

**Overlapping Layers of Fire Management
Examined through the Lens of Post-fire Erosion**

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List of abbreviations/acronyms

WUI	Wildland Urban Interface
MSF	Multiple Streams Framework
NCWFMS	National Cohesive Wildland Fire Management Strategy
BLM	Bureau of Land Management
ACEM	Ada County Emergency Management
IDL	Idaho Department of Lands
IOEM	Idaho Office of Emergency Management

Keywords

Wildland Urban Interface, decision making, wildfire, Multiple Streams Framework, interviews, policy

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Abstract

At the Wildland Urban Interface (WUI), where undeveloped landscapes meet the built environment, there is a complex interaction among local, state and federal land and hazard stakeholders that must work together to protect life and property from wildfire. The effective use of wildfire science is considered key to successful wildfire management and mitigation at the WUI, however, it is not well known how science may be effectively used in wildfire management. In this study, we used Multiple Streams Framework (MSF), a popular policy process model that outlines the components of policy creation, as a lens to examine the role science plays in wildfire policy and management. By examining wildfire policies at the WUI of Boise, Idaho USA and interviewing land and hazard managers, we targeted what makes science useful as managers make wildfire decisions. We found that city, state and federal stakeholders address wildfire hazards with distinctly themed sets of policies. Interviews revealed that science is considered useful for managers when it draws boundaries, is quick to understand, and helps stakeholders acquire funding for mitigation projects. This study contributes new understanding regarding the push and pull of science by decision-makers at the WUI by identifying what attributes of science make it useful when making decisions at the Wildland Urban Interface.

Objectives

The objective of this study was to provide a ‘best practices’ tool for decision makers conducting Wildfire Hazard Assessments at the Wildland Urban Interface (WUI) that includes the incorporation of site-specific science in decision-making by answering the following questions:

1. What is the structure of stakeholder interaction during the creation of Boise’s Wildfire Hazard Assessment?
2. How is science used and communicated by stakeholders within this structure?

This work being completed by the Student PI at the time of this research worked to model, map and interpret the nature and spatial distribution of post-fire debris flow hazards in the Boise WUI. This work led the author to interact with multiple governing agencies in Boise, where the complexities of fire hazard management and challenges of effectively communicating scientific outcomes to managers, thereby motivating the questions being addressed in this research.

This objective was designed in response to the Graduate Research Innovation (GRIN) Award's call to examine ‘societal issues and fire’ by creating a connection between science creator and potential end-users (i.e. land and hazard managers) at the WUI. The ‘best practices’ tool that resulted from this study was the novel application of the Multiple Streams Framework (MSF), a

public policy framework, to explain how science influences problems, policies and politics at the WUI. MSF has not previously been used to explain decision-making at the WUI. We conducted this study anticipating that findings from MSF's novel use at the WUI aid in a more pointed transfer of science creator to end user.

We hypothesized that how a stakeholder defined a wildfire hazard would be reflected in the set of policies that address wildfire hazards at the WUI. We assumed, under MSF, that science influences problems and policies. As a result, we posited that we could identify how different stakeholders may use science at the Wildland Urban Interface as a function of their wildfire policies. Upon project commencement, we found that there is very tight stakeholder interaction taking place at the Boise WUI. As a result, our research focuses heavily on answering question 2.

Background

As wildfires grow in size and severity, fires increasingly cross jurisdictional boundaries, and so too must wildfire management. The “All hands – all lands” approach of the National Cohesive Wildland Fire Management Strategy (NCWFMS) exemplifies today’s wildfire management in the United States. The NCWFMS provides direction for planning, risk analysis and collaboration between local, state and federal agencies, and tribal and non-governmental partners to restore and maintain resilient landscapes, create fire-adapted communities, and respond to wildfires (Department of the Interior, Office of Wildland Fire).

The NCWFMS is structured around using the best-available science, while the National Action Plan, which supports the implementation of the Cohesive Strategy, underscores the need to use science and data to support decision-making at all levels (National Action Plan, Cohesive Strategy). Science is framed as being capable of providing solutions to modern wildfire management problems and fire-adapted communities, and is considered to be the key to successfully preparing for wildfire at the WUI (Integrating the Local Natural Hazard Mitigation Plan into a Community’s Comprehensive Plan, 2013). Management strategies, including the Cohesive Strategy, highlight the importance of the distribution and production of science from which sound decisions can be made at the local to national level.

Yet while there is a push by the NCWFMS for wildfire managers to use science, there is also continually a pull by managers and funders to make science “useable”. This is exemplified by the Joint Fire Science Program, with the slogan “Research Supporting Sound Decisions”, and the Fire Science Exchange Group, which is dedicated to aid in the transfer of science to decision-makers. Despite the motivation of these groups to hand science to decision makers, what exactly makes science “useable” remains poorly and broadly described in the literature. For example, the National Wildfire Coordinating Group describes usable science as that which is capable of “integrating [with] the missions of resource management in fire-adapted ecosystems” (Machelis et al., 2002). However, literature review reveals little about what makes fire science useful to decision makers. In fact, little is known about how fire managers make decisions given the information in front of them (Machlis et al., 2002), and we may know more about what makes science *not* usable; a lack of trust between scientist and manager (Sicafuse, 2011), differences in culture and values between researchers and decision makers (Finch and Patton-Mallory, 1993), a

lack of time to examine and interpret scientific findings (Wright, 2010; Hunter, 2016), and differences in what is considered 'salient' between scientists and managers (Lemos et al., 2012) are all considered to limit the use of science in decision making.

According to Machlis and others (2002), what makes knowledge usable to decision-makers requires it to provide information (e.g. data), insight (a well-rounded understanding of the system be worked in), prediction (forecasts) and actions (e.g. suggested ways that the impacts of wildfires can be reduced). In addition, science must address a decision-maker's needs at a level of detail appropriate to the decision (Machlis et al., 2002). Creating and distributing science that meets these requirements is understandably challenging to achieve at the WUI, where one form of science is being delivered to stakeholders at many levels; different decision-makers have different problems that science can inform.

Wildfire science has been found to be useful when it is provided within general technical reports that provide user guides and synthesize major findings (Barbour, 2007). Barbour also found that distributing science through seminars and publications were less favored to active learning through field trips. Additionally, Hunter (2016) found, through interviews, that science is most frequently used during the planning processes of management. However, while these attributes describe under what circumstances wildfire science has been used, there is no indication of what attributes of science makes science useful.

The studies summarized above reveal the necessity to understand what makes science useful to decision makers. Though the studies unveil that some attributes of science, including succinctness and tangibility, provide utility to managers, a comparison of science's utility between managers, especially at different levels of management, has yet to be seen; is wildfire science that is considered useful to a county hazard manager the same as what is useful to a state forester? Additionally, the studies do not focus on the transfer of science to management at the WUI. As wildfire at the WUI threatens lives and infrastructure, understanding how science informs the safety and wellbeing of residents who may be affected by wildfire is paramount. Lastly, the aforementioned studies do not divulge how science is used in the policy making process. At the WUI, policies play a particularly important role in preparing for and responding to wildfire. The need to understand the role that wildfire science plays when managers make wildfire policy decisions is growing as more people expand into the WUI.

Materials and Methods

Problems, Policy and Politics: the Multiple Streams Framework

This project identifies how wildfire science influences problems and policies under local politics at the Boise WUI. By examining decision-making at the Boise WUI through a formalized public policy framework, we can systematically understand how wildfire science influences the problems and policies that land and hazard managers must address when making wildfire hazard decisions. The Boise Foothills WUI provides an excellent case study location on this topic; a diverse set of wildfire stakeholders work collaboratively while individually representing diverse jurisdictions and goals. Additionally, both the County and State updated their hazard mitigation plans in 2016 (the year of this study), and three wildfire events threatened hundreds of homes in

the Boise WUI. As such, 2016 provided an optimal time period to examine wildfire decision-making and the role of wildfire science at the WUI.

The Multiple Streams Framework (MSF) is a public policy model that explains the decision-making process. MSF explains how policies are made under ambiguous conditions; ambiguity in the policy-making process refers to having multiple ways of thinking about the same condition (Sabatier and Weible, 2014). Ambiguity in policy-making results from an accumulation of multiple ways to define problems that policy makers face, and results in the creation of multiple policy solutions to address those problems.

MSF is comprised of four main components: problems, policies, politics, and a window of opportunity (Figure 1). The problem stream contains all of the possible problems that a government may be attending to at any given time. Decision makers in government are often aware of problems due to indicators. Indicators are often simple statistics, and may comprise of a single value (e.g. ninety firefighters died on-duty in 2015), or a trend in values (e.g. the number of acres burned annually in wildfires has increased since the 1980s). Decision makers are also made aware of problems through focusing events. A focusing event is a sudden development, such as a disasters or crisis, which calls the attention of policy makers and, likely the public (Kington, 1982). How a decision maker describes a problem is called ‘problem definition.’ How a problem is defined influences how a problem is ultimately addresses with a policy.

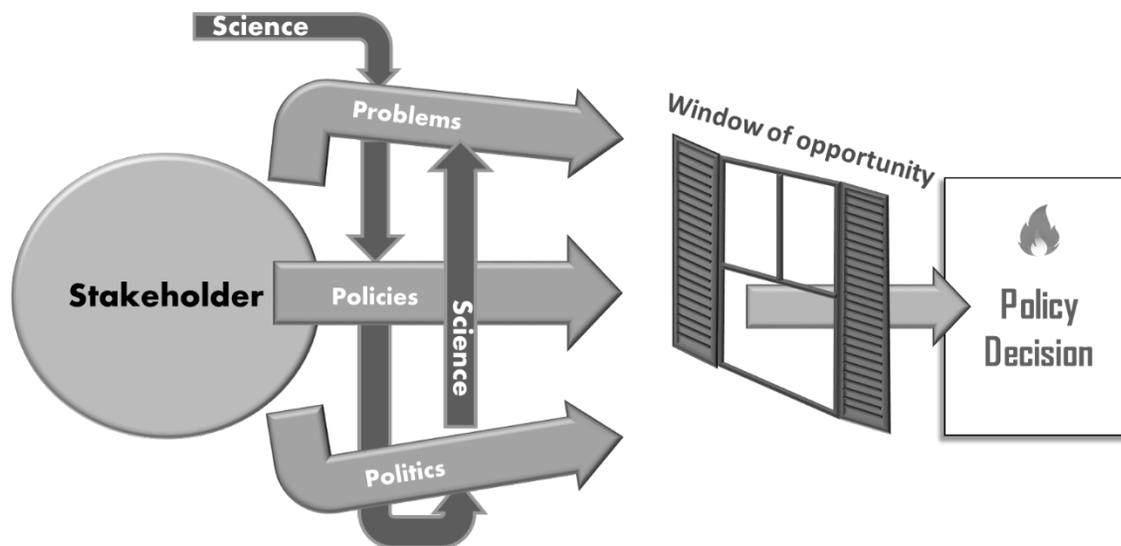


Figure 1 The Multiple Streams Framework

The policy stream is comprised of potential policy solutions to problems. The policy stream holds many policy ideas that are supplied by stakeholders within policy communities (i.e. decision makers at the WUI). Every stakeholders has their own set of solutions to a given

problem, but only policy solutions that are technically feasible and accepted by fellow stakeholders are seriously considered (Kingdon, 1982) and implemented as new policies.

The final stream, the politics stream, is comprised of the public mood and changes in government authority (e.g. a new governor is elected). The mood of the public alters how receptive civilians are to government decisions, and will influence the support or opposition of a given policy. Changes in government authority may alter how stakeholders define a problem which, in turn, will alter the favor of the public to policy solutions under consideration.

The Multiple Streams Framework assumes that the problems, policies and politics streams flow independently of each other until the streams merge and flow through a window of opportunity, during which time a new policy is implemented. A window of opportunity may open and close quickly; a new administration may have the momentum from a recent election to push new policies through the window in quick succession while the public mood favors the new administration, but lose momentum over time. Similarly, a window of opportunity may open suddenly as the result of a disaster. Hypothetically, a city may have several new wildfire-oriented building codes drafted for implementation, but it is not until a wildfire destroys several homes and businesses that the building codes pass as new ordinances. Windows of opportunity may also open and close slowly. Climate change, for example, may act as a slow opening window through which several policy decisions may flow through as the salience of climate change permeates the politics stream.

Science plays a key role in all three streams of MSF. Science can identify new problems (i.e. newly-discovered toxins in wildfire smoke), and is often the source of indicators used to identify problems. For example, countless measurements, calculations, analyses and interpretation have culminated into the recognition that wildfires have increased in size and severity since 1980 (Westerling, 2016). Spatial analyses and statistical assessment have identified that growing fire size and severity can be both attributed to fire suppression (Marlon et al., 2012) and climate change (Westerling, 2016; Abatzoglou and Kolden, 2013). Science may also aid in creating and informing policy solutions. Science can create or be the source of the discovery of new things that may act as an exciting new solution to a problem. Science may also influence the politics stream. New scientific discoveries may become salient to the public around a given issue, and change the public mood surrounding a problem.

Multiple Streams Framework and the Wildland Urban Interface

MSF provides a formalized framework to observe the policy-making process, making it ideal for observing the use of science when producing wildfire policy and making wildfire decisions at the WUI. At the WUI, wildfire policies are made by a diverse policy community: city, state, and federal stakeholders that each have policies that address wildfire hazards. The jurisdictions and policies of these stakeholders often abut or overlap one another, creating management complexity within shared space. MSF, however, allows us to examine the policy-creation process of each stakeholder at times when the window of opportunity is open and new science is being considered in the decision-making arena. By examining how each stakeholder defines a problem, identifies a solution to said problem, and brings it through the window of opportunity

with information that wildfire science provides, we can better understand how diverse sets of stakeholders ultimately use science to make decisions at the WUI.

Study Area

The Boise, Idaho WUI (Figure 2) provides an example of a WUI where diverse land and hazard managers must work in close proximity to one another. Three land management agencies and two hazard management agencies have a stake in the wildfire activity at this interface, including the City of Boise, Idaho Department of Lands (IDL), and the Bureau of Land Management (BLM). Hazards within the Boise WUI are managed by Ada County Emergency Management (ACEM) and the Idaho Office of Emergency Management (IOEM). These stakeholders collaborate frequently, and share knowledge that informs wildfire hazards in the ignition-prone, topographically complex WUI.

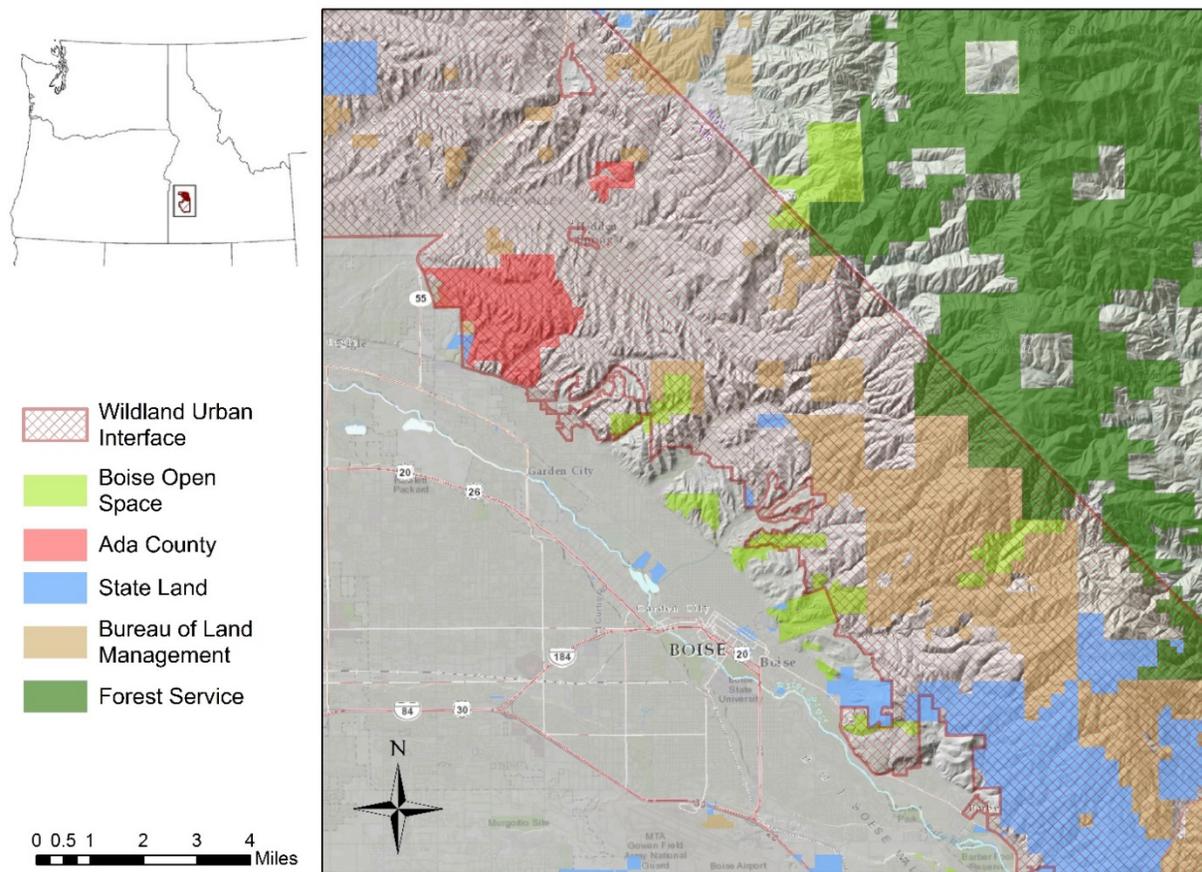


Figure 2 Map of the Boise Wildland Urban Interface

County and state hazard agencies work closely with local, state and federal land managers to prepare for wildfire hazards and mitigate its potential effects on life and property. This policy community gathers annually for the Southwest Idaho Wildfire Mitigation Forum, where

managers and practitioners share new information, discuss ongoing projects and consider lessons learned during the previous wildfire season. Additionally, it is common for these stakeholders to work together to supply education and outreach to the public, share data and collaborate on wildfire prevention projects, including fuel breaks, mowing projects, and Firewise gardens.

While stakeholders often make decisions independent of each other, Boise represents a WUI where stakeholders are tied closely to one another, and decisions are often reached through collaboration and information sharing. Despite having different goals and jurisdictions, these stakeholders confront similar wildfire risks, namely that wildfire may burn on their land and threaten life and property at the WUI. Similarly, members of this closely confined policy community have a similar science-based knowledge of wildfire hazards in the foothill because information sharing among agencies is high; managers have the same science at their disposal from which they can make decisions. However, despite having similar sets of knowledge about the area, each stakeholder addresses the same wildfire risks with different policies.

Research Design

We collected quantitative and qualitative policy data from Boise WUI stakeholders using explanatory sequential design (ESD, Figure 3). ESD is designed to collect qualitative data (i.e. interview results) that help explain quantitative findings (Creswell, 2015). We began by compiling Boise WUI wildfire policies currently in place by each stakeholder. We then performed a content analysis of the collected policies to assess and interpret different themes between the wildfire policies. The resulting themes were coded into distinct categories to quantify and compare the policy themes of each stakeholder. Subsequently, we interviewed managers representing each Boise WUI stakeholder to qualify the results of the coding to determine how science is used to inform their policies and problems.

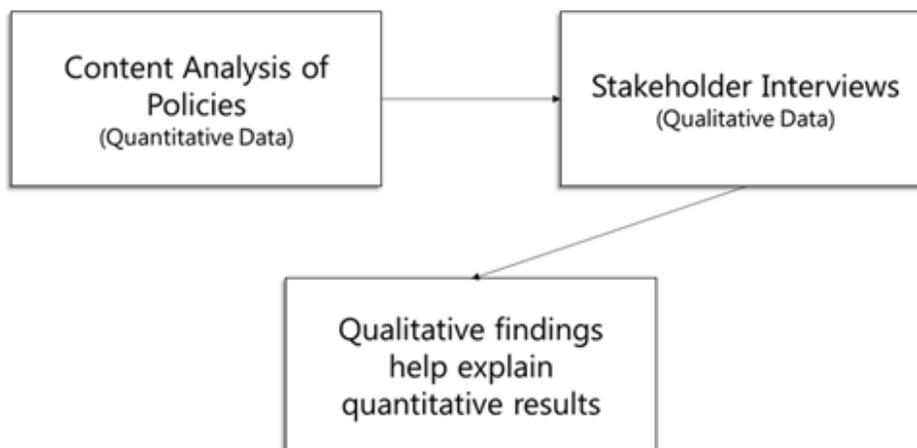


Figure 3 Explanatory Sequential Design

Quantitative analysis (policy assessment)

We collected the wildfire policies of the land and hazard managers who participate in wildfire management at the Boise WUI. We acquired policy documents from stakeholder websites. Policies of the stakeholders included ordinances, codes, statutes, goals, and objectives (see Table 1). From these policy documents, we identified policies that specifically address wildfire hazards at the WUI, which include wildfire prevention, wildfire response, wildfire mitigation, and secondary wildfire hazards (i.e. flooding and erosion). The resulting list of policies were placed into an excel workbook for content analysis, and include key descriptive data about the policy source for possible future assessment.

Table 1

Stakeholder	Policy Documents
City of Boise	Boise City Code, Comprehensive Parks and Recreation Plan
Bureau of Land Management	Manual Transmittal Sheets: Fire Program Management, Fire Planning, Land Health, Integrated Vegetation and Management, Land Use Planning, Burn Area Emergency Stabilization and Rehabilitation
Idaho Department of Lands	Idaho Statutes
Ada County of Emergency Management	Ada County All Hazards Mitigation Plan
Idaho Office of Emergency Management	Idaho Hazard Mitigation Plan

We completed content analysis of the WUI wildfire policies to measure the latent content (underlying meaning) of the policies in regards to how a policy addresses a wildfire hazard. We divided the policies into distinct themes. We required themes that succinctly describe the way each stakeholder addresses a wildfire hazard, thus informing the problem stream of MSF. It was important that the themes were both simple and exhaustive. Once we established the codes, we assigned a code to each policy. Policies that fit under more than one theme were given multiple codes.

The policies of the Boise WUI policy community were found to fit under one of four policy themes, which we adopted from the Ada County Hazards Assessment (Ada County All Hazard Assessment, 2013). The four policy themes are (1) manipulate, (2) reduce exposure, (3) reduce vulnerability and (4) increase ability to respond to a wildfire hazard. *Manipulation* was coded for policies that address controlling or altering a wildfire hazard. Examples of policies that manipulate wildfire hazards include landscaping ordinances (e.g. specific vegetation not allowed to be planted because it's highly flammable) and building standards (e.g. foundation fill must be as compact as undisturbed hillside). *Reducing exposure* to a hazard was coded for policies that prevent intersecting with wildfire and secondary hazards in the first place. For example, there are

city zoning codes that prevent development from taking place on slopes greater than 25% grade, while IOEM has a policy that encourages the purchase landslide-prone lands to prevent developers from building on them. A policy was coded as *reducing vulnerability* if the policy attempts to increase the ability of an object to withstand a wildfire hazard. An example of reducing vulnerability is the city policy requiring that new homes constructed within the WUI use fire resistant products on exterior walls. A policy was coded as *increasing the ability to respond* to a hazard when the policy increases access for emergency response (e.g. fire trucks) or when the policy is aimed to educate citizens and managers about wildfire hazards. Examples of policies that increase the ability to respond include mandating all homes in the WUI to have turn-around access for fire trucks, but also include goal-oriented policies such as increasing collaboration between stakeholders or providing public outreach.

We also coded each policy for who is considered responsible for implementing the policy, and included (1) an individual, (2) a group of people, or (3) the government. The individual refers to a homeowner, landowner or business owner. The group may refer to a subdivision developer, advocacy group, or Firewise community. The government refers to the local, state or federal government that enforces the policy. Responsibility was not always made clear in the policy, we interpreted the most appropriate and logical responsibility for each policy. In many cases, multiple parties were interpreted to be considered responsible. .

Qualitative assessment (interviews)

We interviewed at least one member of every land and hazard management agency within the Boise WUI. Individual interviewees were selected based upon our knowledge of wildfire managers representing different stakeholders within the Boise WUI policy community. Other managers were recommended to us during the initial set of interviews in a quasi-snowball sampling method.

Our semi-structured interview script was designed to acquire information about individual managers' experiences with wildfire science and policies at the Boise WUI. We divided the semi-structured interviews into four sections (1) background questions about the managers, (2) stakeholder interaction questions, (3) wildfire problems and policies and, (4) use of science by managers.

Interviews focused heavily on the problem and policy streams of MSF. *Problems and policies* questions were designed to link interviews into two of the MSF streams. We conducted this portion of the interview by asking questions that sought to identify what wildfire problems the managers currently face, how they define those problems, and provide potential policy solutions to those policy problems. *Use of science* questions were designed to glean information as to how different stakeholders and individual managers access, analyze and use science to make decisions. We used interviewee responses to the *problems and policies* interview questions to create a direct link between MSF and the use of science by managers. By asking the same core questions of every manager, we were able to compare the responses by stakeholders in tandem with quantitative results of the policy coding assessment.

Results and Discussion

Quantitative analysis results

Stakeholders of the Boise WUI policy community have a combined 164 policies that address wildfire hazards at the WUI (Table 2). A complete list of annotated policies for each stakeholder is described in the Metadata for this report.

Each stakeholder addresses wildfire hazards with distinct policy themes (Figure 4). At the city level (divided into Fire, Zoning, and Parks and Recreation), fire and zoning ordinances dominantly work to manipulate and reduce vulnerability to wildfire hazards, while 78% of city Parks and Recreation policies address wildfire by increasing the ability to respond to hazards. 79% of IDL policies reduce exposure to wildfire hazards, though many of their policies fall under more than one policy theme (e.g. requiring that salvage loggers dispose of excess slash both manipulates and reduces exposure to wildfire hazards). The majority of BLM policies, 67%, manipulate and increase the ability to respond to wildfire hazards (e.g. providing slope stabilization after wildfire and providing early warning for flood evacuation in burned areas). The IOEM was found to have a fairly even distribution wildfire policy themes, while the policies of ACEM policies most frequently address reducing a resident's vulnerability to wildfire hazards (~45%) and to increase the ability of both citizens and emergency personnel to respond to a hazard (~50%).

Table 2

Stakeholder	Manipulate	Reduce exposure	Reduce vulnerability	Increase ability to respond	Total
City of Boise	25	14	28	15	68
Boise City Fire	8	7	12	6	27
Boise City Zoning	16	7	14	2	32
Boise City Parks and Recreation	1	0	2	7	9
Ada County Emergency Management	3	4	10	11	22
Idaho Office of Emergency Management	4	6	5	6	13
Idaho Department of Lands	8	15	5	6	19
Bureau of Land Management	16	10	5	12	42

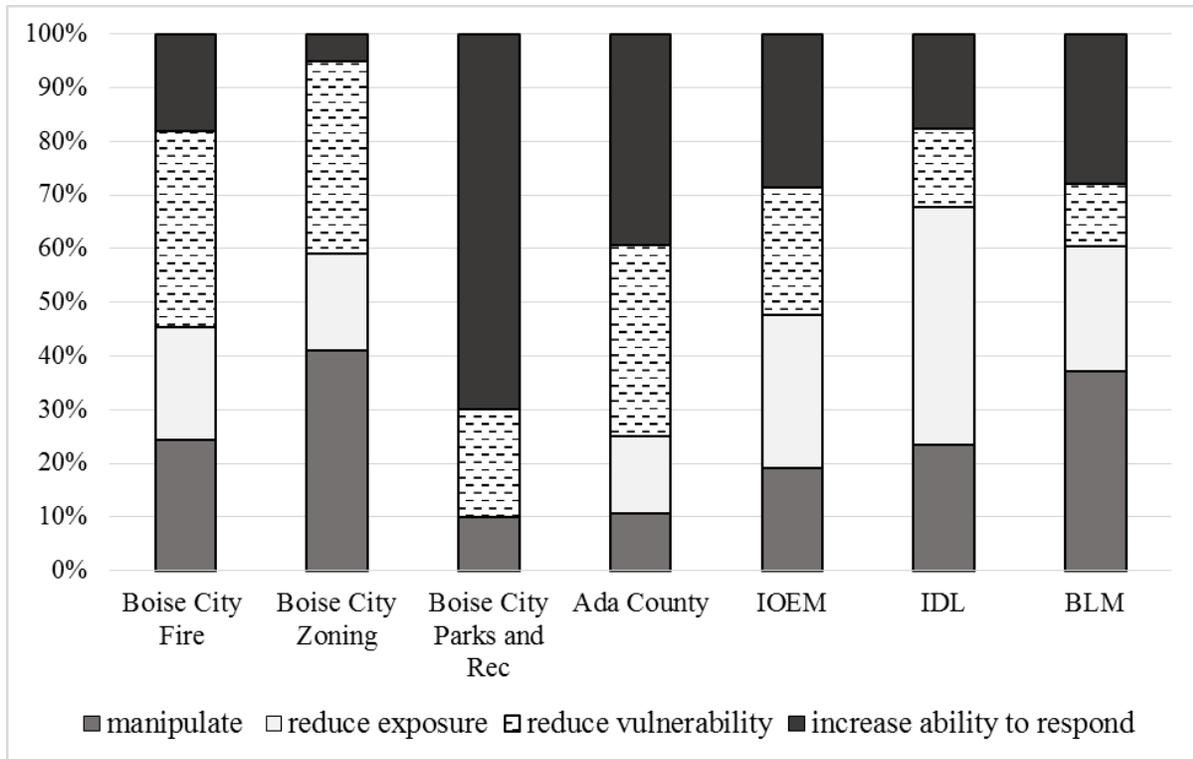


Figure 4 Portion of policies falling under four policy themes, divided by stakeholder

Dividing the 164 policies into who is responsible for implementation, we found that different stakeholders held different people responsible for upholding WUI policies (Figure 5). At the city level, ~37% of policies were written to be carried out by individual homeowners or business owners, while ~63% were written for implementation by groups of people, and only ~16% of policies were considered to be the responsibility of city government itself. Conversely, at higher levels of government, more responsibility of policy implementation was placed at the government level; 100% of policies at IOEM and BLM were written such that those agencies considered themselves responsible for implementing those policies. A complete breakdown of policy responsibility is found in Table 3.

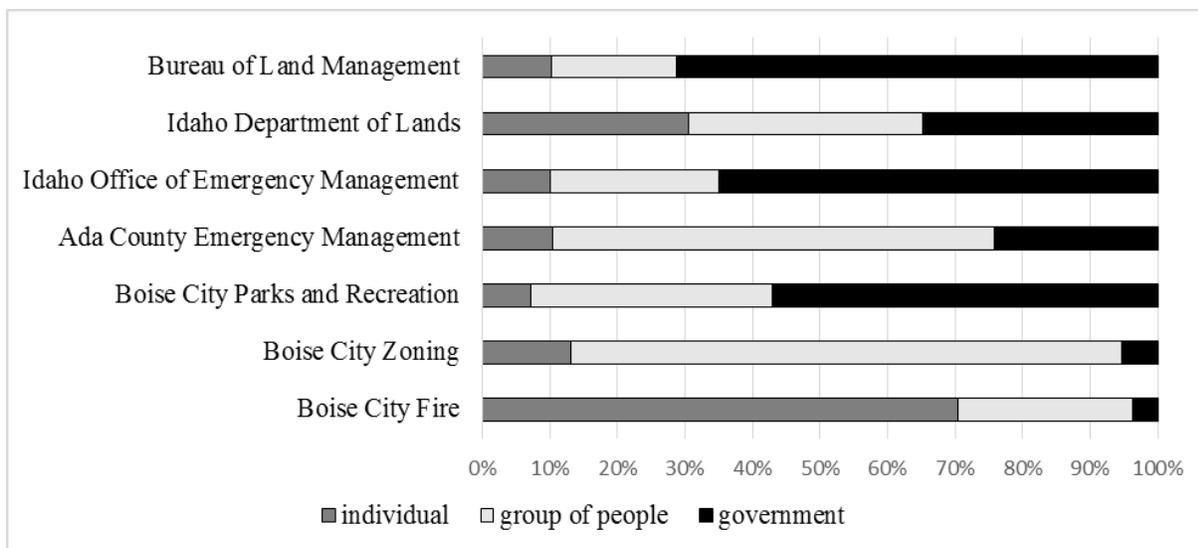


Figure 5 Relative responsibility to implement a policy divided by stakeholder

Table 3

Stakeholder	Individual	Group of people	Government	Total policies
City of Boise	25	43	11	68
Boise City Fire	19	7	1	27
Boise City Zoning	5	31	2	32
Boise City Parks and Recreation	1	5	8	9
Ada County Emergency Management	3	19	7	22
Idaho Office of Emergency Management	2	5	13	13
Idaho Department of Lands	7	8	8	19
Bureau of Land Management	6	11	42	42

Qualitative interview results

Problems

Managers identified several wildfire problems at the Boise WUI. Interviewees frequently described development in the foothills as a problem that the community is currently facing; ACEM, IDL, BLM, and IOEM noted that continued development into the Boise Foothills and

toward hazardous areas was one of the top wildfire problems that they will face in the coming years. Another frequent wildfire problem identified through interviews is that humans cause their own wildfire hazards. The City, BLM, IOEM and IDL all discussed the presence of wildfire hazards that are caused by people living in the WUI. Examples from interviews include human-caused ignitions, flammable vegetation in close proximity to homes and people having an “it’s not going to be me” mentality. Other recurring wildfire problems brought up by managers included dense, flammable vegetation in occluded areas and flammable non-native grasses. Secondary hazards (i.e. post-fire flooding) was only mentioned once as a major wildfire problem. A complete list of WUI problems identified by managers can be found in Table 3.

Table 4

Interviewee	Problem definition
ACEM	Economic loss from disasters
	Development in foothills
	Flooding
BLM	Getting people to actually prevent wildfire
	Preventing fire long enough to restore a landscape
	Development in hazardous areas
	Bulldozers making fuel breaks - hard to turn around
	Number of recreationists in foothills that would need to get out if a fire took place
	Lack of anchor points for combating fire
City Fire	Amount of hazardous vegetation in proximity to homes
	Lack of defensible space
	Lack of fuel breaks between homes and open space
	Occluded areas (e.g. open space) with dense vegetation near homes
IDL	Public complacency
	Inadequate resources in government
	Lack of planning and building codes
IOEM	Where hazards intersect homes
	Where hazards are highest
	Development at the WUI
	Drought

Policies

We asked interviewees to describe potential policy solutions to the problems that they identified (described above). Some managers had unique solutions for each wildfire problem they identified, while other managers described one overarching policy solution to multiple problems (see Table 4). For example, interviewees of the BLM had unique policy solution ideas for each problem they identified; the problem of developments in hazardous wildfire areas could be solved with a policy that encourages fuel breaks around those developments, while the problem of having a lack of anchor points (tactical locations to combat wildfire) within WUI developments could be solved by creating a policy that requires anchor points in new

developments. Conversely, the Boise Fire Department addressed the wildfire problems that they identified, including a lack of defensible space around homes, occluded areas, a lack of fuel breaks, and dense vegetation near homes, with a single policy solution of increasing the capacity to get funding to take action on these problems.

Table 5

Interviewee	Policy solution
ACEM	ID hazard areas, collaborate with groups that can implement policies that can reduce economic loss
BLM	Create "accommodation space" from which "actual" change regarding wildfire protection can take place (people need to be eased into big changes)
	Create fuel breaks
	Fuel breaks
	None
	Create safety zones in foothills for recreationists to go in case of fire. Could double as site for education about wildfire
	Create hardscaping anchor points in new developments
City Fire	Prioritize funding and get more funding to meet the problems that science addresses (e.g. informs location of prescribed fires)
IDL	Educate to reduce the "it's not going to be me" mentality. Rural communities are more accepting of wildfire than urban areas
	Move money/funding from on the ground to wildfire management
	Assist in moving legislation for building and zoning codes
IOEM	Always coordinate to protect life and property.
	IDWR responsibility
	Use native grasses and shrubs in slope stabilization projects. Aligning goals of road ignitions prevention with other agencies
	Allocate funding to ID those location, map, and understand those hazards

Use of Science

Finally, we asked managers how science could be used to help solve the problems they identified, and how science could help develop policy solutions. If interviewees were unable to identify how science could best inform problems and policies.

Three major themes regarding how science is used to make decisions emerged from interviews. The first is that science is used to spatially identify and delineate wildfire hazard locations or future project areas; ~86% of interviewees, including managers for the City, ACEM, BLM, IOEM noted that science is used when making decisions regarding the spatial location or extent of a current or future project. A second theme that emerged from interviews is that science is useful when it is understood quickly. ~57% of interviewees, including managers for ACEM, the

BLM and IOEM discussed how science is most useful when it conveys information in an efficient way. The BLM noted that “a 700 page document is nothing compared to a map that can visualized and understood immediately”, while the IOEM mentioned that science is useful when it tells a story. The third theme that arose from interviews was that science is considered useful when it helps managers acquire and allocate funding. ~57% of managers we interviewed, including two BLM managers and the city both noted that science is often used to prioritize and justify budgets and funding proposals.

Discussion, Implications for Management, and Future Research

Through quantitative analysis of WUI policies, we found that different stakeholders have unique policy themes to address wildfire hazards in Boise, Idaho. Stakeholders at the City level (i.e. Boise Fire Department and Boise Zoning) address wildfire problems with policies that manipulate and reduce vulnerability to wildfire hazards; in order to combat wildfire hazards that threaten life and property, city-level managers must write ordinances that reduce the danger placed on homes already at the WUI. Policies of the Idaho Department of Lands more frequently address reducing exposure to wildfire hazards, and the Bureau of Land Management policy focuses on manipulating and increasing the ability to respond to wildfire hazards. Hazard managers at the county level (ACEM) have policies that dominantly work to decrease vulnerability and increase the ability to respond to wildfires, while state hazard managers (IOEM) have evenly distributed policies that address wildfire hazards.

Under the Multiple Stream Framework, because Boise WUI stakeholders were found to have distinct policy themes, we anticipated interviews to unveil that each stakeholder finds science to be useful for distinct reasons; we hypothesized that, because different stakeholders have different wildfire problems that they address with policies, their use of science to make decisions should also vary. However, in the case of Boise, Idaho, stakeholders commonly define their wildfire problems similarly. Interviews revealed that that development in the foothills and human influence on wildfire hazards (i.e. landscaping, ignitions) were both considered top wildfire problems that the majority of stakeholders face in the Boise WUI, while other problems defined by stakeholders were not frequently mentioned.

Additionally, interviews revealed that managers described science as being useful at the WUI for similar reasons. Firstly, when asked how science is used to make decisions about these problems, managers described that science is useful when it is visible and helps boundaries. For example, the IOEM described how visual aides are a good educational tool for telling stories, which is useful when conveying information to the public in a meaningful way. This result relates to the findings of Machelis (2002) regarding how science is used to make decisions; maps are succinct and tangible. When designed well, maps convey a great deal of information in a short period of time, and draw boundaries indicating where and where not hazards exist or money needs to be allocated.

Secondly, managers commonly mentioned that science is useful at the WUI when it helps acquire and allocate funding for wildfire mitigation projects. Many managers discussed that visual tools could help allocate where funding for projects is most necessary, such as areas where

dense vegetation surrounding homes could most benefit from receiving the services of a woody biomass chipper or education and outreach.

Thirdly, science is considered useful when making decisions at the WUI when it can be understood quickly. An interviewee with the BLM described that a 700 page document that may convey important scientific information, but that maps and visual tools are able to convey that information rapidly and conveniently. As a hypothetical example, there may be several reports about where herbicide treatment has and has not reduced flammable invasive grasses, but only a map displaying those locations of success and failure may help managers to tangibly understand whether or not that treatment should be prescribed on their own land.

We hypothesized that because different stakeholders at the WUI used different policies to address wildfire problems that each stakeholder would describe science as being useful for distinct reasons, thus fitting within the Multiple Streams Framework; science, as it flows through the problem and policy streams of each stakeholder, will be used differently, as each stakeholder has different policies to address problems. However, stakeholders described that science is useful for similar reasons. Science is considered useful when it draws boundaries, helps allocate funding, and when it can be understood quickly. Collaboration between stakeholders may explain why stakeholders identify similar wildfire problems and find science to be useful for similar reasons. When collaboration is low within a policy community (i.e. wildfire stakeholders at the Boise WUI), there is often a disconnect, called fragmentation, between stakeholders as to the solution to a given problem (i.e. wildfire) (Kingdon, 1982). At the Boise WUI, however, knowledge sharing is high and fragmentation is low; ACEM encourages collaboration between City, State and Federal stakeholders. As such, it is not uncommon for the BLM to co-educate the public with the City Fire Department or for IDL to work with the County on Community Wildfire Protection Plans. Because fragmentation is low between stakeholders, it is possible that managers at the Boise WUI, representing City, State and Federal land and hazard stakeholders, can be treated as one large stakeholder group. Within a spatially confined location (i.e. the Boise WUI), stakeholders must address the same wildfire problems regardless of their differences in policies.

Additionally, annual windows of opportunity (i.e. wildfires in the foothills) create situations where stakeholders at the Boise WUI must work together on the same wildfire problem, because wildfires frequently cross jurisdictional boundaries. The 2016 Table Rock Fire, for example, burned within City, State and Federal land in the foothills above Boise, Idaho, creating the opportunity to collaborate on rehabilitation projects. This may explain why science considered to be useful for the same reasons across stakeholders; at the WUI, where local, state, and federal stakeholders all manage land, local needs influence a unified utility of science of diverse stakeholders, despite employing distinct wildfire policies.

While not confirmed through interviews, it is possible that science must also be addressed to the right people in order to be usable (Figure 4). City-level policy often relies on individuals (e.g. homeowners) to implement the policies set forth, while state (IOEM) and federal (BLM) policies are to be implemented within their own level of government, rather than being passed on to neighborhoods or individual business owners. Ultimately, in order for science to be used when

pushing policies through the window of opportunity, it must be communicated to the right people, be it individual homeowners or federal level managers. This may be why visual tools, such as maps, are useful by all stakeholders; while most citizens or managers may not understand a piece of scientific literature, like a journal article, most citizens and managers are likely to understand a map containing boundaries and zones of information. This interpretation of our policy coding important for producers of science to consider. At the local level, where home and business owners are the responsible for implementing policies such as thinning vegetation around their homes or cutting flammable grasses, science must be able to speak to the general public. At the state and federal level, managers can use maps to target areas to provide education and outreach to encourage the implementation of wildfire reduction policies. As such, one piece of science would be useful for all levels of decision-making.

The implications of this analysis for Boise, and potentially for other WUIs, is significant. The push and pull of science must be mutual between scientist and user; this is not a new finding (Dilling and Lemos, 2011; Palmer, 2012). However, this study adds to our knowledge of the pull on science by decision-makers at the WUI. While previous studies have described under what circumstances science is used (Hunter, 2016), and other studies have identified what limits the use of science (Finch and Patton-Mallory, 1993; Wright, 2010; Sicafuse, 2011; Lemos et al., 2012; Hunter, 2016), few studies describe what attributes of science make it useful when making decisions (Machelis et al., 2002; Barbour, 2007), and no study has examined what makes science useful to decision-makers at the Wildland Urban Interface. We found that, when a WUI is comprised of an unfragmented policy community, the same scientific information may be useful for all stakeholders; if a piece of science draws boundaries, is quick to understand, and helps allocate funds, it will likely be considered useful by many wildfire stakeholders. When science is presented in a manner that is tailored to the target audience by recognizing which policy themes they are required to follow, science can be better used to identify problems and inform policies that maximizes the use of that science.

While we argue that attributes making science useful for diverse stakeholders at the Boise WUI is the result of collaboration and proximity, this hypothesis must be tested at a different WUI to be confirmed. Ultimately, the Boise WUI is one of many wildfire-prone communities that are managed by multiple land and hazard stakeholders who have policies to protect life and property. In a similar WUI, where there are multiple stakeholders managing for wildfire hazards, would interviews reveal that science is useful for the same reasons? Boise represents a WUI where collaboration between stakeholders is common. Does use of science change at WUIs where there is less collaboration? Do managers consider wildfire science useful for dissimilar reasons when communication and knowledge sharing between stakeholders is low? Answering these questions by examining other WUIs under the lens of MSF will expand upon the findings of this study.

Science can act as an indicator to influence the three streams, and inform the creation of new policies that combat wildfire hazards. These policies can manipulate, reduce exposure to, reduce vulnerability to, or increase the ability to respond to those hazards. It is a matter of producing science that is capable of informing these policies to the levels of government that needs the scientific information. It may be important for scientists to tailor science to meet the needs of

managers, and if not, may lead to a disconnect between science and decision maker; if a scientist learns something about a natural hazard but doesn't inform policy at a level that can use it, the scientific endeavor may not have been worthwhile. Conversely, these findings also indicate that it may be the responsibility of wildfire decision-makers within the WUI policy community to continually inform scientists what scientific information would be useful to them and what will make it useful. As such, the mutual push and pull of science by scientists and decision makers will maximize the utility and use of science, creating more informed, and better prepared and protected Wildland Urban Interface.

Key Findings

A. WUI stakeholders address wildfire problems with unique sets of policies

Stakeholders at the Wildland Urban Interface address wildfire problems with distinct sets of policy themes. Stakeholder policies at the Boise WUI addressed wildfire hazards under one of four themes: manipulating, reducing exposure to, reducing vulnerability to, or increasing the ability to respond to a wildfire hazard. For example, while the majority of city level WUI policies work to manipulate or reduce vulnerability to wildfire hazards while federal-level, BLM policies were dominantly worked to increase the ability to respond to or manipulating wildfire hazards.

B. WUI stakeholder policies are written to be implemented by distinct sets of people

Boise WUI stakeholders lay responsibility to implement WUI policies on different people. All policies examined in this study were written to be implemented by either an individual (e.g. homeowner), a group of people (e.g. neighborhood association) or the government (e.g. BLM). City-level policy often relies on individuals (e.g. homeowners) to implement the policies set forth, while state and federal policies are written to be implemented within their own level of government, rather than being passed onto communities or individual homeowners.

C. Different land and hazard managers describe similar wildfire problems at the WUI

Despite having unique sets of policies to address wildfire hazards, managers we interviewed described a similar set of wildfire problems that they presently face at the Boise WUI. Continued expansion into the WUI and human-caused wildfire hazards were both described frequently by managers in stakeholder interviews.

D. Land and hazard managers at the WUI describe science to be useful for similar reasons

When prompted to describe what attributes of science make it useful when making decisions at the WUI, the majority of managers describe useful science as that which (1) draws boundaries, (2) helps allocate funding, and (3) can be understood quickly. While managers described many attributes of what makes science useful to them as they make decisions at the WUI, these three descriptions recurred throughout many of the interviews.

Literature Cited

Abatzoglou, John T., and Crystal A. Kolden. "Relationships between climate and macroscale area burned in the western United States." *International Journal of Wildland Fire* 22.7 (2013): 1003-1020.

Ada County. "2011 Ada County All Hazard Mitigation Plan". (2011).

Barbour, Jamie. "Accelerating adoption of fire science and related research." (2007).

Burby, Raymond J., and Linda C. Dalton. "Plans can matter! The role of land use plans and state planning mandates in limiting the development of hazardous areas." *Public administration review* (1994): 229-238.

COMPASS. "Communities in Motion 2040 Vision." Available at http://www.compassidaho.org/documents/prodserv/CIM2040/Map_Final.pdf (2012).

Council, Wildland Fire Executive. "The National Strategy: The Final Phase in the Development of the National Cohesive Wildland Fire Management Strategy."

Dilling, Lisa, and Maria Carmen Lemos. "Creating usable science: Opportunities and constraints for climate knowledge use and their implications for science policy." *Global environmental change* 21.2 (2011): 680-689.

Dombeck, Michael P., Jack E. Williams, and Christopher A. Wood. "Wildfire policy and public lands: integrating scientific understanding with social concerns across landscapes." *Conservation Biology* 18.4 (2004): 883-889.

Finch, Deborah M., and Marcia Patton-Mallory. "Closing the gap between research and management." (1993).

Gergel, Diana R., et al. "Effects of climate change on snowpack and fire potential in the western USA." *Climatic Change* 141.2 (2017): 287-299.

Hunter, Molly E. "Outcomes of fire research: is science used?" *International Journal of Wildland Fire* 25.5 (2016): 495-504.

"Integrating the Local Natural Hazard Mitigation Plan into a Community's Comprehensive Plan: A Guidebook for Local Governments. Region X" (2013).

Kingdon, John W. "Agendas, Alternatives, and Public Policies." New York: Longman, 1995. Print.

Lemos, Maria Carmen, Christine J. Kirchhoff, and Vijay Ramprasad. "Narrowing the climate information usability gap." *Nature Climate Change* 2.11 (2012): 789-794.

Machlis, G. E. (2002). "Burning Questions: A Social Science Research Plan for Federal Wildland Fire Management: Report to the National Wildfire Coordinating Group (No. 943)." University of Idaho, College of Natural Resources, Idaho Forest, Wildlife and Range Experiment Station.

Marlon, Jennifer R., et al. "Long-term perspective on wildfires in the western USA." *Proceedings of the National Academy of Sciences* 109.9 (2012): 535-543.

Palmer, Margaret A. "Socioenvironmental sustainability and actionable science." *BioScience* 62.1 (2012): 5-6.

Pyne, Stephen J., J. Bradley Washa. "Rhythm of the Reigns". *Wildfire Magazine*. March 27, 2017

Sabatier, Paul, and Christopher Weible, eds. "Theories of the policy process." Westview Press, 2014.

Westerling, Anthony LeRoy. "Increasing western US forest wildfire activity: sensitivity to changes in the timing of spring." *Phil. Trans. R. Soc.* (2016).

Wright, V. 2010. Influences to the success of fire science delivery: Perspectives of potential fire/fuels science users. *Final report for Joint Fire Science Program* project 04-4-2-01. Boise, ID

Young, Linda. "Flames of Controversy: Interpreting the Yellowstone Fires of 1988". *Wildland Fire Education and Outreach Case Studies*. National Interagency Fire Command. Archived from the original on September 29, 2016. Retrieved September 29, 2016

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Appendix B – Science Delivery

Deliverable	Type
Anticipated submission date – January 2018	Journal Submission
Gibble, K. <i>If It Burns, Will It Flow? And About the Managers Who Would Like to Know</i> . Boise State University, Summer 2017	Graduate Thesis
Gibble, K., Lindquist, E., Pierce, J. <i>Fitting Post-fire Erosion into the Wildfire Hazard Assessment Puzzle: Using Predictive Debris Flow Models to Inform Policy Decisions</i> . Geological Society of America, Annual Meeting in Denver, CO, USA. 2016.	Conference Symposium abstract
Gibble, K. <i>What the Science Tells Us: Incorporating Wildfire Science at the WUI</i> . National Cohesive Wildfire Management Strategy Workshop. All Hands, All Lands: Implementation Rooted in Science. Reno, NV. 2017.	Conference Symposia abstract
Gibble, K., Lindquist, E., Pierce, J. <i>How is Wildfire Science Used to Inform Managers at the Wildland Urban Interface?</i> Great Basin Consortium Conference. Reno, NV. 2017	Posters