DISSERTATION

THE ROLE OF SCIENTIFIC EVIDENCE IN COLLECTIVE ACTION DECISION-MAKING

Submitted by

Ryan Roberts

Department of Human Dimensions of Natural Resources

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Doctoral Committee:

Advisor: Kelly Jones
Co-Advisor: Stuart Cottrell

Robin Reid
Antony Cheng

ABSTRACT

THE ROLE OF SCIENTIFIC EVIDENCE IN COLLECTIVE ACTION DECISION-MAKING

As our world grows ever more complex, novel forms of governance arise that attempt to manage this complexity. One such governing system is collective action, where multiple stakeholders come together to solve large-scale problems for the benefit of all involved. Collective action is especially prevalent in conservation due to the increased degradation of natural resources, which are often public goods that cross administrative boundaries. Stakeholders whom make collective action decisions typically work with limited resources, and as such it is important they work with adequate information to lead to an increase in efficiency and ultimate success. The growing field of evidence-based conservation highlights this point, which urges practitioners to base their decisions on the best scientific evidence available. The literature repeatedly stresses the importance of information in collective action, yet limited studies exist as to the role of scientific evidence as a specific form of information used in collective action decisions. This dissertation set out to determine this role relative to other factors considered important for success. I drew on the rational decision-making model as a framework for assessing the role of evidence. Using a non-random sample of eight watershed partnerships as a case study, I used a mixed method approach and explored: 1) decision-makers understanding of a specific form of scientific evidence available (Chapter 1), 2) the importance of scientific evidence as a motivation to invest in these watershed partnerships (Chapter 2), and 3) the role of scientific evidence in the partnerships' internal decision-making (Chapter 3). I found that scientific evidence is primarily important to wildfire and forestry specialists regarding decision-

making. I also discovered that although evidence is important to internal partnership decision-making, a variety of additional sources of information and other factors that have an equal influence on watershed management exist. The way the watershed partnerships in this study disseminate evidence via outreach strategies was also revealed as a highly important component of success. Synthesizing across these results, I adapted a framework from the literature that incorporates elements of dynamic information pathways that, in conjunction, leads to the long-term success of these eight programs. Some practical considerations for increasing the dissemination and utilization of scientific evidence include translating this type of information into an easily interpretable form and creating web-based tools to organize evidence. Broadly, these results contribute to the collective action literature on the factors necessary in decision-making for the continued endurance of these forms of governance.

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"It's the possibility of having a dream come true that makes life interesting."
— Paulo Coelho, The Alchemist

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DEDICATION

To all, past and present, who work to improve our world

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CHAPTER ONE: INTRODUCTION

1.1. Introduction

The overarching goal of this dissertation is to determine the role of scientific evidence in collective action decision-making. This chapter serves as a justification for the study by familiarizing the reader with the background scholarship upon which it is founded. Sections 1.2-1.4 introduce the topics of complex natural resource systems, collective action as a possible means of managing these systems, the need for an evidence-based approach to conservation management, and the use of a model to conceptualize theoretical decision-making. Section 1.5 describes watershed partnership institutions as a case study to assess the role of scientific evidence in decision-making. Lastly, sections 1.6 and 1.7 outline the dissertation's primary research questions and a roadmap for the remaining chapters.

1.2. Complex Adaptive Systems and Collective Action

The theory of complex adaptive systems is often applied to natural resource systems (Gunderson & Holling, 2002). Characteristics of complex adaptive systems include processes occurring among varying scales, uncertainty of future outcomes, and difficulty with self-organization (Berkes, 2004; Gunderson & Holling, 2002). Complex natural resource systems tend to be mismatched with traditional governance systems produced from rigid, top-down administrations. Conventional strategies are typically inadequate at managing natural resources due to a lack of accounting for unknown outcomes tied to complexity and uncertainty. In place of standard forms of governance, adaptive resource management governance can provide alternative interventions flexible enough to address issues of uncertainty (Berkes, Colding, &

Folke 2003). Collective impact theory complements this school of thought by asserting that new modes of cooperation among diverse actors are essential for creating and ensuring solutions to address large-scale problems found in complex systems (Kania & Kramer, 2011). The collective action process that creates this impact is defined as mutual agreement and cooperation among a group of entities who are working towards a common goal or agenda (Olson, 1965).

Examples of collective action are increasing in the conservation field due to the complex nature of natural resource systems. Resources in the form of public goods (non-excludable and non-rival) often cross several administrative boundaries (Pindyck & Rubinfeld, 2015) and require collective governing of involved actors. Under this novel governance framework, partnerships develop that bring together the expertise and resources of various private and public stakeholders to jointly manage a resource, such as forests or watersheds (Ansell & Gash, 2008). For collective action initiatives to succeed, they require a common agenda, a shared measurement system to track progress, mutually reinforcing activities, continuous communication among actors involved, and a backbone organization in which to be grounded (Kania & Kramer, 2011).

The incentives that exist for stakeholders to expend time and energy participating in collective action is a highly researched question. From Hardin's (1968) standpoint rational resource users will always act in their own self-interest, yet entities in the real-world whom take part in collective action make choices that serve a group interest. Dowding (1996) posits that this transition from self-interest to group-interest can be due to a mutual recognition of the benefits potentially realized through collective action. An associated cost of a certain action makes it impossible for one individual or group to bear alone, but if accomplished with others the action can lead to a larger group benefit and a reduction in marginal individual costs. However, if this

logic were true in every context, collective action problems would no longer exist. There are clearly other factors at play that influence stakeholder cooperation and the resulting success or failure of collective action initiatives.

Ostrom (2000) highlights eight design principles conducive to collective action that may aid in overcoming self-interest and lead to success: 1) establishing geographic and legal boundaries, 2) setting restrictions of resource use based on needs, 3) participation of relevant stakeholders, 4) self-monitoring of the resource regime, 5) the use of graduated sanctions for penalties, 6) access to means of conflict resolution, 7) recognition of operation by external bodies of governance, and 8) the presence of nested layers of governance systems interacting amongst themselves. The establishment of these principles is dependent on numerous factors, such as the biophysical context and the diversity of stakeholders present. Gathering empirical findings from collective action games, Ostrom (2000) stresses the importance of information exchange, highlighting that when stakeholders understand a given situation better, when communication occurs amongst involved parties, and when they believe others will act collectively to alleviate a problem, a substantial increase in cooperation occurs. When stakeholders act on incomplete or missing information, the success of collaborative action programs tends to decrease (Underdal, 2010).

1.3. Evidence-Based Conservation

The field of evidence-based conservation (EBC) is a relatively new movement with the overall goal of increasing the uptake and use of evidence among conservation practitioners (Sutherland, Pullin, Dolman, & Knight, 2004). Evidence in this context is defined as "the available body of facts or information indicating whether a belief or proposition is true or valid"

(Oxford Living Dictionary, 2018). Many scholars in the EBC field believe that a broad definition of evidence is needed to include multiple sources of knowledge. They propose the consideration of qualitative, gray literature, or indigenous bodies of knowledge as relevant types of evidence in addition to quantitative, peer-reviewed studies most familiar to Western scientists (Adams & Sandbrook, 2013; Tengö et al., 2014).

Despite the broadening of the term evidence, the role that scientific information plays in conservation decision-making as a specific form of evidence has increasingly become a subject of interest (Stewart, Coles, & Pullin, 2005). Studies show that many policy prescriptions are traditionally based on previous personal experience or word of mouth, as opposed to scientific data (Pullin & Knight, 2003). In some cases, this has been linked to the lack of efficacy of conservation actions. Case studies are emerging that demonstrate changes to policy prescriptions after exposure to scientific evidence on a given subject (i.e. Svancara, Brannon, Scott, Groves, Noss, et al., 2005; Walsh, Dicks, & Sutherland, 2015), demonstrating the importance of incorporating scientific evidence into conservation management decision-making.

Systematic reviews and systematic evidence maps are increasingly recognized as important tools to methodically and transparently review the available evidence on a specific topic (Pullin & Knight, 2001; Pullin & Stewart, 2005; Sutherland et al., 2004). The availability of large amounts of highly synthesized information in these forms have rapidly increased in availability as a result of the growing EBC movement (Lavis, 2009). Stewart et al. (2005) urges the involvement of relevant stakeholders during every step of the evidence gathering process to improve information flow between scientists and non-scientists and ensure that systematic reviews and maps are relevant to decision-makers.

1.4. The Rational Decision-Making Model

Collective action initiatives are founded on the best available information regarding a given topic; this knowledge is often the premise for relevant stakeholders organizing and coming together to solve collective issues (Underdal, 2010). Given the importance of information to these initiatives, the use of scientific evidence may have a strong impact on the management decision-making processes of natural resource-based collective action initiatives. The role of scientific evidence, however, is unclear due to the complexity of conservation issues (social, economic, and institutional considerations in addition to ecological) being faced by natural resource managers (Adams & Sandbrook, 2013; Cook, Carter, Fuller, & Hockings, 2012).

Scholars within the organizational behavior field study the psychology behind macro-level decision-making processes (Moorhead & Griffin, 1995). A commonly used framework to assess choices made by organizations is the rational decision-making model (Figure 1.1). The originator of this model argues that groups acquire information and use the knowledge gained to make factual judgement calls (Simon, 1976). These informed decisions in theory maximize the value of the outcome in question.

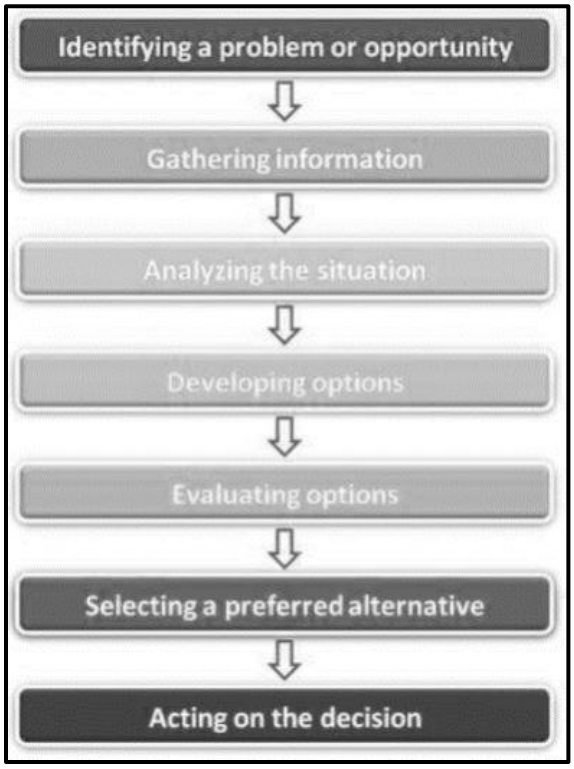

Figure 1.1. Rational decision-making model (Robbins & Judge, 2007)

The rational decision-making model outlines a seven-step process that organizations follow to make choices, from problem identification to decision implementation. Assumptions within this model exist, include the belief that organizations: 1) have access to complete information, 2) are capable of identifying all relevant options, and 3) can choose the option that provide them with maximum utility (Robbins & Judge, 2007). The EBC movement is based off a similar model, as it assumes decision-makers with access to scientific evidence will use that evidence to make more informed decisions. Given the stated importance of science to inform policy decisions in the EBC movement, this study uses the rational decision-making model in a case study on collective action to assess whether scientific evidence is important for securing stakeholder buy-in and making decisions that achieve management objectives.

1.5. Case Study: Watershed Partnership Institutions

Collective action is needed to address multifaceted, large-scale common pool resource issues, which often span several ecological and administrative boundaries. One example of such an issue is the increased frequency and severity of wildfires globally, and the resulting impairments they cause to the quality of surrounding watersheds. Watershed partnerships are a specific form of collective action recently promoted as a means of addressing these problems, with the ultimate goal of ensuring the long-term quality of the given watersheds in their regions. The definition of watershed partnerships adopted for this study is: a collaborative approach among source water protection stakeholders to invest in wildfire mitigation.

The literature states that watershed partnerships can theoretically lead to similar types of benefits as those seen in other successful collective action management regimes, such as slowing down or preventing the degradation of resources. Traditional forms of government are typically inadequate in achieving these goals (Lubell, Schneider, Scholz, & Mete, 2002), forming a niche for organizations like watershed partnerships to develop. The voluntary nature of watershed partnerships means that issues with legal compliance can be avoided, while trust and information sharing can occur faster and on a greater scale. Due to the cooperative nature of these programs, several organizations can work together to minimize the depletion of the watershed resource by sharing different forms of information to create innovative, location-specific watershed policy (Lubell et al., 2002).

Despite the potential benefits associated with partnerships, these and other collective action initiatives can still fail due to several reasons. Carpe Diem West (2011) states that building partnerships with a diversity of stakeholders is one key to success, yet partnerships will only succeed if transaction costs of their operations remain low. As is the case for broader

collective action initiatives, if the costs of partnership involvement outweigh the potential benefits achieved, there is an unlikely probability that the initiative will survive, if it emerges at all (Lubell et al., 2002). Issues with wildfires cross several legal and administrative boundaries and can result in devastating consequences if not managed appropriately. As such, watershed partnerships could utilize scientific evidence to create wildfire mitigation policy prescriptions that aid in setting strategic and achievable management objectives, another key to partnership success (Carpe Diem Healthy Headwaters, 2011).

Several unanswered questions exist for watershed partnerships. Evidence linking wildfire mitigation to broader social and economic outcomes remains weak, yet the need for this evidence in increasing with the growing shift in human movement into fire-prone areas (McCaffrey, Toman, Stidham, & Shindler, 2012). Another understudied component of watershed partnership research is the role that scientific evidence plays in stakeholder organizations' initial willingness to invest their time and human resources into these initiatives (Bennett, Gosnell, Lurie, & Duncan, 2014).

1.6. Research Goal and Questions

The overarching goal of this dissertation is to determine how collective action initiatives view and utilize scientific evidence in decision-making, with a specific focus on watershed partnerships as a case study. To guide this work, I adapted the rational decision-making model to create the conceptual framework displayed in Figure 1.2. The framework shows how scientific evidence may be applied by internal and external stakeholder decision-makers through two information pathways. These pathways address external stakeholder organizations' investment in the partnership and the wildfire mitigation prescriptions used internally by the partnership.

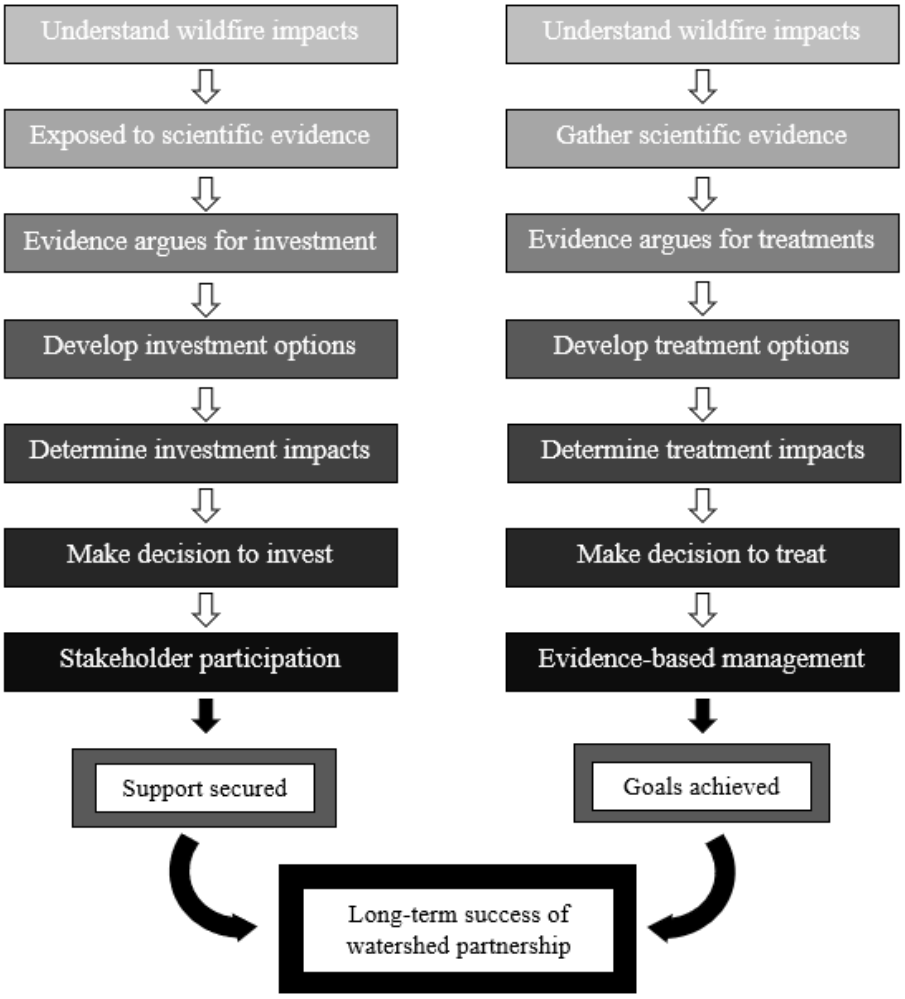

Figure 1.2. The role of scientific evidence in partnership success (adapted from Robbins & Judge, 2007)

The first step in the pathway on the left shows an external stakeholder's understanding of the negative impacts of wildfire. They are then exposed to scientific evidence making the case for investments in wildfire mitigation via watershed partnerships. The stakeholder develops different options for investment (contract lengths, forms of investment, etc.) and determines the broader utility of each option for their organization. Stakeholder's decide that the rational decision is to invest, leading to their participation in the partnership.

The start of the second pathway shows an acknowledgement of wildfire impacts by the partnership, followed by gathering of credible evidence that recommends the implementation of specific mitigation treatments (i.e. prescribed burning, fuels thinning). The partnership develops different treatment options and assesses their predicted impacts based on the scientific evidence. Decision-makers within the partnership examine their options and choose what they believe are the most rational treatment prescriptions to implement, leading to evidence-based management.

The resulting combination of stakeholder support and achievement of partnership goals is expected to influence the initiatives long-term success. Embedded within this framework are the assumptions: 1) stakeholders understand the importance and strength of wildfire management evidence that exists, 2) this evidence is a primary motivator for organizations' decisions to invest, 3) stakeholders utilize this evidence in treatment implementation and 4) the use of scientific evidence in decision-making will lead to achieving their goals.

Despite the potential importance of these pathways (Figure 1.2), few empirical studies exist that assess the role of scientific evidence as a specific form of information used in the broader collective action theory, or how this use affects the success of these initiatives. The results of this dissertation aim to expand the theory of collective action by addressing this knowledge gap. The work advances the following overarching research question: What is the role that scientific evidence plays in the decision-making processes of collective action initiatives? Addressing this question will help to inform watershed partnership groups and the broader scientific community on the role of evidence in this specific form of collective action. To answer this overarching research question, I ask the following three sub-research questions:

1. How do stakeholder perceptions of scientific evidence compare to existing evidence on the linkages between wildfire mitigation treatments and social and economic outcomes?

2. What role does scientific evidence play in motivating organizations to participate in eight watershed partnerships throughout the Western US?

3. What influence does scientific evidence have on wildfire mitigation implementation and ultimate success of eight watershed partnerships throughout the Western US?

1.7. Dissertation Roadmap

This dissertation is comprised of three main chapters, in addition to an introductory and concluding chapter. The three results chapters are intended to be stand-alone peer-reviewed journal articles; thus some redundancy may exist. Although each are independent studies, I used a mixed methods approach to triangulate the data and provide a complete picture of the use of evidence to answer the overarching research goal and question outlined above.

Chapter 2 directly answers the first research sub-question. I catalogued evidence in the form of a systematic map on the relationship between wildfire mitigation treatments and societal outcomes to identify the knowledge gaps (few linkages) and gluts (many linkages) present in the literature. I then surveyed stakeholders to determine their perceptions of this specific type of evidence, to illustrate an example of how perceptions of available science compare to the actual evidence base.

The second sub-question is addressed in Chapter 3. I asked the same stakeholders from chapter 2 to rank their various motivations for investing financial and/or human resources into

watershed partnerships. I use quantitative Q method surveys to accomplish this task and conduct factor analysis on the resulting data. This analysis allows me to identify the influence of scientific evidence on participation relative to other motivations from a broad range of organizations involved.

Chapter 4 addresses the third research sub-question. I conducted qualitative semi-structured interviews with key informants of watershed partnerships to assess how they use science and other sources of information in treatment implementation, and how that utilization influences the perceived success of their partnerships. In this way, I assess the impact of scientific evidence as a specific form of information relative to other factors identified in the literature as important to success.

Chapter 5 synthesizes results from the previous three chapters to answer the overall research question from the three sub-questions.

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CHAPTER TWO: STAKEHOLDER PERCEPTIONS AND SCIENTIFIC EVIDENCE LINKING WILDFIRE TREATMENTS TO SOCIETAL OUTCOMES

Summary

As the frequency and severity of wildfires increases across the western USA, losses to society continue to mount. In response, a variety of initiatives are active or under development to invest in wildfire risk mitigation through pre- and post-fire treatments. The broad range of societal values being impacted by wildfires often require different strategies to effectively reduce impacts. To create effective mitigation programs, the organizations investing in and making decisions about these wildfire mitigation initiatives need to understand the specific social and economic outcomes of the wildfire treatments they fund and manage. The goal of this study was to assess the strength and importance of evidence linking wildfire mitigation treatments with societal outcomes to inform funders or implementers making fuel treatment decisions. I conduct a formal cataloguing of the quantity of scientific evidence that exists about the impacts of wildfire treatments on societal outcomes. To determine if and how this evidence is used to inform decisions, I assess organizations' perceptions of the relative importance and strength of this evidence. A systematic evidence map of 103 studies was created to identify the most common wildfire mitigation treatment and outcome relationships reported. An importance-strength analysis and gap analysis followed to understand current perceptions of these relationships by organizations investing in wildfire mitigation across three western states in the United States. I find that a small number of treatment-outcome relationships have been studied much more extensively than others in the published literature, and that of the 72 treatment-outcome relationships examined, only five are referenced in more than 10 case studies. Many of the organizations managing and investing in wildfire treatments generally perceive that sufficient

amounts of scientific evidence exist on these treatment-outcome relationships. The exception to this is forest and wildfire specialists, who perceive a larger need for additional evidence linking certain mitigation actions with desired outcomes in order to make effective decisions in wildfire mitigation programs. Their views should be considered expert opinion, and combined with the evidence map results, point to treatment-outcome relationships that need more study.

2.1. Introduction

The frequency and severity of wildfire globally is estimated to increase from drought due to climatic changes (Goldammer, 2008; Rocca, Brown, MacDonald, & Carrico, 2014; Westerling, Hidalgo, Cayan, & Swetnam, 2006). This trend can be seen across the United States, where over 1.3 million wildfires were reported post-2000 that burned nearly 130 million acres total (National Interagency Fire Center, 2018). Although many ecosystems are adapted for natural and human-induced wildfires (Goldammer, 2008), the increase in fire prevalence, coupled with increasing housing density in the wildland urban interface, historic land management practices, and ongoing wildfire suppression strategies, have led to a rise in societal losses. Negative impacts due to a wildfire can be numerous, including effects on mental and physical health, increased suppression costs, and loss of life and property (Thomas, Butry, Gilbert, Webb, & Fung, 2017). Expenditures to fight fires have required U.S. federal agencies to spend over $27 billion post-2000 (National Interagency Fire Center, 2018). The 2017 Northern California wildfires alone resulted in 45 fatalities, along with the destruction of 32,000 homes, 4,300 business and 8,200 vehicles across 14 counties. These losses amounted to nearly $12 billion in insurance claims, making it the costliest fire season for the state in recent history

(California Department of Insurance, 2018). Although these wildfires and their resulting losses were unprecedented, they may soon become the new normal.

Increased attention to these societal losses has led to a variety of programs active or under development that aim to create innovative funding mechanisms which invest in increasing the pace and scale of wildfire mitigation strategies. One example of a novel funding strategy is through the creation of partnerships that invest in watersheds. These investments are defined as "any transaction between a buyer and a seller where financial value is exchanged for activities or outcomes associated with the maintenance, restoration, or enhancement of watershed services or natural areas considered important for watershed services" (Bennett & Ruef, 2016, p. 3). Watershed partnerships are often comprised of a collaboration between public and private organizations that invest in wildfire risk mitigation (hereafter referred to as wildfire treatments). To date, there are more than 400 watershed partnerships operating in 62 countries globally and covering over 1.2 billion acres of land (Bennett & Ruef, 2016). Partnership investments can be applied toward wildfire reduction efforts with the ultimate goal of avoided watershed degradation post-wildfire. Investments in wildfire treatments will likely continue to increase in coming years as novel funding mechanisms continue to emerge across the United States (Blue Forest Conservation, 2017). The organizations investing in wildfire treatments often need to assess and evaluate whether paying for wildfire treatments leads to a positive return on investment or not (Jones et al., 2017).

Until recently, fire suppression has conventionally been the most widely used management approach to tackle the global challenge of wildfire (Hurteau, Bradford, Fulé, Taylor, & Martin, 2014). While mitigating short-term risk, fire suppression actually increases future risk by facilitating the ongoing growth of fuel loads (Calkin, Thompson, & Finney, 2015).

Today, fire management is shifting toward more pro-active approaches that aim to restore forests to their historic density to decrease the risk of future wildfires via pre-fire treatments. The most common of these include reducing flammable fuels through mechanical or manual vegetation thinning or removal, and prescribed burning. Reducing flammable vegetation and other materials around homes and other property infrastructure is referred to as "defensible space", based on the theory that low-fuel conditions provide firefighters a safe space to take defensive actions against the oncoming fire. Post-fire restoration treatments are also widely used but costly, with the general goal of repairing a region damaged by wildfires. This can also decrease the risk of losses from future wildfires in that same area. Post-fire restoration typically involves erosion minimization projects, such as mulching or seeding of burned areas to encourage vegetation recovery (Agee & Skinner, 2005; Rocca et al., 2014). Salvage logging is a common post-fire practice as well, which involves the removal of trees in an area already damaged by a wildfire so the economic value of the timber is not completely lost and the timber revenue can help offset post-fire restoration costs.

Overall, the primary goal of pre- or post-wildfire treatments is to alter the physical processes and effects of fire (Reinhardt, Keane, Calkin, & Cohen, 2008). One of the growing issues within the wildfire management field is conflicting views on expected wildfire mitigation outcomes. The term 'mitigation' currently encompasses a broad range of actions and treatments for a diverse set of objectives, such as the reduction of societal losses described above. However, the link between wildfire treatments and these broader outcomes that lead to societal benefits are not typically proposed by scientists or researchers in the field, but rather assigned by policy-makers and other stakeholders (Reinhardt et al., 2008) who have agendas that focus on public outreach and buy-in. For example, prescribed burning is a mitigation treatment commonly

supported by wildfire scientists for reducing fire severity (Kalies & Yocom Kent, 2016), yet stakeholders often fear these fires may lose control and impair ecological or societal features of value. Other types of treatments are sometimes purported in place of prescribed burns to sustain policies that are popular (Reinhardt et al., 2008), even if the scientific evidence linking these alternate treatments to outcomes of interest is not as robust as that of prescribed burning.

Despite their original intent, questions regarding societal impacts of wildfire mitigation treatments have been increasing due to the growing shift of human movement into fire-prone areas (McCaffrey et al., 2012). For example, social outcomes of interest in reducing wildfire risk include a decrease in loss of life, avoided physical or mental health post-wildfire (McCool, Burchfield, Williams, & Carroll, 2006), or improvements to public values and perceptions of management as a result of the mitigation interventions (Toman, Shindler, McCaffrey, & Bennett, 2014; Varela, Bredahl Jacobsen, & Soliño, 2014). Economic impacts of pre-fire treatments can include reduced expenditures on future fire suppression, evacuation, and post-fire restoration (Prestemon, Abt, & Barbour, 2012), as well as avoided losses to property and other infrastructure (McCool et al., 2006) or the added value of forests for timber production or recreation/tourism (Dombeck, Williams, & Wood, 2004).

Although widespread claims exist linking socio-economic outcomes to wildfire mitigation treatments, there is a paucity of syntheses of the scientific basis underlying these claims. A systematic review conducted by Kalies and Yocom Kent (2016) examined the ecological and social effects of two treatment types (thinning and prescribed burning) but excluded economic impacts. Milne, Clayton, Dovers, and Cary (2014) focused on economic outcomes by conducting a review of the costs and benefits of wildland fires. However, their purpose was to develop a framework highlighting literature that exists on costs/benefits of

wildfires and the methods used in those studies. Neither of these reviews broadly summarized the existing evidence between both pre- and post-wildfire mitigation strategies and social and economic outcomes. Improving knowledge on societal benefits from investing in wildfire mitigation treatments could aid in justifying future management decisions, prioritizing actions, and assessing return on investments (Pullin & Knight, 2001; Sutherland et al., 2004).

The goal of this paper is to assess the state of the scientific evidence linking wildfire treatments to societal outcomes and determine the perceptions of the completeness of this evidence from the perspective of watershed investment decision-makers (i.e. funders and/or implementors). The first objective is to catalogue the quantity of scientific evidence that exists on the impacts of wildfire treatments on societal outcomes. To accomplish this objective, I carry out a systematic evidence mapping exercise that summarizes the social and economic outcomes of the most common pre- and post-wildfire treatments found in the peer-reviewed and gray literature. Evidence maps provide a valuable compilation of existing information and identify gaps and gluts to enhance prioritization of future research (Haddaway, Bernes, Jonsson, & Hedlund, 2016). Evidence maps are increasingly recognized as an effective method to gather broad scale evidence on multiple interventions and outcomes, with the primary output being a visual representation displaying the occurrence or absence of these linkages found in the literature (McKinnon et al., 2016).

The second objective is to analyze how organizations managing and investing in wildfire mitigation perceive the relative presence and importance of this scientific information. For the second objective I ask representatives of organizations engaged in watershed partnerships to rank their perceptions on the strength and importance of the prevalent treatment-outcome linkages found in the literature. This information from key decision makers is used to create an

importance-strength analysis (ISA) and gap analysis; methods which help identify specific treatment-outcome linkages where evidence is perceived to be sufficient or missing from the perspective of stakeholder groups investing in these activities. ISA and gap analysis are adapted from importance-performance analysis which is used to determine satisfaction with a given service (Vaske, Kiriakos, Cottrell, & Khuong, 2009). Combined, this information will highlight where agreement or divergence occurs between decision makers' perceptions of current scientific literature on impacts of wildfire mitigation and the existing evidence base. The overlap or disparity between these results can aid in providing recommendations for where future research efforts are needed.

2.2. Methodology

2.2.1. Defining Wildfire Mitigation Treatments and Outcomes

Table 2.1 provides definitions for the five pre- and three post-wildfire mitigation treatments examined in this study. I chose these eight treatments based on an initial scoping search of the literature (see Livoreil et al., 2017), followed by informal conversations with contacts from a wildfire and forestry science institute regarding treatments commonly applied to mitigate the frequency and severity of future wildfires. The societal outcomes listed in Table 2.2 represent changes to various economic and/or social attributes found in the scoping literature search that could occur due to the implementation of the wildfire treatments. The original lists of wildfire treatments and outcomes were presented to the wildfire and forestry specialists and updated it with their feedback.

Table 2.1. Definitions of wildfire treatments

Term	Definition
(Pre-wildfire)	
Prescribed burning	The intentional planned ignition of a fire by managers to reduce fuel buildup and decrease the chances of a severe wildfire
Defensible space	An area around a structure where flammable vegetation and non-vegetation materials have been altered or removed to slow the encroachment and reduce the intensity of wildfire approaching the structure
Thinning	The use of hand tools or machinery to reduce vegetation density
Suppression	The use of diverse techniques, equipment, and training to minimize wildfire events or to completely prevent wildfires from occurring
Fuel breaks	Strips of altered or eliminated vegetation to control the spread of wildfire
(Post-wildfire)	
Mulching	The addition of natural and/or artificial materials to mitigate post-wildfire increases in runoff and erosion from precipitation events and assist with the establishment of plants to stabilize post-fire hillslopes
Rehabilitation	The use of various techniques to recover an area back to pre-fire conditions and reduce the likelihood of irreversible undesirable changes caused by a fire
Salvage logging	The removal of trees in forested areas damaged by wildfire to recover the timber's economic value

Table 2.2. List of changes to social/economic outcomes (Δ=change)

Term	Definition
Employment	Δ in employment opportunities
Future suppression costs	Δ in costs of future suppression
Habitat/biodiversity	Δ in the amount of biodiversity and viable habitat in an area
Infrastructure/property	Δ in costs or avoided costs of impacts to property
Post-fire restoration costs	Δ in costs or avoided costs of future forest restoration
Public perceptions	Δ in public perceptions of wildfire treatments
Recreation/tourism	Δ in the ability to recreate at a site
Timber/non-timber forest products	Δ in costs or avoided costs to value of forest products
Water quality/quantity	Δ in the water quality or quantity in a region

2.2.2. Evidence Map

Data Collection

Literature Searches

I searched for evidence following best practices outlined by Livoreil et al. (2017), which included steps for planning and conducting a literature search, as well as reporting results. All searches were conducted in English, and both peer and non-peer reviewed literature were considered for inclusion to minimize publication bias. To obtain as much evidence as possible, the dates of studies were not restricted. For the peer-reviewed literature, I used Web of Science as a preliminary search engine, followed by relevant databases in EBSCO host. Both databases were explored using the full search string listed in Table 2.3, limited to titles and abstracts.

Table 2.3. Search strings used in evidence map

Full search string	
Intervention Terms	(“fuel treatment” OR “reduction treatment” OR “mitigation treatment” OR “silviculture treatment” OR “forest treatment” OR “wildfire hazard reduction treatment” OR “fuel management practice*”)
AND	
Intervention Adjacent Terms	(“suppress*” OR “control* burn*” OR “prescribe* burn*” OR “mechanical thinning” OR “hand thinning” OR “defensible space” OR “erosion mitigat*” OR “seeding” OR “mulching” OR “salvage log*” OR “rehabilitat*” OR “pre wildfire” OR “post wildfire” OR “pre fire” OR “post fire” OR “forest”)
AND	
Outcome	(“economic” OR “social” OR “non-market” OR “market” OR “service*” OR “good*” OR “benefit” OR “avoid*” OR “externalit*” OR “suppress*” OR “restor*” OR “house*” OR “home*” OR “property” OR “infrastructure” OR “sale” OR “business” OR “work” OR “evacuat* OR “travel time” OR “timber” OR “non timber” OR “aesthetic” OR “scenic” OR “air” OR “water” OR “soil” OR “erosion” OR “sediment*” OR “carbon” OR “habitat” OR “biodiversity” OR “recreat*” OR “tourism” OR “education” OR “science” OR “food” OR “medicin*” OR “graz*” OR “health” OR “injury” OR “human” OR “value” OR “perception” OR “cultur*” OR “spiritual”)
AND	

Outcome Adjacent Terms	(“impact” OR “effect” OR “increase” OR “decrease” OR “ecosystem” OR “cost” OR “loss” OR “lost” OR “beauty*” OR “quality*” OR “quantity” OR “purif*” OR “retain” OR “retention” OR “deliver*” OR “stor*” OR “sequest* OR “provi*” OR “resource” OR “physical” OR “mental” OR “mortality” OR “fatal*” OR “death”)
Modified search string	
(“wildfire reduction treatment”) AND (“economic” OR “social” OR “non-market” OR “market” OR “service” OR “good” OR “benefit” OR “avoided cost”)	

I conducted an additional full-text search in Google Scholar using a modified search string (Table 2.3), where the first 200 hits were screened as is recommended by the literature (see Haddaway, Collins, Coughlin & Kirk, 2015). Science.gov, a search engine covering over 60 databases from 13 U.S. government agencies, was searched with the same modified search string. To avoid publication bias I ran the same search in Google for gray, non-peer reviewed literature by screening the first 200 hits. This was complemented by follow-up searches for articles on specific websites used in previous studies with a similar topic. These included government sources (U.S. Forest Service's ‘treesearch’ and USGS publications warehouse), non-governmental organizations (The Nature Conservancy) and other sources (Wildfire Today, Fire Management Today). Papers from professional contacts were recorded, and relevant references from these studies (Kalies & Yocom Kent, 2016; Leverkus, Gustafsson, Rey Benayas, & Castro, 2015; Milne et al., 2014) were added to the list of citations.

Data Analysis

Study Inclusion Criteria

Articles were required to satisfy the following criteria: (1) *Title Screening*: The title had a clear focus on wildfire or a wildfire treatment and contained any relevant outcome terms or themes. (2) *Abstract Screening*: The abstract had a clear focus on a wildfire treatment and stated a clear link to a social and/or economic outcome. (3) *Full-Text Screening*: The article had a clear focus on a wildfire treatment, described the land area or human population being impacted by the

treatment, and had a clear link to a social and/or economic outcome. Papers focused on ecological outputs (i.e., wildlife habitat and water quality) were only included if they also contained evidence directly linking the outputs to long-term outcomes that provided benefits for people or society (i.e., avoided costs of water remediation, wildlife habitat used for recreation purposes). Literature that reported on purely ecological outcomes was removed during the screening process, as the focus of this paper was on outcomes effected by wildfire that have direct effects on economic and social well-being, rather than impacts on general ecosystem functions.

Article Screening

To minimize bias, I implemented a team-based approach to screen articles (James, Randall, & Haddaway, 2016). The teams determined article relevancy in three steps: (1) *Titles*: A team of 10 researchers reviewed a subset of 20 citation titles found from the search strings. The team compared and discussed the results and inclusion criteria were adjusted as necessary. The total set of citations were then split between five teams of two researchers. Each team member compared 20% of the same citations and discussed any discrepancies with their partner before screening the remaining 80% of titles individually (40% for each team member). Titles that were clearly irrelevant were discarded. When there was doubt to the relevancy, an article was included. (2) *Abstracts*: Each researcher reviewed a practice subset of 10 abstracts of the articles deemed relevant from Step 1. Results were discussed with the entire team and articles deemed irrelevant by the group were discarded, while being conservative with those having doubts on relevancy. The five research teams divided the remaining abstracts, and each pair compared 20% of the same citations and discussed any discrepancies before screening the remaining abstracts individually. (3) *Full Article*: Each researcher screened full-text documents for a subset of 5 articles deemed relevant from Step 2. Results were discussed with the entire

team. The five teams reviewed the remaining articles, each pair of whom compared 20% of the same citations and discussed any discrepancies before screening the remaining articles individually. Studies were discarded if they failed to fulfill the inclusion criteria for any of the steps above.

Data extraction strategy

I utilized Microsoft Excel to store all the meta-data derived from the relevant studies. This included the reviewer's initials, type of study, journal/source, author, year of publication, title, link to full-text paper, study I.D. number, data type, model information, when the data was collected, population type, location name, country, site ownership, scale and time of treatment(s), type of treatment(s), type of outcome, and measurement of outcome.

Creation of evidence map

Between the eight wildfire treatments and nine societal outcomes of interest, 72 treatment-outcome linkages had the potential to be catalogued in the evidence map. I recorded the count of each linkage and symbolized the visual representation of each count using a heat map approach, where linkages reported in more case studies were listed using a darker shade, and those reported on fewer times were shaded lighter. The direction of the treatment-outcome relationships (positive, negative or neutral) was also assessed among the five most common linkages.

2.2.3. Stakeholder Surveys

Data Collection

I implemented a survey to collect data on stakeholder perceptions (Appendix 1). I included representatives of organizations currently investing human and/or financial resources in eight watershed partnerships throughout three Intermountain West states: five in Colorado two in Arizona and one in Oregon. These partnerships were recommended by Carpe Diem West and

Forest Trend's Ecosystem Marketplace, and were chosen based on their diversity of objectives, the number of partner organizations involved, years established, funding securement and geographic scope.

Contacts from the partnerships supplied us with a list of 61 potential survey takers who could represent their organizations' perceptions of scientific evidence. In October 2017 I sent an initial email to this list asking them to take part in the questionnaire. I sent follow-up emails to non-respondents of the first round of outreach once a week for two weeks before being removed from the participant list. In total, 38 respondents completed and returned the questionnaire over a four-month period, resulting in a 62% response rate. Participants represented organizations from a mix of public service groups (n=11) (e.g., water utilities and local governments), non-governmental organizations (n=9) (e.g., The Nature Conservancy), forest/fire specialists (n=12) (e.g., U.S. Forest Service, local fire departments and science institutes), and private businesses (n=6) (e.g., breweries and ranches).

The survey asked participants to rank their perceived importance of having evidence on each wildfire treatment-outcome relationship analyzed in the systematic map. Participants were asked to rank these relationships on a Likert scale from 1 (not important) to 4 (very important). Participants then ranked their perceptions on how strong the available evidence is for these relationships, from 1 (doesn't exist) to 4 (is strong). The participants also had the option to list a 0 (I don't know) on either scale if they were not aware of the importance or strength of any given linkage. I removed 18.75% of the responses from analysis due to an 'I don't know' selection.

Data Analysis

To create the ISA framework the information described above was graphed on an x/y axis. This created four quadrants labeled as follows: Quadrant 1: 'Less Effort Needed' (low importance/high strength), Quadrant 2: 'Continue Good Work' (high importance/high strength),

Quadrant 3: 'Low Priority' (low importance/ low strength), and Quadrant 4: 'Future Prioritization' (high importance/low strength). Gap analysis was then applied to these data to provide a quantifiable measure of the perceived disparity between the mean importance and strength values of each treatment-outcome linkage. For example, through gap analysis it is possible to determine which linkages are thought to be the highest prioritization and which are less of a priority. A larger gap value signified a larger disparity between the importance of a linkage and the strength of that evidence. A positive gap value implied the perception that the linkage was being understudied (high importance/low strength) while a negative value signified treatments and outcomes were being over studied (low importance/high strength). The standard deviation of each mean value was calculated to determine the dispersion of the stakeholder perspectives relative to the average. This analysis was conducted across all 37 respondents, as well as spilt separately between the various organizational affiliations (forest/fire specialists, private businesses, etc.) to determine if these groups hold different perceptions on scientific evidence.

2.3. Results and Discussion

2.3.1. Evidence Map

The initial literature search resulted in 1,211 documents. After duplicate and non-English documents were removed, the remaining 864 papers were organized and catalogued in a Microsoft Excel spreadsheet. Using the inclusion criteria in section 2.2.2, each document was screened by title, abstract, and finally full-text. This resulted in a final set of 103 papers deemed suitable for data extraction. The majority (66%) of papers were peer-reviewed and the remaining (34%) were gray literature. Almost all studies analyzed (94%) were conducted between 2000-2018. Most studies focused on either one forest within one state (38%), or multiple forests

spanning multiple states (33%). Almost half of the studies (47%) focused on wildland urban interface (WUI) areas. The majority of studies examined regions within the Western US, with California (n=35), Oregon (n=23), Montana (n=16), Arizona (n=13) Washington (n=13), and Colorado (n=12) representing the major study sites. Outside of the United States, four papers originated from Australia, two from Spain, two from Italy and one from Portugal. Thus, the geographic scope of the evidence map is larger than that of the watershed partnerships surveyed.

Nearly 58% of the papers focused on one wildfire mitigation treatment type, while the remainder reported on multiple, which resulted in a sample size of 187 case studies analyzed. Thinning was the most common treatment examined (n=63), followed by prescribed burning (n=51) and wildfire suppression (n=24) (Figure 2.1). The least cited treatments were fuel breaks (n=7), mulching (n=6), and salvage logging (n=4). In terms of outcomes, changes in infrastructure/property was the most commonly reported result (n=51), while future suppression costs (n=38) and public perceptions of management (n=31) were the second and third most commonly cited outcomes (Figure 2.1). Impacts of treatments on habitat/biodiversity (n=8) and tourism/recreation (n=4) were the least reported. Nearly 44% of outcomes reported were in the form of economic data, 22% were social, and the remainder were a mix of both. Only 5 of the 72 potential treatment-outcome linkages were referenced in 10 or more case studies (7%) and only 13 out of the 72 potential treatment-outcome linkages (18%) were referenced in four or more. There were 22 possible linkages (31%) not referenced at all in the literature.

		Intervention								
		Thinning	Burns	Suppression	Defensible space	Rehabilitation	Fuel breaks	Mulching	Salvage logging	**Total**
Outcomes	Infrastructure/ property	19	14	5	7	2	2	2	0	51
	Future suppression costs	9	11	10	4	1	2	0	1	38
	Public perceptions	9	9	1	8	1	2	1	0	31
	Timber/non-timber forest products	14	6	1	1	0	0	1	2	25
	Water quality/ quantity	3	2	2	0	3	0	1	0	11
	Restoration costs	3	3	2	1	0	0	0	1	10
	Employment	3	3	1	0	1	1	0	0	9
	Habitat/ biodiversity	2	1	1	1	2	0	1	0	8
	Recreation/ tourism	1	2	1	0	0	0	0	0	4
	Total	63	51	24	22	10	7	6	4	**187**

High number of studies → Low number of studies

Figure 2.1. Evidence map of treatment-outcome linkages found in the literature

Impacts of thinning on infrastructure and property was the most common relationship reported (n=19). Of these studies, 81% provided positive outcome data of thinning on infrastructure and property in the form of a reduction in burn probability of structures, the number of structures saved due to previous thinning projects, and the associated avoided costs to the owners of property and infrastructure. The remaining 19% of papers reported neutral findings of thinning, with no papers reporting negative social or economic impacts of thinning on infrastructure and property. The effects of thinning on timber/non-timber forest products was tied for second most commonly cited linkage (n=14) (Figure 2.1). Almost 89% of these papers reported positive outcomes as well, typically referring to the amount of biomass produced from thinning and the resulting revenue from biomass sales in U.S. dollars. The other 11% of papers

discussed nuetral findings that could result in either positive or negative outcomes depending on the size of the thinning project. These studies mentioned that economies of scale are important to consider to make a thinning project profitable (e.g. Hunter et al., 2007).

The impact of prescribed burns on infrastructure and property was also the second most commonly reported relationship (n=14) (Figure 2.1). All of these papers reported positive social and economic outcomes. Similar to impacts of thinning, these outcomes included a reduction of burn probability of structures and reported the number of homes saved from previous burning projects, as well as avoided acres burned and resulting avoided costs in U.S. and Australian dollars. Prescribed burns were also found to reduce costs of future suppression in 11 studies, all of which reported positive economic outcomes in the form of U.S. dollars saved. Additionally, ten papers discussed fluctuations in future suppression costs due to employing earlier fire suppression techniques (Figure 2.1). Half of these studies reported positive economic outcomes regarding avoided costs of future suppression efforts. The other four studies stated that positive results could potentially occur dependening on the type of ecosystem where the wildfire is being suppressed, or the magnitude of the suppression. One paper cited negative outcomes that could result in the form of an economic strain on the federal budget due to surrounding WUI communities freeriding from supression efforts on public lands (Busby & Albers, 2010).

2.3.2. Stakeholder Survey

Figure 2.2 shows the ISA framework as a complete grid of treatment-outcome linkages across all 38 survey respondents, with perceived importance mapped out on the x-axis and perceived strength on the y-axis. Of the 72 possible linkage combinations, 37 fell into Quadrant 2: ‘Continue Good Work’ and 18 in Quadrant 3: ‘Low Priority’. Quadrant 4: ‘Future Prioritization’ contained 13 perceived linkages, while only four linkages were found to exist in

Quadrant 1: ‘Less Effort Needed’. Appendix 2 lists the specific treatment-outcome linkages that fell into each category.

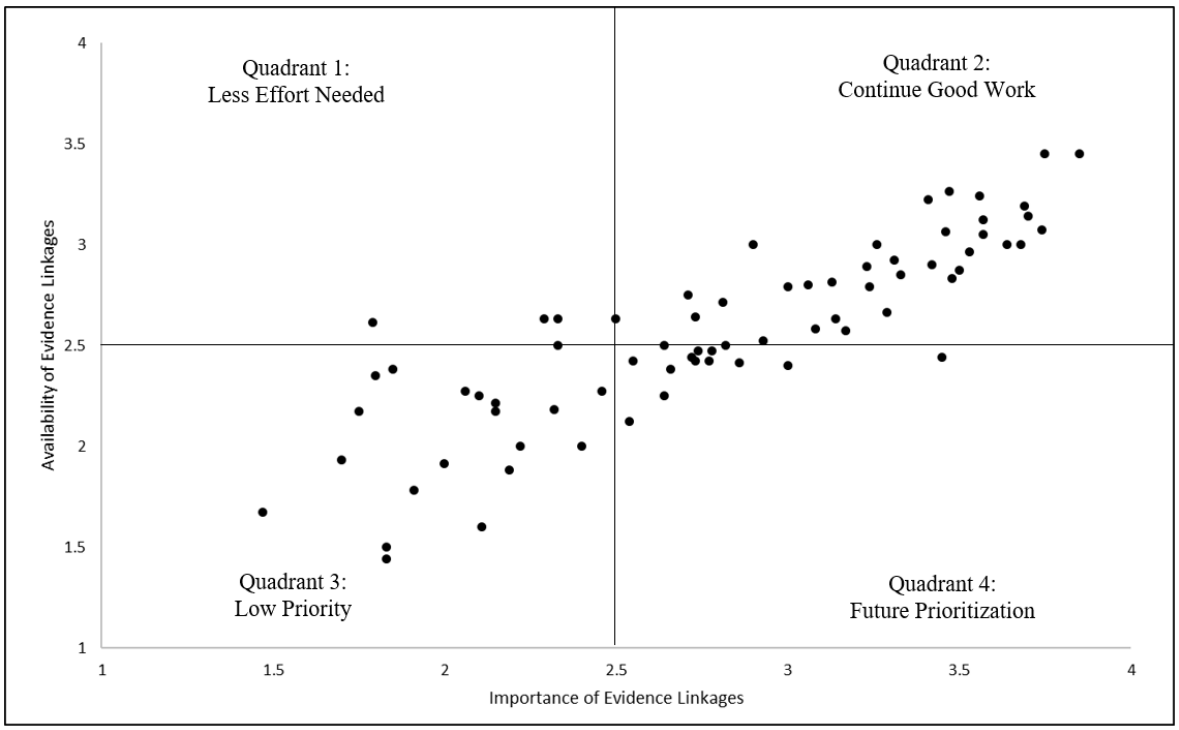

Figure 2.2. Grid of perceived importance and strength of treatment-outcome linkages across organizations

The means and standard deviations for the importance and strength of evidence from each of the treatment-outcome linkages, as well as the gap values for each of these linkages, are presented in Table 2.4. Results show that on average, gaps between the perceived importance and strength of treatment-outcome linkages vary greatly. When generalized across all 38 survey respondents and organizations, the treatment-outcome linkage with the largest disparity between importance and strength was identified as the impact of post-wildfire mulching on water quality and quantity, which had the highest average gap value of 1.01 (Table 2.4). This value was positive and located in Quadrant 4, signifying that the relationship between mulching and water health was perceived to be understudied (very important [mean = 3.45] with weak evidence

[mean = 2.44]). The other linkages in Quadrant 4 that were believed to be most important for future research prioritization included the impacts of: fuel breaks on public perceptions of the treatments (GV = 0.6), rehabilitation on recreation and tourism (GV = 0.45), defensible space on water quality/quantity (GV = 0.42) and mulching on habitat and biodiversity (GV = 0.39).

The largest negative gap value (GV = -0.82) indicating the linkage perceived to be most over studied was the relationship between impacts of post-fire rehabilitation on timber and non-timber forest products. This linkage had a slight importance (mean = 1.79) and moderate strength of evidence (mean = 2.61) linking the intervention to the outcome. The two linkages with the largest standard deviation (*SD* = 1.3) were the impacts of mulching on future suppression costs and the impacts of salvage logging on public perceptions, indicating the highest disparity of stakeholder viewpoints on these relationships. The most agreement occurred regarding the relationship between fuel breaks and employment (*SD* = 0.3)

Table 2.4. Mean importance/strength and gap values of treatment-outcome linkages across respondents (sorted from largest positive to largest negative gap value)

Quadrants	Importance		Strength		Gap Value (I-S)
Quadrant 1: Less Effort Needed	Mean	*SD*	Mean	*SD*	GV
Prescribed burning x timber/non-timber forest products	2.33	1.24	2.5	0.96	-0.17
Rehabilitation x infrastructure/property loss	2.33	1.28	2.63	1.01	-0.3
Fire suppression x timber/non-timber forest products	2.29	1.01	2.63	0.83	-0.34
Rehabilitation x timber/non-timber forest products	1.79	0.92	2.61	0.92	-0.82
Quadrant 2: Continue Good Work	Mean	*SD*	Mean	*SD*	GV
Fire suppression x future suppression costs	3.68	0.57	3	1.08	0.68
Prescribed burning x water quality/quantity	3.74	0.56	3.07	0.84	0.67
Fire suppression x water quality/quantity	3.48	0.99	2.83	0.71	0.65
Thinning x future suppression costs	3.64	0.68	3	0.69	0.64
Fuel breaks x future suppression costs	3.5	0.78	2.87	0.81	0.63
Prescribed burning x public perceptions	3.29	0.94	2.66	0.72	0.63
Fuel breaks x water quality/quantity	3.17	1.04	2.57	0.93	0.6
Prescribed burning x future suppression costs	3.53	0.66	2.96	0.88	0.57
Rehabilitation x water quality/quantity	3.7	0.47	3.14	0.91	0.56
Rehabilitation x restoration costs	3.57	0.75	3.05	0.85	0.52
Defensible space x future suppression costs	3.42	0.81	2.9	0.97	0.52
Rehabilitation x public perceptions	3.14	0.94	2.63	0.9	0.51

Thinning x water quality/quantity	3.69	0.63	3.19	0.78	0.5
Salvage logging x restoration costs	3.08	0.86	2.58	0.79	0.5
Thinning x restoration costs	3.33	0.85	2.85	0.88	0.48
Fuel breaks x infrastructure/property loss	3.57	0.82	3.12	0.71	0.45
Thinning x public perceptions	3.24	0.94	2.79	0.83	0.45
Fuel breaks x restoration costs	2.93	0.98	2.52	0.9	0.41
Defensible space x infrastructure/property loss	3.85	0.53	3.45	0.8	0.4
Thinning x habitat/biodiversity	3.46	0.89	3.07	0.8	0.39
Salvage logging x timber/non-timber forest products	3.31	0.95	2.92	0.95	0.39
Fire suppression x public perceptions	3.23	0.92	2.89	0.88	0.34
Thinning x infrastructure/property loss	3.56	0.65	3.24	0.7	0.32
Rehabilitation x habitat/biodiversity	3.13	0.81	2.81	0.75	0.32
Mulching x restoration costs	2.82	1.17	2.5	1.07	0.32
Fire suppression x infrastructure/property loss	3.75	0.68	3.45	0.74	0.3
Fire suppression x restoration costs	3.26	0.96	3	0.77	0.26
Prescribed burning x restoration costs	3.06	0.9	2.8	0.91	0.26
Prescribed burning x infrastructure/property loss	3.47	0.79	3.26	0.73	0.21
Defensible space x public perceptions	3	1	2.79	.63	0.21
Prescribed burning x habitat/biodiversity	3.41	0.89	3.22	0.75	0.19
Salvage logging x water quality/quantity	2.64	1.01	2.5	0.71	0.14
Defensible space x restoration costs	2.81	1.08	2.71	0.85	0.1
Thinning x recreation/tourism	2.73	1.04	2.64	0.91	0.09
Salvage logging x habitat/biodiversity	2.71	1.2	2.75	0.89	-0.04
Thinning x timber/non-timber forest products	2.9	0.98	3	0.86	-0.1
Salvage logging x employment	2.5	0.97	2.63	0.92	-0.13
Quadrant 3: Low Priority	Mean	*SD*	Mean	*SD*	GV
Mulching x recreation/tourism	2.11	0.93	1.6	0.89	0.51
Mulching x public perceptions	2.4	1.07	2	0.63	0.4
Defensible space x employment	1.83	0.86	1.44	0.53	0.39
Mulching x employment	1.83	0.75	1.5	0.58	0.33
Prescribed burning x employment	2.19	1.11	1.88	0.72	0.31
Mulching x future suppression costs	2.22	1.3	2	0.82	0.22
Salvage logging x future suppression costs	2.46	1.12	2.27	0.79	0.19
Fire suppression x employment	2.32	1.16	2.18	0.4	0.14
Defensible space x habitat/biodiversity	1.91	0.97	1.78	1	0.13
Fuel breaks x employment	2	0.95	1.91	0.3	0.09
Salvage logging x recreation/tourism	2.15	1.07	2.17	0.98	-0.02
Fuel breaks x recreation/tourism	2.15	1.1	2.21	0.97	-0.06
Mulching x infrastructure/property loss	2.1	1.2	2.25	1.04	-0.15
Defensible space x timber/non-timber forest products	1.47	0.84	1.67	0.91	-0.2
Rehabilitation x employment	2.06	1.09	2.27	0.9	-0.21
Defensible space x recreation/tourism	1.7	0.82	1.93	0.83	-0.23
Mulching x timber/non-timber forest products	1.75	0.71	2.17	0.98	-0.42
Salvage logging x infrastructure/property loss	1.85	1.14	2.38	1.06	-0.53
Quadrant 4: Future Prioritization	Mean	*SD*	Mean	*SD*	GV
Mulching x water quality/quantity	3.45	0.82	2.44	1.13	1.01
Fuel breaks x public perceptions	3	0.96	2.4	0.68	0.6
Rehabilitation x recreation/tourism	2.86	1.11	2.41	1.06	0.45
Defensible space x water quality/quantity	2.54	1.22	2.12	0.99	0.42
Mulching x habitat/biodiversity	2.64	1.12	2.25	0.46	0.39

Salvage logging x public perceptions	2.77	1.3	2.42	0.79	0.35
Fire suppression x habitat/biodiversity	2.78	1.17	2.47	0.87	0.31
Prescribed burning x recreation/tourism	2.73	1.18	2.42	1.06	0.31
Thinning x employment	2.72	1.03	2.44	0.7	0.28
Fuel breaks x habitat/biodiversity	2.66	1.08	2.38	0.77	0.28
Fire suppression x recreation/tourism	2.74	1.1	2.47	0.92	0.27
Rehabilitation x future suppression costs	2.55	1.05	2.42	1.02	0.13
Fuel breaks x timber/non-timber forest products	1.8	0.82	2.35	0.75	-0.55
*Positive gap values imply perceptions of treatment-outcome evidence linkage being understudied while negative values signify perceptions of linkage being over studied. The value of the gap (-4 to +4) indicates the magnitude of the perception. Values closer to 0 are weaker perceptions, while those closer to the extremes are stronger. A smaller standard deviation signifies convergence of greater agreement among the survey participants, while a larger standard deviation implies greater divergence or disagreement.					

When broken out by organizational affiliation, the perceptions of almost all subgroups followed similar trends, the exception being the forest and wildfire specialists (Table 2.5). These specialists stated that 19 treatment-outcome relationships were currently being understudied and were necessary to prioritize in future wildfire science research. Of these linkages, the five with the highest gap values were: 1) the impact of defensible space on future suppression costs (GV = 1.56), 2) the impact of fuel breaks on public perceptions (GV = 1.4), 3) the impact of mulching on water quality/quantity (GV = 1.25), and 4) the impact of salvage logging on a) public perceptions (GV = 1.2) and b) timber/non-timber forest products (GV = 1.2). Forest/wildfire specialists also perceived just one linkage belonging in the 'Less Effort Needed' category: the impact of fire suppression on timber and non-timber forest products (GV = -0.67).

Table 2.5. The number of treatment-outcome linkages in each quadrant broken down by organizational sector

	Quadrant			
Organizational Sector	'Less Effort Needed'	'Continue Good Work'	'Low Priority'	'Future Prioritization'
Utilities/local government (n=11)	7	38	24	3
NGO (n=8)	0	41	11	7

Forest/fire specialists (n=12)	1	28	24	19
Private (n=6)	7	49	2	2
AVERAGE (n=37)	4	37	19	12

2.3.3. Comparing Evidence Map and Stakeholder Survey

The five most commonly reported treatment-outcome relationships found in the evidence map were impacts of: 1) thinning on a) infrastructure/property and b) timber/non-timber forest products; 2) prescribed burns on a) infrastructure/property and b) future suppression costs; and 3) current wildfire suppression on a) future suppression costs (Figure 2.1). These five relationships were all located in Quadrant 2: 'Continue Good Work' when averaged across organizations surveyed (Figure 2.2). They were almost all located in the same quadrant when broken down by each organizational sector as well, implying that organizations perceive strength of evidence on these linkages that is supported by what was found in the published literature. Stakeholders also agree that it is highly important to continue producing evidence surrounding these relationships. Although forest and fire specialists placed the least amount of linkages in 'Continue Good Work' (Table 2.5), they listed these top five most commonly cited relationships in this quadrant as well. The evidence map reported overwhelmingly positive societal outcomes of implementing these treatments in the form of avoided costs and social losses.

The forest and fire specialists differed from other organizational sectors in the 'Future Prioritization' quadrant, where they deemed 19 linkages (seven above the average) as highly important but currently being understudied (Table 2.5). Several of these relationships had positive gap values of 1.33 or higher, much larger than the highest average gap value of 1.01 across all organizations (Table 2.1), signifying strong feelings that these relationships are being

understudied. When compared to the results from the evidence map, nine of these relationships were only found once, and another eight were not referenced in the literature. The fact that few studies exist on these linkages perceived to be important by specialists implies a research need, and yet the average participant believed the evidence to be adequate for many of these relationships. Another study comparing stakeholder perceptions to the strength of scientific evidence found similar contrasting observations (Ntshotsho, Esler & Reyers, 2015). Ntshotsho et al. (2015) conclude that the observed disparity could lead to future challenges of advancing an evidence-based approach to management.

In terms of linkages perceived to be over studied in the survey, the average respondent listed four relationships with a low importance/high strength score: 1) prescribed burning on timber/non-timber forest products; 2) fire suppression on timber/non-timber forest products; and 3) post-fire rehabilitation on a) infrastructure/ property and b) timber/non-timber forest products (Figure 2.2). Forest and fire specialists also listed post-fire rehabilitation and its impacts on forest products as the one relationship where less research effort is needed. Interestingly, the evidence map resulted in zero studies currently reporting on this relationship (Figure 2.1). A lack of studies on any treatment-outcome relationship does not necessarily imply an evidence gap- it could rather be due to an absence of any theoretical connection, and thus lack of a need for empirical work on the given relationship (Cook et al., 2012). Regardless of the specific reason(s) for no evidence on this linkage, it is worth noting that the perception of this relationship is one of being over studied. The gap values of this relationship were -0.82 for the average respondent and -0.67 for the specialists (out of a -4 to +4 range), implying that they do not hold very strong perceptions on the need for additional evidence.

Likewise, the average respondent reported gap values close to zero for the impacts of 1) fire suppression on forest products (GV = -0.34), of 2) post-wildfire rehabilitation on infrastructure and property (GV = -0.3), and of 3) prescribed burns on forest products (GV = -0.17). These small negative gap values imply weak perceptions that these relationships are being over studied. The impact of prescribed burns on forest products was the only relationship perceived to be over studied that was reported on by more than two studies in the evidence map (n=6). Again, little to no evidence regarding the other relationships may be due to appropriate reasons, i.e. there is no practical reason for a linkage between certain treatments and outcomes to exist. However, the fact that decision-makers *believe* these linkages are over studied implies a knowledge gap between their perceptions and the evidence that exists within the current literature.

2.3.4. Science and Management Implications

The results of the evidence map and stakeholder survey allow for several practical recommendations to be made for wildfire managers, researchers, and the watershed partnerships starting to invest in wildfire risk mitigation across the United States and elsewhere. First, there was general consensus that the most commonly identified treatment-outcome linkages in the evidence map were highly important, and researchers in the field should continue producing evidence on these relationships. Only a few of the treatment-outcome relationships were found in more than five case studies (Figure 2.1), signifying a lack of many gluts (linkages being over studied).

Second, there was a substantial number of wildfire treatment-outcome relationships that were perceived to be understudied; 13 by the average survey participant and 19 by the forest and fire specialists (Table 2.5). Nearly all (83%) of the linkages the average participant believed to

be understudied were found only once or not at all in the evidence map. Similarly, 90% of linkages that specialists perceived as being understudied were reported on once or not at all. The largest positive gap value reported for both groups was on the impacts of mulching on water quality and quantity. Past studies have found the addition of mulch to be an erosion control best management practice for decreasing runoff flow rates and avoiding the influx of sediment into a watershed (Bakr, Weindorf, Zhu, Arceneaux, & Selim 2012; Bakr, Elbana, Arceneaux, Zhu, & Weindorf, 2015; Faucette & Risse, 2002). The large gap value implies the importance of this relationship for wildfire management researchers to prioritize.

Third, organizations on average believed that only four relationships are being over studied (Figure 2.2), one being the impacts of post-fire rehabilitation on forest products. Forest and fire specialists also perceived post-fire rehabilitation and forest products as being over studied, although the evidence map found zero studies reporting on this relationship. Similarly, only one study reported on the impact of fire suppression on forest products and two studies described impacts of post-fire rehabilitation on property and infrastructure. Small negative gap values resulting from these perceptions imply that forest/fire specialists and other survey participants did not hold strong beliefs about these relationships being over studied. The one linkage perceived to be over studied that was reported on by more than two case studies (n=6) was the impact of controlled burns on forest products (Figure 2.1).

Finally, the views of forest and wildfire specialists differ substantially from other organizational sectors, especially regarding areas that need more research. The perceptions of water utilities, NGO's, and the private sector mostly followed a similar trend; they all typically reported few linkages in the 'Future Prioritization' and 'Less Effort Needed' quadrants (Table 2.5). In contrast, specialists believed that approximately a third of all potential treatment-outcome

linkages were important to prioritize for future research, and that almost no relationship was understudied. This deviation from the average could simply be due to the nature of being a specialist; these organizations are commonly the generators of science or implementors of fuel mitigation treatments, and as such are more aware than other groups of the knowledge gaps that exist within the current literature. Stakeholder perceptions of evidence was found to influence the uptake of that evidence in conservation decision-making (Bennett, 2016), highlighting the importance of understanding the perceptions of specialists as generators and implementors of new science.

A reoccurring issue in natural resource management is a lack of consistency regarding the use of scientific data to inform policy prescriptions (Pullin & Knight, 2003). Studies are emerging which demonstrate an increase in the efficacy of conservation actions due to the incorporation of science into management decision-making (i.e. Svancara et al., 2005; Walsh, Dicks, & Sutherland, 2015). As Reinhardt et al. (2008) recommends, efforts should be made to better integrate scientific evidence into wildfire mitigation treatment programs, which would serve to increase decision-makers' awareness of the current evidence base and decrease confusion as to the purpose of specific treatment types. This could be accomplished via the co-production of new evidence between scientists and decision-makers, which would shift the idea of information from something that is transferred among groups to a 'process of relating' created in a collaborative manner between experts and users of the information (Roux, Rogers, Biggs, Ashton, & Sergeant, 2006). Involvement of these diverse groups in knowledge co-production could minimize disparities between perceptions of available evidence and the actual evidence base that exists (Ntshotsho et al., 2015).

2.4. Study Limitation

The highest quality evidence that can be gathered on societal impacts of wildfire treatments is derived from peer-reviewed studies on controlled, replicated experiments using empirical field measurements. The next highest level of quality is uncontrolled but replicated observations using empirical field measurements. The lowest level of quality is observational studies with no replication. Contacts from the wildfire and forestry science institute deemed the 187 cases analyzed in this study as purely observational; an important caveat to interpreting the positive, negative, and neutral results from the systematic map. The cases lack any sort of empirically measured evidence and can therefore only offer prospective evidence of low confidence. Although these observations are still valid, they do not control for other variables and are not replicable, meaning external validity of these studies cannot be assumed. Methods and data linking specific fuel treatments directly to societal outcomes (i.e. homes saved, loss of life avoided) in a controlled, replicable setting have not been implemented to date. Experiments that results in empirical, high-confidence causal evidence on wildfire mitigation effects is needed moving forward to ensure continued support for these interventions, and the treatment-outcome linkages identified as important by forest and wildfire specialists should especially be prioritized in future research activities.

2.5. Conclusion

Reinhardt et al. (2008) stresses the importance of understanding the diverse outcomes of wildfire treatments to overcome common misconceptions and effectively use the treatments in wildfire management decision-making. This study catalogued the evidence that exists regarding the impact of wildfire mitigation treatments on societal outcomes, and how this evidence-base

compares to the perspectives of stakeholder organizations making decisions regarding investment in these treatments. The results from the evidence map reveal that research on wildfire treatment effects target a small number of outcomes compared to the broad range of potential interests. This does not necessarily imply gaps in the evidence base for all linkages, as some treatment-outcome relationships should not be studied by wildfire management researchers due to a lack of theoretical connections and/or are not priorities of policymakers and wildfire managers implementing these programs. However, according to stakeholders, there are several relationships not adequately covered in the current wildfire mitigation literature that were also believed to be important, especially from the perspective of forest and wildfire specialists. These specialists represent organizations that are very familiar with wildfire treatments. As such, their views on current gaps within the literature should be considered expert opinion. Research scientists would benefit from prioritizing these specific treatment-outcome relationships for future wildfire research to address.

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CHAPTER THREE: EXAMINING MOTIVATIONS INFLUENCING WATERSHED PARTICIPATION IN THE INTERMOUNTAIN WEST

Summary

There has been a rise in environmental collaboratives as a form of governance for watershed management. These collaboratives depend on a diversity of organizations acting collectively by pooling their resources, yet little information exists as to why organizations decide to become involved in these initiatives. One example of these collaboratives is watershed partnerships that participate in source water protection. A subset of these specifically focus on reducing wildfire risk via mitigation treatments. This study attempts to identify why organizations involved in wildfire watershed partnerships decide to participate. I used Q method to survey representatives from 38 organizations currently participating by investing time or resources in these partnerships in the Intermountain Western United States. Factor analysis revealed six distinct perspectives organizations hold that influence their decision to participate: 1) Environmental Mission, 2) Environmental Leadership, 3) Wildfire Information, 4) Partnership Support, 5) Economic Incentive, and 6) Trust Establishment. These findings differ from the broader environmental management literature in that they emphasize internal organizational motivations for participation. Results suggest that diverse strategies are needed to engage potential partner organizations in watershed partnership collaboratives.

3.1. Introduction

A trend observed globally is a weakening of state influence and a shift in power to stakeholders who have traditionally held minimal governing authority (Guízar, 2012). This trend

is prevalent in conservation due to the mismatch between traditional forms of governance and ecosystem structures and processes (McLeod & Leslie, 2009). Unique styles of governance have emerged to address this misalignment, one example being environmental collaboratives (Yaffee, 2012). Environmental collaboratives demonstrate how stakeholder organizations can act collectively to solve a common conservation issue.

One problem increasingly addressed by environmental collaboratives is the growing prevalence of wildfires. Three primary factors have contributed to the increased frequency and severity of wildfires over the past several decades: 1) hotter, dryer seasons due to a changing climate, 2) an increased buildup of fuel loads in forests, and 3) a growing human population in fire prone areas (Schoennagel, Balch, Brenkert-Smith, Dennison, Harvey, et al., 2017). Catastrophic wildfires often result in negative ecological and societal outcomes, such as impaired source water quality due to increased sediment load from runoff (Thomas, Butry, Gilbert, Webb, & Fung, 2017). High quality water is important to the mission statements of numerous public organizations and is a vital component for the daily operations of diverse private entities. The degradation of a watershed often results in the inability to use the resource without costly remediation (Finley, 2012).

As of 2016, over 400 watershed partnerships operate globally across nearly 1.2 billion acres of land (Bennett & Ruef, 2016). Partnerships can be defined as an agreement between public and private organizations to act collectively towards common goals of watershed health, and a small subset of these collaboratives focus on participating in wildfire risk mitigation to avoid future costs associated with an impaired waterway. Programs focused on wildfire risk mitigation have gained popularity most rapidly in the Intermountain West region of the United States due to an increase of fire and water issues in the area. Due to the complexity and often

high costs of implementing wildfire treatments on private and public lands, partnerships are critical for pooling resources across several organizations (Bennett & Ruef, 2016).

Stakeholder organizations participate in watershed partnerships by investing their financial resources, human resources, or a combination thereof into these collaboratives, yet little information exists regarding the various motivations driving this participation (Bennett, Gosnell, Lurie, & Duncan, 2014). Some studies suggest that in addition to regulatory pressure and financial benefits, public support plays a primary role in influencing the decision of private and public entities to participate (Metz & Weigel, 2009). There is also some indication that charismatic leaders or environmental champions may substantially influence an organization's decision to participate (Bennett, et al. 2014; Bruyere, 2015). Understanding the specific motivations for involvement among diverse groups of stakeholders is important information for the creation and maintenance of collaborative governance partnerships.

In this study I add to the environmental management and collaboration literature by determining why organizations decide to invest their resources in watershed partnerships focused on wildfire risk mitigation. Specific objectives were to a) reveal distinct perspectives among organizations for contributing time and/or financial resources in watershed partnerships, and b) identify the specific motivations within each perspective that drive organizations to participate. To accomplish these objectives I administered a mail survey to representatives of 32 organizations asking them to rank motivators. Understanding motivations of organizations currently involved in partnerships will aid in the securement of adequate support and financing of future partnerships— specifically how to best approach organizations not yet participating, but with whom they hope to collaborate with in the future. Furthermore, results will contribute to the

literature by generating a broad understanding of why organizations decide to become involved in environmental collaboration.

3.2. Background and Concept Map

I conducted a review of the literature on organizational motivations for participation in environmental management. I decided to focus my review on this more generalized topic due to the limited number of peer-reviewed studies on motivations for participation in watershed partnerships; much of the gray literature that does exist references this broader body of literature. The review resulted in 21 studies with a relevant focus. Many case studies differentiate between internal and external motivations for involvement (Prajogo, Tang, & Lai, 2012; Tourais & Videira, 2016). Internal motivations include the presence of environmental leaders that attempt to reduce their organizations' environmental footprint (Tourais & Videira, 2016) or access to evidence to help inform their decisions to particpate (Cook, Nichols, Webb, Fuller, & Richards, 2017). External motivations consist of gaining a competitive advantage, ensuring legal compliance, and addressing constituent or interest group pressures (Tourais & Videira, 2016). Within the literature motivations for participation differ widely among organizations based on the various needs and capacity of each entity (for example, see Meath, Linnenluecke, & Griffiths, 2016; Samantha & Jonathan, 2013; Tee, Boland & Medhurst, 2007). For example, large-scale businesses tend to participate in environmental management more often than smaller, but only if the given environmental issues are of considerable concern to their daily operations (Khanna, Koss, Jones, & Ervin, 2007). Studies have additionally found the use of scientific evidence, specifically in organizational decision-making, is typically only prevalent among scientific institutions (Pullin & Knight, 2003). However, exposure to evidence has been found to

directly impact the decision-making process of stakeholders (Walsh, Dicks & Sutherland, 2015), demonstrating the importance of disseminating and better communicating this information.

I recorded the results from the literature review listed above and developed the concept map below (Figure 3.1) by integrating the findings. The motivations within dotted circles identify factors internal to the organization, while those within solid circles represent external stimuli. Each of the motivations is a broad category, with specific motivators within each category identified in the following section. The concept map illustrates how a combination of internal and external motivation categories has an impact on various organizations' decisions to participate in watershed partnerships.

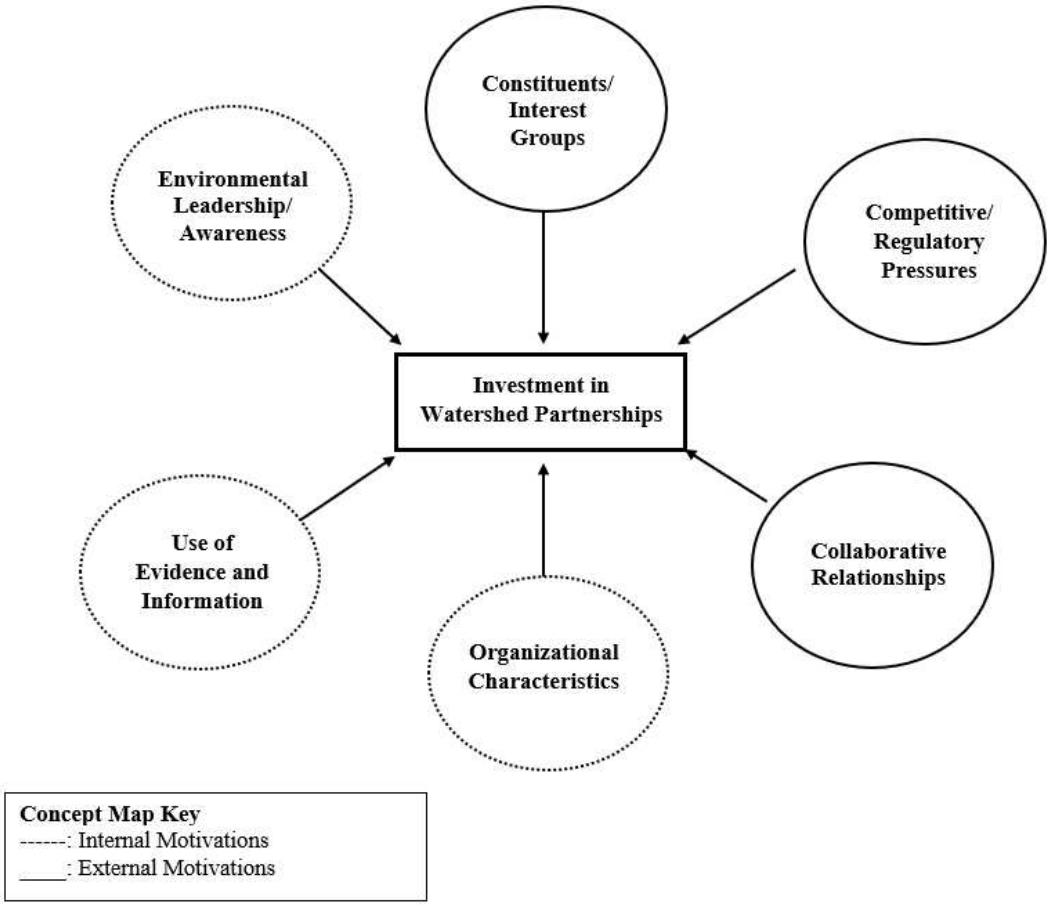

Figure 3.1. Concept map of various internal and external motivations for decisions to participate in watershed partnerships

3.3. Methodology

3.3.1. Q Method Objectives

For this study I employed Q methodology using methods adapted from Webler, Danielson, & Tuler (2009); Q method is typically applied when researchers wish to understand a spectrum of subjective viewpoints on a particular issue (van Exel & de Graaf, 2005) and has been gaining popularity in conservation research to understand the perspectives of diverse stakeholder groups (Zabala, Sandbrook, & Mukherjee, 2018). It is often used in studies with fewer than 60 participants and does not require a random sample (Armatas, Venn & Watson, 2014; Fisher & Brown, 2015) if not sampling from a general population. The purpose of this study was to survey representatives from organizations that have already invested time and/or financial resources in watershed partnerships rather than randomly sampling from a larger population. As such, Q method was an ideal research design. Through Q, it is possible to reduce many individual viewpoints to a few factors participants can rank. In this case study, the desired factors represented various motivations for participation in watershed partnerships drawn from Figure 3.1.

3.3.2. Participants Surveyed

An initial invitation to participate in this study was sent in October 2017 to 61 representatives of organizations whom currently participate in watershed partnerships by investing financial and/or human resources. The organizations were involved with eight watershed partnerships covering a geographic range throughout three Western states: Colorado, Arizona and Oregon (Figure 3.2). I chose these partnerships with guidance from Carpe Diem West and Forest Trend's Ecosystem Marketplace, and the list of potential survey takers was gathered by asking contacts of the partnerships to identify representatives of participating

organizations. These representatives were not selected randomly, thus results drawn from the sample should not be generalized to a larger population. Although these participants were identified via network sampling, they are still only able to express a limited, potentially biased viewpoint. Therefore, results are not meant to characterize the organizations as a whole, but rather one educated perspective within each organization.

I sent two follow-up emails to non-respondents of the initial survey invitation to encourage them to participate. Those who did not respond a week after the third outreach email were removed from the list of potential participants. In total, 38 representatives from 32 organizations completed and returned the questionnaire, resulting in a 62% response rate. Participants included representatives from public service groups (e.g., water utilities and local governments), non-governmental organizations (e.g., The Nature Conservancy), forest/fire specialists (e.g., U.S. Forest Service, local fire departments and science institutes), and private businesses (e.g., breweries and ranches) (Figure 3.3).

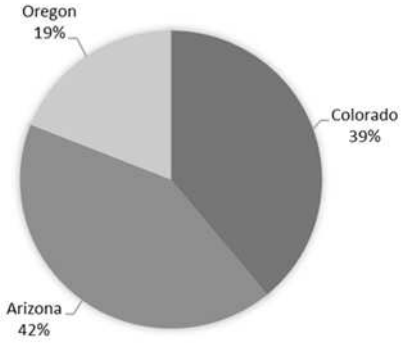

Figure 3.2. Pie chart signifying the breakdown of respondent organizations by state

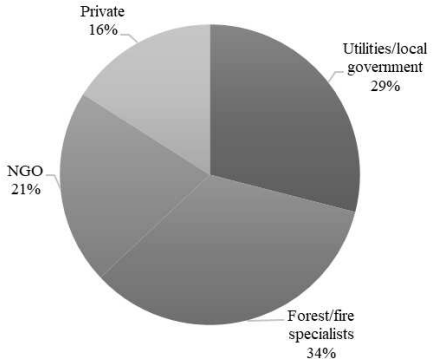

Figure 3.3. Pie chart signifying the breakdown of respondent organizations by sector

3.3.3. Statement Selection

Using methods adapted from Hermelingmeier and Nicholas (2017) I constructed a concourse matrix from the motivation categories identified in the concept map. Table 3.1 lists specific motivators from the literature that fall under each category in the matrix and the specific study where each statement was derived. These statements are opinion-based rather than objective facts, similar to Likert scale survey belief statements. Creating a concourse matrix helps to identify any missing aspects of the motivation categories that should be included, while avoiding overly similar statements (Hermelingmeier & Nicholas, 2017).

I listed out diverse statements drawn from the literature until the concepts they signified became repetitive. A team of four researchers with expertise in wildfire risk mitigation, forestry management, and Q methodology reviewed the statements and those with duplicate meanings were merged or dropped, until the motivation categories included an approximate equal number of statements (four to seven). The resulting 36 statements within the six categories covered a wide range of internal and external motivations for participation.

Table 3.1. Concourse Matrix

Motivation Category	**Statements (Our organization participates in a watershed partnership because …)**
Constituents/ Interest Groups	…of pressure from our constituents to participate. (Caniëls et al., 2013)
	…we are able to obtain higher prices for our products from constituents who are willing to pay a green premium. (Khanna et al., 2007)
	…participation positively affects our public recognition and image. (Ervin et al., 2013)
	…our engagement with community stakeholders has influenced our decision to participate. (Ervin et al., 2013)
	…participation improves relationships with our constituents and/or local community. (Khanna, 2001)
	…of pressure from environmental or other interest groups. (Ervin et al., 2013)
	…our investors or funders like to see us participate. (Ervin et al., 2013)

Environmental Leadership/ Awareness	…of an awareness of environmental issues within our management team. (Caniëls et al., 2013)
	…of a commitment to environmental practices within our management team. (Ervin et al., 2013)
	…one leader on our team has pushed for participation. (Caniëls et al., 2013)
	…the presence of a facilitator has convinced us to participate. (Reed et al., 2014)
	…we specifically care about improving the quality of water for its value to the natural world. (Sangkapitux & Neef, 2009)
Organizational Characteristics	…we have a history of involvement in environmental management. (Khanna, 2001)
	…we are large enough in size to participate. (Khanna et al., 2007)
	…we have adequate financial and/or social capital to participate. (Ervin et al., 2013)
	…our mission generally focuses on environmental protection, so participation is important to fulfilling this mission. (Mosier & Fisk, 2013)
Collaborative Relationships	…we trust other organizations involved due to previously established relationships. (Caniëls et al., 2013)
	…we see participation as an opportunity to foster new relationships with other organizations involved. (Reed et al., 2014)
	…we see participation as a chance to establish communication, learn from, and share ideas with other organizations involved. (Reed et al., 2014)
	…new relationships with organizations involved in the watershed partnership have led to the development of trust, ensuring our continued participation. (Reed et al., 2014)
	…of the collaborative, adaptive style of the partnership program. (Caniëls et al., 2013)
	…the presence of financial support from the watershed partnership (grants, a bond, pooled funding, etc.) is an incentive for us to participate. (Reed et al., 2014)
	…the watershed partnership provides us with some form of technical assistance and expertise. (Khanna, 2001)
Regulatory/ Competitive Pressures	…of current environmental regulation(s). (Ervin et al., 2013)
	…we are planning for potential future environmental regulation(s). (Khanna, 2001)
	…we have a legal mandate specifically requiring us to participate. (Ervin et al., 2013)
	…of pressure to differentiate from competition. (Ervin et al., 2013)
	…water quality is important to our daily operations. (Khanna et al., 2007)
	…participation lowers our costs of labor, capital, and environmental regulations. (Khanna et al., 2007)
	…participation reduces the price of our products, making us more competitive. (Ervin et al., 2013)
	…we believe that wildfire is a risk that must be addressed. (Sangkapitux & Neef, 2009)

Use of Evidence and Information	…we feel that an adequate amount of scientific information exists surrounding wildfire risk. (Pullin & Knight, 2003)
	…we have access to scientific information on wildfire risk. (Pullin & Knight, 2003)
	…we feel that an adequate amount of local and/or regional knowledge on wildfire risk exists specific to our watershed. (Tengö et al., 2014)
	…the watershed partnership has convinced us to participate by previously sharing transparent results of program success. (Reed et al., 2014)
	…information sharing within our organization has increased the awareness of benefits associated with participation. (Caniëls et al., 2013)

3.3.4. Study Design

I sent a mail survey to participants in November of 2017, with instructions to complete and return the survey in an included self-addressed envelope within a two-week timeframe (see survey instructions in Appendix 3). Participants received the 36 motivator statements in the form of individual 2" by 2" statement cards. I asked them to rank order the 36 numbered statements on a response sheet (Figure 3.4) in order of importance as to why they believe their organization participates in a watershed partnership, by answering the question: "Our organization participates in a watershed partnership because…". The instructions asked them to first read through the 36 statement cards and then place each in three piles on the top of their response sheet— one to the right for statements they generally agreed with, one to the left for statements they generally disagreed with, and a pile in the middle for statements of lesser importance, or that they were ambivalent about.

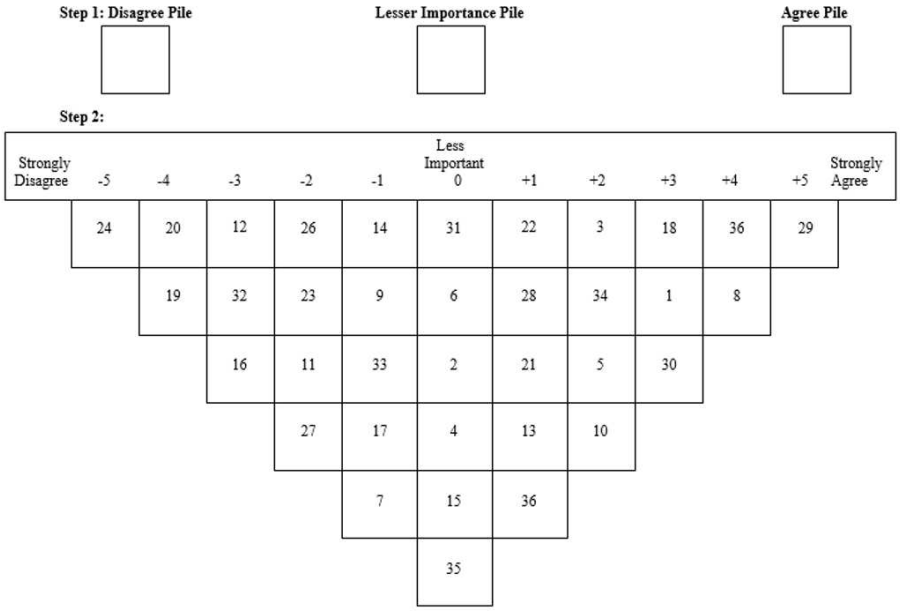

Figure 3.4. Example of a completed response sheet (numbers indicate individual statements)

The next step asked the participants to examine the statements they agreed with and place the statement they believed to be the strongest motivation for their organization's participation in the +5 space on the response sheet. They were then instructed to pick the two statements they next most agreed with and place them in the +4 column. They continued this process for each of the statements they agreed with, and then repeated the same procedure for each statement they disagreed with in the -5 space, -4 column, etc. The extreme columns had fewer slots, while the middle column contained the greatest amount of spaces. Respondents were informed that in Q methodology, the ordering of the statements by row has no significance. Rather, the column where the participants placed their statements (e.g. -3, +5, -5) is what is important. The center column (identified by "0") may be a statement they least agreed or disagreed with, they had mixed feelings about, or are simply not relevant to their organization.

When the participants completed the sorting, the instructions asked them to be sure they had one statement in each square and all squares on the response sheet were filled. When they finalized their responses, participants were instructed to record the statement numbers on the back of each statement card in the appropriate boxes on the response sheet. Each survey was followed up with a brief phone interview asking participants why they chose the responses they had (interview guide in Appendix 4). The purpose of these qualitative interviews was to support initial conclusions drawn from the quantitative analysis (Webler et al., 2009). These interviews also helped to ensure that no important motivator statements were missing from the list of options regarding the organizations' decisions to participate.

3.3.5. Factor Analysis

Upon completion of data collection, I implemented factor analysis to determine dominant factors, or perspectives for participation, that emerged. Through this analysis I also identified the strongest motivations for participation within each perspective. I implemented this analysis by using PQMethod, a free online software program developed specifically for Q method factor analysis (http://schmolck.org/qmethod/). As suggested by Webler et al. (2009), Principal Component Analysis was performed as the factor analysis algorithm, followed by QVARIMAX which automatically rotated the factors to determine how the 'sorts' (i.e. participants) 'load' onto the factors.

I used the normalized factor z-scores produced by the analysis to identify a distinguished sort for each factor; in other words, a participant who loaded highest onto one factor and therefore best represented that perspective. The analysis also generated top statements and normalized Q-sort values for each factor, which characterized the strongest motivations among participants of each perspective. I transcribed phone interviews of the distinguished sorts for

each factor and included portions of this data in the results, as it can be assumed these individuals have viewpoints unique to one perspective, or furthest away from any other factor (Hermelingmeier & Nicholas, 2017). I used the interview data to triangulate the Q-method data and explain the diverse factors generated (Braun & Clark, 2006).

3.4. Results

I repeated the process of factor rotation until six distinct perspectives were revealed, which all had eigenvalues >1, theoretically made sense when rotated, and cumulatively explained 73% of the study variance. I labeled the perspectives according to the interpretation of their themes, or primary motivations for participation. They are: 1) Environmental Mission, 2) Environmental Leadership, 3) Wildfire Information, 4) Partnership Support, 5) Economic Incentive, and 6) Trust Establishment. Table 3.2 lists the top five statements and normalized Q-sort values among each perspective, as well as their associated factor z-scores. Italicized statements distinguish each perspective due to their significance at the $p < .05$ and $p < .01$ levels. Table 3.3 highlights the correlation coefficients between each of the six perspectives. 'Environmental Mission' and 'Partnership Support' were most highly correlated ($r = 0.57$), while 'Wildfire Information' and 'Economic Incentive were least correlated ($r = 0.24$).

Table 3.2. Overview of the six perspectives revealed and their associated five highest ranked statements with normalized Q-sort values and z-scores

Perspective 1: Environmental Mission			**Perspective 2: Environmental Leadership**			**Perspective 3: Wildfire Information**		
Statement	**Q-sort value**	**z-score**	**Statement**	**Q-sort value**	**z-score**	**Statement**	**Q-sort value**	**z-score**
*Participation is important to fulfilling our mission***	+5	2.39	Water quality is important to our daily operations	+5	2.09	We believe that wildfire is a risk that must be addressed	+5	2.24
We believe that wildfire is a risk that must be addressed	+4	1.82	A commitment to environmental practices within management	+4	1.87	*We have access to scientific information on wildfire risk***	+4	1.99
We care about improving water quality for its natural value	+4	1.76	*An awareness of environmental issues within management**	+4	1.87	We have adequate financial and social capital to participate	+4	1.53
Financial support from the partnership is an incentive	+3	1.27	We care about improving water quality for its natural value	+3	1.42	We have a history of partaking in environmental management	+3	1.28
We see participation as a chance to learn and share ideas	+3	1.21	We believe that wildfire is a risk that must be addressed	+3	1.09	*We have knowledge on wildfire risks to our specific watershed**	+3	1.22
Perspective 4: Partnership Support			**Perspective 5: Economic Incentive**			**Perspective 6: Trust Establishment**		
Statement	**Q-sort value**	**z-score**	**Statement**	**Q-sort value**	**z-score**	**Statement**	**Q-sort value**	**z-score**
Financial support from the partnership is an incentive	+5	2.14	Water quality is important to our daily operations	+5	2.11	We believe that wildfire is a risk that must be addressed	+5	1.83
*The partnership provides us with assistance and expertise***	+4	1.64	We believe that wildfire is a risk that must be addressed	+4	1.87	We see participation as a chance to learn and share ideas	+4	1.67
Water quality is important to our daily operations	+4	1.29	Financial support from the partnership is an incentive	+4	1.82	*New relationships with others involved have led to trust**	+4	1.40
We care about improving water quality for its natural value	+3	1.18	*Participation has led to lower costs of labor and capital***	+3	1.44	We trust others involved due to previous relationships	+3	1.21
We want to build relationships with others involved	+3	1.06	A commitment to environmental practices within management	+3	1.20	We support the collaborative, adaptive style of the partnership	+3	1.21

Note: Italics indicates distinguishing statement(s) for factors; * indicates significance at $p < .05$; ** indicates significance at $p < .01$.

Table 3.3. Correlation coefficients between each of the six perspectives

	1	2	3	4	5	6
1						
2	0.52					
3	0.47	0.4				
4	0.57	0.4	0.33			
5	0.46	0.5	0.24	0.38		
6	0.31	0.47	0.46	0.28	0.31	

3.4.1. Perspective I: Environmental Mission

Organizations represented by the first perspective choose to participate in watershed partnerships due to environmental motivations. Those whom carry this perspective are primarily comprised of conservation non-governmental organizations (NGOs) that have some sort of environmental mission they attempt to fulfill by participating in a watershed partnership. The z-score for the leading statement of this perspective, "Our organization participates in a watershed partnership because participation is important to fulfilling our mission", was scored highest among the normalized statements of any perspective (2.39) and was significant at the $p < .01$ level (Table 3.2). The conservation NGO's surveyed typically have much broader missions of conserving and restoring ecosystems, and one of the ways they achieve this goal is through the avoidance of wildfire risk by participating in watershed partnerships. As the distinguishing sort from this perspective stated:

> Really the environmental protection piece for us is ecological sustainability, the restoration of ecosystems. When we're reducing fuels in the forest, we're also restoring habitat. And by restoring habitat in this particular setting in a municipal watershed, we're protecting against high severity fire and the impacts that would have on sedimentation and water quality. So those all kind of fit within our ecological mission.

The watershed partnerships examined all have a focus on protection of their municipal water supply. Although watershed management fits within the mission of conservation NGO's concerned about ecological protection, it is not an expressed primary driver for the participation of most of these organizations. Maintaining the quality of a municipal water supply is rather seen as a byproduct of the mitigation work implemented from the lens of these organizations. As such, statements regarding motivations for source water protection were not entirely applicable to NGO's surveyed and tended to be placed in the middle of the response sheets. This is not to say the NGO representatives necessarily disagree with many of these statements; rather they selected other priorities as stronger reasons for participation.

3.4.2. Perspective II: Environmental Leadership

Similar to the first perspective, organizations aligned with the second perspective also hold environmental motivations for involvement. These two perspectives were the second most highly correlated ($r = 0.52$) among the six perspectives identified (Table 3.3). Organizations within the second perspective may not be driven by a conservation-focused mission, but rather have conservation-minded leadership within their management team aware of environmental issues such as wildfire risk and are committed to implementing environmental practices. Given that water quality for daily operations is the highest sorted motivation of this perspective, organizations found to cluster around this perspective are split between water utilities and private businesses.

Managers aligning with this perspective like their constituents to see them as advocates for the environment. They want to be viewed as part of a long-term solution to water management that will have larger payoffs for their communities beyond just municipal water, such as for recreation. Due to limited budgets, these management teams stress that important trade-offs need to be considered when deciding to participate in a partnership. This perspective's distinguishing sort provided one such example:

> Our management team always asks the question, "What is going to help the most?" It's sometimes a difficult choice, but we want to be a part of that bigger solution. We ask, "What program is already supported by the public? What program will get us results? Who is getting most of the contracts out there to do the work? Who has worked out transportation of biomass? Who has worked out all of these things and the big keys to watershed restoration?" These are the big multi-million dollar questions.

3.4.3. Perspective III: Wildfire Information

The third perspective is predominantly composed of forest and fire specialists, such as scientific institutions, local fire departments, and federal forestry agencies. The highest sorted statement among these entities was "We participate in a watershed partnership because we

believe that wildfire risk must be addressed". They generally participate due to a history of involvement in environmental management, knowledge of fire in their given watersheds (significant at $p < .05$), and access to scientific information on wildfire risk (significant at $p < .01$) (Table 3.2). A fire department representative and the distinguishing sort from this perspective mentioned how a legacy of public outreach and good reputation with their community allowed their organization to engage in a watershed partnership with ease and support:

> We had 15 years of experience prior to introducing that concept to the community. During that time, we had been able to shift the community paradigm about wildland fire. It had previously been seen as a federal problem, not a local problem. Because of the work we had undertaken, not only in public outreach and education but actually doing fieldwork and restoration related things on private and city lands, it was easy to make that transition. So that's critical, it put the fire department in an advocacy or leadership role as opposed to just responding to an issue.

According to this perspective, an informed public leads to community buy-in. This along with access to wildfire science and an extensive knowledge base on fire trends within the region were three primary drivers for becoming involved in the watershed partnership.

3.4.4. Perspective IV: Partnership Support

Private businesses and a few NGO's cluster around the fourth perspective. Overall, this viewpoint tends to represent smaller entities such as ranches or the recreation industry that are motivated to participate due to support from the larger watershed partnership. This support can potentially come in the form of financial aid. The distinguishing sort for this perspective shared the story of a flood that negatively impacted their ranch's livelihood. Participating in the watershed partnership allowed them to apply for a grant from the partnership that helped to divert runoff from cattle pens into the adjacent waterway and improve fishing habitat for tourists. Without this financial support, the ranch would not have had enough money to accomplish these projects:

> There are a lot of ranchers that do not have the finances to do environmental projects due to other priorities. If you have to choose between patching a leaky roof and cleaning up cattle pen runoff, you probably have to take care of the leaky roof first. I think that's true of a lot of agricultural operations in our area where the price of land is so high. As farmers and ranchers get older it's tempting to sell their water rights and cash in for their retirement, even if it is for something that may not be so environmentally friendly.

Even more important than financial support is the technical assistance and expertise the partnership provides; this statement was significant at the $p < .01$ level (Table 3.2). Many watershed partnerships either have specialists at the table who are experts in their fields or hire consulting teams to provide expertise. For example, the distinguishing sort mentioned the partnership they are involved with hired a consulting team who used grant funding to restore trout habitat on their ranch after the flood. They are hopeful their pilot projects will lead to more widespread involvement from farming and ranching communities in watershed work that could result in both environmental and economic benefits.

3.4.5. Perspective V: Economic Incentive

Water utilities comprise the fifth perspective and these entities are primarily driven by an economic incentive to participate in a watershed partnership. Similar to the second perspective, this group recognizes the importance of high-quality water in their daily operations and view wildfire as a risk that must be addressed. Many continue to participate because they have observed economic data on the avoided costs of labor and capital as a result of initial participation via financial investments in wildfire mitigation treatments ($p < .01$).

When a catastrophic wildfire occurs adjacent to water utilities' intake, the sediment and debris produced from the burned forests typically has an impact on water quality or water infrastructure. This influx of contaminants impacts the operational ability of water utilities to conduct their work, since they must spend more on chemical remediation to restore water quality and or dredge reservoirs. The distinguishing sort from this perspective stated the belief that

strategically investing in wildfire mitigation treatments proactively will lower the total costs paid for their organization's water supply in the long run. As such, their leading motivation for participation centers on the long-term economic returns resulting from proactive investment:

> The quality of the surface water can really dictate our operation cost for treating the water and delivering it to our customers. The higher the turbidity in the water, it really drives up our chemical and operation cost at the plants. So anything that can be done to reduce that, we're really supportive of that. And it really wasn't a large amount of money required and we had it available in our operations budget, so we felt that it was a good use of our money.

3.4.6. Perspective VI: Trust Establishment

The last perspective receives benefits from participation in the form of trust establishment. Organizations clustered on this factor may have already had trust in the partnership due to previous relationships with other organizations involved or have potentially been able to foster new relationships which resulted in trust ($p < .01$). Without this trust establishment, participating in wildfire mitigation for source water protection by making a financial investment was seen as too risky. As the distinguishing sort of this perspective stated regarding the past hesitancy of their utility's participation:

> A theme among water utilities management is that it is often difficult to justify an investment on something that may or may not mitigate a potential impact. There exists an unknown element on what the [wildfire] treatment impact is to the utility when something happens, as well as an unknown to the effectiveness of a particular treatment to mitigate a particular impact.

This perspective also described the ability to use other sources of water during previous wildfires as a reason for past non-participation, as well as a politically conservative constituent base not willing to pay for environmental programs. The presence of trust with other organizations involved eventually became the deciding factor to participate, as well as the collaborative, adaptive style of the partnership programs. Entities comprising this perspective generally favor regional partnerships due to the ability to share mutual experiences and learn

from one another. They report that when they do not have solutions for a particular water and fire management issue, they have been able to seek out answers from other groups involved.

3.4.7. Consensus Statements

In Q methodology, consensus statements are those beliefs found to not be distinct among any one factor, or most agreed upon among the diverse perspectives (Webler et al., 2009). Two consensus statements were found in this study: "Our organization participates in a watershed partnership because of pressure from 1) our constituents to participate, and 2) environmental or other interest groups". The first statement was the only consensus statement not statistically significant at the $p < .05$ level across all perspectives. This indicates the most consensus for this statement among participants, and specifically, the consensus was mutual agreement that constituent pressure was *not* a motivation for their organization's involvement. The second consensus statement also had mutual agreement that it was not a motivation for participation.

3.5. Discussion

Findings of this work suggest that the organizations surveyed maintain a variety of motivations for participating in collaborative environmental programs, which supports conclusions drawn from the broader environmental management literature (Tourais & Videira, 2016; Prajogo et al., 2012). This work is the first to survey a diverse set of organizations currently involved in source water protection via watershed partnerships to determine the broader motivations driving these groups to participate in collaborative governance.

3.5.1. Internal Factors Affecting Participation

An assortment of viewpoints, revealed through factor analysis, align with the internal motivation categories outlined in the concept map (Figure 3.1). The first two perspectives have

an environmental focus, which state that organizations surveyed choose to participate due to the presence of either environmental leadership or an environmental mission they attempt to fulfill. Bruyere (2015) surveyed conservation leaders globally and found partnership-building to be the most important skill effective leaders possessed. The second most important skill was establishing a clear vision, and committing to that mission, a finding supported in the broader environmental leadership and collaboration literature (Black, Groombridge, & Jones, 2011; Kark, Tulloch, Gordon, Mazor, Bunnefeld, et al., 2015; Kenney, McAllister, Caile & Peckham, 2000).

Organizations in the third perspective participate due to knowledge of and access to wildfire science, both generally and specific to their regions. This finding echoes a larger trend in conservation toward evidence-based decision-making (Sutherland et al., 2004), yet only organizations with a focus on wildfire science or management fell into this perspective. This outcome supports findings from Pullin & Knight (2003) whom report that the prevalence of evidence in decision-making is often unique to science-based groups or institutions that already prioritize this information. Regardless of the specific organizations represented within each perspective, these first three perspectives directly correlate with the three internal motivation categories for broader environmental management: 1) environmental leadership/awareness, 2) organizational characteristics, and 3) use of evidence and information.

3.5.2. External Factors Affecting Participation

The fourth perspective represents surveyed organizations whom participate due to financial or technical support from the watershed partnership. This perspective is highly correlated ($r = 0.57$) with the first perspective regarding participation stemming from an environmental mission (Table 3.3), most likely due to the influence of conservation NGO's in

this perspective. These organizations are mission-driven as opposed to profit-oriented, and therefore any resources the partnership can provide are incentives to continue involvement. Davidson and de Loë (2016) describe the evolution of environmental NGO's role in watershed governance to a dominant and influential position, highlighting the importance of these organizations' involvement in partnerships. The sixth perspective focuses on the establishment of trust as a reason to participate, which in combination with the fourth perspective encapsulated the external motivation category of participating due to the benefits of collaborative relationships formed.

The fifth perspective derived from the factor analysis focuses on an organization's belief that they receive a type of economic or financial return due to contributing an initial financial investment, which were motivators in the concourse matrix characterized under the external concept map category of 'regulatory/competitive pressure'. These returns come in the form of either lower operating and production costs from increased efficiency (Ervin, Wu, Khanna, Jones, & Wirkkala, 2013) or avoided costs of future environmental regulations (Khanna et al., 2007) and remediation expenses. However, this was the only motivation found to be a distinguishing statement aligned with some sort of competitive pressure to participate, and no regulatory pressure was revealed to drive participation. Likewise, I did not find any motivators as distinguishing statements under the 'pressure from constituents or other interest groups' category. In fact, the consensus statement with the most agreement across perspectives was the lack of importance of the statement: "Our organization participates in a watershed partnership because of pressure from our constituents".

3.5.3. An Adapted Concept Map

From the perspective of the representatives surveyed, motivations related to internal organizational attributes appear to have a much larger effect on the organizations' decisions to participate in watershed partnerships than external. The survey participants originally had a higher number of external (n=21) motivators to choose from the concourse matrix than internal (n=15), further exemplifying the importance of internal organizational motivations for participation. This conflicts with previous environmental management literature, which asserts that organizations hold a relatively even mix of internal and external motivations(for example, see Prajogo et al, 2012 or Tourais & Videira, 2016). This body of literature is primarily composed of corporate entities' motivations for involvement, whom undoubtedly contend with several external pressures due to the nature of existing within a competitive industry. This lies in contrast to the motivations of the diverse organizations comprising watershed partnerships; a contribution to the environmental management literature revealed through this case study. As such, I re-framed the concept map used to theorize organizations' reasons for involvement in environmental collaboratives to reflect these motivations. Figure 3.5 below highlights those changes by removing the 'constituents/interest group' category entirely, renaming the 'competitive/regulatory pressure' category as 'financial incentives', and recoding it as an internal motivation as opposed to an external pressure.

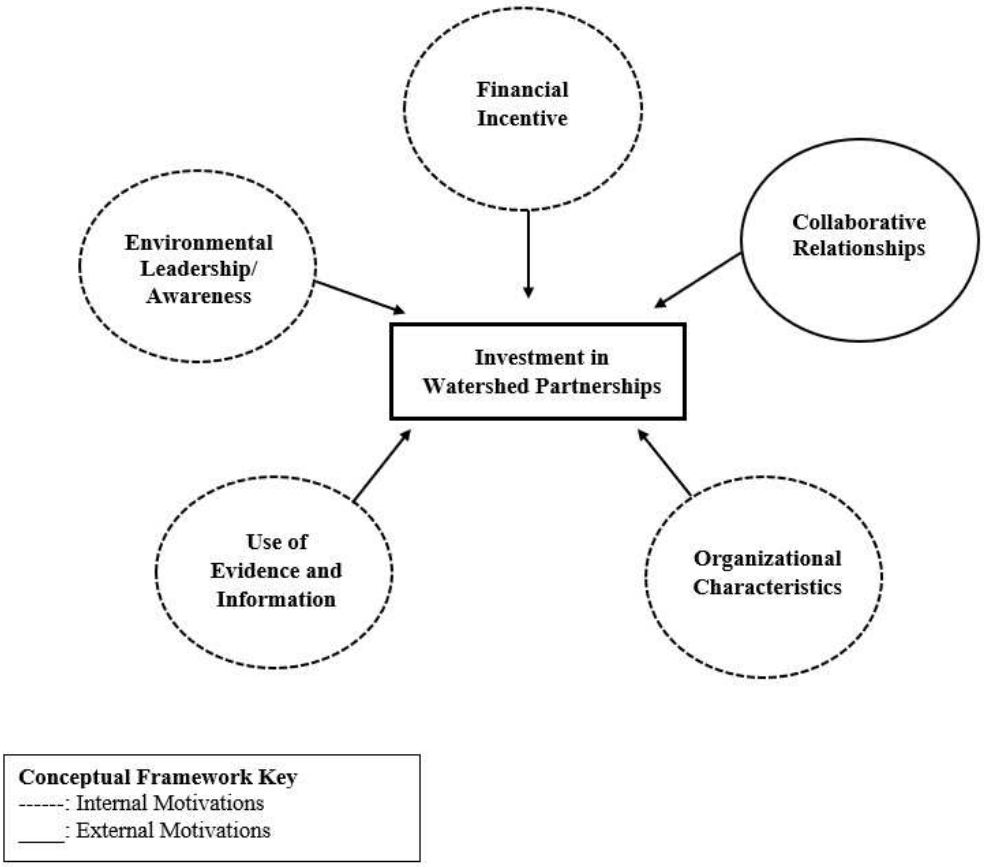

Figure 3.5. Adapted concept map of motivations for organizations' participation in watershed partnerships

The majority of organizations surveyed cite internal motivations (i.e. environmental leadership) for participating in watershed partnerships rather than external (i.e. consumer/interest group pressure), the exception being benefits realized due to collaborative external relationships in the form of trust establishment and partnership support. However, a diversity of motivators exists within those internal motivation categories outlined in the adapted concept map. Understanding the different perspectives organizations have regarding decisions to become involved is important for the future securement of watershed partnership resources and contributes to the broader knowledge of participation in environmental collaboratives.

Although these results cannot be extrapolated to every watershed partnership or environmental collaborative, I provide several practical suggestions for collaborative initiatives to consider based on these study findings. When looking for partner organizations, it would be beneficial to first reach out to environmental leaders or managers that exist within organizations who have shown skill and interest in partnership formation (Bruyere, 2015). Collaboratives could also advertise to larger organizations that have a financial stake in the economic returns of investing in watershed protection, while continuing to build capacity in smaller private organizations and environmental NGO's whom have the potential to play a key role in natural resource governance such as watershed management (Davidson & de Loë, 2016). Lastly, transferring scientific and regional information from scientists and wildfire specialists to non-scientists could help to further make the case for the importance of involvement in environmental management. This could be accomplished by making evidence available in an accessible web-based database (Sutherland et al., 2004) or organized into a hierarchical framework that contained individual studies, systematic reviews, review summaries, and finally decision support systems based on the synthesis of many studies (Dicks, Walsh & Sutherland, 2014). Additionally, an organization like the National Institute for Health and Clinical Excellence could be established for watershed partnerships, where potential partner organizations are provided information on cost-effectiveness of various wildfire mitigation treatments (Segan, Bottrill, Baxter & Possingham, 2011).

Despite organizations involved in these collaboratives having their own standalone projects and different reasons for their interest in wildfire mitigation and source water protection, this study revealed that partnership goals align well with the various objectives individual entities attempt to fulfill with their involvement. As such, it is important to understand the

perspectives and motivations of participating organizations. Even if the primary goals of each organization participating do not perfectly align, an awareness of the co-benefits that can be realized from involvement will allow environmental collaboratives to promote participation as a means of meeting diverse stakeholder objectives simultaneously.

3.6. Conclusion

This study demonstrates that the organizations surveyed whom participate in wildfire mitigation and source water protection via watershed partnerships vary in their motivations for involvement. Q methodology revealed internal motivations play a much stronger role in driving these organizations to participate than do external. The importance of internal motivations is a distinguishing feature of watershed partnerships over the broader environmental management literature. Determining the diverse perspectives of participating organizations is important in collaborative governance to maintain and increase involvement in these programs. Knowledge about motivations can aid in the securement of adequate support and sustainable financing for watershed partnerships, and more generally environmental collaboratives, by allowing them to frame the benefits and outcomes of these collaborative groups to a broader range of perspectives and organizations.

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CHAPTER FOUR: ASSESSING FACTORS IN THE PERCEIVED SUCCESS OF WATERSHED COLLABORATIVES IN THE INTERMOUNTAIN WEST

Summary

Environmental collaboratives are a common form of natural resources governance due to the need in conservation for cross boundary work involving multiple stakeholders. Given limited resources in the conservation field, it is important that environmental collaboratives have a firm understanding of the factors necessary for them to succeed. Watershed partnerships are one type of collaborative that invest in source water protection. A subset of watershed partnerships protect source water by carrying out wildfire mitigation treatments. The goal of this research was to determine factors deemed necessary in the perceived success of partnerships at varying levels of development. I conducted semi-structured interviews with four established and four emerging watershed partnerships in the Intermountain West region of the United States and asked them to share if and how factors of success found in the environmental collaboration literature influence the success of their initiatives. I discovered that many of the factors identified in the literature are relevant for the watershed partnerships in this study, but additional sub-themes emerged that were not addressed by previous research. Additionally, key distinctions were made regarding factors of success between partnerships classified as established versus emerging. Outcomes of this study will be of practical significance to emerging watershed partnerships striving for success and will contribute to the broader environmental collaboration literature by strengthening the knowledge base on factors necessary for these types of initiatives to succeed.

4.1. Introduction

Natural resource management has been shifting focus to the prioritization of large-scale conservation features of interest (Long, Charles, & Stephenson, 2015), such as holistic watershed health. This trend is often attributed to an awareness of the mismatch between traditional governance systems and natural ecosystem dynamics (McLeod & Leslie, 2009). Environmental collaboratives are one example of these regimes that are becoming more common due to the inherent necessity of cross boundary management involving multiple areas of knowledge and stakeholder interests (Yaffee, 2012). Given the often limited financial and human resources available in the conservation field, it is important that stakeholders involved in collaborative governance understand the factors necessary for these initiatives to succeed. Findings in the current literature on environmental collaboratives suggest several key factors help ensure the long-term success of these programs. These factors are typically split between internal operations of the initiative and external influences on the collaborative. Some of the more prominent internal drivers of success include stakeholder engagement (Clark, 1998; Aas, Ladkin, & Fletcher, 2005), the establishment of power norms among parties involved (Brisbois & de Loë, 2015; Kenney et al., 2000), and the securement of adequate funding (Adams et al., 2016; Mottek-Lucas, 2015). External factors shown to play a strong role in collaborative success include an effective outreach strategy for reporting results (Mottek-Lucas, 2015; Plummer, 2007) and public support (Howarth & Butler, 2004; Mburu & Birner, 2007).

Watershed partnerships are one type of environmental collaborative, often defined as an agreement between public and private organizations to act collectively towards common goals of watershed health and source water protection (Blue Forest Conservation, 2017). Due to an increase in the frequency and severity of catastrophic wildfire, a sub-set of watershed

partnerships invest in fire mitigation to reduce the risk of degraded water quality associated with wildfire events (Thomas et al, 2017). Watershed partnerships focused on fire mitigation are popular in the Intermountain West of the United States given the concentration of wildfire and water issues the region is currently facing (Huber-Stearns, Goldstein, Cheng, & Toombs, 2015). These partnerships often involve water utilities and private corporations, such as breweries, investing in upstream wildfire mitigation as a risk avoidance policy. The involvement of multiple sectors in watershed partnership collaboration stems from a growing recognition that diverse stakeholders mutually depend on watershed health, and a high-quality source of water for their daily operations. Benefits of collaboration among various sectors include pooling human and financial resources, as well as differing expertise among private, public, NGO, and academic sectors (Clark, 1998).

The overall goal of this study is to assess relevant factors necessary for eight watershed partnership case studies to succeed. I focus on partnerships within the Intermountain West region since these initiatives are a collaborative governance system still understudied to date (Huber-Stearns et al., 2015). It can be assumed established partnerships that have endured for several years are able to persist due to recognition of factors vital to success. These groups have the potential to share lessons learned on key factors to newer partnerships classified as emerging. Therefore, the three primary objectives of this paper are to: a) determine how both classifications of partnerships evaluate their own success, b) identify factors present that have allowed for perceived success, and c) determine the primary distinctions of success between established and emerging groups. This information is of practical importance to watershed partnerships of all levels to improve their governance processes, and more broadly contributes to the environmental

collaborative literature by assessing the importance of factors necessary for collaborations to succeed.

4.2. Factors of Success for Environmental Collaboratives

There is general consensus within the environmental collaboration literature on the factors that influence the success of collaborative programs. These factors are specifically derived from two seminal papers written in the early 2000s. Kenney et al. (2000) collected survey data from 118 watershed collaboratives throughout the Western United States and compiled the top ten factors of success reported. Schuett, Selin, & Carr (2001) similarly surveyed 671 participants involved with 30 diverse environmental collaboratives and identified six broad categories of factors relevant to their success. These included: 1) identifying specific goals and clearly defined roles from the onset, 2) reporting monitoring results to relevant stakeholders and the public, 3) organizational support, 4) personal communication among those entities internally involved, 5) relationships/team building to ensure trust and being able to work together, and 6) effectively reporting of accomplishments to all involved parties. These factors combined with the main factors of success from similar papers are listed in Table 4.1 below.

Table 4.1. Key factors of success identified in the environmental collaborative literature

Factors	*Citation*
Appropriate leadership	Aas et al., 2005; Kenney et al., 2000; Reyers et al., 2010; Underdal, 2010; Wei-Skillern, 2013
Problem identification	Kark et al., 2015; Kenney et al., 2000; Reed et al., 2014a; Schuett et al., 2001; Silveira et al, 2016
Long-term vision	Kark et al., 2015; Kenney et al., 2000
Stakeholder trust and participation	Aas et al., 2005; Kark et al., 2015; Kenney et al., 2000; Reed et al., 2014a; Reyers, 2010; Schuett et al., 2001; Silveira et al, 2016; Wei-Skillern, 2013
Establishment of power norms	Brisbois and de Loë, 2015; Kenney, 2000; Silveira et al, 2016; Underdal, 2010
Agency/institutional support	Kenney et al., 2000; Miller et al., 2017; Schuett et al., 2001; Silveira et al, 2016
Project follow-through	Kark et al., 2015; Kenney et al., 2000; Reed et al., 2014a
Adaptive management through monitoring and evaluation	Kark et al., 2015; Kenney et al., 2000; Plummer and Armitage, 2007; Reed et al., 2014a
Consistent funding	Aas et al., 2005; Adams et al., 2016; Kenney et al., 2000; Miller et al., 2017; Silveira et al, 2016
Public trust and outreach	Aas et al., 2005; Adams et al., 2016; Howarth and Butler, 2004; Kenney et al., 2000; Miller et al., 2017; Reed et al., 2014a; Reyers, 2010; Schuett et al., 2001

Several more recent case studies support findings from Kenney et al. (2000) and Schuett et al. (2001). Strong leadership often acts as a means of catalyzing collaboratives (Aas et al., 2005; Kenney et al., 2000; Reyers et al., 2010; Underdal, 2010; Wei-Skillern, 2013), helping to identify a problem (Kark et al., 2015; Kenney et al., 2000; Reed et al., 2014a; Schuett et al., 2001; Silveira et al, 2016) and create a long-term vision for the project (Kark et al., 2015; Kenney et al., 2000). Effective leaders are also skilled at involving relevant stakeholders from the initial planning phase (Kenney et al., 2000), which establishes crucial trust and buy-in from these individuals and organizations (Aas et al., 2005; Kark et al., 2015; Kenney et al., 2000;

Reed et al., 2014a; Reyers, 2010; Schuett et al., 2001; Silveira et al, 2016; Wei-Skillern, 2013) oftentimes missing in traditional governing systems (Powell, 2009). Having multi-jurisdictional participation from entities that can work cross boundary is important for success (Kenney et al., 2000), as is the collaborative establishment of power norms among decision-makers to avoid potential confusion and conflict (Brisbois & de Loë, 2015; Kenney, 2000; Silveira et al, 2016; Underdal, 2010).

Several case studies discussed the importance of agency or institutional backing (Kenney et al., 2000; Miller, Nielsen, & Huang, 2017; Schuett et al., 2001; Silveira et al, 2016) to aid in the securement of funding, which is one of the greatest logistical concern facing collaboratives (Aas et al., 2005; Adams et al., 2016; Kenney et al., 2000; Miller et al., 2017; Silveira et al., 2016). Once the collaborative planning phase is complete, following through with the work and accomplishing project objectives was also identified as important to success (Kark et al., 2015; Kenney et al., 2000; Reed et al., 2014a). Monitoring and evaluation procedures should be put in place to ensure that the initiative is achieving its short- and long-term goals, and that projects can adapt if needed (Kark et al., 2015; Kenney et al., 2000; Plummer and Armitage, 2007; Reed et al., 2014a). Establishing a public outreach component to report on program outcomes can help to further increase support for the initiative (Aas et al., 2005; Adams et al., 2016; Howarth & Butler, 2004; Kenney et al., 2000; Miller et al., 2017; Reed et al., 2014a; Reyers, 2010; Schuett et al., 2001).

4.3. Methodology

4.3.1 Data Collection

I collected data for this study through qualitative semi-structured interviews on-site in 2016 with key informants of eight watershed partnerships in the Intermountain Western U.S. Semi-structured interviews allowed the partnerships the freedom of addressing questions in an open and flexible format. I chose four established and four emerging watershed partnerships for analysis with guidance from Carpe Diem West and Forest Trend's Ecosystem Marketplace. The criteria for being defined an established partnership was:1) being in existence for over four years, 2) the securement of over $9 million since formation, 3) being in an active phase of development, and 4) the existence of a Memorandum of Understanding or some other formal commitment for funding. The criteria for emerging groups was: 1) existing for only four years or less, 2) under $9 million in total funding, 3) being in the planning or demonstration phase and 4) lacking any sort of formal funding commitment.

I decided on the final list of partnerships using a purposive sampling strategy (Schuett et al., 2001); Bernard, 2002). While each of the partnerships had a management focus on watershed protection via wildfire mitigation treatments, I attempted to ensure that a wide variety of geographies, stakeholders involved, primary objectives, and status of programs were represented. Four interviewees directly provided an interview each, while one interviewee provided information for three of the case studies and the remaining three other interviewees gave different perspectives on the same partnership. This resulted in eight total interviews from eight respondents. More information on the interviewees and partnerships can be found in Table 4.2 below. Due to the small sample size of this study, some bias may be present in the data and thus

the results should not be extrapolated to a larger population, but rather offered as suggestions for novel partnership initiatives to consider.

Table 4.2. Descriptive information of watershed partnerships and interviewees

Watershed Partnerships			**Interviewees**		
Status	Established	4	***Organization Represented***	U.S. Forest Service	2
	Emerging	4		National NGO	2
Location	Colorado	5		Local fire department	2
	Arizona	2		Municipal water utility	1
	Oregon	1		Water fund	1

Interview questions were related to the factors of success identified in the previous section (Table 4.1); specifically, (1) how the partnerships define and measure success (problem identification, long-term vision, and monitoring techniques), (2) the internal characteristics of the partnerships related to perceived success (importance of leadership, participating stakeholders, establishment of power norms, agency support, and funding status), and (3) their external outreach strategies (reporting on project follow-through and securing public trust) (see interview guide in Appendix 5). All interviews were recorded through RecUp, a smartphone recording application

An initial review of the results revealed the importance of information use and dissemination in partnership success. I conducted follow-up phone interviews with all participants in late 2017 to ask three additional questions. These questions focused on: 1) the sources of information the partnerships use to inform wildfire treatment implementation, 2) how

information derived from monitoring efforts is reported back to external stakeholders, and 3) the type of information shared among internal partners, and how that sharing influences the collaborative aspects of the partnerships.

4.3.2 Data Analysis

I analyzed interview data using a six-step process for creating a thematic analysis outlined by Mann (2016). Upon completion of data collection, I transcribed and coded the interviews using NVivo 12 qualitative coding software. The interview guide allowed pre-determined themes and initial codes to exist a priori (Table 4.1), but new themes and sub-themes also emerged during data analysis (Miles & Huberman, 1994). I created a codebook with standardized annotations for each code, which I used as an indexing system in NVivo (Newing, 2011).

A fellow researcher and I carried out the coding process. We coded the same interviews independently using identical codebooks and then met post-coding of each interview to compare and discuss results. Although quantitative metrics were not applied to assess inter-rater reliability, we adjusted the codebook during every meeting as necessary, ensuring intercoder agreement throughout the entire coding process (Campbell, Quincy, Osserman, & Pedersen, 2013). We then reviewed themes and grouped similar concepts together, creating sub-themes under each main theme. I created the thematic analysis (Mann, 2016) by building a narrative based on these themes related to key factors of watershed partnership success. Responses were compared among the emerging and established partnerships to determine any major differences between the two groups. The quantitative results from the Likert scale questions were averaged and reported along with the qualitative data in the results section that follows.

4.4. Results

The representatives of established watershed partnerships gave an average rating of their collaborative's success as a 4.8 (extremely successful) on a five-point scale. They described funding as somewhat of a limiting factor; the partnerships could do much more work with increased funds. However, given the scope of their objectives and timelines for anticipated milestones, the established partnerships overwhelmingly felt success in accomplishing their project objectives. In contrast, the four interviewees representing the emergent partnerships provided a slightly lower average success rating of 4.12. The primary reason provided for a lower perception of success for these groups was due to the fact that although they felt they had made an impact in their demonstration/proof of concept phase, the long-term impacts that the partnerships may create were still unknown. When referring to the overall goals of the emerging groups, success was described as being only partially accomplished or not yet achieved at all.

The interview transcripts for the established groups generated five themes associated with factors relevant to success, broken down into 17 sub-themes (Table 4.3). The emerging group interviews identified the same five major themes on keys to success as the established partnerships, which were also divided into 17 sub-themes. Together both groups shared 14 of the same sub-themes. Each of these themes and sub-themes are further detailed below; distinctions are highlighted between the established and emerging partnerships and between literature-supported and emergent sub-themes in Table 4.3

Table 4.3. Themes, subthemes, and example quotes associated with perceptions of watershed partnership success

Themes	***Subthemes***	***Example Quotes***
1) Importance of Leadership	**a) Necessary skillset**	1a) "They get work done. They're good communicators, so everybody knows what is going on. They provide direction."
	b) Committed partnership catalyst	1b) "They are the ones that spearheaded the whole proposition, the groundwork to get the word out. They held a lot of public meetings… I know they were able to raise like $8,000 in 2010 to do all of this work and they did a really good job with a small amount of funds."
2) Funding Security	**a) Commitment to funding**	2a) "We have the funding in hand at this point to complete the initial treatments, the full extent of the initial treatments. What we will need is funding to sustain the long-term maintenance. And any expansion of the footprint."
	b) Ability to leverage funds	2b) "We used the funding that we had already to kind of leverage, say, hey we've got this investment… so the large grant triggered all of these other investments."
	c) Self-sufficient funding	2c) "We think that an MOU is needed to get at the scale issue, and to get at the reoccurring funding issue. That it's not just each year we're begging for money, but we decided together that between these businesses and these utilities and these breweries, we're going to fund the partnership with X dollars for X number of years. That's success for us."
3) Internal Collaboration	**a) Leveraging social capital**	3a) "They've done a lot of good things locally, so they get a lot of support from an element that wouldn't even support the fire department I'm sure. So they have been able to speak to those people. They say, oh they're involved? I like the project. It's great."
	b) Unique perspectives and expertise	3b) "You've got the city government represented by the fire department which has an obvious interest in wildfire…the conservation NGOs, they bring an immense amount of credibility to the project because they're seeing it as wanting to be good stewards of the land. TNC has kind of a global appeal… and they bring that science perspective which is really important…It was a thoughtful mix of different strengths and views and scopes of awareness that have all grown and adapted and integrated with the others. It's a well-oiled machine."
	c) Additional/pooled funding	3c) "Without funding from our partners, the partnership wouldn't be a reality. If the USFS hadn't stepped up and really expedited the EIS process and diverted some amount of funding into the project, we would not be successful at all."
	d) Holistic involvement	3d) "I'm just as involved in reviewing silviculture prescriptions, because forestry is my background, as all the other partners are involved in doing community

		engagement. We have meetings on all those topics and we have equal opportunity to give input."
	e) Access to information	3e) "We've already got these relationships established, so they know they can pick up the phone and call me or call whoever and get answers right away and we can start the ball rolling on stuff before wildfires are happening. And so that sounds small but it's actually huge because, before this, I mean they wouldn't even know where to start. It might take weeks for them to be able to find the right person to call."
	f) Access to larger landscape	3f) "Being able to bring on the NRCS to help the project expand across boundaries. Now being able to work on private lands, across boundary, or even spending state dollars on federal parts of the project to help complete that."
4) External Outreach	**a) Establishing trust/social capital**	4a) "Success is also the social piece and bringing your community stakeholders and citizens on board. Were you able to do [the treatments] in a way that people were appreciative of the work? That they understood the reasons for doing it?"
	b) Adaptive management	4b) "One of the goals of this project is to protect the legacy trees. So what we did was, any tree over 24 inches, so basically 25 inches and bigger, if it was marked to cut we GPS'd that tree and basically offered to take anybody out to them to look at them. There was actually one that we did that we ended up unmarking after a discussion with somebody from the community."
5) Role of Information	**a) Impacts of information sharing**	5a) "There were some issues with best management practices and it was a great learning opportunity for the partnership, for the implementers especially, to come together and learn from those mistakes and how we can prevent them moving forward. So something that, at first was kind of unsettling turned out to be a really good opportunity for collaboration and learning from one another."
	b) Monitoring	5b) "We have some steam gauge, water gauge, weather station type of equipment across project areas that measures annual precipitation, stream flow, like when the snow's melting into the reservoir."
	c) Planning efforts	5c) "We know where our collection systems are for our water supply in our source water. Within those watersheds there was an analysis done on where the biggest bang for our buck in terms of forest and watershed health improvements."
	d) Regional wildfire information	5d) "There's a pretty good fire history in and around our city. A lot of fires. But it wasn't until 2009 that we actually had a fire here… and that burned 200 acres right next to town."
	e) Expert opinion	5e) "We have an implementation review team that consists of three folks that don't work on this project at all. One is an environmental person, one who's part

		of another forest collaborative, and then a State Extension person. So we have this three person team that come out and look at things.
	f) Practical considerations	5f) “After we look at what we suspect could be the treatable acres by sort of running it through a slope and distance to road kind of thing, where we can get equipment to do treatments, there's still going to be sort of like, rock outcroppings or things that limit where we can treat.”
	g) Community input	5g) “Under the Healthy Forest restoration Act the community was allowed to put forth an alternative, and so they kind of provided their idea of what we should do.”
	h) Science validation	5h) “Part of success then is having data to check your work and to keep us as managers honest. There's a lot of times where we get numbers back from monitoring and go, whoa, that's interesting because I thought it looked good. But the data says something else.”

Bold Font: Both partnership types
Regular Font: Established partnerships only
Italicized Font: Emerging partnerships only
Non-shaded cells: Literature-supported themes/sub-themes
Shaded cells: Emergent sub-themes

Importance of Leadership

A major theme from the literature supported by both established and emerging partnerships was the importance of leadership. The respondents all described leaders involved as having essential characteristics needed to act as a catalyst for their partnerships to emerge and endure.

Necessary skillset

Respondents described the specific skillsets of leaders as important to the formation of the partnerships (Table 4.3, quote 1a). Some leaders were business savvy and/or had a politically connected background, which helped them understand important aspects of management such as policies in place, permissions needed for different project aspects, how to fund specific program components, and potential barriers to program implementation. Initial leaders were also effective communicators that were sufficient in providing direction. It was important for them to be skilled at fundraising and "finding really innovative ways to get money" and having the ability to stretch a small amount of funds if needed.

Committed partnership catalyst

One of the most important aspects of an initial leader in terms of overall program success was their ability to act as a catalyst to ensure the partnerships' initiation. These "partnership champions" were committed to the programs' success by doing initial outreach to determine public support, stakeholder engagement to find potential partners, and acting as an overall facilitator by bringing together all the necessary partnership components (Table 4.3, quote 1b). As one respondent stated, "If we were going to be successful, we needed somebody who was really shepherding this thing, who was committed to it."

Funding Security

A determinant of success mentioned by every respondent was the presence or absence of funding security for the partnership. Several respondents measured success by hitting their funding targets— how funds were allocated compared to how much of the project area had seen acres treated. Participants reported that the securement of funding can be greatly enhanced by establishing a commitment to funding among partners, as well as having the ability to leverage the funds that were secured. The emerging groups generated an additional sub-theme regarding their perception of success, which was acquiring self-sufficient funding.

Commitment to funding

Each of the established watershed partnerships in this study had an agreement in place that committed stakeholders to funding initial treatments on priority acres within their contract timeframes. Two of the groups partnered with water utilities received funds from their constituents, which came in the form of a mandatory fee rolled into their water bill. The other two established groups had their constituents agree to pay an obligatory tax which funded their partnership efforts. In contrast, almost all the funding mechanisms in place for the emerging groups were voluntary, and primarily came in the form of private businesses donating financial contributions to the partnerships. Every respondent from both the established and emerging groups stated the need for additional commitments to sustain the long-term maintenance of wildfire treatments (Table 4.3, quote 2a).

Ability to leverage funds

Another factor of partnership success that aided in funding security was the ability to leverage funds, which every group reported having success at accomplishing to varying degrees. This leveraging came in many forms. For one group, city funds were matched by private and NGO partners to reach their intended budget. In two other instances, funds from a large grant

were used to trigger the acquisition of additional sources of funding (Table 4.3, quote 2b) by creating a "steamroller effect". Potential partners who were undecided saw the initial investment and chose to participate. A respondent from an emerging group described observing a "success breeds success" phenomenon by initially convincing a larger city to invest, which then created a domino effect with surrounding smaller cities following suit.

Self-sufficient funding

Emerging partnerships interviewees revealed one additional sub-theme related to funding, which was the belief that self-sufficient funding was an indicator of success. The presence of a constant funding stream as opposed to one-time voluntary contributions would allow newly emerged partnerships to plan for their projects well into the future, without spending substantial effort searching for additional funds. This sustainable funding source could come in the form of a Memorandum of Understanding signed with partners such as those each established group had in place (Table 4.3, quote 2c).

Internal Collaboration

Another major theme from the literature supported by the interviews was the impact of internal collaboration on the success of watershed partnerships. One of the primary objectives reported by the partnerships was to "demonstrate collaboration and success to create a model that could help increase the quality, pace and scale of forest restoration around the West." One respondent felt that by creating an efficient and trusted collaboration, it became much easier to establish clearly articulated goals of the initiative and garner support from the community. The respondents from both types of partnerships provided several examples of how collaboration can impact partnership success, such as: leveraging existing social capital of partners involved, a synthesis of unique perspectives and expertise in decision-making, opportunities for additional

sources of pooled funding, and holistic involvement in the project among each partnering organization. Respondents from emerging partnerships also reported impacts of collaboration in the form of access to new sources of information and to a larger landscape.

Leveraging social capital

Leveraging social capital (i.e. the value of social networks) of involved partners was identified as a sub-theme resulting from internal partner collaboration. Having well-established and supported partnerships on-board that had name recognition (e.g. local conservation NGOs) was important. Due to the social capital they had already established, these partners were able to speak to individuals that may have otherwise opposed partnership activities and assured them of the benefits of active management (Table 4.3, quote 3a). Having the credibility of a local fire department present was beneficial due to their oftentimes high favorability rating with communities. Additionally, having business partners present with strong customer relationships meant that they often spoke well of the partnership to their constituents.

Unique perspectives and expertise

The most commonly cited benefit of a collaborative process that emerged as a sub-theme was the ability to bring together the unique perspectives and expertise of each partner involved. The organizations whom participated in the partnerships each lent their various strengths to the initiatives (e.g. institutional support, the use of a volunteer workforce, various interest group perspectives, access to scientific/ecological knowledge) (Table 4.3, quote 3b). An emerging partnership provided an example of the benefits they've seen from strategically adding partners by creating an agreement between a large water utility and an NGO. They used the business relationships from the utility to get private interests to invest, while the NGO had congressional authority to hold USFS contracts. The combination of diverse strengths and viewpoints of all

parties involved lent itself to an increase in partnership capacity, and often influenced the final decisions of the groups.

Additional/pooled funding

Another emergent sub-theme regarding a benefit of collaboration was the ability to pool funds from involved partners. Some groups sought to partner with NGO's, who were often able to receive grants to implement monitoring plans. Other partnerships came to agreements on which organizations funded certain aspects of the projects. For example, in one group an entity decided to pay for monitoring equipment while their partners paid staff to incorporate the equipment into their monitoring efforts. Beyond increasing efficiency, other participants reported that their partnerships could not even exist without some sort of pooled funding (Table 4.3, quote 3c). Even large organizations with an extensive amount of financial and human resources expressed the necessity for multiple funding sources derived from partner collaboration.

Holistic involvement

A sub-theme that emerged from all the established groups was the holistic involvement of every internal partner in each step of the partnership's initiatives (Table 4.3, quote 3d). Building capacity among the individual entities ensured that partnership goals were met with greater efficiency. One partnership spearheaded by the USFS tasked all their partners with collaboratively laying out the project boundaries and designing their treatment prescriptions. Although time consuming, this process allowed the partnership to move forward with complete understanding and consensus.

Access to information

Emerging partnerships reported an additional impact of collaboration in the form of access to new sources of information. The establishment of trust meant that when a wildfire event occurred, partners were aware of exactly who they needed to contact to receive

information (Table 4.3, quote 3e). Two emerging partnerships reported the ability to incorporate long-term watershed data gathered by a participating partner into their general databases, which was then used by fire managers to make more informed decisions. Participants also described benefits associated with generating new data through collaborative work. One science institute worked with a partnership to create cost optimization models that aided in treatment implementation decision-making, the methods of which have the potential to be transferred to other watersheds and have broader region-wide impacts.

Access to larger landscape

A second collaboration sub-theme revealed through the emerging partnership interviews was access to a larger landscape. For example, one partnership began working with the Natural Resource Conservation Service, which provided additional funds that expanded the project footprint to work cross boundary and cover private lands as well as federal (Table 4.3, quote 3e). One USFS employee explained that as more partners became involved the project footprint and resulting impact essentially doubled. Collaborating with other coalitions doing similar work also helped the partnerships think strategically about how the work carried out by each initiative could add up to have a larger influence on the landscape.

External Outreach

A consistent theme that was shared broadly among respondents was the importance of external outreach to the success of their partnerships. Outreach typically occurred in the form of public tours to treatment sites, via the creation of science briefs containing monitoring results, or partnership representatives speaking at local events. One partnership decided to implement a GIS online application, which helped to inform the public when and where they were burning piles of fuel in real time. Respondents primarily cited two reasons for reaching out to the public: building

trust/social capital, and for the established groups, receiving public feedback to adapt for future management activities.

Establishing trust/social capital

The establishment of public trust and the subsequent building of social capital were the most commonly cited benefits derived from external outreach. Several respondents stated that a measurement of success to them was not just the number of acres treated, but that they were treated in a way that brought the community on board (Table 4.3, quote 4a). Given that thinning and prescribed burning operations often lack in aesthetics, a robust outreach strategy was especially required to ensure continued support. One group discussed the concept of social capital in a "figurative bank account". This capital was built up via public outreach, which could then be 'spent' whenever it became necessary to take actions that were potentially unpopular, such as the closing of recreation trails so treatments could occur.

As a result of their outreach strategies the established partnerships gave an average public support rating of 4.5. The emergent groups held a lower average public support rating of 3.5, primarily due to the fact that widespread awareness of their partnerships did not yet exist. One respondent from an emerging partnership referenced how their group lacked any sort of public outreach component at the time of the interview, and another was unsure of their group's future role in public outreach.

Adaptive management

In addition to building social capital, established watershed partnerships communicated with the public to help themselves plan for the future. They were interested in connecting the public to their watersheds and showing them that they had an active role to play in watershed and forest protection. Partnerships were interested in getting landowners engaged by learning what the priorities and concerns were for people living in the watershed. After sharing monitoring

results with community members, two groups referenced adapting their management practices as a results of landowner feedback (Table 4.3, quote 4b).

The Role of Information

The importance of acquiring and sharing information throughout a partnership's life cycles was the most commonly cited theme among respondents. Every interviewee referenced using science to varying degrees as a specific type of information in their monitoring and planning efforts. When asked the certainty of scientific evidence regarding impacts of wildfire treatments on source water risk reduction, the average response for established partnerships was 4.58, and 4.5 for emerging groups on a five-point Likert scale. One respondent stated their organization would never consider investing funds into wildfire treatments unless the science was certain that treatments would lead to a measurable return on investment in the form of avoided costs. In addition to general scientific evidence, respondents also reference other sources of information that they use in their treatment implementation processes, such as regional wildfire information, expert opinion, practical aspects to consider, and community input.

Impacts of information sharing

A sub-theme related to the partnership's collaborative processes was the impact of internal information dissemination among partners involved. The primary impact reported was an increase in project transparency due to working relationships formed. The increase in collaboration from information sharing meant that disagreements or misunderstandings were greatly reduced (Table 4.3, quote 5a). As one respondent stated, "there's nobody in our partnership that's going out and doing something that the rest of the partners aren't aware of." Increased trust due to internal conversations also led to a maintenance of public support, additional funding avenues, and opportunities to expand project footprints. One respondent from

an established group explained that those additional benefits were "all a derivative of a single narrative that is science-based and that is backed with all of our supporters."

Monitoring

Each partnership group generated some type of scientific evidence in their pre- and post-implementation monitoring efforts (Table 4.3, quote 5b). Partnerships specifically incorporated data into acres change fuel models to determine changes in proportion of forest states and the resulting changes in predicted fire behavior to generate an overall landscape measure of resilience. Another type of monitoring came in the form of return on investment and cost avoidance modeling, which aimed to go beyond acres treated and show cost savings. The results generated from monitoring were shared with partners in order to build trust through transparency. For funding partners, the cost avoidance studies showed that their investments prevented sediment loading and resulted in future cost savings in the form of minimized risk.

Planning efforts

Another emergent sub-theme was the use of science from monitoring efforts to influence treatment management plans. Many partnerships reported using monitoring data to create "zones of concern" that allowed them to prioritize specific forest units to focus their efforts. Respondents stated "gaining a lot of efficiencies and cost savings" by using science to inform this method, the importance of which was referenced several times (Table 4.3, quote 5c). In addition to science, the partnerships reported the ability to capitalize on a diversity of information sources (outlined below) which allowed them to become more strategic and integrated in their management efforts over time.

Regional wildfire information

Understanding the history and patterns of regional wildfires influenced the formation of partnerships and later their treatment decision-making. All partnerships referenced wildfire

events in their region as a major catalyst to the formation of their initiatives (Table 4.3, quote 5d). Historic wildfires made stakeholders aware of the ecological and social impacts associated with the disasters, including post-fire flooding and damage that occurred and the subsequent costs associated with remediation. This was a similar trend that each partnership reported experiencing, regardless of their geographic location. Therefore, knowledge on the impacts of wildfires due to previous events, especially their effects on a region's municipal water supply, was a primary factor for partnership formation.

Expert opinion

Every partnership referenced seeking expert opinion to inform aspects of their groups' activities. For example, the USFS brought together prescribed fire specialists, fire managers, and silviculturists during the creation of their watershed assessments to collaboratively identify priority areas where high severity wildfire and post-fire flooding impacts would be the greatest. Environmental consultants were contracted to create the zones of concern modeling previously mentioned. Another partnership utilized a science institute to completely run their monitoring activities, stating, "we leave it to the experts to deal with the ecology behind it all." TNC followed a similar approach by initiating an independent implementation review team, which included an employee of an environmental group, an extension forester, and a representative from a different collaborative, all of whom periodically assess the partnership's activities and provide recommendations for future programming (Table 4.3, quote 5e).

Practical considerations

Regardless of recommendations drawn from scientific evidence or expertise, practical considerations emerged as a common sub-theme across partnerships as an important type of information used in decision-making. Access to a forest unit was a common consideration referenced in the decision to treat an area, despite some units identified as zones of concern.

Crews oftentimes determined that steepness, ruggedness, and proximity to roads and watersheds, in addition to short-term weather conditions, made some areas inoperable (Table 4.3, quote 5f). Another respondent described work being carried out in the larger landscape as a practical type of information they considered when deciding on priority projects to implement. Additionally, temporal considerations regarding grant funded project timelines, contractor availability, and having projects immediately ready to implement further influenced treatment decision-making.

Community input

The last source of information that uniquely emerged from the established partnership respondents was input from community members living near fire-prone watersheds. One partnership group described how their local residents created a community alternative to a NEPA document permitted under the Healthy Forest Restoration Act (Table 4.3, quote 5g). The USFS worked with lead community members to incorporate elements of the alternative into an updated document that was approved. As previously mentioned, discussions with community residents pre-treatment implementation led to altered plans for thinning individual trees or burning certain areas.

Science validation

An additional sub-theme that emerged from the established groups was the importance of having their treatment work validated by science. Respondents stated that having science and technical information was essential to support treatments implemented and to determine the progress of the partnerships. Scientific or technical data from monitoring helped to reinforce the need for treatments, but it also revealed areas for management adaptation and improvement (Table 4.3, quote 5h). Partnerships on average felt successful when their monitoring efforts revealed that the wildfire treatments were generating impacts aligned with their desired ecological or societal outcomes.

4.5. Discussion

The three primary objectives of this study were to: a) determine how these eight partnership case studies evaluate success, b) identify factors present within the partnerships that have allowed for their perceived success, and c) determine the primary distinctions of success between established and emerging partnerships. Established partnerships on average self-evaluated having a higher level of success (4.8) than emerging groups (4.12) on a five-point Likert scale. The first sub-section of this discussion will outline the factors revealed to have an influence on perceptions of success, as well as any key difference in these factors between established and emerging groups. The role of information throughout a partnership lifecycle will be discussed separately in the second subsection.

4.5.1. Factors of Success in Watershed Partnerships

This research assessed factors highlighted in the literature as necessary for environmental collaboratives to succeed, applied to case studies of watershed partnerships in the Intermountain West. The five broad themes determine to influence partnership success (importance of leadership, funding security, internal collaboration, external outreach, and the role of information) were all identified by the literature as relevant to collaboratives. Within the leadership theme, both sub-themes (necessary skillset and committed partnership catalyst) were also supported by the literature. Leaders are important to conceptualize a focal problem and aid in the creation of a plan to address an issue (Underdal, 2010). Leaders are skilled in reaching out to relevant stakeholders, often taking on a facilitator role (Kenney et al., 2000; Reyers et al., 2010). Wei-Skillern (2013) states that the most effective leaders in environmental collaboratives rely on the establishment of trust among involved parties to pioneer an initiative, as opposed to an authoritarian form of centralized control.

The leaders of the partnerships in this study were also able to acquire initial funding for the projects to begin. Having secure funding was identified as a common theme of success, often accomplished by the ability to leverage existing funds. Miller et al. (2017) discuss the ability to offset transaction costs related to a collaborative's operations with funds leveraged from an initial pool of funding. Other studies highlight the importance of secure funding (Kenney et al., 2000; Silveira et al., 2016), and the struggles other collaboratives experience when funding is short-term or inadequate to match project needs (Aas et al., 2015; Adams et al., 2016). The emerging partnerships in this case study were aware of this need, as the establishment of self-sufficient funding was a prevalent sub-theme that uniquely rose in those groups.

The role of internal collaboration was key to partnership success, and the ability to leverage the social capital of existing partners was a sub-theme also back up by the literature. The presence of unique perspectives and additional funding sources were revealed as benefits of collaboration among both the established and emerging groups. Additionally, information sharing through holistic partner involvement was uniquely referenced as a sub-theme by established groups to increase stakeholder buy-in and create a more trusting collaborative, a finding referenced in several past studies (Aas et al., 2005; Kark et al., 2015; Kenney et al., 2000; Reed et al., 2014a; Reyers, 2010; Schuett et al., 2001; Silveira et al, 2016; Wei-Skillern, 2013). The benefit of access to new sources of information and a larger working landscape were sub-themes that were revealed by emerging groups only.

After a project is carried out, each partnership utilized some sort of monitoring to assess project impacts, consistent with the environmental collaborative literature (Kark et al., 2015; Kenney et al., 2000; Plummer & Armitage, 2007; Reed et al., 2014a). The resulting information gathered was disseminated externally, aiding in the securement of public support via the

establishment of trust. Participants believed that this building of social capital as a result of public support led to the long-term continuance of partnership success. Several studies (Aas et al., 2005; Adams et al., 2016; Howarth & Butler, 2004; Kenney et al., 2000; Miller et al., 2017; Reed et al., 2014a; Reyers, 2010; Schuett et al., 2001) support these findings by stressing the importance of public support via a robust outreach strategy to secure success. Information derived from monitoring and/or community feedback on the project led to adaptation of future management, a sub-theme only referenced by established groups to further increasing public support for the partnerships.

The creation of power norms among stakeholders was not a prevalent factor that emerged in this study compared to previous work (Brisbois & de Loë, 2015; Kenney, 2000; Silveira et al, 2016; Underdal, 2010), nor was the need for agency or institutional support (see Miller et al., 2017 or Schuett et al., 2001). These deviations from the broader environmental collaborative literature could be due to an awareness of pre-existing power norms for new groups joining established watershed partnerships, such as is the case with a partnership initiative in Arizona. One of the primary partners in the partnership is the USFS, who is the primary entity with jurisdiction to plan and implement wildfire treatments on federal land (Miller et al., 2017). As such, power norms and agency support may already be embedded in the structure of the established watershed partnerships in this study, and have potentially not yet been addressed by the emerging groups.

4.5.2. The Role of Information in Partnership Success

A common subject that arose in this study was the importance of information in success, both as a standalone theme and throughout almost every theme and sub-theme identified. The partnerships used a combination of regional wildfire information and scientific evidence to

justify the initiatives and coordinate treatment implementation. Both established and emerging partnership groups felt that scientific evidence was extremely strong regarding the impacts of wildfire treatments. The need for projects to be validated by science was a sub-theme unique to established groups. The gathering and incorporation of science into the partnerships' decision-making processes echoes the greater shift in conservation toward an evidence-based management approach (Sutherland et al., 2004).

After referring to science, several additional sources of knowledge emerged from the interviews as aiding in treatment implementation decision-making, the most common being expert opinion and important practical factors to consider. The established groups also uniquely referenced community input as an information source. They reported higher levels of perceived public support than emerging groups as well, potentially due to the incorporation of community feedback into their adaptation of management plans, or the establishment of robust outreach strategies for reporting on monitoring results.

After program implementation, dissemination information in the form of sharing monitoring results from the project aided in increasing trust and social capital through public support. In contrast, a respondent from an emerging group explained their low score for public support due to their partnership's complete lack of any outreach efforts, while another mentioned that they were unsure if outreach would be a long-term goal of their partnership. Soomai (2017) discusses the benefits of project decision-makers taking an active role in information dissemination, such as increased levels of public support for a project, highlighting the importance of effective outreach. Frondel, Lehmann, and Wätzold (2012) complement this finding by stating how sharing project outcomes can lead to a more informed public with an awareness of the project.

The summation of these information pathways aids in collaborative decision-making and success. Reed et al. (2014b) posits that information exchange is an iterative process, one that must constantly be adapted and refined, but has the potential to assist researchers and decision-makers alike to work together in environmental management. As such, the exchange of information within watershed partnerships should be viewed as a continually evolving process comprised of components that are interconnected by information use and dissemination channels, with the overall goal of leading to long-term success of the collaborative.

4.6. Conclusion

This research assessed how factors important for the success of environmental collaboratives applied to eight watershed partnership case studies. Several factors identified by previous studies were found to be essential, including strong leadership, funding security, internal collaboration, external outreach, and the role of information. Various co-benefits of internal collaboration and the use of multiple sources of information in the planning and adaptive management for wildfire treatments were additional sub-themes that emerged. Two important aspects unique to established partnerships were the presence of robust outreach strategies and the use of community feedback to inform decision-making. Established partnerships also reported higher levels of public support and agreements for secure sources of funding- two factors the literature states as relevant in collaborative success. These results identified by partnerships that have endured for several years will be of practical importance to emerging watershed partnerships striving for success. Furthermore, highlighting which factors from previous studies are present or absent in these watershed partnership examples contributes to the broader literature on specific components necessary for long-term environmental collaborative success.

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CHAPTER FIVE: CONCLUSION

Sir Francis Bacon, an early proponent of scientific inquiry, is famous for coining the phrase 'knowledge is power' (Short, 2013). He argued that empirical knowledge is of vital importance for understanding and making decisions about our world. This dissertation assessed the role of scientific evidence in the decision-making processes of collective action initiatives, which have emerged to address some of our most pressing and complex problems facing society in the field of natural resources. To assess this role, I asked the three following research sub-questions, using watershed partnerships as a case study:

1. How do stakeholder perceptions of scientific evidence compare to existing evidence on the linkages between wildfire mitigation treatments and social and economic outcomes?

2. What role does scientific evidence play in motivating organizations to participate in eight watershed partnerships throughout the Western US?

3. What influence does scientific evidence have on wildfire mitigation implementation and ultimate success of eight watershed partnerships throughout the Western US?

In the following sections I triangulate results generated from answering these questions to determine a) stakeholder perceptions compared to the evidence base of a specific type of scientific evidence, b) the role of evidence in organizations' decisions to participate in the eight watershed partnership case studies, c) how scientific evidence is used in the partnerships'

wildfire mitigation implementation relative to other types of information, and d) how this use influences the perceived success of these partnerships. Based on these findings I create a new conceptual framework in section 5.4 on the broader use of information in collective action. I also provide considerations in section 5.5 for future direction regarding the role of scientific evidence in collective action decision-making.

5.1. Perceptions versus Evidence

I conducted a systematic mapping exercise to catalogue the evidence that exists on 72 linkages between wildfire mitigation treatments and societal outcomes. I then surveyed 38 representatives of organizations participating in watershed partnerships to determine their perceptions on the importance and strength of the same treatment-outcome linkages. I conducted importance-strength analysis and gap analysis to understand where these participants feel: 1) less effort is needed, 2) good work should continue, 3) low research priorities, and 4) future prioritizations for wildfire scientists to study. I compared these results with those of the evidence map to identify stakeholder understanding of the evidence base.

Results show the treatment-outcome linkages most commonly identified in the evidence map were rated as highly important from the perspective of the survey participants. This signifies that these participants were generally aware of the importance of the linkages that constitute the bulk of the evidence base and, due to very few perceptions of linkages being overanalyzed, supported the need for multiple studies on these relationships. However, the average survey participant also perceived 12 linkages to be understudied, and the sub-group of forest and fire specialists felt that more research was needed for 19 linkages. These results lend themselves to future research in wildfire management by revealing the treatment-outcome linkages

organizations investing in and managing these interventions believed to be important and worth studying in greater detail. Attention should especially be given to the perceptions of forest and fire specialists, who are experts in their field. As such, the linkages they identified as being understudied should be prioritized in future work.

5.2. Role of Scientific Evidence in Participation

I implemented Q-method surveys with 38 representatives of organizations participating in watershed partnerships by asking them to rank 36 statements regarding their organizations' motivations for involvement. I analyzed the responses by conducting factor analysis, which revealed six distinct perspectives organizations held that determine their reasons for participation. One of these perspectives was labeled 'Wildfire Information'. The organizations that aligned with this perspective generally participated because they believed that wildfire is a risk that must be addressed, and they had access to wildfire information for their specific watersheds and more general scientific evidence on wildfire risk and management.

Results from the factor analysis demonstrate that scientific evidence regarding wildfire information was not a primary driver for involvement from every type of participating organization, but rather those who were already in the forestry and wildfire field (i.e. scientific institutions, local fire departments, federal forestry agencies) and had a history of involvement in environmental management. They understood the importance of this information in decision-making and decided to participate due to access to various forms of wildfire evidence.

5.3. Impact of Scientific Evidence on Perceived Success

I conducted qualitative semi-structured interviews with four established and four emerging watershed partnership groups throughout the Intermountain West region to determine the role of scientific evidence on the perceived success of the partnerships. I transcribed and coded these interviews and then created a thematic analysis to help answer the chapter's primary research question.

I found that every partnership used a combination of scientific evidence and knowledge of regional wildfire trends in their treatment implementation to varying degrees. However, the use of evidence was often followed-up by other types of information which equally influence management. Practical considerations were often taken into account, such as accessibility to intended project areas or the ability to leverage projects within a larger working landscape. At times, expert opinion or community input was also found to alter decisions that were previously based on scientific evidence.

Each partnership stressed the importance of transparent information sharing among stakeholders involved to increase collaboration and sub-sequent long-term success. Established partnerships on average reported higher levels of perceived success than their emerging counterparts. The established groups also felt more supported by the public, and each attributed this success to a robust and transparent public outreach strategy, which shared scientific evidence in the form of program monitoring results. In contrast, some of the emerging partnerships did not have any sort of public outreach component or were unsure if it would be necessary for their partnership do to so in the future. Established groups also mentioned altering their wildfire management prescriptions due to input from the community, a theme that was not present among the emerging groups.

5.4. A New Conceptual Framework

The original framework (Figure 1.2) proposed in the introductory chapter of this dissertation adapted the rational decision-making model to demonstrate two potential pathways for the incorporation of scientific evidence into collective action decision-making. This model essentially illustrated how exposure or use of science will lead to internal and external stakeholders making rational decisions that eventually result in partnership success. The findings described above show that this model alone does not adequately cover all of the information channels used for making decisions. Toomey et al. (2016) instead offers a description for the relationship between scientific research and implementation as "a series of crucial, productive spaces in which shared interests, value conflicts, and complex relations between scientists and publics can interact." The findings from this study support this point, demonstrating how many diverse types of information, motivations, and other factors influence collective action decision-making beyond scientific evidence alone.

In place of the rational decision-making model, information pathways used by internal and external stakeholders to make collective action decisions are more closely aligned with an alternative framework proposed by Tanenbaum et al. (2013), called emergent dialogue. Emergent dialogue downplays the role of scientific evidence as one out of many variables influencing decision-making. This model focuses on groups engaged in planning efforts and stresses the importance of collaborative processes to arrive at consensus. In emergent dialogue, “ideas conflict, clash, and combine until something new appears” [Hammond et al., (2003), p.146]. In contrast to the focus on a single group or entity within the rational decision-making model, this framework centers on decision-making at the collective level, where several

stakeholders come to consensus on a shared goal through iterative dialogue (Tanenbaum et al., 2013).

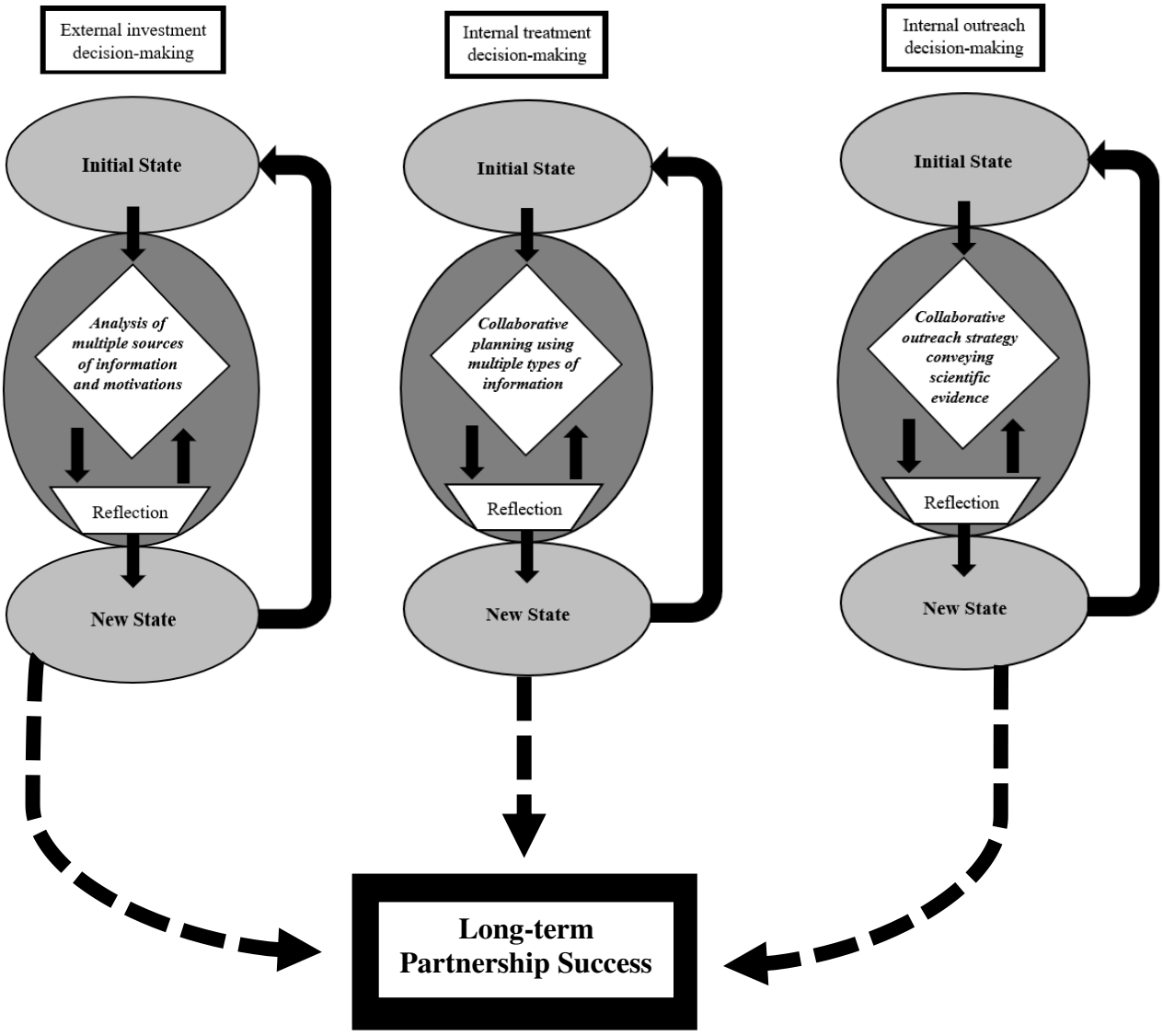

Figure 5.1. Decision-making pathways used by collective action stakeholders (adapted from Tanenbaum et al., 2013)

In the new framework demonstrated above (Figure 5.1), I propose that decisions to invest in collective action initiatives by external stakeholders and decisions to conduct conservation

interventions by internal stakeholders use an emergent dialogue approach. In chapter 4 of this dissertation, the role of disseminating new evidence gathered through partnership monitoring was also found to be highly important. Therefore, a third information pathway was created which describes the decision-making for outreach conducted by internal stakeholders.

In external investment decision-making (left side of Figure 5.1), stakeholder organizations exist in an 'initial state' and are then either exposed to or already foster several diverse motivations for potential investment in collective action. Given these motivations, organizations discuss and reflect internally on the possibility of investment. This process can ultimately lead to a situational 'new state' in the form of an investment of financial and/or human resources. When formulating a problem to address or deciding on interventions to employ through collective action, internal stakeholders collaboratively plan by using multiple forms of information in addition to current scientific evidence (middle of Figure 5.1). This process of dialogue and reflection leads to mutually agreed upon management solutions. Once a project is implemented and data is gathered through monitoring, a very similar process occurs for communicating results (right side of Figure 5.1). The internal stakeholders collaboratively decide on the best approach for communicating evidence on their program outcomes. If the strategy leads to an increase in public support, as seen with many of the established watershed partnership groups, this support combined with effective management and adequate funding will result in the long-term success of a collective action initiative.

The combination of models presented in Figure 5.1 shows a more realistic framework to predict decision-making and resulting long-term success for collective action initiatives than the rational decision-making model alone. Emergent dialogue allow diverse stakeholders to collaboratively arrive at mutual solutions to decisions. This makes sense for collective action

initiatives, which are inherently collaborative by nature. The limitation to this conclusion is the fact that it is derived from a relatively small dataset of watershed partnership case studies. As such, it cannot be generalizable to all watershed partnerships or environmental collaboratives. Rather, these findings contribute to the theory of factors necessary in collective action decision-making and long-term success, showing that multiple factors are necessary for complex governance processes to develop and persist.

5.5. Future Practical Considerations

Although internal stakeholders who manage their partnerships reported using scientific evidence in their decision-making processes, results from chapter three revealed that this evidence was only an important driver for the participation of forest and fire specialists. Furthermore, chapter two demonstrates that general stakeholders felt less linkages are understudied than specialists. These perceptions and lack of evidence as a participatory driver could be due to issues with access to scientific evidence described in the introductory chapter.

The EBC literature provides several suggestions to help facilitate the access of scientific evidence in conservation management, attempting to overcome barriers to the acquisition and use of important information. One of the most common recommendations is to translate relevant evidence into an easily interpretable form (Pullin & Knight, 2003; Pullin et al. 2004). This was already being accomplished by established partnership groups, who shared transparent monitoring results in a variety of public venues and outlets. A future study could quantitatively compare the various outreach strategies and information shared between established and emerging groups, as well as levels of support from the perspective of public stakeholders.

The creation of a web-based database was proposed by Sutherland et al. (2004), where scientific evidence could be more accessible to decision-makers by allowing them to limit their search of evidence to various fields (e.g. country, habitat, conservation action). This information could also be organized into a knowledge hierarchy, starting with individual studies, then moving up to evidence maps or systematic reviews compiling these studies, then broader summaries of the evidence, and finally the creation of decision support systems based on the synthesis of these summaries (Dicks, 2014). Additionally, an organization similar to medicine's National Institute for Health and Clinical Excellence could be established for conservation, which would give users guidance on appropriate steps to take for a natural resource intervention by utilizing a cost-effectiveness approach for that specific intervention (Segan et al. 2011).

Another important question to consider is the very meaning of the term "evidence". This study defined evidence as "the available body of facts or information indicating whether a belief or proposition is true or valid" (Oxford Living Dictionary, 2018). Many EBC scholars have argued for expanding this definition from its traditionally limited scope of Western science to include other sources of information as equivalent forms of evidence, such as qualitative data, gray literature, and indigenous knowledge (Adams & Sandbrook, 2013; Tengö et al., 2014). Results from this dissertation support the argument of broadening the concept of evidence by highlighting how scientific evidence is just one out of many factors the watershed partnership case studies consider before making a decision.

One recommendation to broaden evidence use and further improve knowledge exchange between scientists and decision-makers is through co-production of knowledge via a transdisciplinary process (Cvitanovic, C., Hobday, A.J., van Kerkhoff, L., Wilsond, S.K., Dobbs, K., Marshall, N.A., et al., 2015). A common mechanism for implementing the co-production of

knowledge is by actually embedding scientists into decision-making agencies (Cook, Mascia, Schwartz, Possingham, Fuller, 2013). This helps to ensure that scientists are aware of priority knowledge gaps and can aid in addressed them. The inclusion of completely separate entities into decision-making processes, such as boundary organizations or knowledge brokers, have also been demonstrated as effective strategies for facilitating knowledge co-production and exchange (Cvitanovic et al., 2015). These entities can aid in facilitating communication between parties, ensuring the knowledge being generated is of use to all stakeholders involved. Transparent dialogue between scientists and decision-makers can help to strengthen the establishment of trust and thus increase knowledge co-production between the groups (Reed et al., 2014b). Evaluations of knowledge co-production and exchange are highlighted in the literature (see Fazey, Bunse, Msika, Pinke, Preedy, et al., 2014) to assess and improve the uptake and use of vital evidence in conservation decision-making.

5.6. Conclusions

In 1962, author Rachel Carson published her groundbreaking novel *Silent Spring*, which described the numerous adverse environmental impacts of pesticide use. Since then, the use of DDT has been banned and the National Audubon Society recognized Carson as an environmental champion (National Audubon Society, 2007). Her book was influential to the point of being referenced as one of the "main intellectual underpinnings of environmentalism in America" (Long, 2001, p. 3) and is a clear example of how exposure to scientific information can have a direct impact on behavior change and decision-making. However, there still exists a multitude of examples of information not resulting in any effect on a decision-making process. Further research is needed to determine when, how, and why science leads to its intended impact.

This dissertation attempted to determine the role of scientific evidence in the decision-making processes of collective action initiatives using watershed partnerships as a case study. Results show the partnerships studied whom reported high self-perceived levels of success incorporated scientific evidence throughout every step of their treatment implementation decision-making process, although other sources of information were equally important to consider. Although it is encouraging that internal actors of partnerships were using evidence in their decision-making, general partnership stakeholders did not perceive as many wildfire treatment-societal outcome linkages as being understudied as forest and wildfire experts, nor did they rate scientific evidence as a primary driver for their organizations participation in watershed partnership initiatives. As access to evidence was cited as one of the largest barriers to its use, a few recommendations are provided in section 5.5 to help increase the general uptake of scientific evidence for conservation practitioners involved with collective action management regimes. Creating mechanisms that would allow groups to more easily access and utilize scientific evidence will aid in the effectiveness of these collective action initiatives moving forward and will help them in achieving their long-term objectives.

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APPENDICES

Appendix 1. Importance and strength of scientific evidence survey

This survey focuses on the amount and importance of scientific evidence available regarding various social and economic outcomes of wildfire risk mitigation. In this context, we are defining scientific evidence as any information from peer-reviewed or gray literature sources that aid in generating knowledge for the purposes of management action.

Part 1: ***Importance*** of Evidence

STEP 1: Using the list of wildfire treatments on the left-hand side of the table below, please check "Yes" under the Step 1 column for any treatments that you believe are important to the watershed partnership.

STEP 2: For each of the intervention types that you checked with a "Yes" in Step 1, please rate how important you feel having scientific information is (for the purpose of pre- and post-wildfire risk mitigation) linking that intervention to the outcomes listed across the top row. For example, if you checked “Yes” for “Defensible space”, fill in a number between 0 and 4 (explained below) for every column to the right of “Defensible space”. If you did not check “Yes” on “Defensible space”, leave that intervention row blank.

Rate between 0 and 4 using the following definitions. Evidence linking this intervention to this outcome is:

0	1	2	3	4
I don't know	Not important	Slightly important	Moderately important	Very important

	STEP 1:	STEP 2: OUTCOMES								
	YES	Infrastructure/ property	Suppression costs	Management perceptions	Forest products	Restoration costs	Water quality/ quantity	Employment	Habitat/ biodiversity	Recreation/ tourism
INTERVENTIONS										
Controlled/ prescribed burning										
Defensible space										
Thinning										
Fire suppression										
Fuel breaks										
Mulching										
Rehabilitation										
Salvage logging										

Part 2: *Strength* of Evidence

We are also interested in understanding your perception on the strength of scientific information for pre- and post-wildfire risk mitigation. **For each of the intervention types that you checked with a "Yes" in Step 1 above**, please rate how strong you feel the CURRENT scientific information is linking that intervention to the outcomes listed across the top row. For example, if you checked "Yes" for "Defensible space" above, fill in a number between 0 and 4 (explained below) for every column to the right of "Defensible space". If you did not check "Yes" on "Defensible space", leave that intervention row blank.

Rate between 0 and 4 using the following definitions. Evidence linking this intervention to this outcome is:

0	1	2	3	4
I don't know	Doesn't exist	Is weak	Is moderate	Is strong

	OUTCOMES								
	Infrastructure/ property	Suppression costs	Management perceptions	Forest products	Restoration costs	Water quality/ quantity	Employment	Habitat/ biodiversity	Recreation/ tourism
INTERVENTIONS									
Controlled/ prescribed burning									
Defensible space									
Thinning									
Fire suppression									
Fuel breaks									
Mulching									
Rehabilitation									
Salvage logging									

Appendix 2. Average stakeholder perceptions of wildfire treatment-societal outcome linkages found in each quadrant of ISA framework

Quadrant	Intervention	Outcome
Quadrant 1: Less Effort Needed	Prescribed burning	Timber/non-timber forest products
	Current fire suppression	Timber/non-timber forest products
	Post-wildfire rehabilitation	Infrastructure/property Timber/non-timber forest products
Quadrant 2: Continue Good Work	Prescribed burning	Infrastructure/property Future suppression costs Public perceptions Future restoration costs Water quality/quantity Habitat/biodiversity
	Defensible space	Infrastructure/property Future suppression costs Public perceptions Post-wildfire restoration costs
	Thinning	Infrastructure/property Future suppression costs Public perceptions Timber/non-timber forest products Post-wildfire restoration costs Water quality/quantity Habitat/biodiversity Recreation/tourism
	Fire suppression	Infrastructure/property Future suppression costs Public perceptions Post-wildfire restoration costs Water quality/quantity
	Fuel breaks	Infrastructure/property Future suppression costs Post-wildfire restoration costs Water quality/quantity
	Mulching	Post-wildfire restoration costs
	Post-wildfire rehabilitation	Public perceptions Timber/non-timber forest products Post-wildfire restoration costs Habitat/biodiversity

	Salvage logging	Timber/non-timber forest products Post-wildfire restoration costs Water quality/quantity Employment Habitat/biodiversity
Quadrant 3: Low Priority	Prescribed burning	Employment
	Defensible space	Timber/non-timber forest products Employment Habitat/biodiversity Recreation/tourism
	Fire suppression	Employment
	Fuel breaks	Timber/non-timber forest products Employment Recreation/tourism
	Mulching	Infrastructure/property Future suppression costs Public perceptions Timber/non-timber forest products Employment Recreation/tourism
	Post-wildfire rehabilitation	Employment
	Salvage logging	Infrastructure/property Future suppression costs Recreation/tourism
Quadrant 4: Future Prioritization	Prescribed burning	Recreation/tourism
	Defensible space	Water quality/quantity
	Thinning	Employment
	Fire suppression	Habitat/biodiversity Recreation/tourism
	Fuel breaks	Public perceptions Habitat/biodiversity
	Mulching	Water quality/quantity Habitat/biodiversity
	Post-wildfire rehabilitation	Future suppression costs Recreation/tourism
	Salvage logging	Public perceptions

Appendix 3. Q-Sort Survey

Thank you for agreeing to take this survey. We are conducting this research as part of a larger project funded through Colorado State University, exploring the factors that influence organizations to participate in partnership programs targeted at wildfire risk reduction for source water protection. We hope that the knowledge gained from these surveys will help us to provide recommendations to watershed partnerships on diverse management strategies and techniques which will lead to more successful partnerships. We would be happy to share the final results with you upon completion of the research project.

The survey is comprised of two parts: The first is focused on participation in a source water protection partnership. We are interested in determining your organization's primary motivations for contributing time and/or money to the partnership. Please refer to the document title 'Part 1: Q-Sort Instructions' for further directions on completing this section. The second piece of this survey focuses on your perceived importance and strength of scientific information on aspects of wildfire management for the importance of wildfire risk mitigation. It concludes by asking a few demographic questions. **When you've finished, please send both sections of the completed survey and this signed consent form to the address on the enclosed postage-paid return envelope.** The survey will be followed-up by a brief phone interview.

Your participation in this study is completely voluntary. Should you elect to discontinue participation, any information already collected will be discarded. There are no risks or direct benefits to you, but this study will help to identify knowledge gaps related to wildfire management and source water protection. The information from the survey will only be used for research purposes; the university researchers will not use your name and will be sure to submit information to the university with all personal details or potential identifiers omitted (i.e. names of specific people or places). The survey should take approximately 25 minutes to complete. Providing your signature below indicates that you are over 18 years old, that you have read and understand the information provided above, that you willingly agree to participate, and that you may withdraw your consent at any time and discontinue participation without penalty.

Print Name_____

Signature_____ Date _____

Please contact Ryan Roberts at (315) 368-7095 or rmrobert@rams.colostate.edu with any questions or concerns you may have about this survey or the broader research project. If you have any questions about your rights as a volunteer in this research, contact the CSU IRB at (970) 491-1553 or RICRO_IRB@mail.colostate.edu.

Q-Sort Instructions

In this study, we ask for you to provide your viewpoints regarding your organization's motivation to participate in source water protection partnership efforts. ***You are acting as a representative for your organization***. Please provide us with your viewpoints by answering the question: **"Our organization participates in a watershed partnership because…"**. You answer this by sorting the 36 statements provided on the statement cards along a scale from most agree (+5) to most disagree (-5). *How you prioritize these statements, and how you consider the trade-offs in this process,* is what is important for us. This is not a test and there are no right or wrong answers. The objective is to meaningfully understand your opinions and your reasons for them.

What to do:

Step 1: Place the response sheet on a table with enough room to be comfortable. Read through the 36 statement cards (wrapped in a rubber band). Place the cards in three piles on the top of the response sheet- one to the right for statements you generally agree with, one to the left for statements you generally disagree with, and a pile in the middle for statements of lesser importance, or that you are ambivalent about. Keep in mind that you are answering the question: "Our organization participates in a watershed partnership because…".

Step 2: Examine more closely the pile of statements you generally agree with. Spread these out and select the one you most strongly agree with. Place this in the +5 space according to the response sheet. Then pick out the two statements that you next most agree with and place them in the +4 column. Continue this with all the statements you agree with. In this methodology, what columns you place your statements in (e.g. -3, +5 or -5) is what is important. The ordering of statements by row has no significance. If you become stuck on where to place statements, just pick your best option and do not deliberate for long, as all survey results will be aggregated during analysis. Repeat the process for the statements you disagree with for the -5 space, -4 spaces, etc. The center column (identified by "0") may be statements that you least agree or disagree with, that you have mixed feelings about, or that are not relevant to your organization.

When you have completed the sorting, all 36 statements will be arranged in front of you on the response sheet. **Please be sure that you have one statement in each square and that all squares on the response sheet are filled**. At this point, you may review your ordering and change the positions of any statements. When finished, please record the statement numbers (on the back of the cards) in the appropriate boxes on the response sheet. *An example of a completed response sheet is shown in the diagram on the next page*. **Please send your completed response sheet along with part 2 of the survey and the signed consent form to the address on the enclosed postage-paid return envelope.**

Appendix 4. Q-Study Interview Guide

Interviewee coded number (do not save name in this document):

Interviewer:

Interview date and time:

Brief instructions and reminders:

- *Thank the participant for being part of the study.*
- *Ask them if they have any questions about the consent form. Remind them that their statements are anonymous. Nothing they say will be attributed to them in the final report.*
- *Ask them if you have their permission to begin asking them questions.*
- *Remember to have them send you their response form. They can either mail it or scan and email it, along with parts 2 and 3 of the survey.*

1) What statements did you most agree with and why?

2) What statements did you most disagree with and why?

3) What statements wound up more in the middle section and why (not applicable, mixed feelings, etc.)?

4) While deciding what statements you agreed or disagreed with, were there any trade-offs that were particularly difficult?

5) Considering that these statements represent organization's motivations for participation in a watershed partnership, do you feel that your organization's viewpoints and opinions are represented? Is there anything missing?

6) Are there any other aspects regarding participation in watershed partnerships that we haven't discussed, such as recent, local events (i.e. social, economic, ecological changes) close to you that have influenced participation? Is there anything you'd like to add?

7) Is there anything else you would like to share that you haven't said already?

Thank you for your willingness to participate in this study. Again, all of your responses will remain anonymous. We expect the final report to be available in Spring 2019.

Appendix 5. Semi-structured interview guide

Consent Form

Thank you for agreeing to meet. I am conducting this interview as part of a larger research project funded through Colorado State University, exploring the factors that influence participation in and success of programs targeted at wildfire risk reduction for source water protection. The purpose of this interview is to gain insight into the various factors that lead to establishment of and success within watershed partnerships. Results from this interview will be analyzed with responses from five other watershed partnerships throughout the Intermountain West.

We hope the knowledge gained from these interviews will help us to provide recommendations for watershed partnerships on diverse management strategies and techniques which lead to more successful partnerships. We would be happy to share the final results with you upon completion of the research project. This interview should take approximately 60-90 minutes.

This interview will be followed-up with surveys administered to potential and established watershed partners in your area. At the end of this interview we will ask you if there are individuals or groups that you suggest we survey. The goal of the survey will be to assess knowledge of and participation in watershed partnerships across a broader group of stakeholders.

Please keep in mind that your participation is voluntary and your responses will remain confidential, as we will not attach your name or organization to your responses. All write-ups of the data will protect individuals' identities by not giving individual names or potential identifiers, such as names of specific places. We will keep all materials that link your responses with your name in a secure location.

You signature indicates that you have read and understand the information provided above, that you willingly agree to participate, that you may withdraw your consent at any time and discontinue participation without penalty, and that you have received a copy of this form.

Print Name_____
Signature_____ Date _____

We would like to record the interview today with an audio recording device. Recording the interview will allow us to utilize direct quotes and to avoid misinterpretation.
Do we have your permission to record this interview? Yes___ No___

Feel free to contact the primary investigators on this project Esther Duke at esther.duke@colostate.edu, Ryan Roberts at rmrobert@rams.colostate.edu, or Dr. Kelly Jones at kelly.jones@colostate.edu, with any questions or concerns you may have about our research.

Interview Guide

Personal Information

1) Can you please state the name of any watershed partnership that you are involved in and describe your role in the partnership(s)?

2) How did you initially become involved in the partnership(s)?

Partnership Information

3) In what year did the planning for the establishment of your partnership originally begin?

4) Is your partnership now formally established and active? Yes___ No___
    a. If so, how long has your partnership been formally established?
    b. If not, what phase of implementation best describes the state of your partnership?

        a. Planning/design phase b. Demonstration/pilot stage

            i. How long has your partnership been in this phase?

5) Was the creation of this partnership motivated (at least in part) by previous experience with wildfires in the region? Yes___ No___
    a. What other factors motivated its creation?

Watershed Partnership Objectives and Activities

6) Can you please describe the specific objectives of your watershed partnership?

7) What types of on-the-ground interventions or management activities are currently being utilized (e.g., fuel reduction treatments, forest restoration, etc)?
    a. Are there any interventions or management activities that your partnership would like to carry out in the future that you are not currently doing? What are they?

8) In your opinion, how certain is current scientific evidence that these interventions or management activities will lead to changes in severe wildfire and reduce the impacts associated with wildfire events?

1	2	3	4	5
Not at all certain	Somewhat certain	Certain	Very Certain	Extremely Certain

9) Do you have any indicators or measurements in place to evaluate the outcomes of these interventions or management activities?
    a. If yes, what are they? Why have these indicators/measurements been adopted?
    b. If no, why not?

10) Does your partnership communicate with the public regarding its progress or results? Yes___ No___
    a. If yes, what is the purpose of this outreach? What type of outlets are used?
    b. If no, why?

Sources of Funding

11) What are the current sources of funding for your partnership?
    a. Is an MOU or some form of commitment established for your source(s) of funding?
    b. If the funding is coming from watershed partners in your area, is the funding voluntary or mandatory (i.e. watershed protection tax for rate users?)
    c. Has there been any attempts to leverage these funds? Yes___ No___
        i. If so, have these attempts been successful? Yes___ No___
        ii. Why or why not?

12) What is the current funding amount (budget) of your partnership?

13) Is current funding sufficient to meet your objectives? Yes___ No___
    a. If no, what is the percent of unmet funding need? ___%

14) Are there sources of funding you have not been able to successfully access?
    a. If yes, is this because you haven't tried or haven't been successful?

15) What is the decision-making process used to allocate funding (i.e. prioritization criteria)?
    a. Who is involved in the decision-making?

Understanding Success

16) How does your watershed partnership define success?

17) How successful do you feel your partnership is with achieving its objectives?

1	2	3	4	5
Not successful	Somewhat successful	Successful	Very Successful	Extremely Successful

Collaboration

18) What is the total number of organizations or stakeholders involved in the partnership today?
    a. What are the types (e.g., water utility, private sector, academic institution, government agency) of organizations involved (or list each one)?

19) How does the mix of organizations involved influence or contribute to the success of the partnership?

a. Are there any stakeholders or groups that your partnership is missing that you think would add to the success of your efforts?

Public Support

20) We are interested in the role that public support plays in the success of watershed partnerships. We define public support as the knowledge and goodwill of involved and uninvolved stakeholders towards the partnership. Please rank your perceived level of public support for your partnership:

1	2	3	4	5
Not at all supported	Somewhat supported	Supported	Very Supported	Extremely Supported

21) What role does public support play in the success of your partnership, if any?

22) Have there been any attempts to survey the public in order to gauge public support for your partnership? If yes, can we have access to this survey/ survey results?

Leadership

23) As your partnership was getting off the ground, was their one individual or organization that stood out as a leader in facilitating this process?
   a. If so, how long have they been/ were they involved?
   b. What are the benefits of having someone like this present?

Other

24) Are there any other factors at play that I didn't ask about, which you feel affect your partnership's ability to achieve success?

Additional Information

25) If I have follow up questions about this interview and your responses may I contact you?
   a. What is the best way to get in contact with you?

26) Our team is applying for additional funding to conduct an analysis of the strength of the networks and collaborations across organizations involved in watershed partnerships. If we receive this funding, we may need to ask additional questions. Would you be willing to answer these additional questions we may have?

27) Would you be willing to identify contacts at other organizations involved in your watershed partnership that we could reach out to for a broader survey on knowledge of and participation in these partnerships? Would you be willing to include a short statement or letter of support with that survey to increase participation rates?

28) Are there any stakeholders or organizations that are not currently involved in your watershed partnership that you think it would be beneficial to survey? For example, any groups you listed in question 19a?

Thank you for your time. Do you have any questions or clarifications that I can address?