

Decision Making Under Uncertainty: Recommendations for the Wildland Fire Decision Support System (WFDSS)

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Abstract—The management of wildfire is a dynamic, complex, and fundamentally uncertain enterprise. Fire managers face uncertainties regarding fire weather and subsequent influence on fire behavior, the effects of fire on socioeconomic and ecological resources, and the efficacy of alternative suppression actions on fire outcomes. In these types of difficult decision environments, even well-trained and experienced individuals can become susceptible to cognitive limitations and decision biases, as indicated by several recent analyses of fire manager decision making. This extended abstract focuses on fire management decision making under uncertainty, in relation to current decision support provided by the Wildland Fire Decision Support System (WFDSS), offering several recommendations to improve decision content and process.

Introduction

Management of wildfires presents myriad sources of uncertainty (Thompson and Calkin 2011). These uncertainties are manifest across a variety of decision contexts including fuel treatment planning, incident response planning, and incident response (Figure 1). The natural variability surrounding the locations and timings of unplanned ignitions, along with fire weather conditions driving fire behavior, are perhaps the most obvious sources of uncertainty, typically quantified probabilistically through the use of stochastic wildfire simulation systems (Finney and others 2011a; Finney and others 2011b). Addressing uncertainties surrounding the quantification of socioeconomic and ecological consequences of fire can be even more challenging (Venn and Calkin 2011), although some combination of expert judgment and multi-criteria decision analysis is often used (Thompson and others 2013a). Further, fire managers face uncertainty regarding partial control and the relative efficacy of alternative suppression actions and other wildfire management strategies (Thompson 2013).

When faced with such complex, dynamic and uncertain decision environments, humans tend to fall prey to a number of cognitive biases and heuristics that can lead to suboptimal decisions (Thompson 2014). Thus there is interest in expanding the role of risk and decision analysis to help support high quality decision making, and in identifying opportunities for improving decision support functionality within the Wildland Fire Decision Support System (WFDSS). Critically, attention on improved decision support needs to focus on both decision content and decision process (Thompson and others 2013b).

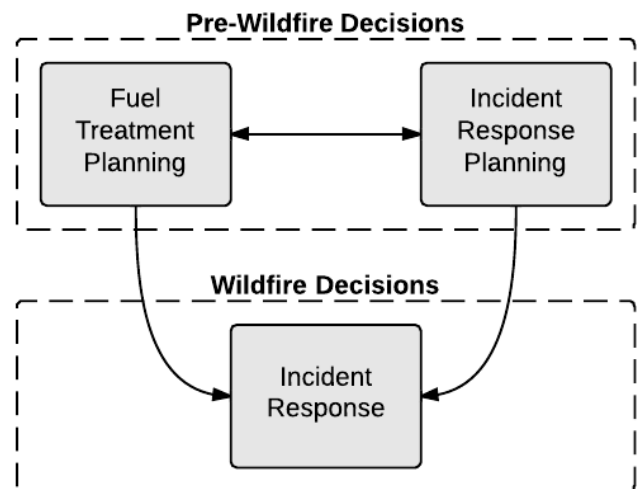


Figure 1—Pre-wildfire and wildfire decision contexts. Ignition prevention, although important, is not considered here because of a focus on planning for large wildfire.

- **Decision content:** Characterization of the risks posed by wildfire, as well as the potential ecological and economic costs and benefits associated with various fire management actions, leading to a more complete understanding of options and tradeoffs.
- **Decision process:** Characterization of the complexities and uncertainties faced in wildfire management, leading to delivery of targeted decision support tools and approaches, and promotion of frameworks for systematic, structured, and risk-informed decision making.

WFDSS currently provides a structured format for information management, risk assessment, and decision documentation, and has likely helped fire managers arrive at and justify risk-informed decisions (Calkin and others 2011; Zimmerman 2012). Recognizing the importance of decision process, however, suggests that decision support efforts

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need to extend into the pre-fire environment to set the stage for good decisions before smoke is in the air. Successful decision-making is largely premised on clearly framing a decision, articulating objectives, and identifying performance measures (Marcot and others 2012). In the next section several suggestions are presented for how to better integrate principles of risk and decision analysis into WFDSS.

Implications for WFDSS

Potential improvements and implications for future directions with WFDSS center around three hierarchical premises:

1. The linkages between fuel planning, incident response planning, and incident response need to be strengthened (Figure 1).
2. In support of #1, there is a need to expand application of spatial wildfire risk assessment frameworks (Scott and others 2013) that consider the likelihood and intensity of wildfire along with the susceptibility of resources and assets (Figure 2).
3. In support of #1 and #2, the possible benefits from wildfire need to be better recognized and quantified from an ecological perspective in the context of fire-adapted ecosystems, and also from a fuel treatment perspective wherein wildfires can exert controls on the extent and severity of future fires (Parks and others 2014). Similarly, the role of suppression actions in transference of risks to the future needs to be better acknowledged.

Recommendations for Establishing Stronger Planning Linkages

The recommendations below outline steps to help establish stronger linkages across fire planning contexts to support risk-informed decision making.

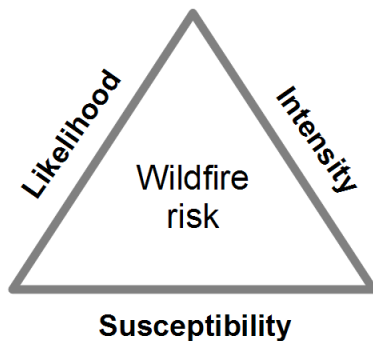


Figure 2—The three primary components of wildfire risk (Scott and others 2013) are wildfire likelihood (i.e., probability of occurrence) and intensity (i.e., heat release per unit length or flame length), along with resource or asset susceptibility (i.e., potential for loss/benefit due to exposure to wildfire).

Fuels Planning & Incident Response Planning

- Treatment strategies should be designed in concert with response planning to identify and evaluate how different spatial treatment patterns could improve the safety and effectiveness of suppression operations. This could, for instance, entail the creation of “low hazard fire containers” where aggressive suppression may be unnecessary, or conversely “high hazard fire containers” where fuel breaks along roads and other natural barriers afford opportunities for restricting fire growth (Ager and others 2013).
- The scope of treatment strategies could extend to the landscape-scale in order to increase the likelihood that treatments actually interact with fire and the likelihood that treatments can measurably influence landscape-scale fire behavior.

Fuels Planning & Incident Response

- Spatial information on treatment location should be integrated into WFDSS to provide fire managers with improved situational awareness (currently underway).
- Auxiliary information on treatment age, treatment type, and treatment objectives could be succinctly characterized, and simulation exercises on pre-treatment and post-treatment landscape conditions (Ager and others 2010; Cochrane and others 2012) could help fire managers to better anticipate fire behavior within treated areas.

Incident Response Planning & Incident Response

- Spatial fire management plans should more clearly characterize objectives within various fire management units, including fundamental objectives (what are we trying to accomplish) along with means-based objectives (how can we accomplish it). Early efforts characterizing strategic response categories (Thompson and others 2013c) at the national scale identified issues with missing or unclear objectives, highlighting a need for more thoughtful locally-based input. Current spatial fire planning efforts within WFDSS that allow fire managers to spatially characterize strategic objectives and management requirements could provide refined information to support development of risk-informed strategies and tactics.
- In support of developing spatial fire management plans with variable management objectives, and potentially delineating these areas at a smaller resolution than the size of some fire management units, spatial risk assessment efforts could be expanded. This could include not only identification of patterns of likely benefits and losses across the landscape (Scott and others 2013), but also the delineation of areas where ignitions pose significant risk transmission threats (Scott and others 2012; Thompson and others 2013d). Spatial risk assessment efforts could integrate complementary information such as the FIRESEV Severe Fire Potential map (Dillon and others 2011).

Summary

The basic thesis of this document is that risk-based wildfire management will succeed only to the degree that pre-fire planning efforts incorporate risk-based information, with feedback loops and information sharing across planning contexts. Key recommendations are to more strongly link pre-fire planning and assessment with actual incident response, to use spatial risk assessments to inform planning efforts, and to more comprehensively evaluate the short-term and long-term risks and benefits of wildfire. Many of the analyses as part of these planning efforts are outside of the WFDSS environment itself, but nevertheless could yield improvements in both decision content and decision process when fire managers find themselves managing an active incident and analyzing risks and documenting decisions within WFDSS. Work is ongoing from partners within the National Fire Decision Support Center and elsewhere to expand availability of data layers and functionality within WFDSS to more clearly define and delineate fire management objectives, to more explicitly recognize opportunities for ecologically beneficial fire, and to support a broad range of management options.

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