that certain people, partnerships, and organizations were active prior to major fires from 2013 – 2015. As explained by one participant:

> So I'm going to go back to 2015 because that was pretty much the catalyst for a lot of this stuff. The Sleepy Hollow Fire. So if you look at the fire adapted communities learning network, and how those kind of things go together… we had the Sleepy Hollow Fire. That was one week after the city of Wenatchee was absorbed into Chelan District 1… And just timing was right. Right place, right time (Participant 16).

These fires included the Okanogan Complex Fire (2015), the Carlton Complex Fire (2014), and the North Start Fire (2015), which were the largest, second largest, and fifth largest fires in the state's history, respectively.

Fortunately, partnerships and programs such as the Washington Fire Adapted Communities Learning Network (WaFAC), which was established in 2013, and the Chumstick Wildfire Stewardship Coalition, which was established via a Community Wildfire Protection Plan (CWPP) in 2008, were in place prior to these fires. These partnerships enabled specific stakeholders to reach out during and immediately after these fires in order to promote community resilience:

> We officially formed in August to September of 2014. And there were three different communities that were involved… And so those three geographical locations created one board to stream resources in, and to be able to funnel information in and out with a large network. So we made sure no one was left in the dust, or wasn't getting covered (Participant 3).

The success of these collaborative partnerships led to increased recognition and institutional support, increasing the size and scope of collaboration in the system. This theme aligns with literature on collaborative governance (Brooks et al., 2006). Equally as important as having these collaborative structures in place was having the right people in these positions, which is also consistent with literature (Cheng & Randall-Parker, 2017).

Thus, the existence of these networks in place prior to these large wildfires allowed for more effective wildland fire governance. A key here is "collaboration... working with statewide networks… Having a statewide network, which helps to make a more educated group of people around these issues. That ultimately supports our mission" (Participant 4). Conversely, "The more siloed you are, the more chances you're getting miscommunication and somebody's going to not be accounted for and be in the wrong place at the wrong time" (Participant 15).

4.3. Explicitly Reflexive Wildland Fire Risk Governance Strategies

When asked about how the network has changed over time, or how they would like the network to be different, participants called attention to several explicitly reflexive wildland fire risk governance strategies. These strategies served to change stakeholder mental models of the system, which would in turn change the system, or they are aimed at directly changing the system in order to align with ideas about how to better manage wildfire risk. These strategies include, but are not limited to: a guide to fire resistant landscaping, the creation of a community liaison position in a local fire district, the expansion of WaFAC, and the recognition of the multiple benefits of agreements between federal and state agencies and other institutions. More details are provided below.

Fire Resistant Plants Guide

As a prime example of the relationship between reflexivity and collaboration, a guide to fire resistant landscaping was developed by a partnership between the Cascade Conservation District, the Washington State University (WSU) Extension Master Gardener Program, Washington DNR, and the USFS. This guide is specific to the landscape ecology of Chelan and Douglas counties in Washington and is freely available in both English and Spanish (Chelan/Douglas County Master Gardener Program, 2017). By partnering with WSU Extension's Master Gardener Program, this guide serves to communicate wildfire ecology to different stakeholders and serves to address household wildfire risk by associating landscaping with wildfire risk. The guide opens with a direct statement: "a well-designed landscape around a home is key to reducing the risk of loss from a wildland fire" (Chelan/Douglas County Master Gardener Program, 2017).

This guide was the product of existing connections in the network, and also led to the creation of new connections in the network. One participant who played a key role in the creation of this guide explained during the participant mapping portion of the interview that the "WSU Master Gardener Program, they're in there" (Participant 10), as a result of this effort. Thus, this act of reflexivity increases collaborative governance.

Chelan County Fire One Created a Community Liaison Position

As another explicitly reflexive act, after the major fires from 2013 – 2015, one local fire district chief created a dedicated community liaison position. The creation of this position was explicitly intended to create and improve collaboration with community members and state and federal agencies. The creation of this position was in direct response to the difficulties faced in wildfire response and recovery after these high severity fires.

During interviews, many different participants referred to this community liaison when asked about collaboration or during participant mapping. In interviews with other local fire district employees, participants indicated that other local fire districts were looking to create a similar position based on Chelan County Fire One's success. Thus, the creation of a community liaison changed the way other stakeholders think about their own collaborative capacity and the potential utility of a dedicated community liaison. Furthermore, these community liaisons work to establish new connections and collaborations, which explicitly changes collaborative governance systems.

Expansion of WaFAC

Due to the pivotal role played by WaFAC during the high severity fires of 2013 – 2015, many participants indicated that this network has been intentionally expanded. The role of WaFAC in the Wildland Governance system is now significantly expanded and further institutionalized. When asked about their participation in WaFAC, one local fire district employee stated:

> There is no manual for [collaboration]. It is six people sitting around a table brainstorming, 'how do we figure this out?' And that is the type of work that is really valuable at WaFAC. And we do our conferences, we do our workshops, we call each other, we email, we will collaborate, and then we go out and party [laughter] (Participant 10).

Thus, WaFAC serves a vital role in establishing collaborative connections in the network. This network also facilitates the creation of official agreements between federal and/or state agencies and NGOs.

4.4. The Importance of Agreements

Federal, state, and NGO participants discussed the structural necessity for creating and renewing official funding agreements where money earmarked for treatment is spent on collaboratives or given to NGOs or local government organizations such as local fire districts in order to achieve these treatments. This has a cumulative benefit:

> It's just the network has just grown, and where we've… tested all these partnerships, like, 'Where do we have strength? And where do we have similar goals and objectives?' …the Land Trust for example… We had no relationship with them, other than when there was a fire on their property… But now, through my position, we're working with them to do fuels treatments and site education opportunities… My crew went up and thinned it and then they put up signage along the trail describing wildfire in the shrub-steppe... And so that partnership is now this really strong – and through the project work and success, we've moved that partnership from almost non-existent to now I collaborate with them all the time (Participant 10).

By putting money towards these agreements, this investment serves a double benefit of achieving forest management treatments as well as financially supporting collaborative capacity. And funded projects lead to new connections.

These agreements were used by participants to indicate successful collaborative governance. In their interview, the BLM employee indicated that: "we host about 70 local-government agreements for suppression and Incident Management Team suppression… So right now, we host about 200 team members through our BLM agreement" (Participant 9). However, this participant indicated that these agreements are currently under threat due to changes within the BLM. Similarly, the Forest Service FMO indicated:

> We've taken a huge step laterally, I think, over into the wildland-urban interface communities. We're a pretty big player in responding [monetarily] to our cooperators. And that's just the way it is… but again, we're not really funded for that… we're not really trained all that well for it, but we are certainly in it constantly. (Participant 15).

Conclusion

These results offer insights into the structural aspects and personal agency factors leading to collaboration in a wildland fire risk governance social network centered in northcentral Washington. Participants described the need to design more flexible wildland fire risk governance systems that allow for more collaboration across institutions. However, participants also acknowledged that, ultimately, successful collaboration requires a substantial expenditure of time and effort from specific individuals. Since these individuals need to be personally passionate, technically competent, and integrated into the community, participants expressed reservation about how many people could meet this description. Furthermore, after finding and/or training actors to fill these roles, these roles and the individuals occupying them need better institutional support in order to reduce actors leaving the system.

Without institutional support, current collaborative momentum could be at risk, especially as individuals burn out or move out of the system in favor of more stable employment. Promoting a combination of structural capacity and flexibility will allow actors to collaborate in ways that align institutional objectives across different institutions. This may require adjusting the duties of employees to allow them to attend meetings and support more egalitarian efforts. However, institutional support for collaboration could threaten the organic nature of the successful collaboratives that have emerged in northcentral Washington. Therefore, institutional support needs to be calibrated to collaboration realities in transboundary landscapes. This can be bolstered by the creation of official collaborative positions and expanding the use of agreements between institutions to achieve biophysical risk reduction.

Spending federal and state agency funds earmarked for fuels treatments on agreements with local institutions and NGOs serves a double benefit; through this mechanism, not only are acres treated but these funds serve to promote organizations that also increase collaborative capacity. Also, federal, state, and local institutions should consider creating dedicated 'liaison' positions with dedicated funding (rather than soft funding) in order to maintain network connections. However, more research is needed to assess the direct benefit of these specific roles in a wildland fire risk governance social network.

In conclusion, based on these data, federal, state, local institutions and NGOs should hire individuals who recognize the necessity for collaboration and possess the patience to see outcomes through to the end. Federal and state agency personnel may need to adjust their expectations about the immediate benefits of collaboration and recognize the potential for mutual benefits in a slower process. In order to treat more acres, collaboration between agencies through agreements will be necessary, as will adjusting rules that complicate collaborative governance such as laws governing air quality. Similarly, for alternative management strategies such as prescribed burning, politicians, managers, and other stakeholders need to properly adjust their expectations or they may inaccurately perceive these efforts as futile or ending in failure. These findings could inform future efforts aimed at improving collaboration in this network as well as other transboundary landscapes threatened by wildland fire risk across the western United States.

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Appendix 3.1: Interview Questions

INTRODUCTION [5 minutes]:

- Thank you for agreeing to this interview and your continuing involvement in this research.
- In the survey you filled out previously you mentioned that your role is [read answer] can you tell me more about that?

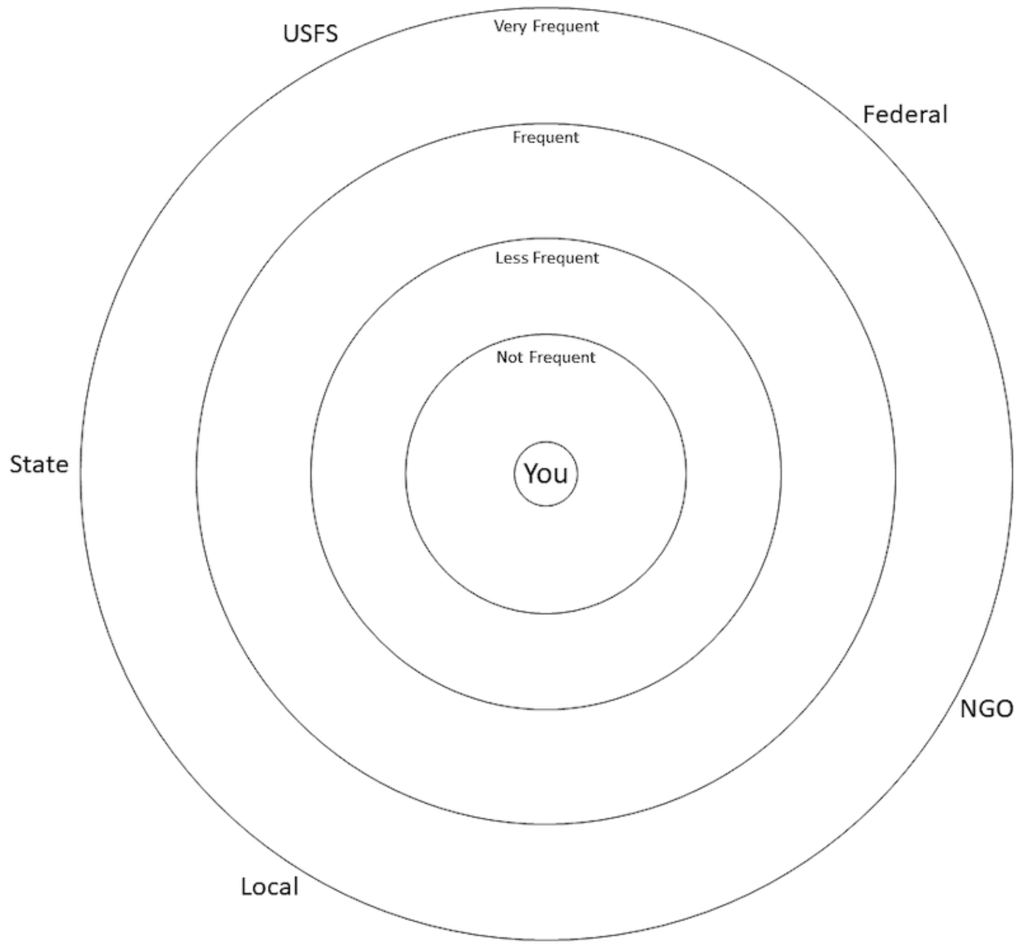
POSSIBLE PROBING QUESTIONS [20 minutes]:

- Can you please write down the primary people/institutions you interact with in this diagram and draw the connections between actors? [give diagram]
- Can you describe these connections?
- How do you communicate? Interact? By what modes? On what topics?
- In what ways could collaboration be improved?
- How have these relationships changed over time?
- What do you think are the critical factors that enable your relationships?
- Are there any relationships [here] that you would like to change?
- Are there people, agencies, or other entities missing that you would like to see included and why?

POST NETWORK MAPPING [35 minutes]:

- **What is your institutional mission? [structure]**
- **What are the current priorities for your organization? [structure]**
- **What is your role in the institution? [structure]**
- **How would you describe yourself in this process? [structure/agency]**
- **Is that based on your personality or your specific position? [structure/agency]**
- **We are curious about whether collaboration is a function of a job description or person's personality, what are your thoughts? [both]**
- **Does your role specifically involve working with others? [structure]**
    - Is there a difference between your personal role and professional role?
- **Do your supervisors or bosses support that collaboration? [structure]**
- **Do you see yourself as more or less of a collaborator than average? [agency]**
- **Qualifying questions [agency]**
    - Bring people together?
    - Mediator?
    - Do you see yourself as a bridge between groups?
    - Do you see yourself as more of an agent or go between?
    - Does your role exist to fills gaps?
- Are there any opportunities you see for improving wildfire management?
- Thank you so much for your time. Is there anything else you think I should know about managing fire risk in this place?

Appendix 3.2: Interview Instrument



Appendix 3.3: Contact E-mail

Dear (insert name),

I am contacting you today because of your prior participation in research for the Co-Management of Fire Risk Transmission Project. Specifically, you have participated in two previous rounds of surveys. We are now entering a phase of the project that involves expanding on this survey data through qualitative interviews.

Your participation in these interviews is completely voluntary, we know you have already contributed greatly. However, your input would be most welcome and extremely valuable.

Interviews will be taking place from May through August at a time that can be scheduled as far in advance as fits your schedule. I know fire season can be a busy time, so we appreciate any time you can dedicate. The interviews will take anywhere from 60-75 minutes, depending on the length of your answers.

If you agree to participate, we can schedule a meeting time and place that works best for you. I will follow up if I do not hear anything back in a week.

Attached is a letter of information with more details.

Again, thank you so much for all the time you have dedicated and information you have provided already and thank you in advance for helping with these interviews.

Have a great day,

Brett Alan Miller
[phone number redacted]
[email redacted]

Note: Any questions or concerns about the recruitment process can be sent to the project's faculty investigator, Professor Courtney Flint at [email redacted].

USU IRB Protocol #10110

Appendix 3.4: Letter of Information

Assessing the Quality of Connections in a Wildfire Governance Social Network

Introduction

You are invited to participate in a research study conducted by Brett Alan Miller, a PhD Candidate, and Dr. Courtney Flint, both in the Department of Sociology, Anthropology and Social Work at Utah State University. The purpose of this research is to better understand the relationships between fire managers in the wildfire governance system associated with Wenatchee Washington. Your participation is entirely voluntary.

As described in more detail below, we will ask you to draw a diagram of the wildfire governance system in Wenatchee Washington and ask you questions aimed at better understanding relationships between individuals. Someone like you might be interested in participating because of your work in the wildland fire governance system and helping researchers better understand this unique system. Although there are no risks associated with this study, you may not wish to participate. It is important for you to know that you can stop your participation at any time. More information about all aspects of this study is provided below.

This form includes detailed information on the research to help you decide whether to participate. Please read it carefully and ask any questions you have before you agree to participate.

Procedures

Your participation will involve being given a piece of paper with a blank diagram on it and writing all the names of the people who you interact with in your role as a wildland fire manager. After you have finished the drawings we will ask questions aimed at better understanding the drawing. The interview should take 60-75 minutes depending on the length of your answers. We anticipate that 40 people will participate in this research study.

Risks

This is a minimal risk research study. That means that the risks of participating are no more likely or serious than those you encounter in everyday activities. If you have a bad research-related experience or are injured in any way during your participation, please contact the principal investigator of this study, Dr. Courtney Flint, right away at [phone number redacted] or [email redacted].

Benefits

Although you will not directly benefit from this study, it has been designed to learn more about how to better understand wildland fire governance. We cannot guarantee that you will directly benefit from this study but it has been designed to solely learn more about wildland fire governance and how managers build and strengthen relationships.

Assessing the Quality of Connections in a Wildfire Governance Social Network

Confidentiality

The researchers will make every effort to ensure that the information you provide as part of this study remains confidential. Your identity will not be revealed in any publications, presentations, or reports resulting from this research study. However, it may be possible for someone to recognize your particular situation and activities.

We will collect your information through audio recording and notes of the interviews. Audio and written data will be securely stored in a restricted-access folder on Box.com, an encrypted, cloud-based storage system or in a locked drawer in a restricted-access office. Audio-recorded interviews will be transcribed and recordings will be deleted by 12/31/2020.

It is unlikely, but possible, that others (Utah State University, or state or federal officials) may require us to share the information you give us from the study to ensure that the research was conducted safely and appropriately. We will only share your information if law or policy requires us to do so.

Voluntary Participation & Withdrawal

Your participation in this research is completely voluntary. If you agree to participate now and change your mind later, you may withdraw at any time by telling the researcher that you wish to withdraw your participation. If you choose to withdraw after we have already collected information about you, we will delete all data we have collected related to your participation. If you chooses to withdraw after we have deidentified the data, we will not be able to remove their information, as we will be unable to determine whose data is whose.

IRB Review

The Institutional Review Board (IRB) for the protection of human research participants at Utah State University has reviewed and approved this study. If you have questions about the research study itself, please contact the Principal Investigator at [phone number redacted or [email redacted]. If you have questions about your rights or would simply like to speak with someone *other* than the research team about questions or concerns, please contact the IRB Director at [phone number redacted] or irb@usu.edu.

Courtney Flint, PhD	Brett Alan Miller
Principal Investigator	Co-Investigator
[phone number redacted]	[phone number redacted]
[email redacted]	[email redacted]

CHAPTER IV

SAVING THE FOREST FROM THE TREES: EXPERT VIEWS ON FUNDING RESTORATION OF NORTHERN ARIZONA PONDEROSA PINE FORESTS THROUGH REGISTERED CARBON OFFSETS

Abstract

Ponderosa pine forests in the southwestern United States of America are overly dense with volatile forest fuels, increasing the risk of high-intensity, potentially stand-replacing wildland fires, which result in the loss of terrestrial carbon and the release of carbon dioxide, contributing to global climate change. Restoration is needed to restore forest structure and function so that a natural regime of high frequency, lower intensity wildfires returns. However, the cost of this restoration limits the amount currently achievable. In 2015, in response to this dilemma, a methodology for the estimation and verification of the carbon benefits generated by the restoration of ponderosa pine forests in northern Arizona as registered carbon offsets was submitted for review by a carbon registry, but it was ultimately rejected. Through mixed-methods analysis, this paper analyzes the potential atmospheric carbon benefits of this carbon offset methodology as well as public and peer-reviewed comments from the associated review process. Results demonstrate potential reductions in released carbon, but also illuminate barriers that complicate registering these reductions as carbon offsets, such as uncertainty about the timing of carbon benefits, which will require reflexivity to overcome.

Keywords: carbon offset; ecosystem service; forest restoration; ecological modernization; reflexivity; alternative wildland fire management

1. Introduction

Worldwide, as climate change and expansion of the wildland-urban interface exacerbate wildland fire risk frequency and severity (Calkin et al., 2015), the potential utility of mechanical thinning and prescribed burning as forest restoration is receiving increased attention (Covington et al., 1997; Kalies & Yocom Kent, 2016). However, these forest treatments are difficult to implement due to prohibitive costs and other institutional barriers (Wu et al., 2011). Fortunately, emerging scholarship on the ecosystem service value of carbon sequestration presents a potential method of providing additional funds to meet restoration goals (Matzek et al., 2015; Waring et al., 2020).

Various methodologies are being developed that quantify the net benefit of reductions in atmospheric carbon from forest restoration as carbon offsets and/or credits (Walton & Fitzsimons, 2015). Where "carbon credits" refer to tradable reductions in carbon emissions that can be credited against an official limit or "cap" (Lippke & Perez-Garcia, 2008), voluntary offsets quantify reduced or avoided atmospheric carbon emissions that do not qualify as official credits (Wise et al., 2019). In Australia, legislation is already allowing carbon abatement attributable to forest restoration treatments to be considered tradable carbon credits (Perry et al., 2019).

Unfortunately, despite the consensus that these treatments will result in overall carbon emission abatements (Hurteau et al., 2008; Sorensen et al., 2011; Hurteau and Brooks, 2011), uncertainty about the timing and precise amount of sequestered carbon creates potential difficulties for registering this ecosystem service benefit as carbon offsets and/or credits (Halofsky et al., 2018). Moreover, the standards and practices employed by the carbon registries that verify, monitor, and ultimately register carbon offsets and credits are oriented towards projects on private land (Porter et al., 2020), whereas many forests in need of treatment are on public land managed by federal agencies for the public benefit. For instance, millions of acres of National Forest System Lands in the United States (U.S.), which are overly dense due to a legacy of logging and aggressive fire suppression (Brown et al., 2004; Moore et al., 2008), are managed by the U.S. Forest Service (USFS) and other federal agencies (Addington et al., 2018).

An estimated 65 to 80 million acres of USFS land need restoration to reduce the risk of forest loss due to high-intensity wildfire, drought, and disease (United States Congress House Committee on Natural Resources, 2013). Additionally, approximately 3.1 million forest acres need tree planting to assist with forest recovery (United States Department of Agriculture Forest Service, n.d.). Both restoration and tree planting activities require substantial and sustained funding commitments beyond what is currently available (Hurteau et al., 2016; Mavsar et al., 2012; Wu et al., 2011). Also, many of these forests are in cross-boundary landscapes where multiple different agency jurisdictions and private land ownership abut, further complicating restoration efforts and costs (Charnley et al., 2020; Cyphers & Schultz, 2019).

Quantifying carbon abatements from forest restoration and tree planting on public lands as registered carbon offsets presents an opportunity to increase private funding for the shared stewardship of these public and cross-boundary landscapes. This will require wildland managers to reexamine their current management strategies and protocols for implementing forest restoration (Ruane, 2019). One region in the U.S. where this restoration is particularly important is the southwestern U.S. due to a combination of climatic and biophysical factors that make forests in this region particularly vulnerable to high-intensity, stand-replacing fires (Williams et al., 2015). Specifically, ponderosa pine forests in northern Arizona are overdue for restoration aimed at restoring their natural adaptation to more frequent and lower intensity wildfires (Covington et al., 1997; Graham et al., 2004; Hurteau et al., 2016). This paper presents a mixed-methods examination of one such restoration-based carbon offset methodology.

In 2015, the American Carbon Registry (ACR), a prominent carbon registry in the U.S., began the approval process of a methodology aimed at increasing restoration of northern Arizona ponderosa pine forests entitled "Southwestern Forest Restoration: Reduced Emissions from Decreased Wildfire Severity and Forest Conservation" (Woods & Plumb, 2016). This carbon offset methodology, which was developed by Katharine Duffy (formally Woods) and Spencer Plumb (2016), with support from the National Forest Foundation and Northern Arizona University, provides a carbon accounting framework for the measurement, monitoring, reporting, and verification of carbon emission abatements from the reduced risk of high-intensity fires and the continued carbon sequestration of restored forests after treatment (American Carbon Registry, n.d.). After three years of public comment and a two-year peer-review by a panel of subject matter experts, this methodology was ultimately rejected.

The research presented here is a mixed-methods examination of the Southwestern Forest Restoration (SFR) methodology aimed at understanding: 1) the potential net carbon abatement of the SFR methodology, and 2) the rationale for rejecting this methodology as a registered carbon offset program. The methods employed in this paper include an analysis of forest model data (provided by SFR methodology authors) projecting the effects of restoration on total surface carbon, and a review of public and internal peer-review comments from the period of 2015 – 2019 on the SFR methodology (which are publicly available), respectively. Thus, this analysis is a post-mortem of the rejected SFR methodology in order to understand why it was rejected by ACR and how the issues that caused it to be rejected can be avoided in the development of future methodologies.

The sequential transformative mixed-methods (Creswell, 2009) approach employed in this research facilitated a robust program and policy analysis of the SFR methodology proposal to generate carbon offsets on public lands through restoration and the possibility of integrating federal directives, forest plans, and project level procedures with the standards that guide carbon registry best practices, including but not limited to the Greenhouse Gas Protocol for Project Accounting (Daviet & Ranganathan, 2005), American Carbon Registry Standards (American Carbon Registry, 2019), and the Climate Action Reserve Program Manual (Climate Action Reserve, 2019). Therefore, this research is aimed at revealing both opportunities and limitations for using carbon offsets and/or credits to address climate change more generally through forest restoration on federally managed public land (Waring et al., 2020). With these goals in mind, this research is aimed at answering the following research questions:

Research Questions:

1. What is the potential net atmospheric carbon abatement of forest restoration in northern Arizona ponderosa pine forests following the SFR methodology?
2. What do subject matter experts identify as incompatible about potentially generating carbon offsets through forest restoration following the SFR methodology?

2. Southwestern Forest Restoration and Generating Carbon Offsets

Reconsidering current forest management directives, forest plans, and project level procedures to incorporate carbon registry standards that verify and monitor carbon offsets for the generation of carbon credits will require considerable reflexivity by federal managers, voluntary carbon registries, and other subject matter experts. In social sciences, the concept of reflexivity simply refers to individual and/or institutional (re)consideration of how systems are understood and subsequently managed (Cheng & Randall-Parker, 2017). By reexamining the understandings that led to previous management choices and the consequences of those choices on the system, management practices can be reconsidered (Ruane, 2019). For instance, recognizing that years of fire suppression has actually led to increased wildland fire risk frequency and intensity is an act of reflexivity (Rodríguez et al., 2018).

Illustrative of the effects of these past management decisions, ponderosa pine forests in the U.S. Southwest are now particularly prone to increased wildfire risk and intensity. These forests are naturally characterized by low intensity, high frequency wildfires (Moore et al., 1999). This fire regime maintains a low-density forest structure with a stable carbon carrying capacity and maintained forest function (Fulé et al., 1997). However, these forests are now overstocked with small diameter trees (Dore et al., 2010). This new forest structure brings active fire into the forest crown, increasing wildfire intensity (Hurteau et al., 2008). See Figure 4.1 for an illustration provided by SFR

Fig. 4.3 Carbon consequence of wildfire in untreated southwestern ponderosa pine forests. Provided by SFR methodology authors and used with permission.

methodology authors, used with permission. Thus, millions of acres of southwestern forests require restoration in order to contend with the effects of past management choices (Brown et al., 2004), and to improve ecological function, including carbon sequestration and storage (Polley et al., 2013). See Figure 4.2 for an illustration provided

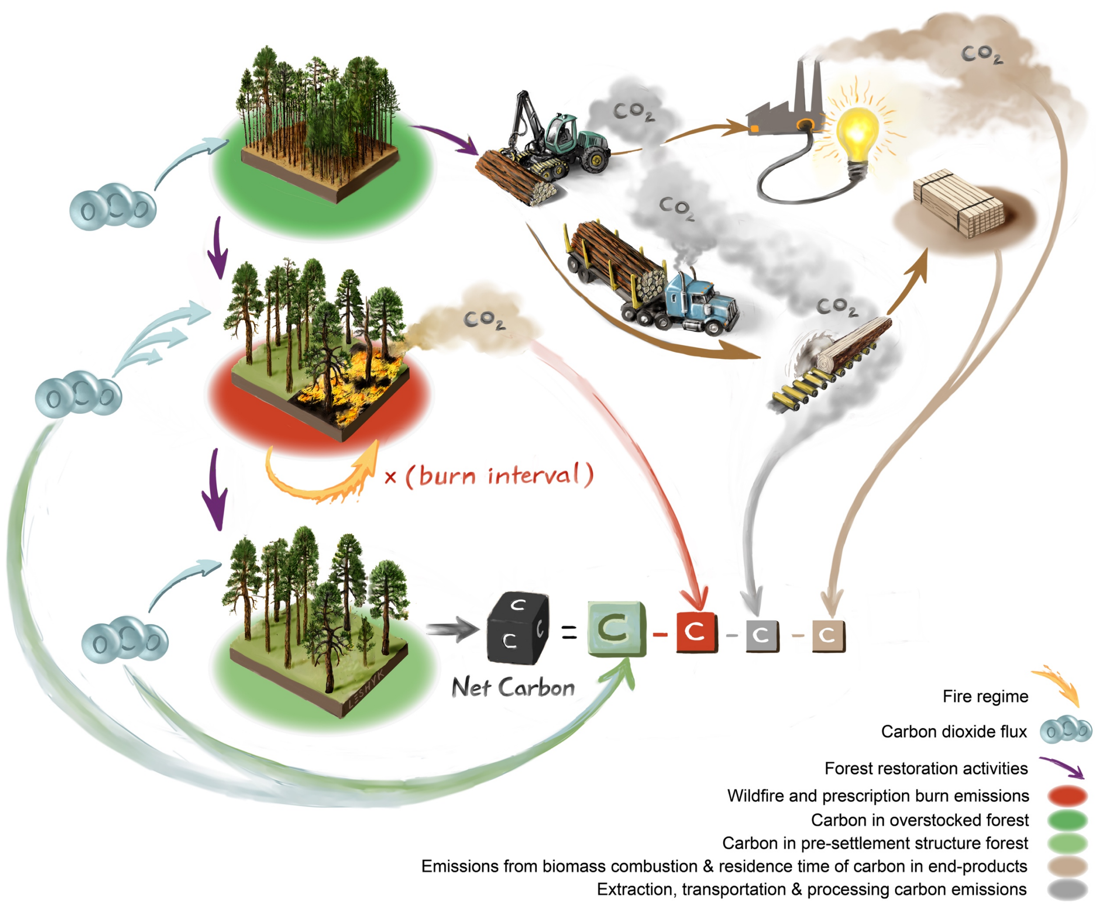


Fig. 4.4 Net atmospheric carbon gains due to restoration of southwestern ponderosa pine forests. Provided by SFR methodology authors and used with permission.

by SFR methodology authors, used with permission. However, this restoration remains prohibitively expensive and consequentially underfunded, particularly at landscape scales (Hjerpe & Kim, 2008; Stephens et al., 2012).

A number of financing mechanisms have been considered over the last decade to meet these funding shortfalls and accelerate restoration efforts. For instance, forest restoration is often funded through stewardship contracts that require restoration treatments as a part of timber sales (Powell et al., 2017). However, the smaller diameter wood produced through forest restoration treatments holds little commercial value (Wu et al., 2011). Therefore, additional financial mechanisms for aligning restoration benefits with restoration costs is required (Miller et al., 2017).

Voluntary carbon offset registration potentially provides this mechanism. If the carbon benefits of forest restoration could be registered as voluntary carbon offsets, then the sale of these offsets could help fund forest restoration. In order for this to work, a carbon registry needs to ensure that carbon offsets from restoration are based on verified, measurable, and monitored reductions in atmospheric carbon dioxide. Unfortunately, the standards and methodologies used by voluntary carbon registries have not been easily integrated with projects on USFS forests. For instance, the National Forest Foundations' Carbon Capital Fund (USDA Forest Service; National Forest Foundation, n.d.) established two voluntary carbon offset projects on national forests in Colorado and California, U.S. in the last decade (Kempka, 2017; Roosevelt, 2009), but no other registered carbon offset or carbon credit projects exist on USFS national forests (Kempka, 2017; Plumb, 2020, personal communication).

One such complication is the fact that registries typically require 100-year agreements to ensure the permanence of an offset (American Carbon Registry, 2019). While private landowners are able to enter into long-term agreements for such projects, public land agencies must follow more dynamic planning cycles that make these agreements untenable. Registries also require a transfer of offset title, which holds monetary value and represents the rights and interests associated with the carbon offset (Daviet & Ranganathan, 2005). Selling a property right for carbon stored on public lands could create a conflict with the public ownership of USFS land (Porter et al., 2020). Finally, the most difficult aspect of registering carbon offsets for the carbon abatement generated by forest restoration is the concept of additionality.

When considering carbon offset programs, both biophysical and financial additionality need to be considered (Wunder & Albán, 2008). Registered carbon offset projects need to establish that through intervention (in this case, forest restoration), additional carbon storage and/or sequestration will occur above a non-intervention baseline (Perry et al., 2016). Relatedly, it needs to be established that without additional financial capital (generated through the sale of carbon offsets), these interventions will not occur. This additionality can be hard to establish on public lands due to biological and managerial complexity at landscape scales (Urgenson et al., 2017). For instance, the USFS already prioritizes forest restoration and implements as much as financially possible, so clearly delineating the restoration paid for with carbon offsets (financial additionality) may be difficult (Halofsky et al., 2018). Also, after restoration, the uncertain timing of wildfire events complicates the calculation of biophysical additionality (Pacheco et al., 2015).

This additionality is precisely what is verified and monitored by carbon registries (American Carbon Registry, 2019). After implementation, carbon projects need to be continuously monitored in order to assure that project benefits are actualized (Wise et al., 2019). Verification and monitoring are costly and time-consuming (Goetz et al., 2015). Therefore, registering forest restoration as a verified carbon offset methodology presents additional costs and complicates an already complex process (Butler et al., 2015). However, precisely by generating funds through private investment, these financial costs could be allayed. Also, while facilitating restoration through registered carbon offsets increases restoration costs in the short-run, generating specific methodologies to register, implement, and monitor restoration projects on USFS national forests could allow the forest restoration process to be scaled-up and streamlined, leading to more efficient implementation and the development of other forest management innovations.

Pursuing and implementing forest management innovations (such as but not limited to incorporating the concept of carbon offsets into forest restoration practice) requires active reflexivity (Ruane, 2019). Through careful reflexivity, these managerial and technological innovations, such as the specialized tools required to achieve restoration (Schultz et al., 2018), provides tangible ecological benefits (Addington et al., 2018). These innovations could therefore be characterized as an act of ecological modernization, which describes the process of environmental management improvements stemming from economic development and technological innovations (Mol et al., 2014). The concept of ecological modernization in environmental social sciences serves as an alternative theoretical proposition to more critical theories that link environmental degradation directly to economic development and technological innovations (Dunlap & York, 2008; Gould et al., 2004; Rudel et al., 2011; York et al., 2011).

This debate over the role of economic development, technological innovations, and the potential for market-based solutions to solve environmental problems (McAfee, 2015) relates directly to the concept of achieving increased forest restoration through carbon offsets, and by extension the SFR methodology, because carbon offsets as a payment for ecosystem service is based on the ecological modernization proposition and the value of carbon offsets is derived from the value of reducing climate change (American Carbon Registry, 2019). The challenge for the SFR methodology authors in developing their methodology and then responding to reviews during the two-year peer-review by the ACR panel of subject matter experts, was to demonstrate that this innovation (i.e., payments for restoration of northern Arizona ponderosa pine forests) would necessarily lead to clear and quantifiable reductions in atmospheric carbon.

During this two-year review process, SFR methodology authors developed an ecological model to estimate the net carbon benefit of restoration in response to reviewer comments and questions. This model was created to provide some indication of when carbon benefits from restoration would occur, temporally, and to assuage doubts about the conceptual validity of generating carbon offsets through restoration. Therefore, some of the peer-review comments are in direct response to this ecological model and model output. The relationship between the ecological model developed by SFR methodology authors and peer-review comments established the basis for the transformative mixed-methods used in this analysis where output from this model was analyzed and then compared to a qualitative analysis of public and peer-review comments.

By estimating the potential biophysical additionality created by the SFR methodology (i.e., analysis of ecological model estimates of net carbon offsets over time) and comparing those results with a qualitative content analysis of the rationale for rejecting the SFR methodology from public and peer-review comments, the research presented here provides insights about the feasibility of generating carbon offsets through restoration in general and possible future approaches and/or methodologies. Both of these methods, together, provide more insight than either, separately. Reflexivity is ultimately required to interpret these results and address the larger question of whether or not this or similar market-based solutions can be implemented in the future.

3. Methods

Sequential transformative mixed-methods analysis of the SFR methodology took place in two stages. This method integrates quantitative and qualitative methods in a successive process to improve insights (Creswell, 2009). First, the model output data for a case study conducted by SFR methodology authors in response to reviewer comments and questions was analyzed by fitting a linear regression to modelled estimates of total surface carbon with a three-way-interaction of time, climate change, and treatment. Results of this regression analysis allowed for estimations of total surface carbon at different time periods under different climatic and treatment conditions. These results provide an illustration of potential restoration benefits for carbon storage in the case study area. Second, these results were paired with qualitative analysis of comments on the SFR methodology.

Qualitative assessment of public and internal peer-review comments on the SFR methodology provide a more detailed examination of the perceived potential benefits of and barriers to creating carbon offsets through forest restoration. These comments also reveal important insights into how subject matter experts conceptualize the idea of carbon offsets and/or credits more generally and the reasons this or similar methodologies may or may not be theoretically and/or operationally possible. Which is to say, these qualitative data expose the inherent complexity and potential complications of what seemed initially like a simple proposition.

Analysis of Total Surface Carbon Modelling

In response to peer-review comments and questions, SFR methodology authors constructed an ecological forest model of a case study area based on data from the Cragin Watershed Protection Project provided by the USFS. SFR methodology authors submitted this model, model outputs, and a report on the model and outputs as supplemental documents for reviewers during the peer-review process. These model output data were used for this regression analysis.

The study area for the ecological forest model is 64,433 acres, with 37,667 acres identified for thinning and 63,634 acres identified for prescribed burning. The study area is located approximately 55 miles south of Flagstaff, Arizona on the Mogollon Rim Ranger District of the Coconino National Forest (USFS, Decision Notice and Finding of No Significant Impact, 2018). Data on 220 forest plots was provided by the USFS, with data on planned fuel treatments by the USFS and data on fire behavior in the case study area. Out of 220 forest plots, 189 plots were actually used after data cleaning. Four climate change scenarios were applied to account for the potential effects of climate change under baseline and project scenarios.

Forest plot data were collected and compiled according to USFS protocols for Forest Inventory and Analysis (Forest Inventory and Analysis, 2007). These plots were originally sampled in 2014 within the study area for the purpose of a National Environmental Policy Act (NEPA) review of proposed forest treatments (USFS, Decision Notice and Finding of No Significant Impact, 2018). The Climate Extension to the Forest Vegetation Simulator modelling program was utilized to model these data at 10-year intervals from 2014 through 2054 with and without treatment under different climate change scenarios. In the model, forest treatments occurred within the first time step.

In this case study, SFR methodology authors extracted gridded mean fire return intervals using the LANDFIRE modelling program for each sampled plot, which were inputted to a Weibull distribution of fire probability for a calculated fire return interval with a shape parameter of 2 to indicate increased flammability of materials over time (Grissino-Mayer, 1999). Decadal estimates of wildfire occurrence were calculated from the Weibull distribution via the cumulative probability of fire at each time step after subtracting the previous time step's cumulative probability. This wildfire parameter was then applied as a percentage of the stand that burned within each time step. This entire process resulted in a total of 7,560 data points since each of the 189 forest plots was modelled at five time steps under four climate change scenarios for both the forest treatment and baseline (i.e., no treatment) scenarios.

For the regression analysis conducted as part of these mixed-methods, a linear regression was fitted to model output data with total surface carbon (measured in tons per acre) as the dependent variable, using Stata statistical software version 14.2 (StataCorp, 2015). A three-way-interaction among restoration treatment as a binary variable, year as an ordinal variable, and climate change as an ordinal variable served as the predictor in this linear regression. An interaction effect is tested for if there is a suspected relationship between independent variables on the dependent variable (Mehmetoglu & Jakobsen, 2016) such as the relationship between forest treatment and time on total forest surface carbon. Since this relationship is also affected by climatic variables (Addington et al., 2018), climate change scenario was added to this interaction. The climate change scenarios were: no climate change, low climate change, moderate climate change, and high climate change, based on climate projections used in the Climate Extension to the Forest Vegetation Simulator modelling program. See Figure 4.3 for the equation:

$$Y_i = \beta_0 + \boldsymbol{\beta_{rtc}X} + \varepsilon_i$$

Fig. 4.3 Regression equation where the dependent variable (Y_i) is total forest surface carbon (measured in tons per acre), which was regressed against a three-way-interaction where $\boldsymbol{\beta_{rtc}X}$ is a vector that covers year as an ordinal variable (r), forest treatment as a binary variable (t), and climate change scenario as an ordinal variable (c), with forty total combinations as independent predictor variables (X). The parameter β_0 is the total surface carbon intercept, while the unexplained portion of the model is captured by the residuals (ε_i), which are assumed to be normally distributed with a mean of zero.

In total, there were forty combinations of treatment, year, and climate change scenario. For each of these combinations, coefficients and the lower and upper bounds of 95% confidence intervals were added to the total surface carbon intercept (which is without treatment, in 2014, and without climate change) to establish forty surface carbon estimates. For this analysis, only the full model is interpreted, which is a valid approach to analyzing ecological model data (Whittingham et al., 2006); thus, the full model F-statistic and R^2 of this linear regression indicate whether the three-way-interaction has a statically significant effect on total surface carbon and (if so) how much variation in stored surface carbon can be attributed to this three-way-interaction (Mehmetoglu & Jakobsen, 2016). The main effect of each variable were not used in the regression model as the coefficients for these main effects are not interpretable since the phenomenon in question is the effect of restoration over time, and this relationship is unavoidably moderated by climatic variables.

Also, restoration treatment has an immediate and negative direct effect on stored surface carbon since this treatment constitutes the explicit removal of surface carbon. This would complicate interpretation of the main effect as well as each of the interaction terms if main effects were included in the model (Crawford et al., 2014). Even when excluding main effects, this complicates interpretation of interaction coefficients since the regression treats all carbon equally, operationally, which is not ecologically valid (Waring et al., 2020); the goal of the restoration is to change the *type* and *structure* of vegetation so that it is more resilient to wildfire. Unfortunately, these distinctions are not present in this analysis. With these caveats in mind, and by graphing the forty estimates of total surface carbon for each combination of variables, it is possible to observe changes in stored surface carbon over time with and without treatment. Combined with full-model statistics, results are interpretable (Whittingham et al., 2006).

Qualitative Analysis of ACR Comments

A qualitative analysis of public and internal peer-review comments on the SFR methodology provides a useful follow-up analysis to the model data analysis. The SFR methodology was submitted to the ACR for review in 2015. To review this methodology, ACR followed the process defined in the ACR Standard v.4.0 (Chapter 7) (Winrock International, 2015). ACR completed their internal review of the methodology in early 2016. Public comment was initiated in summer of 2016 and closed by August 17th. By mid-2017, ACR initiated an interval peer-review to determine if the SFR methodology qualified for verification.

A panel was assembled for this peer-review from experts in the fields of forest fire science, forest management, forest carbon offset project development and verification, forestry carbon modeling and remote sensing. Panel members were recruited from academia, governmental organizations, non-governmental organizations, and other private entities. These experts assessed the methodology and commented on the validity and/or appropriateness of the methodology as a carbon offset program. During this period AFR methodology authors completed and submitted the forest model, discussed above.

Four out of seven reviewers remained engaged throughout the two-year peer-review process and provided a final recommendation to ACR in May, 2019. The SFR methodology and revisions as well as comments, responses to comments, and the final recommendation are all available on the ACR website (American Carbon Registry, n.d.). These documents serve as the raw data for the qualitative portion of this sequential transformative mixed-methods inquiry.

A content analysis of these publicly available comments was conducted in order to identify patterns, themes, and biases of commenters and reviewers (Berg & Lune, 2012). Methodology, comments, revisions, and final recommendation documents were uploaded in NVivo 12 for coding and analysis. In vivo coding was used to code both manifest and latent content (Berg & Lune, 2012). Manifest content provides express and direct comments on the SFR methodology and potential feasibility of producing carbon offsets with it (Creswell, 2009). Latent content coding identifies the underlying theoretical position of commenters, reviewers, and methodology authors in document text (Berg & Lune, 2012).

For instance, examples of reflexivity that openly acknowledged the relationship between socially constructed and contested knowledge and structural reality at a landscape scale were coded as ‘reflexivity.’ Also, any comments that expressed uncertainty or provided uncertainty by questioning SFR methodology assumptions and assertions was coded as ‘uncertainty.’ Several similarly emergent themes were coded as documents were comprehensively read for technical content. These results were then compared to results of the linear regression, resulting in sequential transformative mixed-methods results where interpretation of each method in sequence provides better interpretation of the SFR methodology than each method in isolation (Creswell, 2009).

4. Results

Results of the linear regression predicting total surface carbon is statistically significant with F (39, 7520) = 11.02, $p < 0.0001$, and with an R^2 of 0.0541.[15] See Figure

[15] For coefficients and estimated surface carbon for each interaction term, see Appendices 4.1 and 4.2

4.4, which graphs surface carbon estimates reported in Appendix 4.2. The residuals of this regression model met parametric assumptions. Although the high amount of

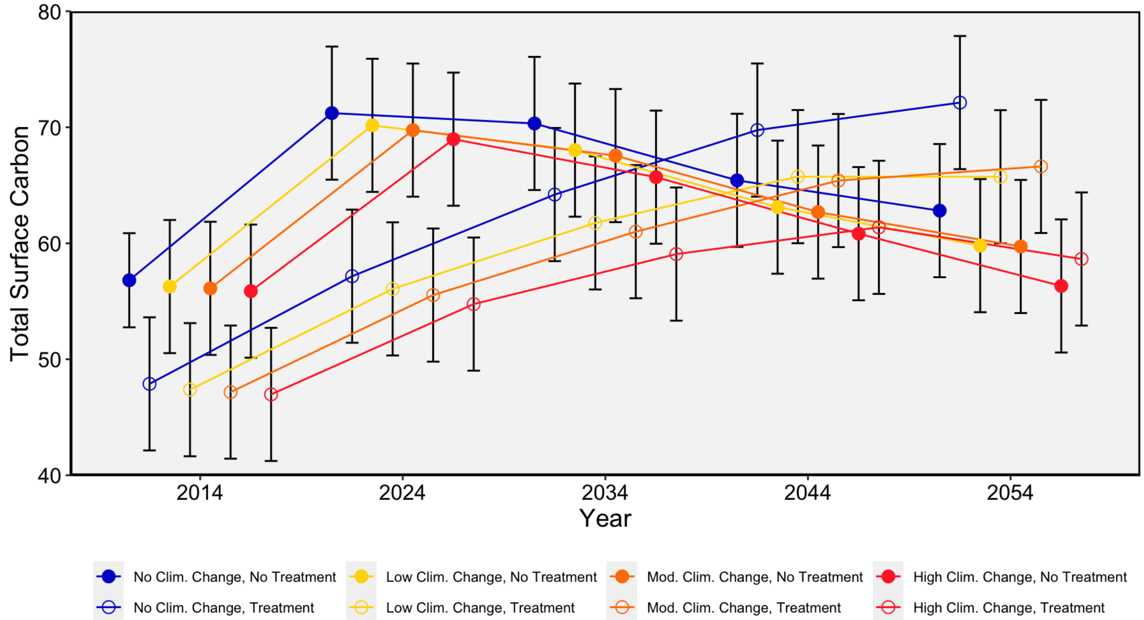


Fig. 4.4 Total surface carbon by treatment, year, and climate change scenario. This figure graphs the results of the linear regression predicting total surface carbon (measured in tons per acre) based on a three-way-interaction interaction among treatment, year, and climate change. Points with closed circles are *without treatment* whereas open circles are *with treatment*. The colors denote climate change scenario (see legend). Lines connecting points illustrate change in surface carbon over time (recorded along the horizonal axis). Without treatment, surface carbon accumulates from 2014 until 2024, at which point it declines. With treatment, surface carbon accumulates from 2014 until 2044 when carbon gains level off under low and moderate climate change scenarios and decline under high climate change. Comparing treatment to non-treatment, 2044 is the year when treated forests have more stored surface carbon in every climate change scenario. The model is statistically significant with F (39, 7520) = 11.02, $p < 0.0001$, and with an R^2 of 0.0541.

replications increases the likelihood of finding a statistically significant relationship, even if it is weak or there is a lot of uncertainty, these result show that under every climate change scenario, treatment (i.e., thinning and prescribed fire at the first timestep) results in more stored surface carbon by 2054 than if left untreated. See Table 4.1. Also, treated forests have more stored surface carbon in 2054 than untreated forests do in 2014. See Appendix 4.2. The net difference in carbon between the first and last timestep and/or between treatment and no treatment in 2054 is, therefore, considered additional.

Table 4.1 Total stored surface carbon in 2054, comparing ***with*** *and* ***without*** *treatment*, measured in tons per acre.

	Lower Bound		***Mean Surface Carbon***		***Upper Bound***	
	With	**Without**	**With**	**Without**	**With**	**Without**
No Climate Change	66.39	57.07	72.13	62.81	77.87	68.55
Low Climate Change	59.99	54.06	65.73	59.80	71.47	65.54
Moderate Climate Ch.	60.88	53.98	66.62	59.72	72.36	65.46
High Climate Change	52.91	50.58	58.65	56.32	64.38	62.06

More important than total surface carbon in 2054 is the direction of the change in stored surface carbon over time. See Figure 4.4. Where stored surface carbon is going up or plateauing under three of the four climate change scenarios with treatment (no climate change, low, and moderate climate change), stored surface carbon is going down under every climate change scenario without treatment. However, the variance in total surface carbon within the 95% confidence intervals reveals a substantial overlap between the results of treatment and non-treatment scenarios (see Figure 4.4).

Indeed, the relatively low R^2 of the model indicates that it only predicts a small amount of observed variance in total surface carbon, which is either due to a weak relationship, a high degree of uncertainty in model projections, or both. These confidence intervals suggest that uncertainty is leading to the low the R^2 (i.e., explained variance) of the model. This uncertainty is due primarily to the probabilistic nature of wildfire in the model since wildfire is the primary factor leading to surface carbon losses. However, since wildfire is added post hoc instead of being propagated through the forest model it's difficult to verify this supposition.

Uncertainty

The high degree of uncertainty regarding the precise timing and amount of change in stored surface carbon in this analysis is consistent with one of the more prominent critiques of the SFR methodology. For instance, in their decision to reject the SFR methodology, ACR cited a "lack of accurate and conservative assessment of uncertainty" as one of the six major reasons for rejection (American Carbon Registry, n.d.). The results presented here (Figure 4.4) demonstrate that uncertainty by calculating the 95% confidence interval for all time steps under a combination of treatment and climatic factors whereas in the SFR methodology submitted for review by the ACR, "the uncertainty is assumed to be zero" (Woods & Plumb, 2016). This prompted many commenters to highlight the issue of uncertainty as problematic with comments such as, "for this methodology to be credible it should at least acknowledge uncertainty not just in the magnitude of change, but the directionality" (Reviewer 1).

However, far from disapproving, comments on and reviews of the SFR methodology indicated a general agreement with and support for the basic proposition that increasing restoration will improve forest surface carbon storage. In their final decision, the ACR panel summarized their assessment by first praising the SFR methodology for being the "first of its kind… with many technical merits" (ACR website). This decision statement clearly articulates that:

> ACR and the peer review panel do not dispute the author team's assertion of the massive environmental benefit of the project activity, the urgency to

> conduct these activities nor the scientific literature demonstrating that without treatment, major losses of living trees and carbon sequestration in SW [southwestern] ponderosa pine ecosystems will occur… [but] the methodology was not recommended by the peer review panel (ACR Decision).

Thus, the carbon benefits potentially provided by the SFR methodology are not under dispute. Indeed, almost none of the public comments nor peer-review comments question if the methodology will produce carbon emission abatements, eventually. Critique is focused on modelling techniques: “I disagree that this case study shows clear evidence of carbon benefit. Not without at least estimating uncertainty” (public comment). Instead, comments focus on issues such as timing. One public comment concluded that “the relevant uncertainty is that surrounding the timing and magnitude of simulated carbon stock oscillations” (public comment). The primary driver of the timing and magnitude of carbon offsets is the timing and magnitude of wildfire.

When will the forest burn? In the model, wildfire risk is determined by a Weibull distribution of cumulative probability of wildfire based on LANDFIRE modelling, which results in a majority of the study area experiencing fire by 2034 (Figure 4.4). However, many reviewers felt that this was not precise enough nor accurate enough to enable reliable prediction of carbon benefits since those benefits are primarily driven by differences in fire frequency and intensity:

> [Wildfire] uncertainty in [the] baseline is the most important part of this whole methodology, and it reads to me like you are just grasping at straws, rather than articulating an integrated approach that, through model iteration propagates BOTH the stochasticity of fire, weather, and regeneration, AND uncertainly in our ability to estimate it (Reviewer 1).

Clearly this reviewer had strong reservations about how wildfire risk uncertainty is handled in the model.

Another reviewer felt that “the burn probability dataset is fairly coarse-scaled” (Reviewer 3) while yet another reviewer felt reassured that “the large area helps with projecting wildfire occurrence which is very stochastic” (Reviewer 7). Thus, while it is possible to predict wildfire across the whole study area in a 40-year period and therefore estimate the total gains in surface carbon (see Table 4.1 and Appendix 4.2), it’s not possible to predict when exactly wildfires will occur at a fine scale such that they have a measurable impact on the landscape, which makes it impossible to predict exactly when atmospheric carbon abatements (and therefore carbon offsets) occur.

Additionality

Along with concerns about uncertainty and similarly complex issues such as, “frequency and magnitude of reversals and the impact to the buffer pool” the ACR decision lists one of their six concerns as simply: “additionality.” The issue of additionality is not easily resolved. One reviewer offered the following considerations:

> I understand why proof of additionality is being evoked here (i.e., if the restoration was going to occur anyway for social and ecological reasons, then one could not attribute gains, or losses, of carbon to the crediting procedure). However, this requirement is hypocritical with respect to many other efforts to manage carbon through energy offsets. For instance, to most effectively credit carbon offsets to energy produced from forest biomass, one must first make the case that the biomass is an inevitable byproduct of forest management that would have occurred regardless... In the methodology proposed here, baselines begin before treatment (insuring additionality can be attributed to treatment); in renewable energy accounting schemes, baselines begin after treatment (insuring additionality can be attributed to the byproduct of treatment) (Reviewer 1).

What this reviewer is referring to is the fact that in the SFR methodology, and consequently these data, treatments occur during the study period, not before (see Figure 4.4). This effectively reduces the estimation of surface carbon accounted for between treatment and non-treatment (see Table 4.1), allowing gains to be more conservatively attributable to treatments and not just an inevitable function of these forests.

Striking at a similar conundrum with the issue of financial additionality, another reviewer asked:

> What about the case where a federal agency has a forest plan that specifies 'common practice' fuel reduction treatments, but lacks the resources to carry out such treatments? If someone comes along with funding to then support 'common practice' that is applied well beyond what the agency is capable of, then this seems like it should be considered additional even though it is still 'common practice' (Reviewer 7).

Ironically, this question actually summarizes the central justification of the SFR methodology. This reviewer seems to worry that these "common practice" treatments will be left out of the SFR methodology because they aren't as discretely associated with a separate, clearly *additional* restoration project, but filling this funding gap is precisely what these carbon offsets would be used to accomplish. In order to do this "a funding shortfall must be demonstrated in order to demonstrate additionality… [but] the source of this shortfall… is not specified by the methodology" (response to comment).

The issue of additionality is a bit of a question of what comes first, the chicken (i.e., carbon offset) or the egg (i.e., restoration). For instance, one public commenter asked: "additionality [is] declared in part because the [USFS] has insufficient funds, but how would potential future increases in funding affect the declaration of additionality?" As in, if the USFS receives more funds for restoration in the future, does that reduce the case for the need for carbon offsets? This question and the difficulty defining additionality for the SFR methodology reveals that despite undisputed atmospheric carbon abatements, forest restoration may be incompatible with carbon offsets and/or credits as they are currently conceived. It's almost as if comparing carbon gains from restoration to the idea of carbon offsets and/or credits is akin to comparing proverbial apples to oranges.

Apples and Oranges

One consistent critique of the SFR methodology was the idea that "the method compares apples with oranges" (Reviewer 5). This difficulty in comparison has many different dimensions. In this case, the reviewer is suggesting that "the [methodology] has to compare EITHER apples with apples OR oranges with oranges," which is to say, that "the same hypothetical fires at the same frequency would be modeled with and without fuel treatment" (Reviewer 5). Whereas, in the data used to generate these results wildfire probability is modeled for each scenario independently, which is consistent with the SFR methodology. This reviewer suggests manually entering wildfire events in the model at the exact same times for each scenario. Reviewer 5 felt that without comparing the exact same instances of wildfire it is not possible to evaluate treatment benefits. This is notably a very different approach to the solution Reviewer 1 offered for addressing wildfire uncertainty.

A more fundamental issue is the fact that in order to generate these net carbon benefits, forest restoration actually releases more carbon in the short run (see Figures 4.1 and 4.2). This causes some concern: "I can't see how a carbon project can work if no emission reductions are achieved for 20 years" (public comment). Another issue is the fact that carbon benefits are derived from estimating wildfires that explicitly don't happen or which occur at a significantly lower intensity. Thus, it's impossible to definitively determine carbon benefits of restoration, since “the net carbon storage attributed to treatment comes not from what this landscape retains under treatment, but from what it will not lose to unmitigated wildfire” (public comment). Not only will potential carbon benefits not occur for 20 years, “after 40 years, you will never know what did not happen to these forests and are left with nothing but virtual verification” (public comment). The issue of the initial release of more carbon in the short run leads to another conceptual concern: is it theoretically justifiable to short sell carbon offsets?

Short Selling Carbon?

The fact that the SFR methodology requires the release of more carbon dioxide in the short run in order to produce more net carbon abatements in the long run prompted one reviewer to describe the SFR methodology as “a carbon short-sell” since these carbon offsets are essentially sold at a discount before the benefits are in hand, much like a day trader selling shares of a stock they don’t own based on market speculation. This is due to the fact that treatment reduces surface carbon on the speculation that wildfires will occur and that restored forests will be more resilient to these fires because of surface carbon removals and restructuring:

> Betting on restoration… is really a carbon short-sell, which depends… on the failure of untreated forests to hang on to their carbon, [more] than it does the success of treated forests to hang on to theirs. After all, if the untreated stands continue to escape fire and grow as they have up to now, they will always have more carbon than those subject to thinning (Reviewer 1).

This concern is echoed by another reviewer who pointed out that the actual act of forest restoration “will not increase carbon storage… [but rather] will decrease above-ground carbon storage" (Reviewer 7); without wildfire, these forests will have more stored surface carbon if they are not restored. This reviewer suggested that:

> It would be more accurate to specify that the treatments will result in above-ground carbon storage that is higher than if the project [without treatment] were subject to a high-severity fire, but lower than current storage (Reviewer 7).

This statement may be inaccurate since results of this analysis suggest that in 40 years restored forests indeed hold more surface carbon than current storage (see Appendix 4.2). But again and again, the issue is the uncertainty of wildfire timing and intensity. This forces one to consider the question of whether it is theoretically acceptable to issue carbon offsets under such speculation, or, would it take 40 years for a private funder to be able to claim the carbon abatement benefits as an offset after monitored verification? Almost an answer to this question, Reviewer 1 offered the following musing:

> Here is the funny thing about describing the potential carbon benefits of removing trees using the same language more often used to describe the carbon benefits of not removing trees: Concerns regarding permanence (and for that matter additionality and verification) lie not so much [in] events that could later rob carbon from your projects, but the lack of such events you insist will befall the untreated areas (Reviewer 1).

Here, Reviewer 1 is reflexively acknowledging that the "language" of carbon offsets and carbon credits may be hard to apply to this methodology since it is essentially a total reversal of standard practice; instead of planting trees or preventing trees from being cut down (which allows applicable projects to count all carbon sequestered by identifiable trees as carbon offsets), the SFR methodology requires trees removal and subjecting forests to fire. Thus, for both SFR methodology authors and reviewers, the proposal requires a reflexive consideration of what a carbon offset actually represents.

Reflexivity and Carbon Offsets

In response to questions about the central premise of the SFR methodology, its authors suggest that "this methodology relies on the same counterfactual logic employed in [other accepted] methodologies where credits are generated if emissions in the project scenario are reduced below what would have occurred in the baseline" (response to reviewers). Thus, depending on how one thinks about the concept of carbon offsets (which is an act of reflexivity), these different types of projects may seem more or less similar. Authors, reviewers, and methodology commenters employed similar reflexivity in their negotiation of the potential of the SFR methodology.

For instance, one reviewer was concerned that the SFR methodology may present a "perverse incentive to increase revenues by extracting larger trees (that still meet diameter cap restrictions) … while discouraging creative solutions to reduce fire severity" (Reviewer 3). These creative solutions could include "novel and/or more intensive prescribed burning" (Reviewer 3), as well as non-prescribed but managed fires. Letting "naturally ignited fires burn on a case-by-case basis" is a cheaper way to get fire on the landscape than explicitly prescribing and then igniting fires intentionally (Reviewer 3). So, this reviewer wonders:

> Could offset contracts prevent tribes and public agencies from letting naturally-ignited fires burn through or near project areas?... If tribes and agencies are required to suppress these fires, low cost common-practice fire-reduction benefits will be lost and suppression costs will increase (Reviewer 3).

SFR methodology authors replied by indicating that "managed natural fires are explicitly included in both the baseline and project scenarios" (response to reviewers). However, this doesn't quite address the concern.

Indeed, in the model data, wildfires occur in both baseline and treatment scenarios, but this reviewer is thinking about actually managing forest stands at a per acre scale. If a wildfire starts after restoration, might managers face a perverse incentive to suppress that fire in order to protect carbon gains? This reviewer recommended that "fires managed for resource benefits should be considered in baseline carbon pools and emissions, and explicitly discussed in the protocol" (Reviewer 3). Thus, these data provide clear insights and potential recommendations for adapting SFR and similar methodologies to address potential limitations.

5. Discussion and Conclusion

These results are consistent with the observation that sequential transformative mixed-methods produce robust and meaningful results in program and policy analysis (Makrakis & Kostoulas-Makrakis, 2016). In this case, insights and recommendations garnered from qualitative analysis of comments on the SFR methodology and results of a linear regression fitted to model output data of forest surface carbon illuminate both the opportunities and barriers for funding restoration through voluntary carbon offsets. These data support the assertion that, in the long-run, restoration of southwestern ponderosa pine forests will lead to a net abatement of atmospheric carbon (Addington et al., 2018). Despite uncertainty about the precise timing and magnitude of these carbon benefits, this analysis adds to an emerging literature on carbon sequestration and other ecosystem service benefits of forest restoration (Ontl et al., 2020).

This restoration is even more urgent in the U.S. Southwest where high intensity wildfires are converting significant forest acreage into shrubland or grassland ecosystems with lower carbon storage potential (Ager et al., 2017). Moreover, the loss of these forests results in the loss of watershed services and other vital ecosystem service benefits (Marcos-Martinez et al., 2019; Wine & Cadol, 2016). Although not included in this analysis due to data reliability issues, forest model projections beyond 2054 indicate that stored surface carbon will decrease even more dramatically without treatment.

Beyond 2054 it becomes more difficult to reliably predict stored surface carbon due to the compounding nature of innumerable social and biophysical variables (Riley et al., 2018). For this reason, this research only analyzed model data from 2014 – 2054. The complexity of social-ecological interactions in the model could account for the relatively low R^2 of this linear regression, since this goodness-of-fit measure indicates that the percentage of observed variance in stored surface carbon determined by the combination of treatment, time, and climate change in these data is low. Moreover, the high replication in this dataset (7560 data points) increases the likelihood of finding a statistically significant relationship, even if it is weak or mitigated by uncertainty (Wilkerson & Olson, 1997). On the other hand, the model F-statistic indicates a statistically significant relationship between the interaction of these variables and total surface carbon.

The size of the dataset is useful in this analysis because it relies on a three-way-interaction. A large sample size provides many degrees of freedom which increases the amount of independent information for each parameter estimate (Dawson & Richter, 2006). In this case, the 7560 data points are divided by forty parameters, resulting in 189 data points per parameter (which is the number of plots in the study area). But the R^2 is low, suggesting a potentially weak relationship or, more likely, a lot of uncertainty.

Results of this linear regression are consistent with other research that indicates that forest restoration leads to reduced carbon losses from high-intensity wildland fires, which translates to increased carbon sequestration and stored surface carbon over time (Hurteau et al., 2016; Matzek et al., 2015). However, the high degree of uncertainty about the timing of those avoided high-intensity fires creates substantial uncertainty. As the qualitative data unambiguously demonstrate, the issue of uncertainty complicates any efforts to commodify this additional stored surface carbon (Campbell et al., 2018).

In an Appendix to the revised SFR methodology, and in response to public and peer-reviewed comments on the ecological model, a procedure is offered to account for uncertainty, done in part through the use of 95% confidence intervals similar to the methods presented in this paper. However, this only provides a more conservative estimation of regression coefficients rather than an actual expression of wildland fire risk and other biophysical uncertainties. To better account for these uncertainties, Reviewer 1 suggested modeling wildfire probability as part of the initial model, rather than manually entering wildfire probability at each timestep post hoc, which would provide a more stochastic modelling of wildfire probability as an ecological process that interacts with other model logic (see Dietze, 2017 or Pearse et al., 2017 for rationale and examples).

Also, if this revised model were run hundreds of times then results would provide a better indication of uncertainty (Mazel et al., 2018). But this solution wouldn't perfectly fix the underlying issue that, ultimately, the exact timing of wildfire starts cannot be predicted with perfect precision (Thompson et al., 2016), and the intensity of those wildfires is based in part on climatic conditions that vary throughout the year (Stephens et al., 2009). Thus, there will always be an unavoidable inability to measure the timing and magnitude of something that didn't happen because of treatment (Gifford, 2020).

Some reviewers felt that this unavoidable limitation makes registering these carbon benefits as offsets untenable. This presents a potential incompatibility between restoration methods as the proverbial apple and carbon offsets as the proverbial orange. However, SFR methodology authors pointed out that this methodology is just as counterfactual as other payments for ecosystem service schemes aimed at preserving forest function (Murtinho & Hayes, 2012). What is counterfactual in either case is the fact that what is being 'produced' is actually not produced at all but rather not produced: carbon emissions (Barbier & Tesfaw, 2012). Furthermore, comparing a project scenario to baseline assumptions is a standard approach for estimating net carbon benefits (American Carbon Registry, 2019).

In this way, the SFR methodology is neither less nor more problematic than any other effort to reduce total atmospheric carbon emissions through market-based solutions (Tacconi, 2012). Is any voluntary carbon registry an exemplar of ecological modernization leading to measurable reductions in atmospheric carbon? The evidence is mixed (see Barbier & Tesfaw, 2012; Matzek et al., 2015; Perry et al., 2019). Despite technological innovations and measurable improvements in per capita and nation-level carbon emissions, total global carbon emissions continue to climb (York & McGee, 2016). One issue with market-based solutions to the compounding problem of accumulating carbon dioxide in the atmosphere is the fact that economic productivity remains highly correlated with carbon emissions (Prell & Sun, 2015). Thus, the ability to pay for carbon offsets unavoidably comes with the production of yet more carbon dioxide (McAfee, 2015).

Therefore, it may not be possible to purchase a measurable reduction in carbon dioxide without more substantial structural changes to the economy (Greiner & McGee, 2020; Rudel et al., 2011). But even if these market-based solutions are not sufficient to reverse course on anthropocentric climate change in isolation, achieving substantial reductions in atmospheric carbon will require a suite of different solutions (Pacala & Socolow, 2004). Achieving as many of these solutions as possible will force natural resource managers and policymakers to continually, carefully, and reflexively reconsider the theoretical construction and implementation of different solutions (Sinclair et al., 2017).

So, the question remains: can registering carbon benefits from restoration be theoretically aligned with the concept of carbon offsets and/or carbon credits through reflexive reexamination of the concept of carbon offsets and credits? Theoretically, more and more researchers believe this is possible (Lee et al., 2018; Matzek et al., 2015; Wu et al., 2011). Although carbon offset and carbon credit programs will remain problematic (Gifford, 2020; Tacconi, 2012), in all foreseeable likelihood, the adoption of carbon offsets and/or credits will increase as more nations, states, and corporations start to address their carbon footprints (IPCC, 2014; Wara & Victor, 2008). As the adoption of carbon offsets and carbon credits increase while climate change realities manifest, the necessity for forest restoration will also increase (Littell et al., 2018). This foreseeable reality will provide new conceptual understandings of both forest restoration and carbon offsets that will accelerate the evolution of forest restoration carbon offset frameworks that align restoration benefits with funding partner interests (Kotchen, 2009).

In practice, however, there may be other limitations. For instance, these carbon benefits may be more speculative than tree planting or avoided deforestation projects (Gifford, 2020). Unfortunately, many carbon markets explicitly forbid carbon speculation such as California's Carbon Market (California's Cap-and-Trade Program, 2019), which is the first such market to be implemented in the U.S. On the other hand, SFR methodology carbon offsets are decidedly not presented as tradable carbon credits but rather voluntary carbon offsets that private firms can purchase to show a good faith effort to address their emissions (Lee et al., 2018). This distinction is not substantially parsed by reviewers, who therefore don't reflexively consider the theoretical or practical differences between these different tools (Matzek et al., 2015; Wara & Victor, 2008).

Therefore, the speculative nature of these carbon offsets is perhaps not as limiting as the complexity of aligning restoration on public land with federal agency directives, plans, and procedures (van der Gaast et al., 2018), as well as the standards and best practices of carbon registries (American Carbon Registry, 2019). Adding carbon offsets into forest restoration may complicate the already complex management landscape navigated by federal land managers (Butler et al., 2015). Also, assigning offsets a monetary value may interrupt other methods for funding restoration, such as funding as part of timber extraction (Powell et al., 2017) and selling removed trees from restoration as forest products (Western et al., 2017). However, the low value of this small diameter timber is not in high enough demand to even pay its way out of the woods (Wu et al., 2011). Thus, more funding mechanisms are required, even if they are not simple to implement (Miller et al., 2017).

These results indicate that in order for the carbon abatement benefits of forest restoration to be registered as carbon offsets, more careful consideration of these potential incompatibilities and complications is necessary. Perhaps the USFS and/or other agencies that manage wildlands could develop proprietary criteria for registering, monitoring, and verifying carbon offsets from restoration? This novel voluntary carbon registry could work within the statutory limitation of federal agencies (Halofsky et al., 2018), while maintaining the key tenets of voluntary carbon registration (American Carbon Registry, 2019; Climate Action Reserve, 2019). Alternatively, the USFS and other federal agencies could partner with an existing voluntary carbon registry to collaboratively co-produce this methodology (USDA Forest Service; National Forest Foundation, n.d.).

Although the SFR methodology was ultimately not adopted by the ACR, these data (including ACR internal peer-review comments and decision) demonstrate the potential utility and temporal urgency of this and/or similar methodologies; not only does the forest model data (where the majority of plots burn by 2034) confirm the possibility that many of these forests stands, if left untreated, may not return as forests after high-intensity fires (Addington et al., 2018), but the in their decision not to approve the SFR methodology the ACR even cites the “urgency to conduct these activities” as undisputed.

Therefore, rather than abandoning this approach, these data demonstrate the imperative for public land agencies and partners to design solutions to address identified complications. For instance, more research and consideration on the issue of additionality is needed. Of the approaches suggested by the SFR methodology authors and reviewers, none can be categorically declared correct, but several approaches could be defended (Asuka & Takeuchi, 2004; Campbell et al., 2018). The decision is ultimately a theoretical question with practical implications, both of which need to be carefully considered and incorporated into future methodology guidelines through reflexivity.

New or revised methodologies should also make more explicit consideration of the suite of alternative wildland fire risk strategies employed in interagency wildland fire risk management, such as managed natural fire starts (Thompson et al., 2018). Also, administrative conundrums need more explicit consideration. For instance, it will be necessary to delineate restoration facilitated by carbon offsets and/or credits from current interagency efforts to restore forests (Stephens et al., 2016). Fortunately for the SFR and similar methodologies (but unfortunately for the future of healthy forests), there will be plenty of acres left untreated under almost any remotely plausible increase in interagency funding (Ager et al., 2017). Therefore, with careful articulation, there will be plenty of acres available to treat with restoration funded through voluntary carbon offsets and maybe even tradable carbon credits in the future. This reality is precisely why wildland managers and those interested in carbon mitigation alike should collaborate quickly to resolve the issues highlighted in this analysis in order to get as much forest restoration completed as possible before it’s too late.

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Appendix 4.1: Table of interaction term (treatment [0/1], year, and climate change scenario [0,1,2,3]) coefficients with statistical significance and confidence intervals.

Interaction	*Coefficient*	*Std. Err.*	*t*	*P > t*	*95% Conf.*	*Interval*
0 2014 1	-0.5405337	2.927452	-0.18	0.854	-6.279158	5.19809
0 2014 2	-0.6973443	2.927452	-0.24	0.812	-6.435968	5.04128
0 2014 3	-0.9352769	2.927452	-0.32	0.749	-6.673901	4.803347
0 2024 0	14.41095	2.927452	4.92	0.000	8.672326	20.14957
0 2024 1	13.35524	2.927452	4.56	0.000	7.616617	19.09386
0 2024 2	12.94262	2.927452	4.42	0.000	7.203999	18.68125
0 2024 3	12.16183	2.927452	4.15	0.000	6.423202	17.90045
0 2034 0	13.51681	2.927452	4.62	0.000	7.778181	19.25543
0 2034 1	11.21883	2.927452	3.83	0.000	5.480208	16.95746
0 2034 2	10.74473	2.927452	3.67	0.000	5.006109	16.48336
0 2034 3	8.889621	2.927452	3.04	0.002	3.150997	14.62824
0 2044 0	8.615195	2.927452	2.94	0.003	2.876571	14.35382
0 2044 1	6.301535	2.927452	2.15	0.031	0.5629109	12.04016
0 2044 2	5.87693	2.927452	2.01	0.045	0.1383062	11.61555
0 2044 3	4.015739	2.927452	1.37	0.17	-1.722885	9.754362
0 2054 0	6.002697	2.927452	2.05	0.04	0.2640731	11.74132
0 2054 1	2.986948	2.927452	1.02	0.308	-2.751676	8.725571
0 2054 2	2.911163	2.927452	0.99	0.32	-2.82746	8.649787
0 2054 3	-0.4892262	2.927452	-0.17	0.867	-6.22785	5.249398
1 2014 0	-8.930919	2.927452	-3.05	0.002	-14.66954	-3.192295
1 2014 1	-9.431163	2.927452	-3.22	0.001	-15.16979	-3.692539
1 2014 2	-9.640043	2.927452	-3.29	0.001	-15.37867	-3.901419
1 2014 3	-9.836918	2.927452	-3.36	0.001	-15.57554	-4.098294
1 2024 0	0.3492027	2.927452	0.12	0.905	-5.389421	6.087827
1 2024 1	-0.742844	2.927452	-0.25	0.800	-6.481468	4.99578
1 2024 2	-1.276313	2.927452	-0.44	0.663	-7.014937	4.462311
1 2024 3	-2.054827	2.927452	-0.7	0.483	-7.793451	3.683796
1 2034 0	7.388061	2.927452	2.52	0.012	1.649437	13.12668
1 2034 1	4.944968	2.927452	1.69	0.091	-0.7936563	10.68359
1 2034 2	4.19079	2.927452	1.43	0.152	-1.547834	9.929414
1 2034 3	2.257595	2.927452	0.77	0.441	-3.481029	7.996219
1 2044 0	12.94754	2.927452	4.42	0.000	7.208921	18.68617
1 2044 1	8.935554	2.927452	3.05	0.002	3.19693	14.67418
1 2044 2	8.593823	2.927452	2.94	0.003	2.855199	14.33245
1 2044 3	4.565567	2.927452	1.56	0.119	-1.173057	10.30419
1 2054 0	15.31586	2.927452	5.23	0.000	9.577232	21.05448
1 2054 1	8.92411	2.927452	3.05	0.002	3.185487	14.66273
1 2054 2	9.81185	2.927452	3.35	0.001	4.073226	15.55047
1 2054 3	1.834603	2.927452	0.63	0.531	-3.904021	7.573227
Intercept	56.81011	2.070021	27.44	0.000	52.75229	60.86793

Appendix 4.2: Table of estimated surface carbon for each interaction term (treatment [0/1], year, and climate change scenario [0,1,2,3]) based on coefficients and confidence intervals added to total carbon intercept (i.e., no treatment, 2014, no climate change).

Year	*Interaction*	*Coefficient*	***Total*** *Lower*	***Surface*** *Mean*	***Carbon*** *Upper*
2014	0 2014 0	0.000000	52.75229	56.81011	60.86793
2014	0 2014 1	-0.5405337	50.530952	56.2695763	62.0082
2014	0 2014 2	-0.6973443	50.374142	56.1127657	61.85139
2014	0 2014 3	-0.9352769	50.136209	55.8748331	61.613457
2024	0 2024 0	14.41095	65.482436	71.22106	76.95968
2024	0 2024 1	13.35524	64.426727	70.16535	75.90397
2024	0 2024 2	12.94262	64.014109	69.75273	75.49136
2024	0 2024 3	12.16183	63.233312	68.97194	74.71056
2034	0 2034 0	13.51681	64.588291	70.32692	76.06554
2034	0 2034 1	11.21883	62.290318	68.02894	73.76757
2034	0 2034 2	10.74473	61.816219	67.55484	73.29347
2034	0 2034 3	8.889621	59.961107	65.699731	71.43835
2044	0 2044 0	8.615195	59.686681	65.425305	71.16393
2044	0 2044 1	6.301535	57.3730209	63.111645	68.85027
2044	0 2044 2	5.87693	56.9484162	62.68704	68.42566
2044	0 2044 3	4.015739	55.087225	60.825849	66.564472
2054	0 2054 0	6.002697	57.0741831	62.812807	68.55143
2054	0 2054 1	2.986948	54.058434	59.797058	65.535681
2054	0 2054 2	2.911163	53.98265	59.721273	65.459897
2054	0 2054 3	-0.4892262	50.58226	56.3208838	62.059508
2014	1 2014 0	-8.930919	42.14057	47.879191	53.617815
2014	1 2014 1	-9.431163	41.64032	47.378947	53.117571
2014	1 2014 2	-9.640043	41.43144	47.170067	52.908691
2014	1 2014 3	-9.836918	41.23457	46.973192	52.711816
2024	1 2024 0	0.3492027	51.420689	57.1593127	62.897937
2024	1 2024 1	-0.742844	50.328642	56.067266	61.80589
2024	1 2024 2	-1.276313	49.795173	55.533797	61.272421
2024	1 2024 3	-2.054827	49.016659	54.755283	60.493906
2034	1 2034 0	7.388061	58.459547	64.198171	69.93679
2034	1 2034 1	4.944968	56.0164537	61.755078	67.4937
2034	1 2034 2	4.19079	55.262276	61.0009	66.739524
2034	1 2034 3	2.257595	53.329081	59.067705	64.806329
2044	1 2044 0	12.94754	64.019031	69.75765	75.49628
2044	1 2044 1	8.935554	60.00704	65.745664	71.48429
2044	1 2044 2	8.593823	59.665309	65.403933	71.14256
2044	1 2044 3	4.565567	55.637053	61.375677	67.1143
2054	1 2054 0	15.31586	66.387342	72.12597	77.86459
2054	1 2054 1	8.92411	59.995597	65.73422	71.47284
2054	1 2054 2	9.81185	60.883336	66.62196	72.36058
2054	1 2054 3	1.834603	52.906089	58.644713	64.383337

CHAPTER V

WHERE THERE IS SMOKE THERE OUGHT TO BE REFLEXIVITY: AN AUTOETHNOGRAPHIC REFLEXIVE ESSAY

One morning, with less than a week left before I needed to submit this dissertation, I woke up to our bedroom filled with smoke from a wildfire. There was no mistaking it – that sweet, piney smell. I am always surprised by how much I enjoy the aroma. And I often think that somehow it smells, cold? Fresh, somehow? Why is that? I was asking myself, as my wife's Forest Service radio went off. She must have turned it on while I was still trying to wake up. Sure enough, dispatch was reporting a new fire, and it was near the Old Pioneer Cemetery, which is less than a mile from our house!

Fortunately, it wasn't much of a fire and it was easy to access, so there wasn't much danger (except the smoke, which is a hazard no matter how good I think it smells). But it served as an ironic reminder of how real the increasing risk of transboundary wildfire is. Sure enough, an investigation would determine that the fire was human caused, just off of a trail in the national forest, very close to the small town of Idaho City, Idaho. My wife was actually the investigator trainee assigned to the fire, so off she ran. Unfortunately that meant she would be extended, again, and I would need to look after our son, Corvid, for a little longer that day when I needed to be finishing this dissertation. But maybe she would be able to stop by the house briefly, which is why we were renting this place for the summer, after all.

It's an old house, built in the 1930s by the U.S. Forest Service, and located at the old research station for the Boise Basin Experimental Forest. This location is actually kind of perfect as a place to write up my research, since the experimental forest, which was established in 1933, is a ponderosa pine forest that has been carefully treated, monitored, and exposed to wildfire since its establishment. The ponderosa pines are healthy, beautiful, and right outside our windows, with bright green lichen all over the darker, bare, lower branches, which frame unmistakable trunks of red, maroon, and cinnamon colored jigsaw pieces. It's not often that I actually get to be inspired by the presence of the thing I study while I write up results. But that ancillary benefit is not why we are living up here for part of the week.

During the week our little family splits its time between our apartment in Boise and this house in Idaho City in order to be closer to my wife's current duty station on the Boise National Forest because Corvid is less than a year old. This way she gets more time with him at the beginning and end of the day and sometimes she can even stop by or we will go for a walk to see her at the warehouse. All around, being here just feels right.

Which is why I wanted to find a way to write about it in this autoethnographic[16] essay. Especially because this is a *reflexive,* autoethnographic essay, where I reflect on my understanding of, experience with, and relationship to the subject of wildland fire risk as the object of my study, both personally and professionally. I got started on this essay because a mentor pointed out that writing a dissertation oriented by the theoretical framework of Reflexive Sociology but not actually engaging in reflexivity, personally,

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[16] Autoethnographic research is qualitative research where the researcher gives voice to their personal experience to advance sociological understanding. The intimate and personal nature of autoethnographies provide details otherwise lost to the research process (Wall, 2008).

would be at least a little hypocritical. But as soon as I started writing, this became something more, and is now one of my favorite parts of the dissertation.

This mentor had originally recommended that I write this reflexive essay as a companion piece to some of the less orthodox aspects of this dissertation. For instance, Chapter II is a general technical report (GTR), which is a document type that has an internal peer-review process, but that process is not generally considered to scrutinize for scientific rigor as well as the review process for a peer-reviewed journal. Fortunately, by including this GTR in this dissertation, it actually benefits from several iterations of review by different (types of) reviewers than it would have otherwise.

I was initially resistant to the idea of this essay since, for instance, I believe that a GTR is an appropriate output given the complexity of this topic, which necessitates participatory (e.g., collaborative) and transdisciplinary, post-normal research, and that research benefits from publicly available GTRs. I was also resistant because I wrote about this in the introduction, where I also offer some reflexive consideration of how this GTR is the product of the collaborative and iterative research CoMFRT partnership. Towards this reflexive purpose, in the introduction I consider my position in the CoMFRT project and my positionality as it relates to the GTR as well as the research presented in Chapter III, which is also a product of the CoMFRT project.

But after starting this essay, I found that I had more to say. So, in this chapter I write a bit more about my positionality in regards to the CoMFRT project. Moreover, I discuss how Chapter IV is a product of my involvement in the SFR research project, which is an extension of the research partnership that produced the SFR carbon offset methodology examined in that chapter. This positionality provides important context for examining my own role in the research process. Then I write about my personal experience with wildland fire. Towards this end I go back and forth between short reviews of relevant literature and brief reflections on my past and present as a researcher in order to make connections across the varied environmental topics that I have studied, leading me to this point in my career. Finally, I discuss my ambitions for my future research, which I hope will make more sense in this context. All of this is done on the basis that in order to truly understand one's own research, one must understand their own relationship to the subject of their study.

On the research process, Bourdieu & Wacquant (1992) lament that so many researchers forget that they are not studying or describing an object but rather their relation to the object through their study. According to Bourdieu, the act of research inevitably positions the researcher apart from the subject of study and this positionality inevitably distorts their findings (Bourdieu & Wacquant, 1992). Reflexive Sociology is a theoretical framework that builds on a recognition of this researcher positionality in order to "objectivize the objectivizing point of view of [research]" while still employing those methods (Bourdieu & Wacquant, 1992, p. 69). This is, of course, the framework I use in this dissertation.

At the same time, Bourdieu also reminds the proverbial researcher that the act of research is conducted within a system defined by social norms, taboos, habitus, and, potentially, inward reflexivity. Thus, while the researcher separates themselves from the subject (i.e., object) of their study they also (re)position themselves within the social field of research (Bourdieu, 1988). Therefore, although research is an inherently reflexive act because it necessarily involves thoughtful examination of how one understands a system (Bourdieu, 1988), researchers should also be reflexive about this process (Clark et al., 1990). Habitus is when people act on established norms and routines without thinking about them (Decoteau, 2016), whereas reflexivity, well-defined throughout this dissertation, denotes the consideration of those norms and one's own positionality. Likewise, the research presented in this dissertation is based on my position in relation to the subject of wildland fire risk governance via the research projects described as well as my personal life.

When I have participated in the research projects that I have disclosed and described in this dissertation, I often find myself thankful for the insights garnered from my personal relationship with wildland fire. Not the least of which include the innumerable insights offered by my wife who works for the U.S. Forest Service (USFS) and who has served as a wildland firefighter. Through her experiences, I have gained some understanding of the actual process of managing wildland fire incidents, which in turn informs my reading of the literature.

For example, when reading research aimed at exposing the maladaptive path dependencies or other limitations of the wildland fire risk governance system (Fischer et al., 2016), I notice some potential incompatibilities between theory and practice. For instance, in much of the work on the biophysical aspects of wildland fire risk, scholars promote a more tempered approach to wildland fire suppression (Houtman et al., 2013), arguing for allowing more naturally started, low-intensity fires to burn when conditions are favorable (Thompson et al., 2018). To some researchers and managers, this is called 'good' fire (Schultz & Moseley, 2019). To many stakeholders, this sounds like the infamous 'let it burn' policy that left a lingering resentment for many communities affected by wildland fires.

Since moving to the western U.S. to start my graduate training, I have heard more than once from both academics and laypersons about some period in the past when the USFS 'let it burn,' and how damaging that was to stakeholder relations. Exactly when this occurred varied according to different people. In reality, there never was an actual, comprehensive 'let it burn' policy in place for the USFS or other federal agencies (Duewel, 2017), but rather, there was simply an emerging awareness among managers (and researchers) in the late 1980s that suppressing all fires leads to the buildup of forest fuels, leading to higher intensity fires in the future (Nadolski, 1989). These ideas were not well received by the public who felt that their values were not being prioritized (Paveglio et al., 2010), and, in this contested atmosphere, following some contentious fires, the idea emerged that the USFS, unduly influenced by (urban) environmentalists, were letting fires burn at the expense of (rural) property and lives (Carroll et al., 2006; Daniel et al., 2007).

To this day, many residents of the wildland-urban interface swear they have personally experienced a wildfire let burn out of control due to a 'let it burn' management decision (Duewel, 2017). In reality, the fire in question may not have been able to be fully suppressed due (ironically) in part to the buildup of fuels that resulted from a previous overemphasis on suppression (Fischer et al., 2016). But for many residents of communities affected by wildfire, this assertion is regarded with skepticism (Duewel, 2017), which speaks to the many dilemmas created by the conjoint constitution of wildland fire risk that makes governance of it a wicked problem.

As a USFS employee, my wife has had innumerable interactions with members of the public who believed that the USFS had lit a prescribed fire that had burned out of control but which was actually a naturally started fire, or who believed that the USFS was not suppressing a fire for political reasons rather that accepting the explanation she offered that due to current biophysical conditions, it simply wasn't possible to suppress. As a researcher studying the human dimensions of the environment and natural resources, I have heard from by many research participants on their perception of the ineptitude and/or corruption of the USFS even when my research topic had nothing to do with National Forest System lands. Moreover, I have interviewed public land managers who express a kind of double consciousness[17] about their dual identities as land managers and community members. I have personally experienced this uncomfortable duality, myself.

As I drive up to Idaho City every week with our seven-month-old son,[18] we pass a billboard that depicts a blazing wildfire (a crown fire no less) with the inscription, "environmentalists, you own this!" Underneath in smaller text it says, "log it, thin it, or ***burn*** it." Interestingly, I happen to know that the spouse of the owner of the business

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[17] "Double consciousness" is a term coined by W.E.B. Dubois to describe the experience of being a minority in a majority culture and the duality of how a minority sees themselves versus how they know the dominate culture sees them. As such it's not perfectly analogous here as the USFS and other federal agencies actually possess and exhibit power in these communities, but the on experience on individuals, the application offers some comparison worth reflecting on (Itzigsohn & Brown, 2015).

[18] By the time I submit this dissertation, Corvid will be ten months old.

where this sign is located is actually a USFS employee herself. This also speaks to another common perception that a lack of timber extraction, due to prohibitive USFS policies, is what is leading to the build-up of forest fuels. This is, quite simply, not the case (Brown et al., 2004; Moore et al., 2008).

Outside of a few notable exceptions, such as in the Pacific Northwest where logging of old growth forests was restricted due to rapidly declining Spotted Owl habitat[19] (Thomas et al., 2006), the reduction in timber extraction in western U.S. National Forests is an economic phenomenon (Pugliese et al., 2015). In previous research I have conducted in former mill towns, this economic reality is often glossed over as residents reminisce about the past. Moreover, the extensive logging of the past, followed by even-age forest regrowth unchecked by so-called ‘healthy fire’ is actually what has led to the build-up volatile forest fuels in many western forests. And finally, the USFS and other federal agencies would love to thin these forests but lack the finical resources to do so (Kalies & Yocom Kent, 2016).

Although the sale of thinned, small diameter trees is utilized as a funding source (Western et al., 2017), the value of such small diameter timber is so low it does not pay its way out of the forest (Wu et al., 2011). The inability to fund forest restoration (e.g., thinning) is the impetus for the carbon offset methodology examined in Chapter IV. Thus, many forests do indeed need thinning, and many scholars (including myself) are trying to think of ways to pay for it, but, as always, there are no simple solutions to complex problems.

[19] These old growth forests are also not particularly prone to wildfire.

On the other hand, clear-cutting forests (which can hardly be called thinning) reduces operational costs such that, given a close enough proximity to a mill of some sort,[20] this could be an economically productive activity. And yes, a clear-cut forest won't burn, unless they leave a significant amount of slash and duff on the ground that subsequently dries out and actually creates an ideal fuel structure for fire; but this is akin to the old adage that a stopped clock is right twice a day. How can we affectively manage for forest values by removing the forest? Yes, wildfire risk is (potentially) reduced this way, but so are the other values provided by the forest (Brainard et al., 2009).

The point of this long aside is simply: there is a wide gulf between actual management decisions and priorities and the perceptions and interpretations of many other stakeholders. Which is exactly why the social dynamics of these complex social-ecological systems (SES) need to be considered. For more details, see the GTR in Chapter II. In reality, wildland fire managers suppress wildfires more than they think they ought to, from an ecological standpoint. Although current wildfire management is transitioning away from an over-reliance on suppression (Lee et al., 2011), managers often suppress fires they could allow to burn due to concern for stakeholder health and welfare. For an example, see discussion of this very subject in Chapter III.

The dilemma of (too much) fire suppression consistently comes up as a barrier to achieving more resilient landscapes in the many workshops I have participated in as a member of the CoMFRT project. Yet, solutions remain elusive. As researchers, we ask

[20] This is by far the most important factor. The greater the distance between the timber extraction and the mill that turns the extracted wood into a higher value commodity, the more expensive the extraction is. Inevitability, when mills are operating they extract the closest available timber, moving farther and farther away until revenue is no longer higher than the expense and that mill shuts down (Machlis & Force, 1988).

managers and other stakeholders why fires that could be allowed to burn are instead suppressed. Managers often report that the public needs to be more educated on wildfire in order to increase acceptability, whereas *other* stakeholders suggest that managers need to take greater heed of community perspectives. Both insights are correct but neither are adequate, and we have not yet found the missing piece of the puzzle that if put in place will lead to more low-intensity fires being allowed to burn. The reality is, the actual experience of wildland fire risk is not such a simple or benign subject that it is simply a matter of more education (Brenkert-Smith et al., 2012). And as a resident of the Intermountain West, I can personally attest to the fraught reality of that experience.

Like many who live in this region, I have known summer days when the sky was so thick with smoke from wildfire that you could safely look directly at the sun, but it was not safe to take a deep breath. Thus, I know that asking people to accept summers with a lot more smoke for the rest of their lives is indeed, a lot to ask. Also, although I have never had my life nor property directly threatened by wildfire, I have watched the flames of a wildfire move rapidly across the landscape from where I would sleep that night, and listened to reports of large active fires near me, my friends, or family.

This is a dilemma where values and uncertainties in the short-run take precedence over longer term management. Or, at least, that is my interpretation of the science, but I also named my son Corvid after a family of birds, so maybe I am just one of those environmentalists I have heard so much about. However, it is also true that management decisions about where to place fire breaks, and what areas to let burn as managers establish a safe perimeter, are not always made with local interests in mind (Paveglio et al., 2015), which leads to resentment and skepticism (Duewel, 2017). Rinse, and repeat. For instance, Paveglio et al.'s (2015) examination of communities impacted by the 2006 Columbia Complex Fire, six years after the fact, showed that residents were still angry at wildland fire risk managers' actions due to the perception that their values were ignored.

The composition and characteristics of stakeholders and their communities is often less self-evident than many wildland fire risk managers and/or researchers assume (Paveglio et al., 2016). Communities are complex systems that provide for community members who interact in social fields defined by shared identity and territory (Wilkinson, 1991). In relation to the National Cohesive Wildland Fire Management Strategy goal of promoting fire adapted communities, these complexities mean that successful management needs to take into consideration these different characteristics (see Edgeley & Paveglio, 2017; Murphy et al., 2015; Paveglio et al., 2018; Williams et al., 2016).

In order for communities to have their interests prioritized in the current wildland fire risk governance system, they need to form Community Wildfire Protection Plans (CWPP) (Williams et al., 2012). However, some communities resist the influence of extra-local institutions (Carroll et al., 2006), which is requisite in the process of completing a CWPP (Jakes et al., 2007). Other communities lack the resources (time and/or money) to complete the process, leading to inequality in the communities whose interests are served (Palaiologou et al., 2019). This outcome invites a sociological critique facilitated by researcher/manager reflexivity. Meanwhile, community members are sure to have thoughts about this, themselves.

As anyone who studies complex environmental systems knows, risks and hazards are contested and lead to schisms between so-called experts and non-experts (Flint & Luloff, 2005). This is one of the primary aspects on Ulrich Beck's conception of a Risk Society (Malin & Petrzelka, 2010). According to Beck, anthropogenic risks posed by modernity erode classically hierarchical structures (such as a fixed class system) but lead to new horizontal cleavages between those that benefit and those that pay the cost that will result in a chronically reflexive society that continually (re)examines the influence of the structure of society on people's lives (Elliott, 2002).[21] This horizontal stratification leads to mistrust, misunderstanding, and misapplication of scientific authority that results in skepticism about scientific authority, which defines reflexivity for Beck (Irwin, 2013).

Freudenburg documented this same phenomenon and referred to it as "recreancy" (Freudenburg, 1993). As a scientist, I have confronted this phenomenon as well. For instance, in any research I have conducted on water, the implication of climate change has inspired some participants to get extremely angry with me. People have refused to participate due to the bias they perceive me to have, which is ironic because by not participating they are actually removing their perspective from my research. Occasionally I succeed in explaining this to them. However, in one instance someone actually threatened to physically harm me for trying to 'trick' him.

Climate change is obviously an extremely contested scientific reality (Norgaard, 2011). Research on climate change in the public debate that applies the concept of reflexivity has developed the concept of "anti-reflexivity" (McCright & Dunlap, 2010).

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[21] It strikes me, as I write this, that there is more than ample evidence of this proposition, currently.

This work highlights the effective and well-funded social movements that actively work to undermine trust in scientific authority, which ironically means that anti-reflexivity is very similar to Beck's conception of reflexivity. Fortunately, Bourdieu's more flexible definition of reflexivity allows for a theoretical understanding of anti-reflexivity as a form of reflexivity. According to Bourdieu (1984), reflexivity describes any conscious (reflexive) effort to understand and/or critique systems rather than simply or habitually reacting to and/or within them.

Thus, reflexivity is a potentially contested dialectic between different people and/or institutions. For instance, as actors in the wildland fire risk governance system work to reflexively unpack their understanding of this governance (Rodríguez et al., 2018), other stakeholders are not waiting, patiently, to be told what to believe, but rather questioning best practices for themselves and constructing their own understanding (Champ et al., 2012). Therefore, if this contentious dialectic is not handled carefully, the public can become steadfastly opposed to the validity or legitimacy of wildland fire risk management systems and strategies regardless of the biophysical science (Rasch & McCaffrey, 2019), especially when personal experiences with that system are negative. Which, if I am forcing myself to be reflexive, I can empathize with. However, my experience leads me to different attitudes about wildland fire risk management.

Due to my personal relationship to wildland fire management, I know that wildland fire response occurs rapidly and that the actual operation of the Incident Command System often means that someone unfamiliar with the landscape has to make decisions very quickly (Nowell & Steelman, 2015). These incident command decisions favor a conservative approach that incurs minimal liability to the agency and minimal risk to wildland firefighters' lives (Castellnou et al., 2019). As the person waiting at home for my spouse to return to cell service after countless days out of contact fighting a wildfire, I can appreciate the management decision to favor wildland fire operator safety. I have also gained from this proximity a sympathy for the command decisions wildland fire risk mangers make that are not always well received by other stakeholders. This sometimes speaks to a misunderstanding by those stakeholders, and frankly other researchers, about how wildland fire command structures actually work in practice.

For instance, an Incident Commander Type 1 is a qualification, and not a job. Thus, when some research and/or stakeholders criticize the fact that certain high-intensity fires are managed by an incident commander who is unfamiliar with the landscape and/or the community (Paveglio et al., 2015), that was most likely because that was the incident command team that was available (regionally, and if not available, then nationally) with those qualifications when the Incident Command System was activated. Which is not to say that this disconnect between incident command decisions and community composition and/or priorities is not a problem, as I have discussed. Moreover, as my interviews from Chapter III reveal, many wildland fire risk managers recognize this problem. Unfortunately, it is not an easy problem to solve.

Although there are people on the incident command team specifically to help orient management decisions according to local priorities and landscapes, decisions have to be made quickly in a hierarchical structure. Sometimes these decisions come at a high personal cost for some (Kramer et al., 2018). Other times, no possible action (at least at that moment) could have prevented tragedy, or at least, that is what my training and identity as a scientist leads me to believe about the current biophysical reality of wildland fire risk. But I can only image the helplessness that I would feel if I had to evacuate my home for a wildfire, which consumed it and everything inside. If such a thing were to happen to me, I am sure I would wonder, "could my home have been saved?" But my relationship to both wildland fire risk management and research would probably lead me to ultimately decide that this is the very real risk posed by wildfire that cannot be completely controlled.

Without my personal involvement in both wildland fire management and research, would I come to these same conclusions? Being as reflexive and honest with myself as possible, the answer, somewhat unsatisfactorily, is: I don't know. It's probably impossible to know how I would feel if the past ten years of my life had been substantially different. Without my personal experiences, I anticipate that I would favor the insights offered by the best available science that suggest we need more 'good fire' and be less sympathetic to wildland fire risk managers and other stakeholders. But then again, based on my education, which has a concentration in the environment and community, I would probably reserve some empathy for the local experience, even if I didn't count myself among them.

But while I am not able to adequately imagine my perspective without my personal experiences, I can say with confidence that I believe my positionality actually improves my understanding of this complex topic. Although originally meant to apply to any and all sociological research (Bourdieu & Wacquant, 1992), Reflexive Sociology, as employed in this dissertation, provides a particularly useful framework for me since I am actively and collaboratively engaged in wildland fire risk governance. Bourdieu and Wacquant (really just Bourdieu facilitated by the Socratic questioning of Wacquant's sociology graduate students, 1992) actually suggested that since everyone is a member of society, then all research is affected by positionality. As in, as sociologists we should all be wary of the objectivizing gaze of the researcher that separates us from the subject, whereas, in this research my personal relationship and proximity might actually help reduce the artificial separation between myself and the object of my study created by the research process. On the other hand, it may introduce its own bias (Daniels & Walker, 2012; Sinclair et al., 2017).

This tradeoff reminds me of the distinctions between, and axiological implications[22] of, studying one's own culture versus studying a different culture, which emerges for the reflexive scholar while choosing their research topics (Hartman, 2011). This may seem like a pedantic point to bring up in a dissertation on wildland fire risk (even for me), but I believe it applies. Of the numerous academic articles, books, and GTRs, written on the subject of wildland fire, relatively few are written by someone with personal experience in wildland fire risk management, and the exceptions are notable (see Desmond, 2006). For instance, really excellent work on the role of gender in wildland fire has been conducted by scholars who have not fought wildland fire (see Eriksen, 2013), and again, there are notable counterexamples on this same subject where one of the authors did serve as a wildland fire fighter (see Reimer & Eriksen, 2018), and that

[22] Axiology is the study of the types of and criteria for values and valuation, especially in regards to ethics, thus axiological implications denote the ethical implications presented by certain actions or decisions.

relationship improved their ability to conduct and interpret the results of the research (Reimer, n.d.). However, I have spoken with other women who have fought wildland fire who are researchers now who feel that they could not, out of loyalty to their (respective) agency and their colleagues, write autoethnographically on the subject.

None of these observations are meant to apply only to the subject of gender in wildfire, but rather I mean to illustrate the fact that good research can be done by a researcher as an outsider or a research as an insider, and both positions offer potential benefits and drawbacks. Furthermore, these observations are not meant to denigrate or elevate researchers, managers, or those who occupy both roles. Also, I am trying to point out that, as with many natural resource management topics, there are differences between those that study, those that manage, and those that are affected by those studies and that management (Flint et al., 2008). In this research, I hope that my position, triangulated between my different roles and experiences, provides me some additional insights, as it has done for others (Reimer, n.d.). Especially since so much of this research is qualitative and/or post-normal, and thus requires careful and inwardly focused epistemological consideration.[23] Again, Reflexive Sociology is useful to me since it is particularly appropriate when part of the objective of the research is to understand how we even make sense of the research (Bourdieu & Wacquant, 1992), which is a major aspect of this dissertation.

For instance, the necessity of the GTR presented in Chapter II serves as a problem analysis that unpacks different aspects of wildland fire risk and resilience that are more

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[23] Epistemology describes the study knowledge itself, thus epistemological consideration denotes an effort to examine how knowledge is constructed and/or identified to be objectively true.

complex than they may appear at first. For example, by unpacking the often-ignored fact that the 'risk' aspect of 'wildland fire risk' theoretically requires one to acknowledge values, challenges researchers and managers who try to manage for this risk while remaining agnostic about those values. Also, by explaining how resilience is both a social and biophysical variable, and by showing how different governance strategies may lead to different resilience outcomes, the explicit purpose of the GTR is to challenge the more conventional ways that researchers and/or managers conceive of wildland fire risk and biophysical resilience.

Some have questioned whether this GTR is really a 'technical' document (as the category 'general *technical* report' suggests), due to this focus on theory rather than simply presenting a methodological process. Of those, some have suggested that the appropriate audience for this document may actually be other academics, rather than managers and/or non-academic researchers (e.g., USFS researchers). Ironically, this feedback speaks to the very dynamics that the GTR is aimed at edifying. Specifically, that questions such as, "how can we allow more 'good' fires to burn?" cannot be answered without critically considering both, 1) certain unchecked assumptions about people and/or human systems (e.g., the assumption that the average person is simply uneducated on the subject), and, 2) social dynamics that one may not be aware of existing (e.g., that community identify is conjointly constituted and community member response to wildfire risk and/or management will be affected by that identity). All of this is to say that rather than having only limited interest to an academic audience, the utility of the

GTR is useful to those who might not question their current epistemological approach to understanding the ostensibly objective truth of wildland fire risk.

Bourdieu's definition of reflexivity emphasizes that institutionalized approaches to assessing objective truth are subjective and unavoidably incomplete but they escape critique because they are established practice, which provides tautological support (Bourdieu, 1990). For example, wildfire management best practices, although in flux, define actions which are, by definition, best practices. Similarly, scientific research has methodological best practices that, if employed, convey to other researchers that the information gathered with these methods are rigorous. How scientific rigor is defined is also in flux. According to Bourdieu (1990), established practice or agreed upon rules tend to be preserved unless overtly questioned and even then, the burden remains on the challenger to definitively demonstrate an improvement.

As it relates to the utility and audience for the GTR, it's worth noting that social scientists are trained to recognize their own epistemologies in ways that biophysical scientists often aren't (Freudenburg, 2002). Ironically, this epistemological training leads social scientists to adapt their own language or, or dare I say, jargon, to serve a broader audience (Fry, 2001). Over the years, this has led to the perception by some that social science is not as rigorous or, dare I say, technical, as biophysical sciences (MacMynowski, 2007). In the context of managing wildfire, I suspect that this contributes to the fact that biophysical assessment is significantly more prevalent than social assessment (Toman et al., 2013).

As a social science researcher, I have encountered many biophysical scientists who struggle to understand the scientific rigor of my training. Even as a research fellow in the *interdisciplinary* Climate Adaptation Science program, other members of my cohort and even professors in non-social science departments struggled to see the compatibility between what I study and what they study. Now, I reflexively ask myself if this simply offends my vanity, but thus far I return to the observation that no, this struggle speaks to struggles that some have in confronting the potential positionality of their own epistemology as it relates to biophysical conditions, such as wildland fire realities. And thus, I find myself convinced that these biophysical scientists really do need to learn the definition and meaning of jargon such as, 'reflexivity.' Which is why, in the research presented in this dissertation, I have resolved to carefully use such terms and hope that this helps address the issue of "how do we understand how we understand, wildland fire?"

Throughout this dissertation, I use reflexivity as Bourdieu defined it. Bourdieu's (1974) concept of reflexivity is unique from other conceptions of reflexivity in sociology and the social sciences more broadly in three important ways: 1) the focus is on social and intellectual unconsciousness embedded in analytic tools and operations rather than the individual; 2) as such, reflexivity must be a collective enterprise rather than the burden of the lone actor; and 3) Bourdieu's reflexivity seeks "not to assault but to buttress the epistemological security of sociology" (Bourdieu & Wacquant, 1992, p. 36). Applied to wildland fire, these points serve as reminders that a collective effort to reexamine wildland fire risk management is needed in order to "buttress" current wildland fire risk management and research and that including community members into that process is essential.

Some scholars have misinterpreted Bourdieu's explanation of reflexivity as a post-modern and/or constructivist denial of objective reality that makes attempts at understanding it pointless. In fact, Bourdieu (1990) said that, "of all the oppositions that artificially divide social science, the most fundamental, and the most ruinous, is the one that is set up between subjectivism and objectivism" (p. 25). Thus, reflexivity is not purely a constructivist proposition. As Bourdieu & Wacquant (1992) stress, the understanding of reality has material ramifications on reality. Again, applied to wildland fire risk management, this is the recognition that management based on previous understanding has had very real effects on the current biophysical reality of landscapes susceptible to wildland fire. This is, at the risk of redundancy, the conjoint constitution of wildland fire risk.

Which reminds me of the point I made in both the introduction to this dissertation and in the GTR found in Chapter II that with or without reflexive examination, wildland fire risk is a boundary object. Boundary objects are symbols that different people agree represent something, but upon closer scrutiny, what that is may vary widely by individual perspective (Morisette et al., 2017). At the risk of dating this essay (or at least I hope I am dating it in this way), currently in the U.S. there is an ongoing debate about some statues. These statues are boundary objects. Everyone agrees on what these statues represent, literally. But people disagree on what these statues actually represent, figuratively. Or they agree on that representation, but disagree about whether that is good or bad.

Boundary objects can serve as translators between social worlds, and indeed in the conflict over these statues I do not see that the debate is wholly about these objects, but rather that these objects offer an anchor point for a debate about the very fabric of our society.

Wildland fire risk works much this same way, allowing stakeholders to come together and discuss complex systems where they don't agree, united by the singularity of wildfire risk as an agreed upon condition even if the definition of it varies (Devisscher et al., 2016). Evidence for this abounds in Chapter III, as participants actively and reflexively define collaborative governance in relation to the pursuit of reducing wildland fire risk. Within the framework of Reflexive Sociology, the subjectivity and variability of these definitions are not necessarily a barrier, but an opportunity to reconsider different conceptions of the system experiencing wildfire risk (Han, 2019).

Similarly, Chapter IV explores another boundary object that I do not identify as such: carbon offsets. Due to a history of fire suppression, resulting in the buildup of volatile forest fuels that increases the risk of high severity fires, many U.S. forests are becoming a carbon source as more and more acres burn annually in more frequent and higher intensity fires. The release of carbon dioxide from these fires contributes to climate change, accelerating a positive feedback loop that intensifies drought and wildfire severity (Littell et al., 2018). Since restoration is needed to mitigate this cycle, which provides a carbon benefit, why not fund this restoration through voluntary carbon offsets?

But upon closer inspection, as a boundary object, the idea of one metric ton of atmospheric carbon 'offset' does not represent the same thing for everyone (Gifford, 2020). When does this offset need to occur (Campbell et al., 2018)? Where (Barbier & Tesfaw, 2012)? If a tree is planted in the forest, does it make a difference? As in, if the amount of carbon sequestered by one tree is outpaced by the carbon production associated with the cost of planting it, is there a net carbon benefit? This question makes me think of an age-old debate in environmental sociology on the role of the economy and technological innovations. As I mention briefly in that chapter, it remains a point of contention whether or not economic expansion spurred by technological innovation is ultimately good or bad for the environment (Cohen, 2006; Foster, 2012).

In recognition of the negative relationship between economic productivity and the environment, Schnaiberg (1980) coined the term "treadmill of production," which spurred a great deal of scholarship that incorporated other critical approaches (Bunker, 2005; Gunderson, et al., 2020; Lynch et al., 2018). These critical theories serve as a counterpoint to the antithetical theoretical perspective of ecological modernization, which describes the relationship between people and the environment as facilitated through technology that produces human wellbeing by increasing efficiency (Mol, 1997; Mol et al., 2014; Spaargaren & Mol, 1992). Ecological modernization theory has found support for environmental reform stemming from technological innovation applied to a variety of contexts, including carbon emissions (Mol et al., 2014).

However, these efforts often occur at a firm or sector level (Fisher & Freudenburg, 2001), and do little to address the broader context of environmental degradation (Foster, 2012). Even when applied at national scales, ecological modernization often fails to address the fact that environmental degradation continues to increase despite technological gains, especially carbon emissions (Gould et al., 2004; Dunlap & York, 2008). Likewise, the SFR methodology is a landscape-scale climate change adaptation strategy that arguably will not change the trajectory of global climate change (Schoennagel et al., 2017). However, the SFR methodology could offer a small but measurable increase to USFS budget shortfalls, accelerating forest restoration efforts.

Since I plan to submit Chapter IV to the *International Journal of Wildland Fire*, which publishes interdisciplinary research on the applied aspects of wildland fire science, I opted not to define carbon offsets as boundary objects or frame the main research questions around this debate, per se, but instead these sociological concepts informed how I thought about and presented the a priori justification for this mixed-methods analysis and how I discussed the results. The reason I wanted to conduct this analysis was based on my interest in the contested nature of ecosystem services such as carbon sequestration. In fact, my Master of Science degree in Natural Resources was focused on the science of ecosystem services.

My M.S. thesis was aimed at understanding the ecosystem service value of streamflow for the residents of the Salmon River Basin, Idaho. It was actually through conducting this research that I discovered my sociological identity and began to develop my sociological imagination; in trying to understand the value of streamflow in this region, I was forced to contend with the fact that instrumental valuation could not adequately express the cultural value of this ecosystem service. I was prepared to discuss the contribution of the Salmon River to the various community capitals of the towns in this region, but how could I express the intrinsic values of an environmental feature so closely tied to individual identity that residents were essentially making an economic sacrifice to live near it? I could do some sort of contingent valuation on the deferred income of such a choice, but that's not the point. The point is, I needed to find a scholarly identity that allowed me to talk about the social construction of place, community, and the relationship between those two things, and I found Natural Resource and Environmental Sociology.

During my M.S. program, I became friends with a member of my lab (who was a Ph.D. student at the time). I helped him conduct research on the ecosystem service value of surface water in eastern Oregon and helped write and publish our results. He told me that during his M.S. program at Northern Arizona University, he and a friend had developed a methodology aimed at using the ecosystem service value of the carbon offset benefits created by restoring northern Arizona ponderosa pine forests to pay for the restoration itself. I was impressed to learn that they had even submitted this methodology to be reviewed by the American Carbon Registry! Over the years, as I developed my sociological training and identity, I became a collaborator and research partner on that project, helping think reflexively about the ways we, as scholars, conceive of restoration, resilience, carbon sequestration, other ecosystem services, and, most poignantly for this essay, the very idea of wildland fire risk.

Thus, the SFR research project is an interdisciplinary collaboration between myself, my friend (whose scholarly identity is situated somewhere between an economist and a policy analysist), and an ecologist who specializes in forest modelling. Outside of the assistance that they received in originally preparing the SFR methodology for review, this research partnership is not financially supported. Which is to say, rather than a source of potential funding for me, my participation is indicative of my interest in the topic of applying emerging ideas such as payments for ecosystem services to natural resource management dilemmas such as achieving restoration of northern Arizona forests.

When this methodology was rejected by the ACR, I immediately conceived of the mixed-methods research design found in Chapter IV. I knew that based on my qualitative research training I could analyze comments on the methodology and that if I compared results of that to a new analysis of forest modelling data, a useful and fruitful article might emerge. For instance, since restoration requires actively thinning (cutting down smaller diameter trees) and burning the forest, which results in more carbon emissions in the short run, this restoration proposal is a challenge to the current construction of carbon offsets. Thus, monetizing net atmospheric carbon benefits from restoration requires active reflexivity. The reflexivity required to incorporate forest restoration into climate change mitigation projects also invites other insights on the theoretical plausibility of monetizing climate change mitigation in the first place.

Also, due my positionality in regards to this project, this chapter also represents a reflexive process where I am essentially confronting the failure to get the SFR methodology to be accepted (although I did not actually help draft this methodology). For example, in conducting these mixed methods, it occurred to me that part of the difficulty in registering the SFR methodology with ACR was perhaps explained by a certain stubbornness to accept reviewer critique that conflicted with SFR author conceptions of the system in question. Specifically, conflict over the appropriate treatment of uncertainty proved to be insurmountable. In this effort I believe I have remained as neutral as possible as an objective researcher given my relationship to the subject, which again, I see as a potential strength if handled reflexively.

Similarly, when I became involved in CoMFRT through my fellowship in the Climate Adaptation Science program, I drew on my knowledge of the SFR research methodology to help situate my understanding of climate adaption and alternative forest management strategies. Likewise, my participation in both of those programs improved my knowledge and expertise on these subjects, in turn. As I mentioned in the introduction to this dissertation, my involvement in CoMFRT began through my participation in the Climate Adaptation Science program, which included an internship component. My internship was at the USFS Rocky Mountain Research Station in the summer of 2018. During this internship I began outlining the GTR based on project documents.

However, the true framing and finalization of the GTR was the product of iterative, collaborative research praxis, including biweekly meetings and workshops with managers and other stakeholders. In these workshops, described in greater detail in the introduction, researchers and participants collaborated on identifying barriers to collaborative wildland fire risk governance in transboundary landscapes and potential solutions and/or topics that need more research in order to identify solutions. In these workshops I contributed to the discussion and reflexively employed my training as a sociologist in order to examine interactions as they occur in a manner Bourdieu refers to as being a “spontaneous sociologist” (Bourdieu & Wacquant, 1992), p. 66).

These workshops included one weeklong meeting at the northern Utah Interagency Fire Center in the fall of 2018 and several one-day workshops held in northern Utah in the Spring of 2019, where I personally guided participants in a structured activity designed to unpack and (re)build shared mental models of the wildfire risk governance system in northern Utah. These workshops also served as an important first step to initiating the survey protocol that project partners use to map the social network of wildfire risk managers in northern Utah, similar to the methods employed to generate the social network I utilized as a sampling frame for the qualitative research presented in Chapter III.

I conducted the interviews that comprised the qualitative results for Chapter III in the summer of 2019. Although the social network was centered in Wenatchee, Washington, where the first CoMFRT workshop was held in the summer of 2017, these interviews took me all over the state of Washington. This process gave me a much better appreciation for conjoint constitution of the SES affected by wildland fire in this region. For instance, the contrast between the culture and ecology on the east side of the Cascades, where the vast majority of wildfires occur, and the west side of the Cascades where Washington State DNR is located (in Olympia, specifically), was striking. As many managers pointed out during interviews, it is surprisingly hard for those who live on the west side of the state (even DNR employees) to comprehend the biophysical reality of wildfire in the much drier landscapes on the east side of the state.

Attitudes about wildfire also differed considerably by this geopolitical fault line. For instance, on the eastern side of the Cascades, residents generally favor a more active management of wildland resources and generally accept more wildland fire (although they are also more opinionated about the proper management of said fire). In fact, in the actual city of Wenatchee, there was what I would describe as a concentration of proponents of accepting increased wildfire. This includes one somewhat famous resident, Paul Hessburg, who is a well-known proponent of accepting that we are entering an era of so-called "megafires" (North 40 Productions, 2017). He also works as research scientist for the USFS Pacific Northwest Research Station. The locals refer to him as 'the megafires guy.'

I actually met Paul at a local brewery I often found solace in after driving all over hell and half of Washington.[24] On this particular occasion I was meeting several other CoMFRT researchers and project partners that I ran into quite accidently while conducting interviews at a local fire district. After being introduced, I told him about my research and he replied by enthusiastically telling me that there is no escaping it, we have to prepare for more frequent and destructive wildfires and no amount of alternative management will change that. I could tell by the look on the faces of the other patrons that they had head this speech before. Paul's was a name that came up again and again in interviews, not as a member of the network but as an authority on the subject.

By August of 2019, I had completed my interviews and I drove to Portland Oregon to attend a weeklong CoMFRT meeting. Team members presented their ongoing research and I was able to present my preliminary findings. Afterwards, we reevaluated

[24] It also struck me as I drove through vast and beautiful landscapes just how dispersed these actors were, geographically.

the mission and the direction of the CoMFRT research project, as is common in participatory research. By far the most notable aspect of this meeting was the fact that a conflict within the team that had been building, erupted. The final two days of the workshop were dedicated to working through this conflict on personal, professional, and epistemological levels.

Rather than simply airing dirty laundry, I make note of this because so often the literature on participatory research presents these methods as the solution to interdisciplinary and interpersonal conflicts. However, from my reading of the literature, not enough space is dedicated to a more even-handed treatment of the difficulty of actually doing post-normal science where different researchers with very different trainings are constantly coming together to redefine the process itself. In fact, one source of conflict was frustration felt by some on the need to continually come together in this fashion. But in the end, this conflict, and more importantly it's resolution, led to a stronger coalition.

The most recent CoMFRT workshop was a two-day workshop that I helped organize in Wenatchee, Washington this October. For this workshop I helped design a futuring exercise and wrote the future scenarios utilized therein based on my ever-growing knowledge of wildland fire risk that has resulted from interactions, interviews, and engagement with the literature as well as my personal experience. This process (and futuring more broadly) was specifically designed to give stakeholders scaffolding to facilitate their examination of the structure of wildland fire risk. This type of research is particularly helpful when co-producing insights on complex systems.

Not a synonym for complicated, complexity is produced by multiple diffuse interactions and relationships rather than simply having many parts. In fact, many complicated systems are decidedly not complex. For instance, as modernity marches on, more and more complicated technological marvels are engineered; these products are complicated, but, by design, not complex. Each part of these products has one purpose, and crucial systems even have redundant parts so that a failure in one system does not result in catastrophic failure. The failed part can then be identified and replaced.

By contrast, complex systems are comprised of interrelated parts so that a change in one input will reverberate throughout the system. Where the technological products of human engineers are increasingly complicated, natural systems tend to be complex. To illustrate, a plane is an extremely complicated system, whereas a flock of birds is complex. In a plane, thousands of parts serve one important purpose but if those parts are working then predicting its trajectory is simple. Whereas, the movement of a flock birds is extremely hard to predict because its trajectory is a product of the relationship between every single bird. In fact, modelling a flock of birds is so infamously difficult to do that the first model to do so is somewhat famous, among modelers (Eversham & Ruiz, 2011). At this point, it should be noted that understanding the complicated systems of a plane requires a lot of expert knowledge, but one person is capable of being that expert. The schism between the knowledge of this expert and the perceptions of non-experts contributes to Risk Society and recreancy. Whereas, by definition, no single person can perfectly understand a complex system.

Thus, complex topics such as wildland fire risk, situated in complex systems, such as conjointly constituted SES, cannot be completely or definitively understood by one person (or at all). Understanding wildland fire risk will therefore prove to be an endless process rather than something that can actually be achieved. Therefore, in order to promote the resilience of these SES it is necessary to “anticipate change and shape it for sustainability in a manner that does not lead to loss of future options” (Berkes et al., 2008, p. 354). As I hope this dissertation has made explicit, one way to achieve this is through collaboration.

In these collaborations, actors necessarily have incomplete knowledge of the system due to the complexity of the system (Checkland, 1981). But increased collaboration between actors will increase systems thinking and lead to shared mental models of the system (Daniels & Walker, 2012). Fortunately, even if this collaboration “fails,” increased understanding of the system among stakeholders is increased (Wehn et al., 2018). One way to increase this ancillary benefit and reduce the risk of collaborative failures is to provide some scaffolding such as an activity or model. Modeling is an intentional oversimplification of a complex problem (Barretau et al., 2014). In order for this to be useful, the model should reflect or be flexible to the perceptions of participants (Prell et al., 2007).

Although many think of complicated computer models (Gaddis et al., 2010; Salerno et al., 2010), the most effective models of complex systems that allow for collaboration may resemble, to borrow Bourdieu’s (1984) most consistent metaphor for explaining habitus and reflexivity: games (see Barreteau et al., 2003; Berland & Lee, 2011; Meinzen-Dick et al., 2017; Ostrom et al., 1994). Similar to any other model, and somewhat unlike reality, a game defines all of the rules of interaction between all the moving parts in a way that is explicitly knowable to participants (Leistiko, 2018). Although this may escape the notice of the players as they work together to establish the world of the game, this is why the game must be designed carefully so that it can simulate the themes, emotions, dilemmas, etc. of the topic.

According to Bourdieu, "an adequate model of reality must take into account the distance between the practical experience of agents (who ignore the model) and the model which enables the mechanisms it describes to function with the unknowing "complicity of agents" (Bourdieu & Wacquant, 1992, p. 70). This is similar to Ostrom's "law" that "a resource arrangement that works in practice can work in theory (Fennell, 2011, p. 9). With this in mind, I want to design games about wildland fire risk governance. In fact, I have already designed and play-tested one prototype with CoMFRT researchers and partners.

I based my prototype on my experiences with wildland fire risk from all the personal and professional angles I have discussed in this essay. One of the people who played the game (incidentally the Principal Investigator of CoMFRT) suggested that this game could also be a means to communicate science, which, as I have touched on briefly, is an emerging necessity. It may be obvious to the reader at this point that I have a personal affection for board games. I think it's safe to conclude that this contributes to my belief in the utility of this medium. But it also affords me insight into the maturity of analog game design as a field in it of itself, which has not been well incorporated into academic applications, but which offers the means to addresses natural resource problems that are too complex for deterministic and/or digital models (Malek & Boerboom, 2015).

For instance, Berland and Lee (2011) used a popular cooperative board game that promotes positive interaction between players, called Pandemic, to show how modern board game design promotes strategic thinking. I have played this particular game many times myself. Now that we are living through an actual global pandemic, I think about this game a lot and the insights it offers. For instance, when you play the game it's extremely important to take actions to control the spread of disease early on or else it becomes impossible to do so…

According to Bourdieu (1989), the task of sociology is "to uncover the most profoundly buried structures of the various social worlds which constitute the social universe, as well as the mechanisms which tend to ensure their reproduction or their transformation" (Bourdieu, 1989, p. 7). This is why I believe that incorporating analog games into sociological research and science communication is an effective medium to pursue. Similarly, wildland fire risk structures and mechanisms are hard to uncover or alter (Fischer et al., 2016; Thompson et al., 2018).

This board game, the workshops I have helped organize and participate in, as well as the research presented in this dissertation, are all aimed at uncovering the buried structures of wildland fire risk governance and management, including the structure of governance networks and the implementation of novel funding mechanisms for needed restoration. Throughout these experiences, I see myself as the spontaneous sociologist, utilizing reflexivity to think about how different theoretical propositions intersect somewhere in the conjoint constitution of SES. Thus, I focus on how reflexivity and habitus lead to different outcomes in the management of these complex and adaptive systems. In this essay, I have attempted to employ this same process to an autoethnographic examination of my experiences with and participation in post-normal research. I hope this essay offers useful insight into the construction of this dissertation and its component parts, and serves as a useful stand-alone product.

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CHAPTER VI

CONCLUSION

This dissertation reiterates the proposition that managing wildland fire risk in transboundary landscapes in the face of anthropogenic climate change and increasing development of the wildland-urban interface (WUI) in the western U.S. requires collaborative governance and other alternative management strategies. However, these accumulating biophysical and social stressors, produced by the conjoint constitution of wildland fire, also complicate the development and implementation of these alternative and/or collaborative governance strategies.

Therefore, wildland fire risk managers need to engage in active reflexivity in order to deconstruct and then reconstruct their understanding of the social and biophysical dynamics that define social-ecological systems (see Devisscher et al., 2016; Fischer et al., 2016; Higuera et al., 2019; Rodríguez et al., 2018), and the structural pathways and mechanisms required to bring about change in wildland fire risk governance (see Cheng et al., 2011; Daniel et al., 2007; Haas et al., 2015; Machlis et al., 2002; Paveglio et al., 2018). In other words, managers need to reassess how they think about wildfire in order to innovate new strategies that are sensitive to the changing composition of wildlands that experience fire and the needs of residents who live in the WUI.

Participatory, post-normal science helps wildland fire risk researchers co-produce new insights about social-ecological systems in order to illuminate important insights for achieving collaborative governance and alternative management strategies (see Brooks et al., 2006; Otero et al., 2018; Scott et al., 2017; Williams, 2017; Wilson et al., 2017). Situated in this context, this dissertation presents four independent chapters highlighting participatory, post-normal science on wildland fire risk framed by Reflexive Sociology (Bourdieu & Wacquant, 1992). The overarching goal of this dissertation is the critical examination of conjointly constituted wildland fire risk, governance, and research, which is especially important in transboundary social-ecological systems where different conceptions of wildland fire risk, resilience, and forest restoration are contested, making unilateral management decisions impossible.

Highlighting these challenges, Chapter II is a general technical report (GTR), co-produced through synthesized participatory research processes, products, and workshops, and scaffolded by a Theory of Change. This chapter presents a problem analysis of wildland fire risk governance in transboundary landscapes with a corresponding review of participatory research theories and methods. This GTR is framed by the evolving interagency awareness that fire does not obey social, political, or economic boundaries and therefore in transboundary settings the *shared risk* posed by wildland fire must lead to more *risk sharing* through interagency collaborations and investment in the shared stewardship of fire-prone landscapes in order to achieve the National Cohesive Wildland Fire Management Strategy goals (Ager et al., 2019; Brenkert-Smith et al., 2017; USFS, 2018). Towards this end, this chapter offers actionable recommendations for management and policy about aligning agency objectives, achieving community engagement, and recruiting and rewarding highly-engaged actors.

Building on the insights offered by this problem analysis, Chapter III examines perceptions of collaboration by wildland fire risk managers in order to buttress the shared stewardship and collaborative governance of wildland fire risk. This chapter presents a thematic analysis of interviews conducted with identified members of a wildland fire risk governance social network. Results of this analysis reveal complex interactions between structure and personal agency that contribute to collaboration outcomes. These results provide support for the assertion that successful collaboration promotes alternative management strategies that, in turn, help achieve management goals such as increased forest restoration. However, many barriers remain that hinder these goals, including but not limited to funding shortfalls. Therefore, beyond merely increasing collaboration, other management innovations need to be developed through active reflexivity in order to identify additional opportunities.

Chapter IV presents a mixed-methods analysis of one such opportunity to improve wildland fire risk management by increasing funding for forest restoration. This chapter examines a proposal to fund forest restoration through the sale of carbon offsets. The proposed offsets would be the direct result of reduced wildland fire frequency and intensity. Results of this analysis demonstrate that, indeed, restoration of northern Arizona ponderosa pine forests provides net reductions in atmospheric carbon in the long run, but uncertainty regarding the timing and intensity of future wildfires complicates the application of the concept of carbon offsets towards achieving this restoration.

Based on a synthesis of both quantitative and qualitative results, this chapter provides insights for integrating a similar carbon-offset-funded forest-restoration-proposal into current public land management and wildland fire risk governance policies and procedures in the future. For instance, carbon offsets from additional restoration projects need to be clearly and carefully distinguished as additional to current public land agency management priorities.

Chapter V presents an autoethnographic essay that meditates on the conjointly constituted and contested experience of wildland fire risk, management, and research. This chapter is not guided by research questions but rather utilizes the method of autoethnography to reflexively examine my experience conducting the research projects that culminated in this dissertation. As an autoethnography, this chapter allows me to give voice to my experience (Wall, 2008), which provides insight into the actual process of conducting participatory, post-normal, and transdisciplinary research. I also turn reflexively inward to interrogate my own position in relation to wildland fire risk, governance, and research.

Active reflexivity is a necessary (but not sufficient) condition for engaging in post-normal, participatory research because reflexivity is the act of questioning one's own mental model (Arnold et al., 2017; Murphy et al., 2016). As such, participatory research can help establish shared mental models (Langsdale et al., 2013), which help participants (including researchers) identify potential solutions to complex dilemmas. Since the research presented in this dissertation is ultimately oriented by the normative goal of improving the actual governance of wildland fire risk by identifying these dilemmas and their solutions, this dissertation is meant to be useful to managers and policy-makers and not just interesting to researchers.

Implications for Wildland Fire Risk Governance

The chapters that comprise this dissertation offer important lessons for improving the governance of wildland fire risk, pursuant of the three major goals of the National Cohesive Wildland Fire Management Strategy (NCS): 1) restoring and maintaining resilient landscapes, 2) creating fire-adapted communities, and 3) safe and effective wildfire response (Lee et al., 2011). First and foremost, more collaboration will be needed to achieve safer and more effective wildfire response in the future due to exacerbated social and biophysical conditions.

Collaboration is constrained by both social and biophysical structures. Social structures include the organization and mission of agencies that manage land in transboundary landscapes and the socioeconomic realities faced by communities in the WUI. Despite successful collaboration on wildland fire incidents, incompatibilities in these structures hinder collaboration before and after wildfires occur. Thus, agencies involved in interagency wildland fire risk governance need to align their institutional objectives, and should include the achievement of partner objectives as part of their institutional missions. Furthermore, these agencies need to create positions aimed at collaboration and reward those activities.

Wildland fire risk managers also feel constrained by biophysical realities. Therefore, this dissertation provides support for the structure of the NCS as aimed at achieving its three goals in tandem. Which is to say, improving wildland fire risk governance requires increasing collaboration in conjunction with addressing the biophysical realities that make landscapes less resilient to wildfire. In management terms, this translates to forest and rangeland restoration.

This restoration, which includes mechanical thinning and prescribed burning, will be more and more necessary as a wildland fire management tool in a climate change affected future (Ager et al., 2017). Restoring forests in the western United States is an effective management strategy for mitigating the biophysical realities that complicate wildland fire risk governance. Restoration also provides a variety of other important benefits, both ecological and social (Brainard et al., 2009). Unfortunately, funding shortfalls make this restoration difficult to achieve.

Restoring and Maintaining Resilient Landscapes

Wildland fire management costs are expected to rise but landscape-scale restoration, which would mitigate these costs, is already prohibitively expensive. Unfortunately, the release of carbon dioxide from high-intensity fires contributes to climate change, accelerating a positive feedback loop that intensifies drought and wildfire severity (Littell et al., 2018). Thus, without restoration, climate change realities will have material consequences on forests and forests will affect climate change, in turn (Ager et al., 2017; Polley et al., 2013). Therefore, new funding mechanisms to support the restoration and maintenance of resilient landscapes are required.

With this in mind, reflexive examination of current restoration practice and the concept of voluntary carbon offsets presents an opportunity to achieve more forest restoration through registering the carbon benefits of restoration as voluntary offsets. Chapter IV reveals that one of the major barriers to registering carbon offsets as a funding mechanism to pay for restoration is uncertainty. Specifically, unavoidable uncertainty about the exact timing and location of wildfires in the future makes it impossible to know exactly when net atmospheric carbon benefits will occur. Thus, carbon offsets will need to be arranged such that this uncertainty is not an issue.

Although it may not be possible to predict exactly at what point in the future these fires will occur, in the long run these wildfires are all but a certainty. Therefore, carbon offsets could be awarded as a fifty-year bond based on forest model projections. For the duration of this fifty-year period, this bond could be tradeable, offering the value of these expected carbon offsets, but the offsets themselves would be tied-up in the bond. After fifty years, a forest inventory analysis could determine if more or less carbon was stored than projected, and the final amount would be awarded to the current bond holder.

This is just one possible approach that will need to be more thoroughly explored. There is a temporal urgency to exploring this and other possible approaches since wildland fire risk is expected to increase and many of the forests in need of restoration are not likely to return as forests if they experience high-intensity wildfires. Results from Chapter III reveal that this ecological risk is an opportunity to increase collaboration. Many institutions (such as conservation districts) are primarily interested in protecting wildlands and therefore they are willing to partner on restoration efforts.

If public land management agencies are willing to help pay for and implement restoration on land managed by other institutions, they will reduce the risk of wildland fire transmission onto the public lands they manage. This dynamic also reveals the importance of engaging communities. Since communities in the WUI are a both a source of fire risk transmission as well as stakeholders at risk, restoring both public and private lands collaboratively is an important part of creating fire adapted communities.

Creating Fire Adapted Communities

Based on recognizing and understanding community composition, different pathways followed by agencies involved in interagency wildland fire risk management could lead to improved community capacity to respond to wildland fire risk (Paveglio et al., 2018). Wildland fire risk managers are community members as well, and they consider community needs when making management decisions. However, managers make some potentially incorrect assumptions about other members of their communities. Therefore, public land agency employees should engage stakeholders prior to wildfire in order to correct any false assumption they have and to provide important information about wildfire to correct any false assumptions held by community members.

On the other hand, results of Chapter III also reiterate the caution presented in Chapter II that soliciting the cooperation of community members and other stakeholders without the intention to reciprocate, can potentially damage collaborative capacity in the long run. Therefore, agencies involved in interagency wildland fire risk management should think about the social dynamics of specific communities before starting collaborative approaches. Although collaboration with community members is indeed an important way of creating more fire adapted communities, this is not the only (nor always appropriate) tool for improving safe and effective wildland fire risk management.

Safe and Effective Wildfire Response

Establishing collaborative capacity prior to wildland fires improves wildfire response. In fact, participants interviewed in northcentral Washington (Chapter III) reported that the composition of a collaborative social network prior to a series of high-intensity fires from 2013 through 2015 led to better wildfire management outcomes. These results could inform and therefore improve collaboration in this social network. Participants also confirmed the importance of restoration in mitigating wildland fire risk since forest restoration leads to reduced wildland fire intensity (see Chapter IV), which improves wildfire response. Moreover, partnerships aimed at achieving biophysical restoration can establish connections and increase collaborative capacity.

Addressing these structures is necessary, but changing structures alone is not sufficient to achieving more collaborative governance and alternative management. Even after aligning institutional objectives and missions and creating positions aimed at collaboration, the right people with the right motivations need to be installed into those positions. The most important aspects of personal agency are personal passion and willingness to engage, equitably, in collaborations. After finding the right people, it is again necessary to adjust structures so that those actors do not get burned out and leave those positions, resulting in collaborative inertia.

Reflexive Sociology in Transdisciplinary Research and Practice

Based on these insights and corresponding implications for more effective wildland fire risk governance, this dissertation demonstrates the utility Reflexive Sociology and participatory post-normal science in transdisciplinary research and practice. Moreover, this dissertation provides support for the proposition that wildland fire risk is conjointly constituted. For instance, years of fire suppression has led to increased wildland fire frequency and intensity (Thompson et al., 2018), and recognizing this fact is an act of reflexivity (Rodríguez et al., 2018). Contending with conjointly constituted wildland fire risk requires post-normal research. Specifically, participatory, transdisciplinary research that involves stakeholders other than researchers and managers.

More and more scientific disciplines, research programs, agency initiatives, and academic departments are recognizing the need to make the science of complex problems that have management and policy implications more actionable (Beier et al., 2017). However, it's not yet well-established how to engage in this science-policy-management nexus (Tomlinson & Davis, et al., 2010). Although inevitably context dependent, post-normal scientific methods will be required to engage with these complex problems in actionable ways (Lang et al., 2012).

Conducting post-normal science is a challenge. Not only does it chafe against many of the qualities that traditionally define 'good' science (e.g., controlling for extraneous variables) but it is necessarily slower, requiring continual revaluation and realignment in order to keep diverse stakeholders engaged (see Funtowicz & Ravetz, 1993; Gidley et al., 2009; Wilkinson & Eidinow, 2008). However, for topics such as wildland fire risk, this post-normal and transdisciplinary research is needed in order to make the science of complex problems more actionable (Williams, 2018). On that topic, this dissertation provides some guidelines, with corresponding examples.

However, this dissertation also reiterates many of the challenges of this approach. For instance, research projects take longer to define, and since the definition process is transdisciplinary, it's difficult to draw those boundaries such that results fit into well-defined scientific disciplines and/or research topics. Furthermore, results often lack the clarity that comes from narrowing down the research focus a priori. For instance, these results demonstrate the importance of 'collaboration' as stakeholders define it, but I cannot say how many homes will not burn due to one more collaboration. Similarly, this research supports the assertion that forest restoration has a net carbon benefit, but I cannot say exactly how many tons of carbon emissions will be avoided.

Transdisciplinary, post-normal science in the science-management-policy nexus of topics such as wildland fire risk governance, also presents challenges for researchers attempting to reconcile their disciplinary-specific training with these context-specific topics (Brice et al., 2019, in press). For instance, in this dissertation I have applied my training in sociology in ways that many interested in this topic may not be familiar with. Conversely, sociological peers may have no interest in this topic.

Although there is an emerging scientific discipline of interdisciplinarity, I believe that there are insights that emerge from collaboration among diverse scholars when some of those scholars bring disciplinary-specific insights to transdisciplinary teams. I believe that this dissertation supports that point. For instance, in my analysis of carbon offsets from restoration, I am able to connect this proposal to major themes in environmental sociology, such as the debate over the role of technology and economic development in creating and/or mitigating environmental impacts (Foster, 2012; Mol et al., 2014).

So, as programs such as the National Science Foundation funded graduate training program in Climate Adaptation Science at Utah State University, which facilitated my role in the CoMFRT project, are developed, I believe it's important to allow some participants to engage without abandoning their preferred disciplinary foundations. Inevitably, this may force those individuals to take on more work, and evaluation of scientific outputs may be more complicated. But, traditional metrics of scientific robustness have already proved insufficient in grappling with complex issues. Therefore, new metrics of success that measure the impact of scientifically generated insights in practice need to be developed.

In sociology, this kind of scholarship has a long, rich history (Burawoy, 2012). In fact, consternation about separating sociological research from the application of insights generated, for improving society, is as old as the discipline itself (Romero, 2020). Today, sociological research take many forms, from traditional, basic science to activist and public sociology (Burawoy, 2005). Here, I hope I have provided some evidence for the utility of participatory, post-normal, Reflexive Sociology engaged in transdisciplinary research in the science-policy-management nexus with a normative goal of improving actual management.

Limitations

The most fundamental reason for conducting post-normal research is the inherent limitation of basic science to address complex and contested topics. However, this also means that these post-normal methods are characterized by inescapable limitations as well; adopting a post-normal research paradigm opens up a variety of alternative approaches that correspond with the innumerable amount of approaches possible. Which is to say, if post-normal research on a certain topic is appropriate then by definition there are multiple ways to approach that topic and by choosing one, others are neglected. Moreover, the benefits of post-normal research come at the expense of the controls offered by more traditional, basic science.

The research presented in this dissertation is indicative of these limitations. Chapters II, III, IV, and V offer only four different examinations of the complex topic of wildland fire risk. Moreover, each of these chapters relies in part or wholly on qualitative research methods. Although helpful in elucidating more detail on complex topics (Creswell, 2009), qualitative research methods lack the generalizability potentially offered by quantitative methods (Dominguez & Hollstein, 2014). On the other hand, qualitative approaches delve into the richness of complex problems better than quantitative approaches that are limited to domains that can be quantified and models that inevitably suffer specification errors (Creswell, 2009). For instance, the ecological model data analyzed in Chapter IV does not perfectly operationalize the relationship between forest restoration and vegetation structure and function. Unfortunately, due to ecological differences, the quantitative portion of Chapter IV may also lack generalizability.

The participatory research that resulted in the GTR that is Chapter II may not actually constitute an empirical product. Rather, this GTR synthesizes existing knowledge based on the insights of participating stakeholders. Which means that unlike a systematic literature review (e.g., Brice et al., in press), this literature synthesis is inherently influenced by the stakeholders who participated in the process and thus will be biased according to those participants' personal perspectives. Chapter III has similar limitations.

Rather than results on the objective reality of collaboration (which may or may not be possible), the results presented in Chapter III only represent the perspectives of those interviewed. Thus, only the information presented by these interviewees can be analyzed. Although these participants were systematically sampled based on identification in a quantitative social network analysis, there is a sample bias in the selection of participants and there are too few to generalize to all members of the network. Also, despite a stratified random sampling approach, participants were not perfectly distributed across identified strata. Due to the very fact that potential participants are active in wildland fire risk governance, and interviews occurred during the fire season, it was difficult to arrange time for in-person interviews.

Similarly, the qualitative portion of Chapter IV is only an analysis of the select people who commented on the SFR methodology and/or engaged in the peer-review process. Although this selection provides a de facto self-sampling of subject matter experts, the views expressed by these specific experts should not be misconstrued to represent all expert opinions on such a proposal. Also, the quantitative portion of this chapter relies on data produced by a forest model conducted by SFR methodology authors. Analyzing model data should always be done with caution (Gaddis et al., 2010).

Moreover, this particular modelling technique has some potential limitations. Specifically, rather than running the model several hundred times and averaging results, the model was only run once for each combination of factors. Also, modelled surface carbon data were only produced at ten-year intervals rather than one-year intervals, which would provide a better resolution of wildfire occurrence. Additionally, decadal estimates of wildfire occurrence were calculated from a Weibull distribution of the cumulative probability of fire at each time step (i.e., ten-year intervals) after subtracting the previous time-step's cumulative probability, rather than integrating the probability of wildland fire into initial model logic.

Despite limitations, the research presented in this dissertation provides potentially-useful insights on wildland fire risk and governance in complex social-ecological systems. However, understanding complex systems such as social-ecological systems is a continual process rather than a destination. This process is best served by participatory methods that leverage multiple stakeholder's mental models and/or co-produce more complete shared mental models. This requires researchers to engage in post-normal research methods outside the bounds of how most researchers were trained. But, based on current trends, the future of scientific research will be defined by perfecting these methods and applying insights from basic science.

Directions for Future Research

Conducting research on complex adaptive systems, such as social-ecological systems experiencing wildfire, is an intriguing challenge that will prove to be more imperative in the future. For instance, studying wildfire risk is only going to become more necessary due to biophysical and anthropogenic complexity at the same pace that this becomes more difficult to achieve due to these same factors. As such, the future of research on these complex adaptive systems is as hard to predict at this moment as the systems themselves. This is due to, among other factors, the necessity of integrating the perspectives of stakeholders outside of traditional research institutions into more transdisciplinary, and therefore not yet categorically defined, research methods.

For instance, on the subject of wildland fire risk governance, social-ecological systems that experience wildfire will become increasingly transboundary while biophysical conditions fluctuate due to climatic trends. As such, more collaborative research and governance will be needed. Therefore, the insights offered by the GTR in Chapter II will become even more useful to future researchers. Also, the methods employed in Chapters III and IV could be applied to different contexts and/or topics. For instance, based on insights from Chapter III, I will be conducting similar semi-structured interviews in northern Utah. Complimentarily, social network researchers on the CoMFRT project have adapted their research methods in northern Utah based on insights from this paper and other CoMFRT research products.

I also intend to continue exploring opportunities to apply payments for ecosystem services, conservation finance schemes, and similar ideas about the anthropocentric value of functioning ecosystems to potentially improve social-ecological systems management. Thus, results of Chapter IV provide potential directions for future research that I hope will aid others exploring this rapidly expanding research topic (see Kotchen, 2009; Lee et al., 2018; Lippke & Perez-Garcia, 2008; Matzek et al., 2015; Perry et al., 2019; Porter et al., 2020; Tolentino et al., 2015; van der Gaast et al., 2018). This research, as some (especially those with sociological training) will surely note, is based on a normative goal. Thus, some of my future research endeavors will challenge my ability to claim scientific objectivity.

However, I believe that as researchers contend with complex and contested topics it will become increasingly common (and probably unavoidable) to accept that perfect objectivity is impossible. This is what Bourdieu hoped to highlight in his proposed framework of Reflexive Sociology, which I shall continue to employ (Bourdieu & Wacquant, 1992). Thus, I will always be a sociologist by nature and training even though I will seek out interdisciplinary and transdisciplinary research projects. Interdisciplinary and transdisciplinary research is proving to be more and more common (Heilmann & Pundt, 2017), yet it remains epistemologically challenging (Cheng & Randall-Parker, 2017). Thus, I believe that the role of the sociologist helping researcher partnerships orient their theories and methods based on boundary objects as anchor points will become even more common in the future (Steger et al., 2018).

Also, accepting the positionality of researchers will hopefully help some of them to take on more active roles contending with scientific topics that have been made politically contentious, such as climate change. For instance, a paper that I was the co-lead author of, which will soon be published, highlights the gap between projected climate change effects on public land in the Intermountain West and BLM resource management plans (Brice et al., in press). Which is to say, based on all available documentation, the BLM is not adequately planning for climate change in this region. I plan on conducting a similar analysis with other CoMFRT researchers on USFS forest plans and CWPPs, looking for explicit planning for climate change.

In order to study the projected effects of future trends such as climate change, I also plan to continue to refine my use of futuring research methods, which are a post-normal research method gaining recognition in scientific literature (see Brassett & O'Reilly, 2015; Frame et al., 2008; Raven & Elahi, 2015). One method I am particularly interested in pursuing is the use of analog (i.e., not digital) games. Analog games have been used to explore complex problems, such as complex natural resource systems (see Flood et al., 2018; Meinzen-Dick et al., 2017; Lema et al., 2013). Notably, Elinor Ostrom, who won a Nobel Prize in economics for her seminal work on common-pool resource management (Ostrom, 2000), used analog games to examine common-pool resource problems and identify design principles for more effective common-pool resource management (Ostrom et al., 1994).

Using analog games as a collaborative modeling exercise incorporates the active participation of stakeholders, which applies and challenges their mental models and perceptions of pertinent boundary objects (Morisette et al., 2017). This is particularly useful in examining transboundary natural resource systems (Iñiguez Gallardo et al., 2013; Johnson & Becker, 2015) such as wildfire (Dickinson et al., 2015). Analog models, or "soft systems" modeling methodologies, more effectively produce exploratory qualitative data (Salerno et al., 2010). By utilizing analog games as models, the interaction between structure and personal agency can also be examined more explicitly by bringing people back into the model (Salerno et al., 2010). Additionally, analog games allow users to see the model logic (Berland & Lee, 2011; Maynard & Herron, 2016). The use of analog games could also be used as an interactive method for communicating science.

For all of these reasons, I want to develop analog games to model collaborative wildland fire risk governance in transboundary social-ecological systems as a research method and/or means of communicating science. Towards this end, I developed a prototype analog game on this subject and play-tested it with CoMFRT research partners including USFS policy-makers and mangers. This game was well received and even inspired seasoned wildland fire risk researchers and managers to verbally reflect on new insights about the conjoint constitution of wildfire. If CoMFRT receives a five-year-charter, as a project partner I would like to develop this game into a research work package. Also, in discussion with the Principle Investigator of the CoMFRT project, it was proposed that refining this game based on project insights and distributing it as a board game to the general public could be a novel method of communicated CoMFRT research findings.

Far from an afterthought, developing means to effectively communicate science to an increasingly skeptical public is as important as developing novel post-normal research methods. As researchers, managers, and simply members of social institutions (including communities, states, and nations) increasingly divided over the veracity of problems in complex social-ecological systems as well as solutions to those problems, we are standing at a precipice. Either we, as humans, find a way to understand these complex systems *and* communicate that understanding to the public and policy-makers so that management can be improved, or we will simply have the privilege of documenting the inadequacies of our systems of governance. Although this caution applies broadly, it certainly applies to managing wildland fire risk in the future. Although we cannot yet predict exactly when they will occur, more frequent and more intense wildfires will be a reality for at least the next hundred years. We can either adapt and learn to live with those fires, or we will live with the consequences of our failure to do so.

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Williams, D. (2017). The role of place-based social learning. In E. P. Weber, D. Lach, & S. Steel (Eds.), *New Strategies for Wicker Problems: Science and Solutions in the 21st Century* (pp. 149–168). Corvallis: Oregon State University Press.

Wilson, R. S., McCaffrey, S. M., & Toman, E. (2017). *Wildfire Communication and Climate Risk Mitigation* (Vol. 1). https://doi.org/10.1093/acrefore/9780190228620.013.570

CURRICULUM VITAE

Brett Alan Miller – August 2020

RESEARCH STATEMENT

My research sits at the intersection of social science theory and natural resource and ecosystem service practice. I apply sociological theory to practice, and vice versa, to examine how institutions and individuals think about natural resources and environmental values, policies, and programs. Thus, I focus on individual and institutional reflexivity in examining how diverse actors and institutions think about their roles in complex social-ecological systems, and how that influences environmental governance and natural resource management outcomes. I do this work at the landscape scale and with various qualitative and quantitative methodologies in order to better understand and promote community wellbeing, resilience, and sustainability. My work is often post-normal in design and aimed at promoting these normative goals but my methods are conducted with scientific rigor. Some of these methods are necessarily transdisciplinary, which is to say that I utilize integrated multidisciplinary research methods and collaborate with scholars from diverse social and biophysical science backgrounds along with natural resource managers and other stakeholders.

EDUCATION

Utah State University, Logan, UT *Advisor*: Dr. Courtney Flint
Ph.D. in Sociology, expected September 2020
Specialization: Environmental, Community, and Natural Resource Sociology
Graduate Minor: Climate Adaptation Science
Dissertation: *"Collaboration and Reflexivity on Wildland Fire Risk Governance in the Western United States"*
Certificate: Sociology Teaching Certificate

University of Idaho, Moscow, ID *Advisors*: Dr. Kelly Jones & Dr. Tamara Laninga
M.S. in Natural Resources, May 2015
Thesis: *"A Beautiful River that Eats People: The Value of Streamflow for the Salmon River Bioregion, Idaho"*
Certificates:
Bioregional Planning Certificate 2015
Environmental Education Certificate 2013

Bryant University, Smithfield, RI
B.S. in Business Administration, Accounting Concentration, May 2011
Minor: History

RESEARCH EXPERIENCE

Co-Management of Fire Risk Transmission (CoMFRT) Research Partnership
June 2018 - Present
Funding: USDA Forest Service, State and Private Forestry, Fire and Aviation Management Office of Landscapes and Partnerships
Supervisor: Dr. Daniel Williams

Climate Adaptation Science Graduate Training Program at Utah State University
August 2017 – Present
Funding: National Science Foundation
Supervisor: Dr. Nancy Huntly

Southwestern Forest Restoration Initiative
January 2016 – Present
Funding: National Forest Foundation, Northern Arizona University
Objective: Exploring reduced emissions from decreased wildfire severity in northern Arizona ponderosa pine forests

Innovative Urban Transitions and Arid-region Hydro-Sustainability (iUtah)
January 2015 – August 2017
Funding: National Science Foundation
Supervisor: Dr. Courtney Flint

Participation in Leases for Instream Flows in Oregon, US,
May 2015 – December 2015
Objective: Assessing current rates of, and perspectives on, leasing water rights as payments for instream flows as an ecosystem service

Graduate Research Assistant, University of Idaho, College of Natural Resources
August 2014 – May 2015
Supervisor: Dr. Kelly Jones
Objective: Valuation of the ecosystem service of Salmon River streamflow

PUBLICATIONS

Peer-Reviewed Journal Articles and Book Chapters

Brice, E.M., **Miller, B. A.**, Zhang, H., Goldstein, K., Zimmer, S., Grosklos, G., Belmont, P., Flint, C., Givens, J., Adler, P., Brunson, M., & Smith, J.W. (in press). Impacts of climate change on multiple use management of Bureau of Land Management land in the Intermountain West (USA). *Ecosphere*

Williams, D.R. & **Miller, B. A.** (forthcoming). "Metatheoretical Moments in Place Attachment Research: Seeking Clarity in Diversity" In *Place Attachment*. Routledge

Plumb, S., Paveglio, T., Jones, K., **Miller, B. A.**, & Becker, D. (2018) Differentiated reactions to Payment for Ecosystem Service Programs in the Columbia River Basin: A qualitative study exploring irrigation district characteristics as local common-pool resource management institutions in Oregon, USA. *International Journal of the Commons*, *12*(1).

Miller, B. A. (2016). "Lifeblood" of a Region: The value of streamflow for the residents of the Salmon River Basin, Idaho. *River Management Society Journal*, *29*(2).

Other Publications

Brice, E. M., **Miller, B. A.**, Zhang, H., Goldstein, K., Zimmer, S., Grosklos, G., ... & Brunson, M. (2019). *Impacts of climate change on the management of multiple uses of BLM land in the Intermountain West (USA).*

Zanzanaini, C., **Miller, B. A.**, Everett, P., & Carella, A. (2014). Ecosystem services game: Game Design Document. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE). 27p

In Preparation

Miller, B. A., "The relationship between outdoor recreational activity and community activeness on differentiated water policy perspectives among residents of northern Utah." Target journal: *Rural Sociology*

Miller B. A., Jacobs D., Evers C., Essen M., Williams D. R., "Assessing the quality of connections in a wildfire governance social network." Target Journal: *Social Networks*

Plumb S. , Jones K.W., **B. A. Miller,** & Paveglio, T. B., "Paying for, or investing in, environmental services: Assessing financial instruments used in environmental water transactions in Oregon." Target Journal: *Water Resources Management*

Miller BA, Williams D. R., & Jones K. W. "Bioregional Imagination and the place attachment value of streamflow as an ecosystem service in the Salmon River Basin." Target Journal: *Ecosystem Services*

Miller BA, Flint C, Krannich R, & Laninga T. "Assessing the Salience of a Salmon River Bioregional Field of Landscape Scale Interaction." Target Journal: *Rural Sociology*

Miller BA, Jacobs D, Williams DR, Essen M, & Flint C. "Assessing the Quality of Connections in a Wildfire Governance Social Network." Target Journal: *Society & Natural Resource*s

Wyborn, C., Essen, M., Gray, B., **Miller, B. A.,** Williams, D. R. and L. Yung. Characterizing Wildfire Governance. Target Journal: *Fire*

WORKSHOPS

Wyborn, C., M. Essen, **B. A. Miller,** A. Schmidt, J. Riley, and P. Haggerty. North-Central Washington Wildfire Risk Workshop. Local stakeholder co-production workshop. Wenatchee, Washington, October 2019.

M. Essen, D. Williams., A. Ager, H. Brenkert-Smith, W. Butler, M. Carroll, P. Champ, C. Evers, C. Edgeley, B. Gray, D. Jacobs, **B. A. Miller**, M. Nielsen-Pincus, T. Paveglio, C. Wyborn, and L. Yung. CoMFRT: Co-Management of Cross-Boundary Fire Risk Transmission – Wasatch, Utah. Northern Utah Interagency Fire Center, October 2018

PRESENTATIONS

M. Essen, Williams. D. R., Ager, A. A., Brenkert-Smith H., Butler W., Carroll, M., Champ P., Evers, C., Edgeley C., Gray B., Jacobs D., **Miller B. A.,** Nielsen-Pincus, M., Paveglio T., Wyborn, C., and Yung, L. CoMFRT: Co-Management of Cross-Boundary Fire Risk Transmission – Wasatch, Utah. Utah Department of Natural Resources – State Forester; invited presentation, Salt Lake City, Utah, 2019.

M. Essen, Williams. D. R., Ager, A. A., Brenkert-Smith H., Butler W., Carroll, M., Champ P., Evers, C., Edgeley C., Gray B., Jacobs D., **Miller B. A.,** Nielsen-Pincus, M., Paveglio T., Wyborn, C., and Yung, L. CoMFRT: Co-Management of Cross-Boundary Fire Risk Transmission. First Friday All Climate Change Talks (FFACTs) webinar, USDA Forest Service, 2019.

M. Essen, Williams. D. R., Nielsen-Pincus, M., Champ P., Evers, C., Gray B., Edgeley C., Paveglio, T., Yung, L., Wyborn C., Brenkert-Smith H., **Miller B. A.,** Jacobs, D., Riley, J., Ager, A. A., Carroll M., and Billings M. Approaches to Cross-Boundary Wildfire Risk Governance. 8th International Fire Ecology and Management Congress, Tucson, Arizona, 2019.

Miller, B. A. "Reflexivity in Wildland Fire Systems" *25th International Symposium of Society and Resource Management*. Oshkosh, WI, June 2019.

Williams, D. R. & **Miller, B. A.** "Metatheoretical Moments in Place Attachment Research: Seeking Clarity in Diversity" *25th International Symposium of Society and Resource Management*. Oshkosh, WI, June 2019.

Miller, B. A. "To Lease or Not to Lease: Irrigation Districts and the Social Dilemma of Leasing Water for Instream Flows." *Resilience Frontiers for Global Sustainability*. Stockholm, Sweden, August 2017.

Miller, B. A. & Plumb, S. "Aligning irrigation district objectives with design principles aimed at increasing instream flows in Oregon, United States: A proposal for using agent-based models to test system robustness." *16th Biennial Global Conference: International Association for the Study of the Commons.* Utrecht, Netherlands, July 2017.

Miller, B. A., Dean, T.K., & Flint, C. "Integrating Ecosystem Service and Human Wellbeing Frameworks for Qualitative Analysis of Semi-Structured Interviews with Key-Informants in Northern Utah." *23rd International Symposium of Society and Resource Management*. Umeå, Sweden, June 2017.

Miller, B. A., Dean, T.K., & Flint, C. "Looking for a Local Water Meta-Narrative." *22nd International Symposium of Society and Resource Management*. Houghton, MI, June 2016.

Miller, B. A., Flint, C., & Jackson-Smith, D. "The Influence of Local Waterways, Recreational Activity, and Community Participation on Quality of Life and Conservation Policy Perspectives" *2016 River Management Symposium and National Outdoor Recreation Conference*. Boise, ID May 2016.

Miller, B. A. "'Lifeblood' of a Region: The Value of Streamflow for the Residents of the Salmon River Basin, Idaho." *2016 River Management Symposium and National Outdoor Recreation Conference*. Boise, ID May 2016.

Miller, B.A. "Assessing the Symbolic and Economic Value of Stream-Flow in the Salmon River Basin, Idaho." *21st International Symposium of Society and Resource Management*. Charleston, SC, June 2015.

Miller, B. A, Jones, K., & James, E. "Assessing the Symbolic and Economic Value of Stream-Flow in the Salmon River Basin, Idaho" *15th Biennial Global Conference: International Association for the Study of the Commons.* Edmonton, Alberta, Canada. May 2015.

Miller, B. A. "Forest Carbon Management in Indigenous Territories as a Global Common Pool Resource: A Case Study of REDD+ Opportunity Costs and Indigenous Perspectives on Governance in the Rio Platano Biosphere Reserve, Honduras" *15th Biennial Global Conference: International Association for the Study of the Commons.* Edmonton, Alberta, Canada. May 2015.

Miller, B. A. "'A Beautiful River that Eats People' The Value of Streamflow for the Salmon River Bioregion, Idaho." *2015 Western Forestry Graduate Research Symposium.* Corvallis, OR. April 2015.

Miller, B. A. "Assessing the Symbolic and Economic Value of Stream-Flow in the Upper Salmon River Basin." *2014 Western Forestry Graduate Research Symposium.* Corvallis, OR. April 2014.

TEACHING EXPERIENCE

Adjunct Professor, College of Idaho
Spring 2020
Courses:
- Introduction to Sociology
- Environmental Sociology
- Natural Resources and Society

Instructor, Utah State University
Spring 2017 – Fall 2019
Courses:
- Social Problems
- Sociology of the Environment and Natural Resources

Teaching Assistant, University of Idaho
Fall 2013 – Spring 2014
Courses:
- Society and Natural Resources
- Natural Resource Economics
- Ecology
- Problem Solving in Natural Resources

Environmental Education Field Instructor, McCall Outdoor Science School
2012 – 2013

Rhode Island Teaching Fellows, Providence, RI, Central High School and the MET
2010 – 2011
Courses:
- Biology
- Algebra
- Entrepreneurship

TEACHING EVALUATIONS

Student Course Evaluations on 5-point Scale:

Course	Term	Enrollment	Overall Quality of Course	Progress on Relevant Objectives	Excellent Teacher	Excellent Course
Sociology of the Environment and Natural Resources	Spring 2018	20	4.7	4.7	4.8	4.5
Social Problems	Fall 2017	28	3.8	4.0	3.7	3.5

Selected Student Comments from Evaluations:

"Brett has a genuine interest in every student's success, he also encourages students to become learners." (Social Problems)

"I love how we used multiple tools to learn. [Brett] had us play games in class that would help us review topics and vocabulary and help is [sic] learn more about specific topics. The discussions we had in class were interesting." (Social Problems)

"This course, for me at least, excellently fostered critical thinking and application to real world events and situations." (Social Problems)

"Overall the course was enjoyable. I think [Brett] realized that many people take the class for the elective credit, so he tried to make it interesting and fun for those not going into sociology." (Social Problems)

"I thought Mr. Miller was a great teacher and used many different techniques to teach his class which was great!" (Social Problems)

"[Brett] Created a welcoming environment open for discussion from anyone in any aspect." (Social Problems)

"I'm sad I won't likely get to take another one of the instructors classes because to be honest this is the only instructor I have this semester that I actually like." (Social Problems)

"I've never had a class that's a gen−ed where the professor tried to relate it to our individual majors so frequently and effectively." (Soc. of the Environment…)

"I honestly enjoyed this class a lot. I questioned some of my beliefs and learned a lot about the sociological side of my field. I loved the readings and interdisciplinary views. Great instructor who took great interest in the success of all students." (Soc. of the Environment…)

"Brett is a really great professor and is willing to help students in all aspects of understanding the material, but also willing to help with other things outside of class. Brett is super nice, charismatic, and very intellectual making it fun to hear any knowledge he can feed us with. Brett makes a great professor since he relates to the students really well. He has the street smarts and book smarts making class intriguing and less boring. You would sit with Brett in a cafe for hours if you had lunch with him with all his intellectual insights." (Soc. of the Environment…)

"He made the material make sense, relate to life and easier to understand. He is always upbeat and on his game. He made the whole class want to pay attention and be there. His way of teaching is very enjoyable and kept me interested." (Soc. of the Environment…)

"Brett was able to connect very well with all students. He was personable and made class fun. I wanted to go to class everyday [sic] because I knew I would learn and it would be exciting." (Soc. of the Environment…)

"You are an awesome lecturer and made that hour and 15 minutes fly by every time. Engaging students is your strong suite, no matter how awkward it may feel." (Soc. of the Environment…)

"Overall great experience and was my favorite class this semester and felt like I got the most out of it." (Soc. of the Environment…)

AWARDS, HONORS, SCHOLARSHIPS, AND FELLOWSHIPS

Geddes Family Fellowship, Utah State University
2019 – 2020

Climate Adaptation Science NRT Program Fellowship, Utah State University
2018 – 2019

3rd Place in 11th Annual J. Paul Riley AWRA Student Scholarship Competition
2016

Berklund Graduate Research Fellowship, University of Idaho
2014 – 2015

Louise Shadduck Natural Resource Communication Scholarship, University of Idaho
2014 – 2015

3rd Place in 2nd Annual Western Forestry Graduate Research Symposium, Oregon State University
2014

MEMBERSHIP AND SERVICE IN PROFESSIONAL ASSOCIATIONS

Secretary and Advisory Committee Member of Utah Prescribed Fire Council
2018 – Present

Elected Student Representative, International Association of Society & Natural Resources Council
2019 – 2020

International Association for Society and Natural Resources
2014 – Present

International Association for the Study of Commons
2014 – Present