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Social, Institutional, and Psychological Factors Affecting Wildfire Incident Decision Making

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Managing wildland fire incidents can be fraught with complexity and uncertainty. Myriad human factors can exert significant influence on incident decision making, and can contribute additional uncertainty regarding programmatic evaluations of wildfire management and attainment of policy goals. This article develops a framework within which human sources of uncertainty in wildfire management can be classified and managed, specifically identifying social, institutional, and psychological factors that can affect wildland fire incident decision making. These factors are reviewed in the context of wildland fire incident management and the literature regarding fire manager decision making. I then provide specific recommendations for addressing these issues, with a focus on improving incident decision processes. Extending this framework to consider a broader set of human factors and to consider how human factors affect the broader wildfire management spectrum could lead to improved fire management outcomes.

Keywords decision support, human factors, risk, uncertainty, wildfire management

Managing wildland fire incidents can be fraught with complexity and uncertainty. Federal wildland fire policy in the United States stresses that fire management costs should be commensurate with values protected, highlights the importance of risk management as the foundation for fire management, and directs managers to use decision support processes to assess risks and document decisions (National Interagency Fire Center 2009). In particular, attention is focused on the need for improved cost containment and an improved ability to demonstrate the cost-effectiveness of wildland fire management (U.S. Government Accountability Office 2009). As a result, there is a strong reliance on the development and implementation of systematic and risk-based approaches to support incident decision making, wherein wildfire risk is expressed as a function of the likelihood of fire, the intensity of fire, and the effects of fire (Calkin et al. 2011a).

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Policy changes to allow greater decision flexibility and ideally lead to more cost-effective fire management have emphasized the principles of risk management and championed development of spatial risk assessment tools. Policy changes in and of themselves can be insufficient to attain objectives because of human factors, however, and technical assessments of uncertainty can be insufficient when considering the broader human context in which decisions are made (Brown 2010). That is to say, risk assessment is but one component of a broader decision process for incident management that is driven by human choices and influenced by myriad human factors.

Perceptions of and attitudes toward risk, decision biases and heuristics, internal and external pressures, and a host of other human factors can exert significant influence on incident decision making. Collectively, these human factors may restrict the decision space of fire managers, degrade decision processes, encourage risk-averse behavior, and ultimately lead to suboptimal fire outcomes. More broadly, these human factors contribute uncertainty regarding programmatic evaluations of wildland fire management and attainment of policy goals. It is therefore important to look not only at the factors influencing risk, but at the factors influencing decisions made in the face of risk.

A growing number of studies have highlighted issues related to human factors and their influence on incident decision making, but these studies have yet to be holistically integrated in a coherent manner to facilitate evaluation and improvement of wildfire management. This article closes that gap by synthesizing relevant literature and incorporating key themes into a framework for assessing how social, institutional, and psychological factors may influence wildfire incident decision making. Specifically, this article aims to develop a framework within which human sources of uncertainty in wildfire management can be classified and managed. In particular, this article focuses on studies that directly relate to contemporary wildfire incident decision making and, critically, that present actual data to support hypothesized relationships. These data are collected from a variety of sources, including interviews, surveys, choice experiments, and statistical analyses.

A Framework for Understanding Human Factors Influencing Incident Decision Making

Figure 1 presents a hypothesized conceptual model of incident decision making. Fire managers make decisions regarding strategies and tactics, organizational needs, and firefighting resource deployments in response to information regarding likely fire behavior, threatened resources and assets, firefighting resource availability, and public and firefighter safety (National Interagency Fire Center 2013). To clarify, here the term "fire managers" is used to refer to both agency administrators—who are tied to the local unit (e.g., district ranger) and who are responsible for developing the overarching strategic objectives consistent with land and resource objectives—and incident managers—who are responsible for implementing tactical and operational decisions to achieve strategic objectives. Efficient management of wildland fire incidents is premised on fire managers who are aware of and understand risks, and who respond to those risks in an unbiased manner.

However, social, institutional, and psychological factors have been shown to exert significant influences on incident decision making, as described in the following sections (and, where appropriate, categorized parenthetically). Prominent social

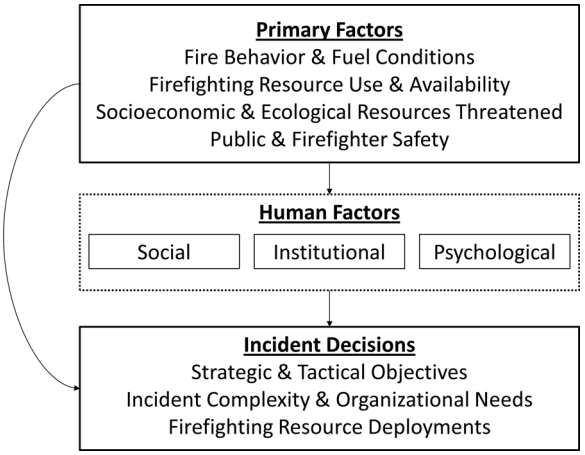

Figure 1. Proposed conceptual model of factors influencing wildfire incident decision making.

factors include trust levels and relationships, as well as sociopolitical pressures brought to bear by the public, cooperators, and media, among other sources. Institutional factors include agency attitudes and beliefs, cultural norms, policies, incentives, performance measures, and so on. Psychological factors relate to decision biases and heuristics, inconsistencies underlying judgment and choice, and deviations from economic models of rational behavior.

These social, institutional, and psychological factors can act as a lens through which primary factors and associated risks are perceived, understood, and acted upon, as shown in Figure 1. Human factors can individually affect decisions, but may also interact and thus compound complexities and uncertainties of decision processes. For instance, intense sociopolitical pressure (social), a misaligned incentive structure (institutional), and decision biases of fire managers (psychological), among other factors, may collectively impair attainment of efficient fire management outcomes.

Much of the work identifying the potential influence of human factors has been based on interviews and surveys of fire managers, as well as mental models of fire manager decision making. Canton-Thompson et al. (2008) interviewed incident management team members to examine how human factors could influence incident decisions and affect suppression costs. Respondents identified a number of salient factors, including strong sociopolitical pressures often being the driving force behind agency administrator decisions (social), potential trust issues between agency administrators and incident management teams (social), a perceived lack of agency support in coping with fire-related lawsuits (institutional), insufficient prefire planning and inexperienced agency administrators (institutional), and a perceived restriction of decision space due to changes in policies, regulations, and rules (institutional).

Results from queries of agency administrators have identified a set of factors similar to those identified by incident management teams, and that similarly can lead to risk-averse fire management decisions. For instance, a survey of U.S. Forest Service line officers by Kennedy et al. (2005) indicated that willingness to take risks is among the least rewarded traits within agency leadership (institutional). Williamson et al. (2007) surveyed U.S. Forest Service district rangers and found that decisions regarding managing natural ignitions for resource benefit objectives were influenced

by perceptions of public support (social), degree of trust and confidence in staff (social), and perceptions of agency support (institutional). Along the same lines, Doane et al. (2006) sent a questionnaire to all Forest Service units with wilderness responsibilities, and respondents identified organizational culture, organizational capacity, and policy directives as institutional factors constraining broader management of fires for ecological benefit.

More recently, Steelman and McCaffrey (2011) presented results from interviews with agency administrators, incident management teams, and community members involved in two fires that were managed with very different strategies. Results were consistent with earlier studies highlighting how sociopolitical pressures can influence suppression strategy development. However, results also suggested that institutional factors, particularly policy documents such as land and fire management plans, can exert significant influence on decision making and can constrain fire management options for less aggressive suppression.

The incentive structure facing agency administrators, which relates to both social and institutional factors, has been hypothesized to be a particularly prominent barrier to improved cost containment (Thompson et al. 2013). Donovan and Brown (2005) proposed a model of fire manager decision making and used it to illustrate how the incentive structure facing fire managers is tilted heavily in favor of excessive suppression expenditures. The rationale is, managers are often able to draw on funds from a national rather than local funding pool to support further suppression activities, and as such they are not forced to consider the opportunity costs of those expenditures.

Psychological factors can also exert a significant, and potentially detrimental, influence on fire manager decision making. Cognitive biases and limitations may become particularly salient in complex incident management decision environments, compromising situational awareness and causing reversions to suboptimal decision heuristics (McLennan et al. 2006). These nonrational processes can manifest in various ways in the fire environment—for instance, the sunk cost bias (continuing with ineffectual suppression strategies/tactics because significant resources have already been expended), the optimism bias (persisting with strategies that expose firefighters to hazards by assuming they can look after themselves), and the overutilization of resources bias (mobilizing more firefighting resources than can be used effectively) (McLennan et al. 2006). These and other biases can lead to systematic errors in estimating the likelihood of events, interpreting probabilistic relationships, and combining information about probabilities and values (Maguire and Albright 2005). Indeed, Donovan and Noordijk (2005) found that fire managers in the western United States tended to underestimate the probability of actual fire size exceeding target fire size and to overestimate the probability of actual fire size exceeding worst-case fire size.

Increasingly, researchers are providing experimental and statistical evidence that strongly support prior assertions and perceptions regarding the influence of human factors on incident decision making. An econometric study by Donovan et al. (2011) helps to consider the magnitude of potential sociopolitical influences on incident decision making, and the presence of costs borne solely by fire managers, such as adverse career consequences and personal lawsuits. The authors evaluated large fire suppression costs and tested for effects of biophysical and socioeconomic variables (e.g., fire size, housing value within a given radius), newspaper coverage variables, and political influence variables. Newspaper coverage in nearby cities with a population over 250,000 and the number of years in office of the member of Congress in whose district the fire started were both found to be statistically significant and

positively correlated with suppression costs. Thus, results suggest that fire managers may "increase suppression spending in response to newspaper coverage and political pressure because they are concerned about the personal costs of adverse wildfire outcomes" (Donovan et al. 2011, 795).

Three recent choice experiments are particularly illustrative of how incident management may not be consistent with assumptions of decision making free from biases or other factors. All studies involved the participation of agency administrators and incident management team members in decision scenarios, wherein participants were given information about hypothetical wildfire events and asked to indicate how they would respond to each scenario. Wilson et al. (2011) presented fire managers with scenarios specifically designed to test for the presence of three common risk-based biases, and found evidence that all biases exist and that reliance on suboptimal heuristics could be prevalent. Specifically, fire managers exhibited the loss aversion bias (favoring safe options more often when consequences of fire were framed as potential gains, i.e., homes saved from fire rather than homes lost due to fire), the discounting bias (favoring reduction of short-term over long-term wildfire risk), and the status quo bias (favoring suppression when suppression was deemed the status quo option). The degree to which such biases were present varied with years of experience and individual attitudes toward risk. The authors suggested that there is likely to be a disconnect between individual manager risk preferences and those imposed by social and institutional pressures.

A choice experiment conducted by Calkin et al. (2012) provides further evidence for such a disconnect and strongly suggests that social and institutional pressures can lead to increased suppression costs. The authors reported significant differences when asking fire managers to differentiate between "expected" and "preferred" wildfire management strategies. Notably, when selecting "expected" strategies, and holding all else equal, fire managers actually favored higher cost suppression strategies. Strategies that fire managers would personally prefer (ignoring community, agency leadership, and political expectations), however, tended to be more sensitive to cost containment objectives.

In a follow-up study based on the same choice experiment data set, Wibbenmeyer et al. (2012) analyzed fire manager strategy selections to better understand the degree to which standard economic models could describe fire manager decision making under risk. Results suggest that fire manager strategy selection is inconsistent with minimizing expected losses (the theoretically optimal approach), and that fire managers appear to respond differently to different types of probabilistic information. One important implication is that fire managers may overallocate firefighting resources in low-risk incidents.

Application of the Framework to Improve Decision Making

Results of the studies cited here all point to a need to explicitly and formally recognize the inherent variability in humans and human systems as a potential source of uncertainty affecting wildfire incident decision making. Only then can uncertainties challenging attainment of efficient wildfire outcomes be appropriately managed (Thompson and Calkin 2011). To enhance the cost-effectiveness of wildfire incident management, decision processes may need to be crafted in such a way as to avoid decision biases and heuristics, and to buffer against internal and external pressures.

There is a role for a stronger incorporation of decision science principles in wildfire management, including explicit identification and prioritization of incident objectives,

as well as identification of key uncertainties. With that said, the temptation to turn to simplified models (e.g., decision trees) should be avoided in favor of approaches that recognize the dynamic, time-pressured nature of incident decision making (MacGregor and González-Cabán 2008). Similarly, it should be recognized that incident management entails complex, multiperson processes and that effectiveness can be degraded by information overload; it may not be the case that if only fire managers had more information, then decisions would improve (McLennan et al. 2006).

Further, there can be a stronger recognition that decisions made in advance of the fire season can significantly affect incident decisions. Clearly framing a decision, articulating objectives, and identifying performance measures are critical components to successful decision making processes (Marcot et al. 2012), highlighting a need for prefire planning to set the stage for good decisions before smoke is in the air. This could entail revision of land and fire management plans, as well as numerous expansions in the realm of fire decision support.

First, increased use of spatial risk assessments could facilitate the contemplation of both detrimental and positive fire effects and the demarcation of areas with disparate fire management objectives. Pre-ignition planning could better lay the groundwork for risk-informed incident responses. Coupled with greater flexibility in fire management plans that do not prescribe specific responses and that allow for assessment of environmental conditions to inform response, these changes could provide fire managers with an expanded decision space and an ability to pursue less aggressive suppression strategies where appropriate.

Second, decision contexts could be reframed to more strongly highlight risk–risk trade-offs across potential suppression strategies and tactics, and to dispel perceptions of the existence of options that are either "safe" or "risky" (Maguire and Albright 2005). Information could be provided to incident managers regarding short-term and long-term risks and trade-offs, for instance, the possible ecological benefits to fire-adapted ecosystems and prospects for future self-limiting fires due to the fuel treatment effects of wildfire. Firefighter exposure to hazards could be quantified and likelihoods of casualties based upon historical statistics could be provided as well.

Third, the tie between decision documentation and existing land and fire management plans could be strengthened. There could be a requirement, for instance, to provide detailed justifications for decisions to pursue aggressive suppression where existing fire management plans promote ecologically beneficial fire. This recommendation relates to the first point, wherein spatial and risk-informed prefire planning could facilitate articulation of both ends-based objectives and means-based objectives for how incident management strategies can achieve desired landscape conditions.

Lastly, the analytical components within existing decision support systems could be used to simulate incident decision environments, in order to provide additional training opportunities and to broaden the experiential base of agency administrators (Calkin et al. 2011b). Simulation and gaming could help managers more fully explore the implications of various decisions and potentially identify latent tendencies toward loss aversion or excessively discounting the future. While even experienced managers may be subject to some biases and heuristics, additional training would likely prove most beneficial for managers who have seen only a few fire events play out during their careers, and who may not have experienced or witnessed the full impacts of past decisions due to changes in job location or position.

Perhaps equally as important as the decision process is the environment in which decision processes unfold, in particular institutional structures and organizational

incentives. Donovan et al. (2011) recommended indemnification of fire managers and development of federal guidelines describing where aggressive suppression may not be warranted, in order to provide managers with "cover" to resist sociopolitical pressures. The U.S. Government Accountability Office (2007) recommended that agencies clearly articulate the relative importance of cost containment objectives, establish cost containment performance measures, and enhance fire manager accountability. Other proposals include establishing suppression budgets to make fire managers more acutely feel costs of investing in suppression effort, and strengthening performance measurement in terms of financial metrics (Donovan and Brown 2005; Thompson et al. 2012).

By helping reframe decisions to avoid biases and lessen institutional and social pressures, it may be possible to ensure an enhanced focus on the primary factors and a reduced contribution of human factors that can unduly influence wildfire management in the face of risk. Complementary work includes ongoing research to better understand factors influencing the effectiveness of communication strategies, and ultimately to engender public support for a broader range of wildfire management strategies. Related work could focus on resolving trust issues, both across agency–community and agency administrator–incident commander relationships. Extensions of this work could consider how social, institutional, and psychological factors affect the broader fire management spectrum, including prevention planning, hazardous fuels reduction, and postfire rehabilitation. The work could also be extended beyond fire managers to consider factors influencing the decision processes and expectations of affected residents and other stakeholders: for instance, considering how media and education campaigns could buffer against future sociopolitical pressures.

A few caveats are worth mentioning. Contextually, this article largely focused on human factors as they relate to federal wildfire management in the United States, although the general framework described here is likely applicable across diverse geographic regions that have wildfire management challenges. The focus on potential flaws and limitations in current decision environments should not be taken as an indication that all fire managers are insensitive to suppression costs or risk–risk trade-offs. It is also recognized that not all decision heuristics or rules of thumb are necessarily a bad thing, and further that policies, perceptions, and practices within the federal wildfire management community could be trending toward greater adoption of risk management principles. Due to space limitations it was not possible to exhaustively review all of the relevant literature, although, as described earlier, the intent here was to focus on contemporary studies providing data largely obtained directly from stated and revealed patterns of fire manager decision making. Readers interested in learning more about the influence of human factors in decision making and their contribution to uncertainty are encouraged to read the work of Maguire and Albright (2005), Ascough et al. (2008), Kahneman (2011), Wilson et al. (2011), and Wibbenmeyer et al. (2012), as well as the literature cited therein. Readers interested in broader issues related to wildfire management and in particular from a social sciences perspective are encouraged to read McCaffrey et al. (2012).

Conclusion

Wildfire management decision making is complicated by the interplay of human factors that can contribute to unpredictability of human decision processes, and potentially to inefficient wildfire management. Decisions relating to incident management are subject to multiple sources of uncertainty, and are made by a broad range of

individuals, across a multitude of biophysical, sociopolitical, and jurisdictional contexts. In contemplating the human dimensions of uncertainty in wildfire management, social, psychological, and institutional factors are highlighted as particularly influential. Although a broad set of tools exists to assess uncertainty associated with modeling efforts, few are directly applicable to analysis of human factors. Characterizing these human-related uncertainties may require the development of methods that can handle subjective and qualitative factors and that can better represent human decision-making processes. The identification of salient human factors affecting incident management is a starting point for improved management of human sources of uncertainty challenging attainment of efficient wildland fire management outcomes. The process of identifying and addressing uncertainties aligns with principles of decision science, a stronger adoption of which could help scientists better design decision support, help agencies better evaluate decision contexts, and help fire managers improve their incident decision processes.

The influence of sociopolitical pressures on suppression expenditures and decision making, the implications of misaligned incentives for fire managers, the reversion to mental heuristics and the role of decision biases, and the structure of social and managerial preferences across values-at-risk are all ongoing avenues of research. Related behavioral economics research has identified issues related to misperceptions of risk, inconsistent expressions of preference, and cognitive limitations that can inhibit decision making in complex, uncertain environments. Additional research is needed to synthesize what is known about decision making, to better understand how preferences, incentives, and cognitive limitations jointly influence decision making, to ascertain what insights and lessons can be taken from the decision sciences literature, and to coherently assemble this information to improve decision support systems and to inform risk-based management. Extending this framework to consider a broader set of human factors and to consider how human factors affect the broader wildfire management spectrum could lead to improved fire management outcomes.

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