How Are Fire Science Exchange Networks Perceived?
A Qualitative Evaluation of The Southwest Fire Science Consortium

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ABSTRACT

HOW ARE FIRE SCIENCE EXCHANGE NETWORKS PERCEIVED?
A QUALITATIVE EVALUATION OF THE SOUTHWEST FIRE SCIENCE CONSORTIUM
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Fire science exchange networks created by the Joint Fire Science Program aim to provide relevant information between researchers and managers for more productive science and use of science in management. Research has found the exchanges to be effective and needed; however, there is a lack of understanding of regional impacts due to the time and resources required by the individual exchanges to conduct evaluations. By using focus groups and interviews, this study seeks to understand how the Southwest Fire Science Consortium (the Consortium) is impacting fire science delivery and wildfire management in the Southwest by exploring how it evolved as a science exchange network, and identifying its successes, barriers, and opportunities. Key events in the Consortium's history have helped influence the use of science on the ground, led to an interdisciplinary board and membership, and put the Consortium into a leadership role. In-person forms of science communication are perceived as the most successful part of the Consortium. The greatest barriers to achieving positive outcomes are funding, time, and staffing constraints for the Consortium and for the organizations it serves. Opportunities to improve include encouraging more research and synthesis in specific vegetation types and social science, as well as providing more virtual products.

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FACT SHEET: HOW ARE FIRE SCIENCE EXCHANGE NETWORKS PERCEIVED?

Introduction

The Joint Fire Science Program (JFSP) created a national network of 15 fire science exchanges to provide information between researchers and managers for more productive science and science use in management. National evaluations find the exchanges to be effective and needed; however, there is a lack of understanding regional impacts because of the time and resources required by the individual exchanges to conduct evaluations. This study seeks to understand how the Southwest Fire Science Consortium (the Consortium) is impacting fire science delivery and wildfire management in the Southwest by exploring how it evolved as a science exchange network, and identifying its successes, barriers, and opportunities.

Methods

This study utilized focus groups and semi-structured interviews with the Consortium's Governing Board. Two focus group sessions (n=16) were conducted to review the history of the Consortium and discuss influential events and stakeholders. Interviews (n=18) were in-person or by phone. Participants were asked questions based on their role as a manager (consumer of information) or as a scientist (producer of information). Focus groups and interviews were audio recorded and transcribed with participant permission. Transcripts were analyzed using a grounded theory approach, which allows common themes to emerge while conducting research.

Results and Discussion

Evolution of the Consortium – Key events helped form and shape the Consortium (see Figure 1).

Successes – Successes are positive outcomes of the Consortium programming. In-person forms of science communication (conferences, field trips, workshops) are favored by Governing Board members and perceived as the most successful part of the Consortium. In-person forms facilitate

two-way communication, build professional connections to both scientists and managers, and provide opportunities to collaborate, develop applicable research, and get science on the ground.

Barriers – Barriers indicate challenges to achieving positive outcomes. The greatest challenges identified by the Governing Board members are funding, time, and staffing constraints. Uncertainty of funding through JFSP is a challenge for the Consortium. Funding cuts to the organizations the Consortium serves may decrease the ability for employees to attend in-person events. As a result, inadequate staffing may increase and employees may perform multiple jobs, which decreases the amount of time they have to learn new science or outreach to managers. For strictly research scientists, working with managers is viewed as a large time investment and may not be measured on performance evaluations.

Opportunities – The Consortium can encourage research and synthesis in vegetation types that were identified as needing more information, such as: pinyon, juniper, and oak woodlands, chaparral, grasslands, shrublands, and riparian areas. Social science research can also be encouraged to better understand effective communication with different audiences. The Consortium can use technology in their products to provide virtual in-person events, explore different ways of communicating, and continue to provide easy to understand information.

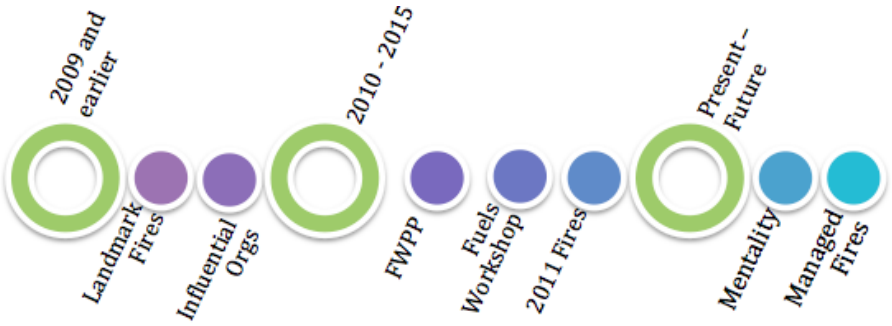

Figure 1.
2009 and earlier: Landmark fires helped demonstrate how wildfires need more science for future management. These fires and organizations like JFSP and the Association for Fire Ecology helped set the stage for the creation of the Consortium to work with multiple partners and deliver fire science information in the Southwest.
2010-2015: The Flagstaff Watershed Protection Project (FWPP) is viewed as a success in directly putting science on the ground; the fuels workshop helped make the Consortium and the Board more interdisciplinary; the 2011 fire season is a realized opportunity for the Consortium to come into a leadership role by providing relevant products and events.
Present – Future: Governing Board members are seeing a change in the mentality of managers wanting to let fire run a natural course. Managed fires are hoped to be used now and in the future to treat landscapes.

INTRODUCTION AND BACKGROUND

Wildland fire management in the United States is increasing in complexity (Pence and Zimmerman 2011) as fire size, occurrence, damage, suppression costs, fire season length, and uncertainty in global climate change effects increase (Westerling et al. 2003; Westerling et al. 2006; Dale 2009; Abatzoglou & Williams 2016). In 1998, the U.S. Congress provided a funding authority to support fire use and mechanical treatments to reduce the occurrence of uncharacteristically severe wildfires (Long et al. 2003). The interaction of fire suppression and past land management practices created hazardous fuel loads in areas where fire historically played an important role in the ecosystem. The impacts of fire on human and ecological values and the long-term consequences of fire suppression were not yet widely understood. When granting the funding authority, Congress expressed concern that land management agencies in the Department of the Interior and the Forest Service in the Department of Agriculture "…lack consistent and credible information about the fuels management situation and workload, including information about fuel loads, conditions, risk, flammability potential, fire regimes, locations, effects on other resources, and priorities for treatment in the context of the values to be protected" (Long et al. 2003, p 388).

As a result of these concerns, the Joint Fire Science Program (JFSP) was created to provide science-based support to fire management programs (Hunter 2016). Congress elected the U.S. Department of the Interior and the Forest Service in the U.S. Department of Agriculture to direct and implement the program. Partnering agencies within these Departments include the Bureau of Land Management, Bureau of Indian Affairs, National Park Service, Fish and Wildlife Service, U.S. Geological Survey, and the Forest Service.

JFSP's mission includes increasing access to scientific information, providing a knowledge base for managers, and providing credible and usable science for planning and on-the-ground application (JFSP 2000). However, the use and delivery of science is often hindered by institutional, cultural, and communication barriers. Institutional barriers may include funding resources, lack of science-oriented personnel, lack of trust, and differing abilities, attitudes, and motivational drivers among individuals (Sicafuse et al. 2011; Wright 2010). Cultural barriers may include differences in organizational norms and values, dissimilar or conflicting job functions and goals, differing time and money allocations, politics, lack of organizational support for science implementation, lack of individual rewards for implementing or outreaching science, and difficulty keeping up with new research (Barbour 2007; Finch and Patton-Mallory 1993; Hollstedt & Swift 2000; Hunter 2016; Seesholtz 2008; Wright 2007; Wright 2010). Communication barriers may include language use, lack of managers relaying information needs, lack of researchers packaging science into useable forms, narrowly focused research, and differing ideas and perceptions among individuals (Finch and Patton-Mallory 1993; Wright 2010).

In 2007 Barbour evaluated the effectiveness of JFSP and offered recommendations for more effective science delivery. Barbour (2007) noted the strengths of JFSP as having high quality science, recognition in the science community, representation of agency interests, board members committed to improving the use of JFSP generated science, fire science education support, and accessibility and responsiveness of program office staff. JFSP was found to not be widely recognized by the management community, had ineffective attempts to include customers, disagreement on JFSP clients among Governing Board members, unfocused science delivery efforts, and ineffective science delivery under funding umbrella themes (Barbour 2007).

As a result of the Barbour (2007) report, JFSP established a network of 15 regional fire science exchanges in the United States with the main purpose of providing and facilitating relevant information between fire researchers, managers, and practitioners (Barrett 2017). The main objectives of the fire science exchange networks include information sharing and relationship building between members, describing and providing existing research and synthesis information, identification and development of methods to assess quality and applicability of research, demonstration of on-the-ground research, support of adaptive management, and identifying new research, synthesis, and validation needs (JFSPa n.d.). There are 15 regional exchange networks, or Consortia, spanning the country. Figure 1 displays a map of these networks.

Figure 1. Map of the JFSP fire science exchange networks (JFSPb n.d.)

JFSP and the fire science exchange networks are considered "boundary organizations", while the principal participants (Principal and Co-Principal Investigators, Governing Board members) are considered "boundary spanners". Boundary organizations, are described by Guston (2000; 2001) to bridge the gap between scientists and non-scientists by existing between

the two social worlds to help solve problems, transfer information, and facilitate collaboration for more productive policy and decision-making. Individuals who work at the interface of science and management are considered boundary spanners (Ritter 2006). To be successful, boundary organizations and the information produced and disseminated must be recognized as scientifically credible, relevant to the needs of decision-makers, and legitimate to both social worlds (Cash et al. 2003). Through the exchange networks, scientists gain a pathway to communicate research findings while managers are able to use science to support fire management decisions and participate in developing research agendas (Kocher et al. 2012).

The exchange networks are found to be effective in conducting boundary work within the fire management community and have improved access, usability, and application of fire science in land management and decision-making (Sicafuse et al. 2015; Hunter 2016). Kocher et al. (2012) found regional similarities in how science is accessed and used, barriers to use, needed research, and a clear need for the exchange networks. A national survey-based evaluation demonstrates how the exchange networks are bridging the gap between science producers and consumers while creating regional impacts (Maletsky et al. 2016). This evaluation also reports the need for regional evaluation to understand the regional impacts of each exchange network (Maletsky et al. 2016). While national evaluations are useful in understanding combined impacts of the exchange networks, each exchange network is responsible for evaluating its regional impacts (Maletsky et al. 2016). However, evaluations of the specific regional fire science exchange networks have not yet been created, published, or made widely available because of common barriers to conducting regional evaluations. These barriers include uncertainty in how to design and proceed with an evaluation, time and resources required to conduct an evaluation, and uncertainty in what to ask or look for (Maletsky et al. 2016). The present study seeks to

understand how the Southwest Fire Science Consortium (the Consortium) is impacting fire science delivery and wildfire management in the Southwest and how it can improve. Because many exchange networks face barriers to conducting evaluations and because there is benefit from sharing knowledge and experiences with each other (Maletsky et al. 2016), this study also hopes to inform other regional fire exchange networks of the findings for more productive fire science delivery and management across regions. This study used focus groups and semi-structured interviews of the Consortium Governing Board members to:

1. describe how the Consortium has evolved as a science exchange network;
2. identify successes and barriers of the science exchange network; and
3. identify opportunities to improve Consortium programming and address identified barriers

This report describes how the Consortium evolved as a science exchange network, how it is perceived now (successes and barriers), and where the Consortium should go from here (future opportunities).

METHODS

Overview

This study utilized focus groups and semi-structured interviews with the Consortium Governing Board members to meet the research objectives. Focus groups and semi-structured interviews are used to gather in-depth information (Dibley 2011; Harrell & Bradley 2009; Kvale 1996; Mason 1996). Governing Board members were purposefully sampled, including Principal and Co-Principal Investigators, board members, and recent past board members (Palinkas et al. 2013) for a total of 18 semi-structured interviews. Recent past board members were included in the purposeful sample for their experience and perspectives about the Consortium once they left the

Board. Prior to conducting focus groups or interviews, the focus group and interview guides (see Appendix D and Appendix E) were presented to and approved by the Institutional Review Board at Northern Arizona University.

People on the Governing Board have either been involved since the beginning of the Consortium or were nominated and voted in by existing members. Governing Board members consist of a mixture of people in academic, research, land management, and practitioner roles. Because fire is an essential ecosystem function, multiple disciplines work together and Consortium products cross resource disciplines. For interviews, respondents were categorized into either "scientist" or "manager" roles. "Scientist" refers to producers of scientific information: typically those in the research or academic community and can include multiple resource disciplines such as fire ecology, wildlife biology, hydrology, and other fields. "Manager" refers to consumers of information: typically those on the management side of fire and forest management and can include decision-maker roles, such as a fire management officer, or practitioner roles, such as a wildland fire fighter or timber marker. To ensure correct categorization, respondents were asked to self-identify as either a scientist or a manager based on the producer or consumer roles.

Focus Groups

Two focus groups were conducted in spring 2017 at the Consortium annual governing board meeting in Flagstaff, Arizona. The Governing Board consists of 18 members. Because the Governing Board is fairly large, two focus groups were necessary to adequately moderate and to encourage participation among all members. Prior to the meeting day, the Consortium program coordinator, who has familiarity with the members, divided members into two groups to distribute newer and older members between the groups. On the day of the focus groups, three

members were absent and one participant was a fill-in for an absentee, resulting in a total of 16 participants. Focus group sessions were approximately 3 hours and participants were audio-recorded with permission and recordings transcribed for analysis. In addition to the recordings, parts of the focus group sessions were written and recorded on a whiteboard and/or paper poster sheets for participants to see throughout the sessions and saved for analysis.

Focus group members participated in a historical scan activity (Earl et al. 2003) and a discussion about stakeholders. The purpose of the historical scan was to review the history of the Consortium and events, issues, and achievements that have influenced the Consortium to date. The historical scan provides an understanding of how the organization has developed over time and also provides context and background information to the analysis. The historical scan began with each participant individually thinking about and sharing key events, and then developing a timeline of the events as a group and discussing the significance of the events.

Once the historical scan activity was completed, groups developed a list of key stakeholders and the significance of the identified stakeholders was discussed. The purpose of the stakeholder discussion was to think about and create an understanding of what stakeholders the organization is reaching or lacking and the current processes used to include stakeholders The two focus groups' discussions were combined for analysis.

Interviews

Interviews were conducted to assess current perceptions of the Consortium from the Governing Board's perspective. In-person (in the Flagstaff, AZ area) and phone semi-structured interviews were conducted from spring-summer 2017. A total of 18 current and past Board members participated in the interviews. Participants were e-mailed an introduction to the project and to schedule an in-person or phone interview if they wished to participate. Four current board

members did not respond and/or participate in the interviews because of time and scheduling constraints. Interview duration was typically 45 minutes to 1 hour and was audio-recorded and transcribed for further analysis with participant permission. Managers and scientists were asked role specific questions. Manager questions focused on the use of scientific information while scientist specific questions focused on science delivery and development. Both managers and scientists were asked about how they became involved in fire science/management in the Southwest, their involvement with the Consortium, communication with managers/scientists, ecosystem resilience, and future challenges of the Consortium. Given that ecosystem resilience is part of the Consortium's current goals, questions about the use of resiliency in science and management were asked. The results from these questions are not discussed in this report but are presented in Appendix C.

Analysis

Focus group and interview transcripts were coded for analysis using a grounded theory approach. Instead of analyzing data with presupposed theories, grounded theory allows themes to emerge while conducting research (Charmaz 2006). Data analysis began with open coding of transcripts and recording responses to focus group and interview questions to identify themes. As analysis progressed, themes were further developed and transcripts were reanalyzed to develop and categorize general themes. Broad categories were pre-determined from the research objectives, specifically, how the Consortium has evolved as a science exchange network, how it is perceived now through its success and barriers, and opportunities to improve Consortium programming. General themes from the focus groups and interviews were assigned to one of the categories then divided into subcategories. The analysis brings together recurring themes from the focus groups and interviews to directly address the objectives.

Although some members were not available for the focus groups or interviews, the collected data is believed to be representative of the entire Governing Board because most of the Governing Board participated in the study. The collected data is also believed to have reached saturation because there is enough information to replicate the study, additional or new information has been exhausted, and further analysis coding is not possible (Fusch & Ness 2015; Dibley 2011; Mason 2010; Charmaz 2006).

RESULTS AND DISCUSSION

Focus group discussions had a mix of managers and scientists in each group. A total of 8 scientists and 8 managers participated in the focus group discussions and interviews included 8 self-identified managers and 10 self-identified scientists. Governing Board members who are managers represent the Forest Service, Fish and Wildlife Service, Bureau of Indian Affairs, Bureau of Land Management, and State land, forest, and wildlife agencies. Specific positions include resource areas such as silviculture, forest and watershed health, fire ecology, fuels, fire management, and wildlife. Governing Board members who are scientists represent Northern Arizona University, University of Arizona, New Mexico State University, Ecological Restoration Institute, Forest Stewards Guild, Forest Service, and The Nature Conservancy.

Results are organized around the three research objectives: the evolution of the Consortium as a science exchange network, how it is perceived now through its successes and barriers, and where the Consortium should go from here through opportunities to improve Consortium programming. Successes reflect perceived positive outcomes of the Consortium programming, barriers are perceived external and internal challenges to achieving positive outcomes, and opportunities indicate potential ways to improve Consortium programming and products.

Evolution of the Consortium as a Science Exchange Network

To understand the evolution of the Consortium as a science exchange network, it is important to understand the key events that led to the formation and growth of the Consortium. To explore these events, the historical scan activity in the focus groups had Consortium Board Members identify key internal and external events (both positive and negative) that have affected the Consortium, jointly array those events on a timeline and discuss their significance (see Appendix D for focus group guide). Participants were also asked to categorize the events, put them into time periods, and then name the time periods. According to the focus group members, the time period names are based off of incident management language: storming, forming, and norming. Here, storming is described for the first time period as "figuring things out", forming is described as reacting to and forming how to react to new events, and norming is described as working towards making managed fires normal now and in the future.

What follows is a discussion of the key events identified by the focus groups. Because this discussion is a retelling of events, specific details may not be accurate, however, the details presented represent how members of the Governing Board perceive the events. Other events during these time periods may be important, however time constraints during the timeline discussions did not allow for extreme detail. Table 1 displays the key events discussed in this section. Appendix A includes all key events mentioned by focus group participants. The recordings of the focus group discussions were not always clear to tell who was speaking; therefore, some quotes may be inaccurately attributed to the speaker.

<u>Storming: Key Events from 2009 and earlier</u>

Landmark fires in the 2000s brought fire management complexity issues to the surface. For example, desert fires brought the role of invasive species in ecosystems and fire regimes to

regional attention. These fires highlighted a data gap in non-forested ecosystems and also threatened people living in the wildland urban interface. The Cerro Grande fire is remembered as an escaped prescribed fire. This fire is perceived to set back policy and set the stage for fire-adapted communities. The 2002 Rodeo-Chediski fire is described as a "wake-up call" because it was an "order of magnitude" bigger than any fire seen before in size, expense, and policy. This fire also led into discussions about severe ecological impacts and fuel treatment effectiveness because there were large high severity burn patches in untreated areas and less severe fire behavior in treated areas. Rodeo-Chediski is thought of as foreshadowing large future fires and a turning point because managers and scientists in the Southwest were coming to the realization that more areas on the landscape need to have fuel treatments.

The establishment of the Association for Fire Ecology (AFE) in 2000 is significant because it is the first professional science-manager organization with the goal of reintroducing fire to its ecological role. In addition to the creation of AFE, the 2008 AFE conference in Tucson, Arizona is thought to have helped build a community of people who wanted to work together on fire issues in the Southwest:

> *"…That [Tucson AFE Conference] just kind of built this community, essentially of practitioners, of scientists who wanted to work on fire together" – Scientist, Focus Group*

Organizational events such as the creation of JFSP and the FY2009 fire science exchange network Request for Proposals from JFSP are significant in how they led to the creation of the regional consortia. In 2009 when the initial proposal for the Southwest Fire Science Consortium was submitted to JFSP and accepted, one Governing Board member remembers calling potential collaborators for the Consortium:

"And I remember that being a positive experience with people being genuinely willing to go 'hey let's try this', 'oh great I want to do this'…And I think it set the stage well for subsequent work" – Scientist, Focus Group

Forming: Key Events from 2010-2015

The 2010 Schultz Fire and post-fire flooding in Flagstaff, Arizona and the following Santa Fe watershed field trip in 2011 put on by the Consortium led to the successfully public-funded, science-based Flagstaff Watershed Protection Project with mechanical and prescribed fire treatments. The Consortium organized and highlighted the event through their communication channels and field trip attendees relayed information to the City of Flagstaff, which led to successfully gaining public support and funding for fuels treatments in the 2012 election. Governing Board members view this project as a success in using and implementing decades of scientific research contributing to a shift in public support and understanding the need of mechanical treatments and prescribed fire. Because this example is a retelling of events, specific details may not be accurate, however, the details presented represent how members of the Governing Board perceive the event.

"And for me that's [Flagstaff Watershed Protection Project] one of our best examples where people attended this workshop, they saw this idea on the ground, they brought it back, they implemented it, and work got done. And it's very hard I think to show that link, that chain of events in many cases. I think it's happened in many other occasions but that is such a perfect example" – Manager, Focus Group

The interagency fuels workshop in 2011 is viewed as the first "real" event organized by the Consortium because it received a lot of positive feedback and led to the development of an interdisciplinary Governing Board. Before this event, the Consortium members were primarily fire managers and scientists. The Consortium made a primarily Forest Service workshop interagency and brought both scientists and managers from multiple resources together. The interagency fuels workshop emphasized the need for interdisciplinary and interagency members

on the Board for planning events and as general members to gain a bigger sense of the Southwestern fire community.

"…The fuels workshop, it really emphasized the need to engage interagency and interdisciplinary…That was also a perfect intersection between management and science." – Manager, Focus Group

"I remember Grand Canyon giving a presentation and talking about owls in the mixed conifer and we can only do this and this and the biologist goes "Well no. Actually it just means that you have to come back to consultation…and I was just like BING! Light on. We do not have the right mix involved right now, like these people have to be at the table planning these events." – Scientist, Focus Group

The 2011 fire season was a turning point in the Consortium's history. In the Southwest, the 2011 fire season resulted in hundreds of thousands of burned acres with large high severity patches and the largest fires in Arizona and New Mexico state history at the time. The 2011 fire season is thought to have brought everyone in the southwestern fire science and management community to the realization that these large fires are not anomalous, the scale of fuel treatments needed is not feasible, and led to discussions about landscape fire use and ecosystem resiliency.

"I think that period [2011 fire season] was really important for me moving from oh we have to stop these fires, we have to figure out how to avoid the next Las Conchas or something to being like this is going to happen, it's going to happen across great areas"- Scientist, Focus Group

After starting, the Consortium began to host conferences in partnership with AFE. The AFE conference in 2012 along with the Consortium's webinars and the Las Conchas fire field trip were timely to respond and address the 2011 fire season and to bring attention to the concerns of managers and scientists.

"…the [2011 fire] season did affect where we went and what we did." – Scientist, Focus Group

The 2011 fire season is believed to have created an opportunity for the Consortium to step into a leadership role. If another large fire, fire season, or other important event or topic occurs, the

Consortium can create products and utilize their platform to address the issue and foster discussions between managers and scientists.

The Consortium began to reach out to the public with events like *Living with fire in northern New Mexico* in 2013 and the smoke workshop in 2014. These events addressed and tried to engage the public as a stakeholder and audience directly for the first time. The communication and interaction with the public in the 2014 smoke workshop did not go as well as the Consortium had hoped because of a low public turnout. However, the public perspective was still addressed and attendees who had not been exposed to public perceptions had direct exposure to the public. The Consortium continues to try and engage the public with WUI summits, which addresses fire adapted communities, and Fires of Change which is a display of art and science open to the public that reached over 17,000 people.

Although the Consortium has events to engage the public, the Governing Board agrees that the focus and strategy on the public as a stakeholder is not clear because the public encompasses a great diversity of people across a diverse landscape. Because the public influences managers, the Consortium believes it cannot influence the managers if it is not influencing the public. This influence on managers led into a discussion about the perception of problems. For example:

> *"I think a lot of times things we think are issues with the public are not as much of an issue as they are but we don't do a lot of management because of that perception." – Scientist, Focus Group*

Managers may be heavily influenced by their perception of what is thought to be an issue with the public as well as actual public perceptions. Smoke impacts on communities were identified as barriers to treatment projects because public perceptions are believed to halt treatments.

Norming: Key Events from Present - Future

Board members identified an age shift in the fire community workforce as people start to retire and in the mentality of managers caring about the ecological impacts of fire in the Southwest:

"I feel like the last 5 years there's been a great increase in managers that really care about what fire does, not just fighting fire…" – Scientist, Focus Group

"I think one of the things that has changed is the mentality, the managers' mentality that they can now treat landscapes with fire. That is a huge change that I would argue 10 years ago, people never thought it was going to be doable. So I think the mentality and I think the Consortium is really about that right? We're about not only producing, having managers use the science, but having them change and I think that's one that I've seen that has produced change." – Scientist, Focus Group

The shift in the mentality of managers caring about the ecological impacts of fire has led to treating more landscapes with managed fire. The discussion and use of managed fire is prominent in 2016 and the Board hopes to increase it in future fire management. For example, the 2016 AFE Conference in Tucson helped create a niche for managed fire and highlighted the need for all land managers, owners, and scientists to communicate and collaborate with each other. The conference signaled a shift in mentality from suppressing fires to using managed fires as a tool for resiliency. More collaboration in using managed fire is desired because fire does not recognize boundaries and landscape level mechanical treatments are becoming less likely to be funded and implemented. There is a concern expressed by the Board that a future managed fire will escape and cease future use of managed fires – this is an opportunity for the Consortium to help prevent and have a plan to respond to future landmark fires, much like how they responded to and had influence after the 2011 fire season.

Table 1. Timeline of key events in the Consortium's history in order of appearance as identified and discussed by Governing Board members. Timeline Acronym Guide (alphabetical) AFE: Association for Fire Ecology; FWPP: Flagstaff Watershed Protection Project; JFSP: Joint Fire

Science Program; NNM: Northern New Mexico; RFP: Request for Proposals; SWFSC: Southwest Fire Science Consortium; WUI: Wildland Urban Interface

Storming: 2009 and Earlier	Forming: 2010-2015	Norming: Present - Future
2000s fires	Schultz Fire + flooding	Large managed fires
Desert Fires (invasive species)	Watershed field trip (Santa Fe)	Tucson AFE Conference
Cerro Grande Fire (WUI)	FWPP bond passed	
Rodeo-Chedeski Fire	Interagency fuels workshop	
Creation of JFSP	2011 fire season	
Creation of RFP Consortia by JFSP	AFE Conference (Santa Fe)	
Establishment of AFE	Las Conchas fire field trip*	
AFE Conference (Tucson)	Living with Fire NNM	
Pre-proposal for SWFSC	Smoke workshop	
Final proposal for SWFSC	WUI Summits	
	Fires of Change	
	Resiliency workshop	

*Las Conchas is a 2011 wildfire that burned 156,293 acres in New Mexico and was the largest fire recorded in state history at the time

How is the Consortium Perceived Now?

Understanding the current perceptions of the Consortium through perceived successes and barriers will help guide the Consortium, and potentially other fire science exchange networks and organizations, for future direction and programming by sharing information. Within the perceived successes and barriers are recurring themes from both the focus group discussions mentioned in the previous section and interview responses. Here, the successes described indicate positive outcomes of the Consortium programming while the barriers described indicate external and internal challenges to achieving positive outcomes.

Successes

Science Communication

The Consortium provides a platform for communicating science and sharing information, ideas, and issues throughout the Southwest region. Table 1 describes the perceived most effective

forms of communicating and disseminating science as identified throughout the interviews and focus groups. Responses were compiled and broken out into direct, indirect, and internet forms of communication and science dissemination.

Direct or in-person communication, such as conferences, field trips, workshops, personal interactions, presentations, webinars, and individual meetings are perceived as the most used and effective for delivering and receiving information between scientists and managers. Other important, but more indirect, ways of communicating science include: published peer reviewed articles and management-focused publications such as fact sheets, white papers, working papers, newsletters, summaries and reviews. Internet information sharing through e-mails, the Consortium website, videos, webinars, and social media are also important ways to communicate and disseminate science.

These communication forms allow members to have more access and awareness of relevant and understandable fire science information, resources, and opportunities for a multitude of different learning styles and needs. Members can see and learn from different projects and implementation techniques, simulate ideas for their work environment, learn about current and in-progress research, ask questions, and make professional connections.

Table 2. Perceived effective forms of science communication and dissemination (in order of how many respondents mentioned them) from focus group and interview responses. Direct forms are mainly in-person, indirect forms are not in person and may be available and accessed online, and internet forms are accessed online.

Direct	Indirect	Internet
Conferences	Scientific Articles	E-mail
Field Trips	Fact Sheets	SWFSC Website
Workshops	White Papers	Social Media
Personal Interactions	Working Papers	Videos
Presentations	Newsletters	Webinars
Webinars*	Summaries/Reviews	
Individual Meetings		

*Live webinars allow direct communication through chat features and discussion

"I think the Consortium provides a wealth of information and a wealth of opportunities to dig in to look at the videos, the website, and then to join field trips and workshops to interact with other folks who are dealing with the same topics, the same types of challenges that we're dealing with in our agency" – Manager 4

"...So after being on the board and working you know, with our sleeves rolled up next to each other and talking about things together…having them [scientists] actually solicit input from wanting to know what folks on the ground need and how we use it, and how we could use it better. I feel like it's instead of it being a relationship of looking up at them with awe, I still do of course, it's more like a two way thing where I feel like I can contribute to science by providing my input on what we need and how we can get the word out and use it better" – Manager 7

"…Sometimes when you're with a scientist sometimes you don't speak the same talk and there's a lot of statistical talk and that kind of stuff. I think it's getting better and I think the Consortium has done a lot of great things in helping to bridge that gap and making sure that managers are able to communicate their needs to scientists and scientists in return, are communicating in a way that's really effective. I do give a lot of credit to the Consortium for helping to bridge that gap because that is a really important one that I see." – Manager 4

In-person Communication

In-person forms of communication are perceived as the most effective science communication strategies. Field trips and conferences are described as the most useful forms because they best facilitate two-way communication between participants. Some Governing Board managers first became involved with the Consortium through these communication forms.

Field trips are often combinations of science, hands-on interactions, learning, and information and idea sharing. The outdoor setting is often comfortable for participants and allows seeing how fire incidents were managed and view on-the-ground fire effects. Field trips also allow scientists to understand the political setting managers work under, such as the process of getting prescribed fire on the ground and smoke impact concerns to nearby communities.

"I find the field trips probably the most valuable thing for me as a manager" – Manager 5

"I've also been fortunate at getting to go on, well only one of the field trips, but wow was it ever informative." – Manager 1

"I think the conversations and the exchange of knowledge when people are out in the woods is always notable and I think better than basically any other mode, even though it's probably the most complicated to get organized" – Scientist 3

Conferences are viewed as large venues for two-way communication between interdisciplinary and interagency scientists, managers, and interactions between the two groups. Scientists and managers have opportunities to present and communicate results and/or gain new information, receive feedback, network, and have discussions with each other about new ideas, problems, and questions. Unlike many other scientific or science-based conferences, managers are able to actively participate and provide expertise in activities. For example, the 2016 AFE Conference in Tucson, AZ had roundtable discussions where managers and scientists worked together to decide on management actions. By working together on a common interest, scientists and managers were able to see different perspectives in a real-life scenario and make connections for future questions, projects, and communication.

"I mean I have people that ask me about going to the different conferences and whether it would be worthwhile and I usually tell them that if they have time, yes for sure. And some of them that haven't been before I think were really surprised at all the information that was there." – Manager 1

"And somebody just had recommended 'hey this is a good conference you should go check it out' and I did and it was really really good and it was really eye-opening because they had some speakers there especially relative to fire and climate change…" – Manager 8

"One of the meetings I actually like going to" – Manager 6

"That's huge that they [FMOs and engine captains] want to come and be able to interact and that they see it not as just, you know, these highfalutin academics talking to each other, that there's actually something there for them" – Scientist 1

In-person opportunities allow managers and scientists to interact, which increases exposure and the amount of communication between the two groups. Involvement with the Consortium expands the network of personal contacts and improves access to differing and diverse perspectives and experiences.

"…Folks working out in the woods have a lot of knowledge themselves either based on experience with a particular place or from years working in different places, trying different things and so often there's a benefit in just that peer-to-peer connection, particularly on topics where the science is sort of an emerging topic whether it's invasive species or changes in fire behavior, something that maybe we haven't seen before, for example the large high severity patches of fire that we've seen in the last decade. There's not enough research out there to guide us necessarily and so having peer-to-peer sessions where managers can say 'Look, I haven't done an academic study on this but this is what I've seen on my landscape when we tried x, y, or z' That can be pretty potent too." – Scientist 3

By attending in-person events, participants are able to see each other more often and become comfortable directly and regularly interacting with each other. Before working with the Consortium, many Governing Board scientists described sparse, individual and local interactions with managers on specific issues, such as giving a presentation on a research topic. Governing Board managers described their interactions with scientists as containing one-way communication. Because of the involvement in the Consortium, there are more direct and consistent interactions of two-way communication and therefore better and broadened relationships. These interactions between scientists and managers shift scientist attention to

applied questions, lead to more use of science and collaboration, knowledge gains about the needs and interests of managers, and wide information distribution.

Professional Connections:

Besides attending in-person events, Governing Board members also indicated the diversity of the Consortium and being a part of the Board as attributing to more two-way communication. As described at the beginning of the Results and Discussion section and in the Evolution of the Consortium as a Science Exchange Network section, the Governing Board and the Consortium members are interagency and interdisciplinary, partially as a result of the interagency fuels workshop in 2011. The workshop emphasized the need for interdisciplinary and interagency members on the Board for planning events and as general members to gain a bigger sense of the Southwestern fire community.

"…Bringing resource people together with fire people together with researchers…building those connections and realizing that each person has their own expertise and that all of the expertise is important. And so the researcher's not always right and the manager's not always right, but they really actually need to work together." – Scientist 2

Because the Governing Board and the Consortium members are interagency and interdisciplinary, Governing Board members described being able to interact, work directly, and develop professional relationships with people from different agencies, backgrounds, and perspectives on fire management, which helps broaden science communication to different audiences and create understanding. Through personal interactions, managers and scientists can network, ask questions, discuss issues, simulate ideas, co-create research, further their knowledge, and develop new interests. Governing Board managers and scientists are able to use these personal connections and interactions from the Board and from other Consortium events in their primary jobs.

"You know I just didn't have those connections and being able to have face-to-face time versus writing an e-mail is really important and kind of building relationships. So now I do know several scientists in the Southwest and I'm much more likely to pick up the phone and give them a call directly or drop them an e-mail." – Manager 4

"And I think the connections with the managers, the people that I know that have cycled through the Governing Board, that I didn't know before, have become very very strong allies and I feel like there's a person in the corner of any piece of the Southwest that I can call up and ask a question and they would more than happily answer the phone if they knew it was me and help me think about that question, or answer it, or give me ideas." – Scientist 1

"I think that it's been helpful in making those professional connections. You know meeting folks that you've either heard of or meeting folks and they say something and you're like 'Hm I need to talk to that person because they may know something that I've been having an issue with or they may know something I've had a hunch on'…" – Manager 6

"…I don't know how you place a value on it, but there's definitely a value [in getting to know scientists] …I guess for people who apply the science, when you know the scientist you can ask them specific questions, you can dive deeper, you can trust the science I guess a little more too." – Manager 7

Applicable Research:

Through professional connections, managers and scientists can work with each other to produce more effective and more useful research. Scientists and managers can work together to address specific management questions and call attention to specific research needs, such as climate change, to fill in data gaps. Scientists can involve managers from the beginning to create more applicable and practical science that is more likely to be used, understood, and lead directly to on-the-ground results. Managers can also reach out to scientists to incorporate research into landscape scale planning and implementation.

"I just don't want to burn out there and have us not learn anything." – Manager 2

"I think the gains for me are being able to contribute information about fire science, being able to share research that I'm doing or that other people are doing that I'm aware of and think is important, being able to hear from managers as to what their needs are, which in turn, you know, helps me develop better research projects" – Scientist 4

Science Use and Implementation:

Both managers and scientists on the Governing Board believe that using science to inform management decisions and seeing science implemented on the ground are successes and benefits of the Consortium. Both managers and scientists use, encourage the use of, and distribute fire science on the Board and in their primary jobs to have some influence and impact on current and future management of Southwestern landscapes.

"I think the real benefits of working with folks outside the research community is that connection to what's actually happening and it takes it from your computer screen or this piece of paper to an actual difference on the land." – Scientist 3

"You can have all the science in the world but if it's not being put on the ground then nothing." – Manager 6

Through the Consortium, scientists benefit in sharing information to see the use of fire and science in management and managers value research by using science to develop and support projects and treatments.

"…it's given me support for science and using science to support some of the things that we're doing in the field…So I think that's the role that I see it - a support system for me. That I'm not just out there kind of preaching all this stuff but someone else is also giving me information to support some of the things we're trying to accomplish." – Manager 1

As mentioned in the Evolution of the Consortium as a Science Exchange Network section, one example of science use and implementation is the public-funded, science-based Flagstaff Watershed Protection Project.

Members of the Governing Board

The Governing Board perceives some of the Consortium's success is attributed to the members of the Governing Board and the energy, creativity, and work they put into the Consortium individually and as a group. From the beginning, the Consortium engaged with and outreached to

multiple state, federal, non-governmental organizations, non-profit organizations, and universities in the Southwest that continue to actively engage as stakeholders. Governing Board members share the Consortium's information with other people from their agencies or groups and reach out to different stakeholder interest groups, which has helped expand the Consortium as a credible organization.

"The fact that people can really come together, not be interested in forwarding their agency, or their university, or this and that, and really just think about the Consortium and think about what we can do together, I think that's our biggest success is our Governing Board and our Co-PIs and the relationship between the two and the level of trust in our managers and our academics have between each other. To me I think that's the biggest key thing that has led to our success" – Scientist, Focus Group

Members also expressed a feeling of accomplishment in the Consortium because of the amount and quality of products and the ability to check off milestones and keep momentum as a result of working with people who have similar goals and objectives. Past and present Governing Board members have directly helped the Consortium evolve to, what they believe, a leadership role for fire science and management communication.

It's when you stop being productive or stop having things that are value added and beneficial to others then it just becomes another meeting…it's like everything else there's ups there's downs, we never just put on a meeting. We try to really think about how is this going to change people when they leave…it's really about setting up this timeline or this thought process of education, success, more education, more success and trying to keep everybody moving through this time of changes in management and policy. And I think that is at least personally what gives me and professionally so much gratification from working with this group" – Manager, Focus Group

Members of the Governing Board are a part of the Consortium because they have a passion for fire, science, and/or they want to have an influence on current and future natural resource management in Southwestern landscapes. Individual involvement comes from a feeling of importance and urgency to have and encourage science informed management decisions because of increased fire severity in wildfires and the threats of climate change. There is personal

gratification for Governing Board members in seeing science being used and implemented on the ground. The Governing Board members also feel they make a difference and improve the well-being and livelihoods of others through the Consortium and in their day-to-day jobs.

"So this idea that we are moving lands into a better condition through fire is something that I'm very proud of… it's something that I feel like I've been a part of…I'm not sure that would have happened without the Consortium" – Scientist 6

"…I hope to gain more knowledge about fire's effects on the landscape and I guess I hope to perhaps have some influence on future management." – Manager 8

"…And if I can look back and think 'You know, hey, I helped. I contributed to a shift in management that really meant that there are still ponderosa pine trees on [a forest] or some other place that's currently under threat of high severity wildfire'. That, to me, is a more important marker than things like 'Oh I got 29 publications'…" – Scientist 3

Successes described in this section indicate positive outcomes of the Consortium programming. As described in this section, themes of the perceived success of the Consortium include science communication, science use and implementation, and the members and stakeholders involved in the Governing Board and the Consortium. The main success of the Consortium is their science communication efforts, which result in favored forms of in-person communication, such as conferences and field trips. In-person communication facilitates two-way communication, professional connections to both managers and scientists, and opportunities to collaborate and develop applicable research. The next section describes perceived external and internal barriers to achieving positive outcomes.

Barriers

Funding

Funding and budgetary constraints were identified as the greatest challenge the Consortium faces, as well as a challenge partnering agencies and organizations face. JFSP is funded through the Department of the Interior and the Department of Agriculture, which are the main sources of

funding for the regional Consortia and an important source of funding for fire science research. There is uncertainty in the amount of continued long-term funding through JFSP, although there is a general belief in how the Governing Board members will continue to work together in some capacity on fire science delivery if funding disappears.

Agencies and organizations often have travel and budget restrictions or constraints to send personnel to conferences and meetings. Although the Consortium provides travel grants to help offset costs and encourage attendance, they are not able to provide support for everyone who may want to attend.

"…Compared to the money that we're spending on dealing with fire crises, spending on fire suppression in a crisis mode, the amount of learning and opportunity for finding more efficient and effective means of avoiding crises is what we're talking about at these meetings…For agencies to effectively deal with fire crises, they need all of their personnel in all of their different disciplines and expertise…the people that are going to be doing the NEPA analysis to allow treatments to occur, the silviculturalist, the timber sale managers who need to be able to actually carry out treatments, that's where the cuts are…That's a perfect example of what keeps us spiraling into a crisis mode. Because all we do is react." – Scientist 4

In addition, agencies and organizations are encouraged to "do more with less" with declining budgets. There is a perception that there is more work needing to be done than money available to implement treatments and that there is greater competition for funding opportunities. The Consortium can step into a leadership role to help agencies and organizations communicate while creating different avenues of science delivery.

<u>Time Constraints and Staffing:</u>

As a result of budgetary constraints, managers may be performing multiple jobs and have multiple responsibilities, which decreases the amount of time available to broaden their knowledge base, collaborate, and communicate with scientists on potential treatment projects. For instance, some governing board managers described how they have multiple jobs and both

Governing Board managers and scientists described these time constraints and staffing issues as challenges managers deal with in general. While the Consortium strives to provide easy to understand and time efficient products, the amount of time managers have to allocate to learning is an ongoing challenge.

Budgetary and time constraints also affect scientists. Governing Board scientists described how collaborating and communicating with managers is a large time and resource investment, which can be difficult for strictly research-oriented scientists, where the metrics of performance evaluations are often the amount of publications and grant funding. Some speculate that scientists in general may not want to engage with the Consortium or collaborate with managers and other stakeholders because those interactions are not valued as highly or are as professionally rewarding as other evaluation metrics. Positions with built-in science delivery metrics, such as extension university positions, have more flexibility and encouragement to communicate and engage management partners in addition to meeting publication and grant funding expectations.

As a result of agency and organization budgetary restrictions, many members who are encouraged to do more with less will generally have less time to engage with the Consortium or be a part of the Governing Board because of other obligations. The Consortium has one full-time staff position, the program coordinator, who handles much of the logistics, planning, communication, and keeps the Consortium operating at a high level. This position may not continue if the Consortium loses funding and would leave a gap in how the Consortium functions and operates in fire science delivery.

Products and Engagement:

Planning and producing easy-to-understand outputs and deliverables in a timely manner is identified as a challenge, partially because of the funding, staffing, and time issues explained above. Other challenges include continuously producing relevant products; keeping up with communication opportunities, such as social media venues; evaluating and monitoring Consortium products; increasing communication between managers and scientists; and reaching out to other stakeholders who may not know of or utilize the Consortium.

Federal planning groups (such as environmental analysis groups) and line officers were identified in the focus groups as stakeholders who may require more direct outreach and influence from the Consortium. There is concern that planners and line officers are not receiving enough relevant information and therefore not applying the information into management project plans. Managers and implementers who are receiving and understanding information from the Consortium may not be able to apply it because there is a disconnect between information and communication with the planners and line officers. Line officers and planners may not see themselves as mangers, practitioners, or scientists, so they may not think there is relevance in attending a Consortium event. Practitioners in the suppression and post-fire communities were also identified as needing more engagement. As mentioned above, time constraints could be a barrier to participation from these groups.

"…[Another challenge is] getting folks engaged in the fire science community that really do use fire science and really need fire science to really get them engaged in the Consortium…I think there are a lot of folks who are in need of it who just aren't connecting with the Consortium for whatever reason" – Manager 4

Some managers expressed feeling overwhelmed by the amount of information available and the lack of time they have to "dig up" useful information. Although the Consortium creates

generally user-friendly products, there is a desire to have more easy-to-understand products, especially since many managers face time constraints.

"There's a lot of research out there and often time the barrier is not so much new research, new data collection, but rather putting together existing information in a way that is intelligible and usable for managers" – Scientist 3

The most helpful is actually is making that science accessible and understandable. I mean that's really important. I love science, I would have been a researcher if I could have gone onto school more…but not everybody likes reading scientific journals. – Manager 7

Access and knowledge of information may still be barriers to science use. Some managers expressed the lack of access and knowledge of treatment and climate modeling, which may be perceived as impacting more state agencies and private landowners who may not be able to access or afford some modeling technology.

Science and Management Topics

Specific topics such as climate change mitigation, managed fire, and public perceptions of fire are identified as challenges because they may be difficult to implement or change. Another challenge is adequately covering topics of interest to various audiences. As the Consortium has grown, there are more interdisciplinary interests but there is also a challenge in balancing the amount of products and topics to keep all audiences engaged. One specific topic challenge is the lack of focus on diverse vegetation types. By not addressing diverse systems, the Consortium is not reaching and addressing the scientific needs of the entire Southwest fire community.

"I'll tell you that when I was talking to my counterpart in the agency and why he wasn't part of this he said 'Because I don't care about ponderosa pine ecosystems'" – Manager, Focus Group

There are also topics that may affect fire science and implementation that need to be addressed but may be outside of the Consortium's main role of facilitating science communication. Such examples include the role of the Consortium in the political realm and involvement in public education through teacher workshops.

Management and Logistical Constraints:

Managers often have to address a multitude of issues outside of science. Public perceptions of fire, smoke impacts, budgeting of treatments and constraints, policies, contracts, treatment timing, internal barriers, and other issues are examples managers, and potentially scientists, may have to work with before and during management implementation.

"They [managers] often think but won't say that science is a very small part of what determines what they do day-to-day…Like okay that's nice and in a perfect world that's what we would do but I can't burn because of the neighbor down the road who would call my District Ranger about smoke and that's what drives my life." – Scientist, Focus Group

For scientists implementing research in an area, these issues can add difficulty in data collection if they are not aware of or do not understand the various constraints under which managers work. Management and logistical constraints may not be understood and may hinder fire management and science implementation in projects.

Agency and Organization Culture:

Agency and organization culture is a challenge because Consortium partners and members represent different interests, such as multiple uses, conservation, preservation, commercial, environmental activism, and other interests. Challenges arise in how to best communicate and stay relevant to differing interests and goals. Because each agency and organization represents different interests, science based decision-making, the use of science, and the ability to change perspectives and management with new science may vary. Some agencies and organizations are also known for high employee turnover, which may hinder relationship building and knowledge exchange between managers and scientists.

"I also think there is a strong sentiment or there's a culture in [some agencies] that 'We know what we're doing' and that can shut down learning from new science. And that, that's also a real challenge and you hit it, you hit that wall and you work around it, and you find the innovators, you find the people that don't want to just do what they've been doing. It's tough. The culture is a tough one." – Scientist 5

This section described perceived external and internal barriers to achieving positive outcomes. The main perceived barriers of the Consortium are externally caused by funding uncertainty, time constraints, and staffing within the Consortium and within the agencies and organizations the Consortium supports. Other external barriers identified are also important but often relate back to funding, time, and staffing issues. These include planning and producing deliverables and engaging multiple audiences, managerial and logistical constraints, and agency and organization culture differences. Internal barriers to the Consortium include specific science and management topics, such as diversifying vegetation type information in Consortium products.

Where does the Consortium go from here?

The previous sections described the evolution of the Consortium as a science exchange network and the current perceptions of successes and barriers of the Consortium. This section will describe where the Consortium can go from here through future opportunities to improve Consortium programming and address identified barriers. Many barriers described in the previous section are external and out of the control of the Consortium, especially barriers relating to funding, time, and staffing constraints. However, some of the challenges can be addressed through further research and directing products to accommodate constraints. This section discusses research and product opportunities to address challenges and provides general suggestions brought up throughout the focus groups and interviews. Appendix B provides a full list of suggestions from the interviews and focus groups that may not be specifically addressed in this section.

Research

Managers are most satisfied with directly applicable scientific information for planning, modeling, and implementing on-the-ground work. Without management considerations, scientific information is more difficult to apply. Managers are generally satisfied with the available scientific information through the Consortium, especially in the ponderosa pine ecosystem. As mentioned in the Barriers section, adequately covering science and management topics are a challenge. Pinyon, juniper, and oak woodlands, chaparral, grasslands, shrublands, and riparian areas are vegetation types that were identified as having information gaps and may have opportunities for future research and synthesis. The focus groups and interviews indicated that more general scientific information on these vegetation types are desired. More applicable scientific information such as the short and long term effects of mechanical and burning treatments in these types, climate change impacts, and modeling and planning information for these vegetation types are also desired. More information, on how fire affects different archaeological sites, wildlife, and hydrology impacts are also desired, especially in the aforementioned vegetation types. For example, from a manger point-of-view, there is disagreement in continuity among archaeologists over what artifacts found in a landscape may be able to withstand fire and what cannot, which can be seen as "holding up projects" if a site in one area cannot burn but a similar site in another area is allowed to burn. The Consortium can help encourage more scientific studies and collaborative research on these topics and vegetation types and can encourage more specialists to attend and/or present at conferences, field trips, and other forms of science communication.

Social science research is another opportunity that may be useful for the Consortium and their stakeholders. For example, information on effective communication with the public and

other stakeholders, like line officers and planners, tribes, and regional and national leadership may be useful in understanding various audiences and improving relationships and communication with them. Because the Consortium has multiple university partners, working with university communication, public relations, and advertising experts may create collaborative opportunities and more useful products.

Monitoring, measuring, evaluating, and quantifying the effectiveness and success of the Consortium and products is another research opportunity. This can include tracking deliverables over time to evaluate which ones are used the most, if they are providing relevant information to their stakeholders, and if outputs are turning into outcomes. Although this report will help evaluate the Consortium, it does not evaluate specific deliverables.

"I think my biggest fear for the Consortium is we become static and we just keep doing these same deliverables and we don't keep pushing some aspect of our deliverables" – Scientist, Focus Group

Products

Most of the challenges described in the Barriers section are externally caused and are tied to the main barriers of funding, time constraints, and staffing. The Consortium can try to work within these barriers by providing creative products to communicate scientific information to their stakeholders through multiple formats. The main successes of the Consortium are perceived to be their in-person communication outlets, however, with decreasing funding, time constraints, and staffing, the opportunities for Consortium members to attend in-person events will likely decrease. Although it would not replace the successes of in-person communication, technology can be used to give virtual tours of in-person events, such as conferences, workshops, and field trips. Video teleconferences can be used to broadcast plenary speakers, for example, or videos can be made to show the highlights of specific events in conjunction with other informative

materials and links to get more information. Conference presentations could also be live webinars and allow viewers to virtually interact by asking questions. Web forums could also be 'live' for activities so people could participate in the conference without being there. Web forums could also be a useful tool on the Consortium website for managers and scientists to reach out and ask questions to the community about specific topics or help with projects. The idea of web forums came from a different portion of this study interviewing general Consortium member scientists and managers that will be analyzed and written separately from this report. These alternative forms of in-person science communication could help improve access and knowledge of information to Consortium members and help in creating an understanding within the community. The Consortium could work with the university partners in various departments to help provide some of these products, especially since the funding, time, and staffing challenges affect the Consortium as well.

The Consortium can continue to provide easy to understand and timely products. For example, if another large fire, fire season, or other important event or topic occurs, the Consortium can create products and utilize their platform to address the topic and foster discussions between managers and scientists, similar to how they addressed the 2011 fire season. The Consortium can also help continue to address more social issues, such as public perceptions and smoke impacts, to help managers navigate these issues and implement work on the ground

While many of the products the Consortium provides are concise, more condensed and varied lengths of products are also desired. For example, 1-hour webinars may be difficult for some to have time to watch. Providing 30-minute webinars, or even more condensed 15 or 3-minute webinars in addition to the 1-hour webinar may appeal to managers who are under time constraints and who can watch the 1-hour webinar or read a fact sheet from the webinar if they

are interested in learning more about a study. Similarly, podcasts and varying lengths of podcasts could be a way to reach parts of the community that are more field going and may not have time to look at a webinar but they can listen to a podcast in their work vehicle. Podcasts can also touch on any topic or problem to create a story and can be more informal than a regular type of presentation, which can help build and expand the Consortium community. More story based information and science news or headlines could also be ways of reaching and engaging different types of audiences through different forms of media, which will help the Consortium stay relevant.

CONCLUSIONS

This paper has described the evolution of the Consortium as a boundary spanning organization, how the Governing Board members perceive it now through its successes and barriers, and where the Consortium should go from here through opportunities to improve Consortium programming. Key events described in the Evolution of the Consortium as a Science Exchange Network section helped shape the Consortium to the successful organization it is perceived as today. Landmark fires in the 2000s, like the Cerro Grande and Rodeo-Chedeski fires, helped demonstrate how large and severe fires need more information for future management, which helped set the stage for the Consortium to eventually come in and work with multiple agencies and organizations. The Flagstaff Watershed Protection Project is viewed as a success in directly implementing science on the ground; the interagency fuels workshop is credited to making the Consortium and the Board more interdisciplinary; and the 2011 fire season is a realized opportunity for the Consortium to come into a leadership role by providing relevant products and events. These key events are centered around the science communication efforts of the Consortium.

As a boundary organization, the Consortium bridges the gap between scientists and managers by existing between the two social worlds to help solve problems, transfer information, and facilitate collaboration for more productive policy and decision-making through their science communication forms (Guston 2000; 2001). In-person forms of science communication, such as conferences, field trips, and workshops, are favored Consortium programming and products. In-person communication facilitates two-way communication, builds professional connections to both scientists and managers, and provides opportunities to collaborate and develop applicable research and implement science on the ground.

The Consortium appears to be recognized as scientifically credible, relevant, and legitimate from how the Governing Board uses and describes their interactions with the Consortium, which are metrics of a successful boundary organization (Cash et al. 2003). The Consortium also facilitates boundary spanners, like the Governing Board members, who work at the interface of science and management (Ritter 2006). Governing Board members either self-identify or describe their roles as boundary spanners between science and management. Members disseminate, communicate and/or translate scientific information for management use and encourage others in their respective agencies or organizations to share information and use the Consortium as an information resource and as a venue to ask scientific and management related questions.

The Consortium's primary barriers to successful science communication are externally caused by funding uncertainty, time constraints, and staffing within the Consortium and within the agencies and organizations the Consortium supports. Though these barriers and others exist, the Consortium can continue providing relevant products and explore creative ways of science

communication through research and different media to work within the identified barriers and to continue bridging the gap between science and management.

This study helps to understand the Consortium as a regional fire science exchange network and the impacts it has on science delivery and wildfire management in the Southwest. Although each regional science exchange network may have a slightly different story of how their exchange evolved, many of the successes, barriers, and opportunities discussed in this report may be similar or shared between the regional exchanges across the country. For example, national surveys of the exchange networks also found in-person communication to be useful in communicating and delivering science (Kocher et al. 2012; Hunter 2016;). Since many of the exchange networks face barriers to conducting regional evaluations (Maletsky et al. 2016), the findings from this study can inform other regional fire exchange networks for more productive fire science delivery and management across regions and contribute to the general knowledge of boundary organizations.

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APPENDIX A: HISTORICAL SCAN TIMELINE TABLE

Table 1. Timeline of all events in the Consortium's history as identified by Governing Board members

Category	2008 and Earlier	2009	2010	2011	2012	2013	2014	2015	2016
Professional (personal)	2000 fires		North Jemez WFU	Interagency fuels workshop	Santa Fe AFE Conference		Resiliency workshop	San Carlos Apache Field Trip	Tucson AFE Conference
	AFE Conference				Las Conchas field trip		Smoke workshop	Fires of Change	
	FSG Collaboration				Track Fire (water-fire connection)		Slide Fire field trip		
							Fires of Change		
Organizational (within SWFSC)	AFE establishment	Pre-proposal workshops (3)		Interagency fuels workshop	2011 fires field trips	Living with Fire NNM	Incident of the Year Awards	Incident of the Year Award	Tucson AFE Conference
	Creation of JFSP			Watershed field trip (Santa Fe)	Santa Fe AFE Conference		Resiliency workshop (Tucson; FAC, resilience thinking	Commitment to make fire "normal"	Fire season overviews
	Creation of RFP Consortia by JFSP				Video production		Smoke workshop	Sponsored post-fire workshop (Santa Fe)	WUI Summits
	SWFSC Pre-proposal	Final proposal for SWFSC					Slide Fire field trip	Fire Season Overviews	Incident of the Year Award
	Coronado science partners						Fires of Change	San Carlos Apache Field Trip	Student position created
								Fires of Change	Fires of Change
Fire Management Community	Cerro Grande Fire (WUI)	Change in policy language	Santa Fe Watershed Management Plan	Interagency fuels workshop	Santa Fe AFE Conference	Yarnell Fire	Seasonal weather predictions	Large managed fires	Large managed fires
	Rodeo-Chedeski Fire	PFC establishment (NM)	North Jemez WFU	Watershed field trip (Santa Fe)	Track Fire (water-fire connection)	FireTREX	Smoke workshop	Multiple objective fires	Monitoring
			Schultz Fire		FWPP bond passed	Arizona PFC	Slide Fire field trip	Fire Season Overviews	Incident of the Year Award

						Living with Fire NNM	Incident of the Year Awards	San Carlos Apache Field Trip	Fire season overviews
							Skunk Fire	Incident of the Year Award	Tucson AFE Conference
									New Mexico PFC non-profit status
Fire and/or Climate Science	Westerling et al. 2006			Wallow and Las Conches Fires	Williams & Baker paper and response	Use of term resilience	Resiliency workshop	Fires of Change	Tucson AFE Conference
	Swetnam tree ring work			Williams paper			Fires of Change		Fires of Change
							Pinaleno Mountains Field Trip		
Fire Regimes/ Behavior	Desert Fires (invasive species)			2011 fire season	Burning up of mixed conifer	Burning up of mixed conifer		Large managed fires	Tucson AFE Conference
	Rodeo-Chediski Fire			Interagency fuels workshop		Living with Fire NNM			Large managed fires
	Cerro Grande Fire (WUI)			Watershed field trip (Santa Fe)					Cedar Fire
Ecosystem Resiliency	Cerro Grande Fire (WUI)						San Carlos Apache "puzzle"	Sponsored post-fire workshop (Santa Fe)	Tucson AFE Conference
	Rodeo-Chedeski Fire						Resiliency workshop		
							Pinaleno Mountains Field Trip		
							Skunk Fire		
Policy/ Funding Environment	Planning rule (first attempt)	Federal Wildland Fire Management	CFLRP projects funded		Planning rule/cohesive strategy				
	Cerro Grande Fire (WUI)	Cohesive strategy			Additional CFLRP projects funded				
		CFLRP bill passed							
		GIFWFM Policy							

Timeline Acronym Guide (alphabetical)

AFE – Association for Fire Ecology

CFLRP – Collaborative Forest Landscape Restoration Program

FAC – Fire Adapted Communities

FSG – Forest Stewards Guild

Fire TREX – Fire Training Exchange

FWPP – Flagstaff Watershed Protection Project

GIFWFM – Guidance for Implementation of Federal Wildland Fire Management Policy

JFSP – Joint Fire Science Program

NM – New Mexico

NNM – Northern New Mexico

PFC – Prescribed Fire Council

RFP – Request for Proposals

SWFSC – Southwest Fire Science Consortium

WFU – Wildland Fire Use

WUI – Wildland Urban Interface

APPENDIX B: LIST OF RECOMMENDATIONS

Product Suggestions and Opportunities

- Condense webinars to 30 minutes or shorter / provide shorter versions for managers
- Explore new ways of knowledge sharing through story telling, especially from managerial points of view. Story telling could also be used as a way reach the public directly and help community building. Examples: podcasts with varying length and detail, social media venues, forums, science "news/headliner" articles, daily science facts, interesting videos
- Create or facilitate more frequent in-person meetings or field trip opportunities for large and small groups (informal meetings preferred)
- Virtual events – combine maps, written material, videos, key points, and recordings of take away points from attendees
- Invite members to suggest themes and focus areas
- Encourage managers to talk about their needs; provide a space where managers, scientists and students can talk about their needs and potentially work together
- Reach out to more line officers and planning groups
- Reach out more to private and state land managers
- Explore the idea of having a science facilitator as a consultant or part of the Board
- Explore involvement with the National Association of Fire Investigators and National Wildfire Coordinating Group
- Highlight differing perspectives for more effective communication
- Define resiliency / explicitly state resiliency in products
- Explain scientific jargon in easy-to-understand terms

- Involve more non-governmental organizations
- Explore options for loss of Consortium funding and loss of the program coordinator position. Examples: broaden base of funding through other sources, discuss creating an interagency position, hire a student assistant for the program coordinator
- Continue to address topics in concise formats (e.g. 1 page fact sheets)
- Maintain the user-friendly and searchable website

Opportunities Outside of the Consortium

- Create a searchable website that collates research (can be outside of fire science) into categories and provides a bibliography and abstract
- Resiliency research in range management
- Resiliency regulations for state/private entities
- Standardize data availability through federal agencies

APPENDIX C: RESILIENCY RESULTS

To understand the focus of ecosystem resiliency in management and science, Governing Board members were asked how much they consider ecosystem resiliency as a part of their work, if they distribute or use resiliency information, and how the Consortium can help them address this topic in their work. Both mangers and scientists generally agree that ecosystem resiliency is a central theme in their work.

"Every time I look at any kind of question or I look at a NEPA document, or I look at a planning document, or I look at fire effects, the background of that is how is this more resilient? Or how is it not?" –Manager 2

Most managers say they use ecosystem resilience information for developing silviculture and planning treatments, understanding fire regimes, or generally looking at available information to better understand the concept. Scientists generally agree that they disseminate ecosystem resilience information through their research publications, fact sheets, and extension channels.

Some managers expressed that they were unsure or not actively managing for ecosystem resiliency in their agency:

"So it's something I think about a lot…I'm not sure it's something I'm actually doing. It's something that I know needs to be done but it's not something that I have control over very much." – Manager 8

Others view resiliency as more of an idea for discussion than a part of current management. Some scientists feel that they need to be more comfortable with the concept before being able to share it effectively. While some managers were not sure if some of the information they are using is explicitly ecosystem resilience, some scientists felt they were not sharing information in an explicit frame; for example, discussing regeneration is often not framed as resiliency but is often considered a component of resiliency. Uncertainty or discomfort in using or sharing

ecosystem resilience information stems from uncertainty in the definition of the term. For example, both managers and scientists questioned the understanding of ecosystem resiliency:

"…It's kind of a fashionable buzzword that nobody really knows what it means…What are we talking about when we're talking about ecosystem resilience and how do we build that into what we do and is it really going to help anything…or are we kidding ourselves that we can build ecosystem resilience through management" – Manager 8

So I'm just beginning to really try to understand what resilience means...and I feel like with resilience, I'm not as comfortable with it or as used to it as I am with some other ideas like ecological forestry or restoration. – Scientist 3

The Consortium can help managers and scientists understand ecosystem resiliency by helping to create a better understanding of what ecosystem resilience means. Governing Board managers and scientists suggest in-person events such as conferences, field trips, and meetings to have an open dialogue, explore concepts, and discuss what resiliency means and how it varies in particular places. Other suggestions of providing information include bulletins, short videos, white papers, and information from current projects such as the Southwest Fire and Climate Project that can be available online.

Both managers and scientists suggested further research on resilience, especially questions, observations, and collaboration from managers, long-term studies in different ecosystem types, and the effects of managed fire, to understand and distribute information about resilience in the Southwest. Other ideas include the Consortium acting as a clearinghouse to pair graduate students with projects and resources to help close science gaps in the Southwest and putting topics such as regeneration and sustaining native ecosystems in a resilience frame.

APPENDIX D: HISTORICAL SCAN GUIDE

Agenda & Questions (total time ~ 2 hours)

Common Understanding of Evaluation (~5 minutes)

- Instructions: The purpose of this brief discussion is to develop a common understanding of the purpose of this evaluation/ case study and to provide an introduction to the project and the historical scan.

Key Events (~15 minutes)

- Instructions: The purpose of this activity is to think about the key events (both positive and negative) that have affected SWFSC and your involvement in SWFSC. We're starting this with a broad focus, so this can include internal (events within SWFSC and your involvement in SWFSC) or external (events that have impacted SWFSC or fire management/ science in the Southwest). It may also be helpful to think about how events have changed over time with respect to fire regimes/ behavior or climate patterns.
- Questions to Consider:
    - What are the key events (positive and negative) in the past 8 to 10 years that were important to you professionally (with respect to your involvement in SWFSC)?
    - Organizationally (within SWFSC)?
    - In the Southwest fire management community?
    - In the fire (or climate) science community?
    - In fire regimes/ behavior?
    - In climate patterns/ change?

Timeline Development (~30 minutes)

- Instructions: Once everyone has recorded their key events, we will develop a timeline on the wall. See example below. Kerry will put the events on the timeline and everyone will have the opportunity to discuss the timing of the events and their significance.
- Timeline Example

	Professional (personal)	Organizational (within SWFSC)	Fire Management Community	Fire or Climate Science	Fire Regimes/ Behavior	Climate Patterns/ Change
2008 & earlier						
2009						
2010						
2011						
2012						
2013						
2014						
2015						
2016						

Timeline Discussion (~45 minutes)

- Instructions: Once the timeline is completed, we will discuss and analyze the overall meaning of the events. The goal is to look at the events from the different perspectives of those present. Kerry will record key points from the discussion, but it will also be recorded and transcribed. The following questions will be asked as prompts if necessary.
- Questions:
    - What are the high/low points or successes/challenges?
    - Where are the shifts or turning points? What kind? Why?
    - How would you name the earlier/mid/later periods (chronologically/vertically)?
    - What trends/issues do you see over the period? Vertically? Horizontally?

Key Stakeholders (~15 minutes)

- Instructions: The purpose of this activity is to develop a list of the key stakeholders/ audience (managers, scientists) of SWFSC and what processes are used to include them in SWFSC activities. Kerry will write down key points from the discussion on the wall, and the conversation will also be recorded and transcribed.
- Questions:
    - Who are SWFSC's major stakeholders?
    - How were these stakeholders identified?
    - Are there any stakeholders missing?
    - Which stakeholders are most influential in SWFSC's work and why?
    - Which stakeholders are least influential in SWFSC's work and why?
    - Who are your closest personal SWFSC -related collaborators?
    - What processes are used to include stakeholders in SWFSC's activities?
    - How did these processes evolve?
    - How are stakeholder interactions evaluated?
    - What are the key lessons that have been learned interacting with SWFSC stakeholders?
    - Has anything changed as a result of what you have learned about stakeholder interactions?

Time for Addition Discussion as Needed (~10 minutes)

APPENDIX E: INTERVIEW GUIDES

Interview Questions for Scientists

Introduction

1. Please introduce yourself and tell me how you're involved in fire science in the Southwest, how you came into your role, and any other relevant background details.

Science Delivery and Development

2. In what ways do you communicate and deliver your fire science research? Who is your primary audience?
3. Do you work with stakeholders outside of the research community in science delivery?
    a. If yes, can you provide examples?
        i. Context
        ii. Who was included and why
        iii. What was done
        iv. What happened
        v. What were the outputs
        vi. Was there anything unexpected
        vii. What – if anything – changed
        viii. Was the process evaluated
    b. What were the major successes? Major challenges?
        i. Were any key lessons learned?
    c. Will you work with these or other stakeholders again?
    d. What are the benefits of working with stakeholders outside of the research community? Best practices? Can you provide some examples?
4. What can be done to make fire science research and information useful for stakeholders?
5. What can be done to facilitate effective fire science delivery?

Involvement with SWFSC

6. Please describe how you became involved with the Consortium, how you interact with the Consortium now, and how that has changed over time.
7. What do you hope to gain from working with the Consortium?

8. In what ways has the Consortium been helpful? How can the Consortium better assist you?
9. Has the Consortium programming impacted your scientific research? If yes, please describe.
10. How would you describe your relationship with fire managers prior to working with the Consortium? How would you characterize your relationship with fire managers now?
    a. (If they note a change): What factors contributed to any change that you described?
11. How would you describe your communication with fire managers prior to working with the Consortium? How would you describe your communication with fire managers now?
    a. (If they note a change): What factors contributed to any change that you described?
    b. In what ways has the Consortium been helpful in your communication of results/with fire managers?
12. In what ways does the Consortium communicate with you? Are these ways useful to you? How can the Consortium improve communication with you?

Ecosystem Resilience

13. How much do you consider ecosystem resiliency as a part of your research? Do you disseminate ecosystem resilience information in your work?
14. How can the Consortium help you investigate ecosystem resiliency in your research

Wrap-Up

15. What challenges does the Consortium face?
16. Is there anything else about science delivery or development or your interactions with the Consortium that you would like to mention?
17. Do you have any questions for me?

Interview Questions for Managers

Introduction

1. Please introduce yourself and tell me how you're involved in fire management in the Southwest, how you came into your role, and any other relevant background details.

Involvement with SWFSC

2. Please describe how you became involved with the Consortium, how you interact with the Consortium now, and if and how that has changed over time.
3. Please describe if and how you use science in your work and where you obtain scientific information. How satisfied are you with the available scientific information?
4. How does your involvement with the Consortium relate to your job? What do you hope to gain from working with the Consortium?
5. In what specific ways do you interact with the Consortium?
6. Has the Consortium programming or your interactions with the Consortium impacted your work? If yes, please describe.
7. Has your use of science changed since you started interacting with the Consortium? If yes, please describe.
8. How would you describe your relationship with scientists prior to working with the Consortium? How would you characterize your relationship with scientists now?
    a. (If they note a change): What factors contributed to any change that you described?
9. How would you describe your communication with scientists prior to working with the Consortium? How would you describe your communication now? What factors contributed to any change that you described?
10. In what ways does the Consortium communicate with you? Are these ways useful to you? How can the Consortium improve communication with you?
11. In what ways has the Consortium been most helpful in your work?
12. In what ways can the Consortium better assist you in your work?
13. What can the Consortium do to make scientific information more useful in your work?

Ecosystem Resilience

14. How much do you consider managing for ecosystem resiliency as a part of your work? Do you use ecosystem resilience information in your work?

15. How can the Consortium help you address managing for ecosystem resiliency in your work?

Wrap-Up

16. What challenges does the Consortium face?
17. How would you like to see research communicated?
18. Is there anything else about the use of science or your interactions with the Consortium that you would like to mention?
19. Do you have any questions for me?