

Effects of Risk Attitudes on Extended Attack Fire Management Decisionmaking¹

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Abstract

Fire management inherently involves the assessment and management of risk, and decision making under uncertainty. Although organizational standards and guides are an important determinant of how decision problems are structured and framed, decision makers may view risk-based decisions from a perspective that is unique to their background and experience. Previous research has shown that individual differences in risk attitudes of fire managers exert a significant effect on fire management practices. Within the USDA Forest Service, Extended Attack (EA) incidents are those not contained within the first burning period after ignition. Simulation-based methodologies offer a potentially viable approach for improving our understanding of the role that risk attitudes and problem framing play in determining key decisions associated with EA incidents, and particularly on the decision to disengage, re-engage after disengagement, and transitioning to a higher level of incident command. Scenario-based exercises in which Type 3 Incident Commanders respond to simulated incident conditions provide an opportunity to study decision behavior based on current theories and models of decision making that point to the role of problem framing and incentive structures as key decision drivers.

Keywords: Decisionmaking, extended attack, fire management, risk assessment.

Introduction

Fire management inherently involves decision making under uncertainty, and the role of human decision makers is central to the accomplishment of fire management goals and objectives. To provide a context for decision making, the USDA Forest Service (as well as other Federal land management organizations) has established organizational policies, plans and directives that provide guidelines to orient decision

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makers toward fundamental institutional priorities. In the case of wildland fire management, agency priorities concerning firefighter and public safety, and the protection of private property are reference points that offer contextual guidance as to how alternative managerial actions should be evaluated.

In recent years, it has become more apparent that the role of the individual managerial decision maker, while central to achieving the agency's mission and goals, represents a source of poorly-understood variability in accounting for decision outcomes. Sometimes this variability is expressed in terms of differences in "risk aversion" or risk-taking propensities of individual managers. At other times, it is expressed as a problem of incentives and incentive structures within which individual managers evaluate decisions and experience the outcomes. Empirical research along these lines requires the development of study approaches that provide opportunities to observe decision behavior in contexts that simulate actual decision-making situations. The development of such approaches requires integrating relevant theories and models from decision-making research with a contextual model of fire management decision making.

Preliminary Research

Individual Risk Attitudes and Fire-related Decision Behavior

Although organizational factors are an important determinant of how decisions are framed and structured, decision making is ultimately accomplished by human managers who may view decisions problems from a different (or modified) perspective than that of institutional policies and plans. Evidence for this comes from a number of managerial studies that have examined how senior managers' risk attitudes influence their decision behavior in the context of prescribed fire decision making. Cortner, Taylor, Carpenter, and Cleaves (1990) found that, in the context of prescribed fire, individual risk-taking propensities varied greatly as revealed in decision-making scenarios that involved varying levels of risk associated with conducting a planned burn, as evidenced by allocations of personnel and equipment.

González-Cabán (1996) presented prescribed fire managers with a set of realistic prescribed fire problems for which they were to provide elements relevant to plan implementation, such as ignition patterns, containment strategies, mopup classifications, season and time of burn, and estimates of equipment and personnel. Results indicated that the largest portion of the variance in estimates of burn costs was accounted for by individual differences between the prescribed fire managers, not associated with their education or experience, the location of the burn, or features of the burn site. Self-ratings of risk-taking propensity revealed that respondents who judged themselves to be risk-averse had lower average prescribed fire costs than

those who judged themselves to be risk-takers.

An in-depth interview-based study by MacGregor (1997) examined the risk attitudes of senior-level prescribed fire managers. The results indicated that the concept of risk was perceived as a complex interaction of a number of factors relating to prescribed fire and its use as a resource management tool, and that prescribed fire managers seek to manage a range of risks that are distributed over time. However, risk management strategies were variable and depended upon individual risk orientations and experiences.

Risk and Regret in Fire Management Decision Making.

An important concept that has come to play a significant role in understanding risk-related attitudes at the managerial level is the precautionary principle (Sandin 1999; Graham 2001). In essence, the precautionary principle is a “better safe than sorry” perspective that orients individuals toward taking self-protective action. The precautionary principle can be interpreted as a corollary of a general propensity for individuals to respond more extremely to decision outcomes that involve losses than those that involve gains (Kahneman and Tversky 1979).

One effect of prospective evaluation and response to decision outcomes is *anticipated regret*. Regret theory has been given central importance as a factor that exerts a strong influence on decision behavior (e.g., Bell 1982; Loomes and Sugden 1982, 1983, 1987). According to regret theory, a decision maker *anticipates* the experience they may have as a result of decisions or choices they make; regret is the psychological experience associated with having chosen an alternative that is less satisfying than an alternative that is foregone. Thus, regret is a function of the satisfaction not obtained from the alternative chosen but that would have been obtained from one or more other alternatives. As result, decision makers seek to minimize regret by anticipating decision outcomes and choosing the alternative with the least possible regret.

Regret theory can be modeled in the context of fire management decision making by examining decisions in terms of two contexts: a *prospective context* in which a decision is analyzed and made, and a *retrospective context* in which a decision is justified and evaluated (*fig. 1*). These two contexts differ in terms of important features. Prospectively, decisions and outcomes are linked probabilistically and numerous outcomes are possible given a chosen alternative. Retrospectively, a particular outcome is experienced and the tendency is to perceive the outcome as causally or deterministically linked to the decision maker’s actions. A decision pertaining to the assignment of a Type 3 versus a Type 2 Incident Management Team to a fire can be represented in terms of a *Prospective Context* that involves decision making about the appropriate level of IMT to assign to a fire, and a *Retrospective Context* that represents a post-outcome evaluation or justification of the decision.

Each of the four cells in a 2 x 2 payoff matrix is associated with each of four outcomes. Two of the cells represent a “Correct” Decision; these are the outcomes for which the prospective choice of IMT matches the level of IMT actually required. These are correct decisions in the sense that a post-decision evaluation of the IMT selection would indicate that the appropriate level of IMT was chosen.

		<i>Anticipated Retrospective Context (Decision Justification)</i>	
		Type I Team Required	Type II Team Required
<i>Prospective Context (Decision Making)</i>	Type I Team Selected	<i>“Correct” Decision</i>	<i>Excess \$\$ costs to the Organization Small Competence Risk</i>
	Type II Team Selected	<i>Inadequate Suppression Mortality & Morbidity Risks Large Competence Risk Career Risks</i>	<i>“Correct” Decision</i>

Figure 1 - Hypothetical payoff matrix for deciding the level of IMT to assign to a fire.

For the two remaining cells, a discrepancy exists between the level of IMT chosen prospectively and the level of IMT justified retrospectively given the outcome of the incident. In the case where the higher level of IMT (Type 2) is selected prospectively, but the lower level of IMT (Type 2) would have been appropriate, two potential payoffs are: (a) excess monetary costs to the organization due to the higher cost of the Type 2 team, and (b) a small (potential) competence loss to the decision maker accruing from their overestimation of the level of resources required for management of the incident. In the case where the lower level of IMT (Type 3) is selected, but the higher level of IMT would have been appropriate, payoffs include (a) inadequate suppression of the fire, (b) potential mortality and morbidity risks, (c) relatively large competence risks to the decision maker, and (d) perceived or actual career risks.

For the diagonal represented by the two correct decisions, the decision maker has no anticipated regret since the managerial decision concerning level of IMT assignment is perceived to be consistent with the outcome. All of the potential regret in the decision is associated with the two outcomes where there is a disparity between the level of IMT assigned and the level that could be perceived as required or justified in hindsight. An asymmetry exists between the value of the two negative

payoffs, with the larger negative payoff associated with a decision to use a lower level of IMT. A decision maker who wishes to minimize their maximum possible regret in such a decision situation would tend choose the higher level of IMT unless other contextual factors intervened to alter their choice.

Sunk Cost Effects in EA Decision Making.

Sunk-cost effects occur when current decisions are influenced by options in which the decision maker has already invested time, money or other resources, even if it is not the best option (e.g., Arkes and Blumer 1985). According to rational economic theory, current decisions should consider only future costs and benefits. Empirical studies of decision making have demonstrated that people often make decisions based on what they have already expended (e.g., Gourville and Soman 1998). In a fire management context, sunk-costs can be manifest in terms of decisions that favor protecting the expenditures associated with line construction, even if such a decision poses greater risks and costs than would be the case if the sunk-cost was not present. One result of sunk-cost decision making is a tendency toward *escalation of commitment* to a suboptimal course of action, based on an investment already made (Staw 1976). Some evidence suggests that sunk-costs effect due not endure indefinitely and that the tendency toward the biasing effects of prior investments diminishes over time (Thaler 1999). How sunk-cost effects specifically manifest themselves in EA decision making and how such effects if present can be de-biased or attenuated are open questions.

Production Systems in EA Decision Making

Production systems are a general class of decision models that described the relationship between humans and the tasks that they perform. In the simplest terms, production systems represent human performance in terms of inputs, system processes and outputs that are connected through a feedback loop that affects the environment within which the system operates (Sheridan and Ferrell, 1981; Wickens and Hollands, 1999). The analogy to fire management is direct.

In a prototypical production system, the inputs include *scheduled and expected events* that serve as *triggers* to system processes (*fig. 2*). The various system processes (e.g., procedures, plans, internal communications) result in *products* that are outputs of the production system. These outputs include decisions, actions and communications that are intended to have an effect on the environment within which the system operates (for example, a fire incident). The impact of the production system on the environment acts as a closed-loop feedback to the input of the system, thereby controlling its actions (Powers 2005). Essentially, production systems are a form of *cybernetic control system* (Wiener 1948) for which output from the system serves as a basis for the evaluation of how well system processes (e.g., fire

management decisions) are meeting the goals and objectives of the system, such as perimeter control.

System processes can be perturbed or altered by human factors, such as physical or mental fatigue and stress. More generally, system processes are influenced by an on-going assessment of capabilities; changes (Δ) in capabilities can alter how the system responds to inputs and how the various processes are implemented with a resulting effect on system outputs. Changes in human resource capabilities can also influence how critical decision cues are recognized and processed (Klein, Calderwood and MacGregor 1989).

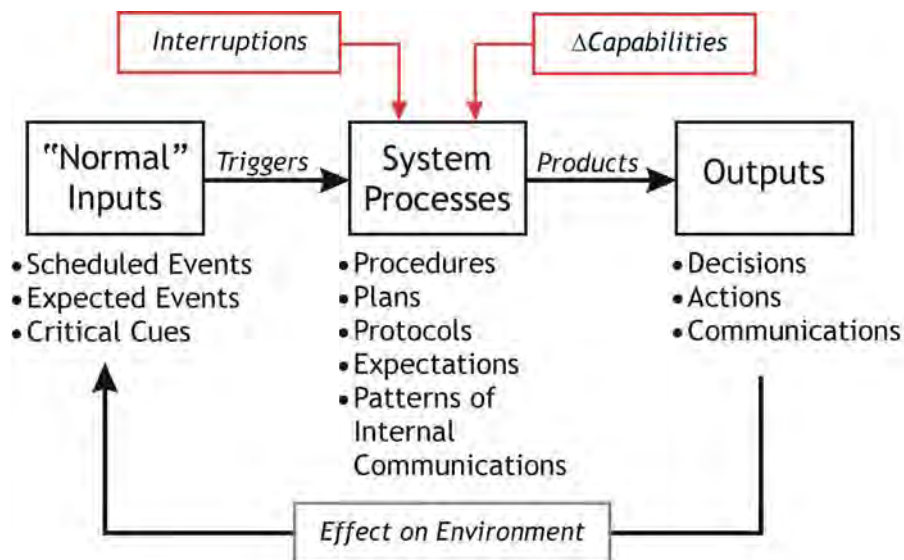


Figure 2 - Prototypical production system decision model.

Alteration can also occur due to interruptions; these are unanticipated events or situations that are external to the system and that prevent the completion of organized actions or sequences. Understanding how interruptions influence the dynamics of production systems is critical to improving their functioning and making them more resilient against degradation and collapse (Rudolph and Repenning 2002).

Method

Characteristics of Extended Attack Incidents

The research approach applied here involves the development of a methodological framework for studying the effect of individual managerial risk attitudes and incentive structures on fire management decision making in the context of Extended Attack (EA) incidents. Within the USDA Forest Service, EA incidents are those that are not contained within the first burning period after ignition. A typical EA incident

is staffed by a Type 3 Incident Commander, or ICT-3, as well as suppression resources. Incident command may also include subordinate staff members who occupy roles associated with logistics, operations, plans, finance and information, depending on the complexity of the incident, availability of personnel, and the management style and/or preferences of the ICT-3.

Extended attack fires can range in size from a few acres (e.g., Class B) to a hundred acres or more (e.g., Class C or small Class D). The actual size of the fire is less relevant than its complexity (e.g., fuel conditions), and guidelines are currently in place by which a ICT-3 can gauge whether or not continuing to manage an incident as a Type III incident is an appropriate management response. Key checklist factors include fire behavior, firefighter safety, organizational capabilities, and values to be protected (NWCG, 2007).

EA incidents are particularly challenging on several grounds, not the least of which is firefighter safety. As an incident goes beyond the capabilities of a Type 5 or Type 4 organization, it grows in size and complexity, and becomes an emerging fire for which a precise characterization of its risks is difficult owing largely to its dynamic nature. Essentially, an EA incident is an incident in transition and for which a locally-organized management response may be effective at averting a much larger and more costly fire, or it may not - the outcome depending in large part on the quality of decision making that occurs during the management of this critical incident stage. Moving too quickly from EA to a Type 2 or Type 1 may incur unnecessary costs if the fire could have been managed effectively as a Type 3 incident. On the other hand, continuing to manage an incident as a Type 3 could expose firefighters to excessive safety risk and increase the likelihood that valuable resources will be needlessly lost.

Extended attack can be characterized as an ongoing decision making process in which the Type 3 organization evaluates both the fire situation and the organization's capability to manage the incident with the resources at hand. In some circumstances, the Type 3 organization may disengage from the incident to assess its capabilities and to assess its likelihood of success if it re-engages the incident. Recurrent decisions concern whether or not the organization can accomplish meaningful objectives with respect to the fire, and/or whether they should conduct a holding action until more resources arrive or conditions improve. Complicating the decision process are human factors such as the mental and physical state of personnel. In essence, the Type 3 organization is often at the limits of its capabilities and operates in a short time frame decision cycle whereby it is constantly adapting its management approach according to a rapidly evolving and dynamic fire situation.

Simulating a Type 3 Decision Making Environment

For training and qualification purposes, Type 3 environments are simulated in two general ways. One way is to give trainees the “feel” for the rapid pace of setup, operations and management associated with a Type III environment where their responsibilities include establishing a management organization as well as monitoring and responding to a dense communication environment that includes multiple channels of radio traffic. Monitoring and updating situation awareness is also a critical aspect of Type 3 management.

A second approach is to simulate the strategic decision making aspects of the Type 3 environment. These include development of staff positions, preparation of an Incident Action Plan (IAP), identification of primary and secondary control objectives, acquiring and positioning suppression resources, and engaging in monitoring activities associated with the production cycle of incident management (*fig. 2*).

The present research uses a strategic context within which to study decision making on EA-type incidents. The simulation environment includes a combination of materials supported by a PC-environment as well as checklists and structured protocols that pose situations and call for responses from study participants.

The simulation environment poses a scenario involving a fire start that has been managed by an ICT-4, but is transitioned to an incoming ICT-3. The scenario develops over a four-day (four burning period) time frame. Within each simulated burning period, the respondent receives information pertaining to the current situation, including topographic maps showing the current fire perimeter, location of resources, status of resources on order, weather conditions, location of value at risk (e.g., residences, wildlife). The respondent then assesses a number of factors associated with the incident, including location of primary and secondary control objectives, probabilities of success for each objective, factors and resources on which success is dependent, probability of containment within 24 hrs., probability of disengagement within 24 hrs., and probability of transitioning to a higher level (e.g., Type 2). A final section of the exercise elicits background information from the respondent, including their fire experience as an ICT-3, cost issues in fire management, and legal liability issues.

Overall, the simulation is designed to represent a wildland fire that emerges into a situation that is marginally manageable as a Type 3 incident. Over the course of the four-day simulated time frame, the incident progresses from one that has a moderate probability of achieving containment to one that continues to elude containment. The intent of the exercise is to focus the respondent on a key set of decisions pertaining to disengagement/re-engagement and transitioning to a higher level of incident management. Simulation variables are constructed to pose situations in which the

respondent is faced with the possible loss of constructed line, allowing an examination of sunk-cost effects. In the context of the situation, risk attitudes are assessed in terms of a range of variables, including probabilities of success/loss, positioning of primary and secondary control objectives, resource ordering and utilization, as well as respondent background and general perceptions of risk-based decision making in Type 3 operations.

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