CAN ACCEPTABLE RISK BE DEFINED IN WILDLAND FIREFIGHTING?

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Abstract.—Risk is an ever-present challenge for fire agencies, fire managers, and firefighters, who must ensure that risks are managed at a level that is as low as reasonably practicable. This challenge provides a significant dilemma as there is no one prescriptive method for—or consensus on—defining "acceptable risk" in the field of firefighting. Risk assessment and determining what is the best course of action for dealing with risk are often weighed based on the potential benefits versus the potential costs or losses. It can be argued that it is impractical to define acceptable firefighting risks in many scenarios due to the unique and constantly changing environment. This paper discusses the factors involved in assessing wildland firefighting risks, reviews past models for defining and assessing acceptable risks, and describes a new approach to these complex topics.

1.0 INTRODUCTION: FIREFIGHTING AND RISK

Firefighting is an unquestionably dangerous activity that requires the application of skilled judgment on many levels to achieve the safest possible outcomes. Because firefighting has inherent risks, the ability to determine which risks are or are not acceptable is fundamental. As J. Adams (1995) has written, "The future is uncertain and inexplicably subjective; it does not exist except in the minds of people attempting to anticipate it" (p.30). Yet firefighters need to be able to predict the future to some degree in order to plan for current and potential risks on the fireground.

Risk in firefighting is as inevitable as the occurrence of wildfires. Indeed, if firefighters did not take risks, fires would go unchecked. Therefore knowing how to approach risk is vital. Treasurer (2003) suggests that "knowing how to take risks should be a part of everyone's core life curriculum" (p. 2). The implication is not that firefighting is a dangerous activity and therefore accidents will occur. Rather, risk must be understood and managed while safety incidents, poor safety practices, and injuries should be treated as the exception (Clancy and Holgate 2005).

In wildland firefighting, several methods for assessing risk go beyond a standard risk assessment template. First, formal preplans for defined areas provide an indication of risk using information about vegetation, fuel loads, and areas of threat. Second, management structures define operating guidelines, personnel roles, and the formal processes for documenting risks. Third, incident, division, or sector plans on the fire-line will detail identified risks. Finally, the firefighter on the ground plays a key role in the risk identification process. Firefighters on the fire-line will receive visual and auditory cues about risk as well as getting a "feel" for the environment.

In the firefighting environment, there is often a fine margin between success and failure when managing risk. Improper risk assessment by fire managers can reduce the effectiveness of decisions about strategies and tactics, thereby compromising safety. Improper risk assessment may occur for a range of reasons, including the immediacy of the decision's impacts, the lack of physical impact the decision will have on the decision-maker as an individual, and the fact that the decisionmaker does not face the physical risk (Clancy 2005).

1.1 The Role of Judgment

There will always be variability in judgments when people are involved in the risk assessment process (Clancy 2005). The risks felt or perceived by an organization prior to a fire may influence how firefighters assess risks on the fireground. Those managing a wildfire will assess the risks differently

from the firefighters on the fire-line, especially in cases where the incident control center is many kilometers away from the fire-line; increased distance heightens the potential for variability in risk awareness and judgments (Clancy 2005).

At some point, all firefighters will be required to make judgment calls on risk. The trigger for this risk decision may be just a feeling that they have. This "feel" is often difficult to quantify but is based on knowledge and skills gained over time for making sense of the environment. Gut feelings, intuition, and professional judgment play a strong role in the overall risk management process when fighting wildfire. The importance of judgment calls in risk management links back to the overarching concept that risk is subjective and contextually driven (Adams 1995, Reason 1997, Clancy 2005, Sadler et al. 2007).

Gigerenzer (2007) describes how the decision-making process strongly relies on judgment, which allows cognitive shortcuts to occur. In essence the mental workload is reduced, allowing for quicker responses to immediate situations by drawing on previous experiences stored in memory. According to Gigerenzer (2007), a gut feeling is a judgment: "1. that appears quickly in consciousness, 2. whose underlying reasons we are not fully aware of, and 3. is strong enough to act upon" (p. 16). Klein (2003) describes how this process unfolds in the pattern-recognition process behind intuitive decision-making. First, there is "a situation" (for example, a wildfire) that generates "cues" that lead to recognition of "patterns" that activate "action scripts" that ultimately go on to affect the situation (p. 13). At all stages of this process, there is an opportunity to identify risk. The decision-making process is continuous so there are ongoing opportunities to decide what is or is not acceptable.

2.0 DEFINING ACCEPTABLE RISK

While defining risk is part of any decision process, the concept of *acceptable* risk differs in its construct across various disciplines. The terms "risk tolerance" and "risk appetite" are used in risk management to describe the level of risk an organization is willing to accept. Firefighters need to be risk-averse individuals—not risk seekers—and need to be aware of their environment as risk-taking has been "closely tied to decision-making" (Treasurer, p. 15). Fischhoff et al. (1981) provide a useful starting point with their definition of "acceptable risk" as "the risk associated with the most acceptable option in a particular decision problem" (p. 3). Under this definition, it is still possible to undertake a dangerous activity since an emphasis on safe options is not specified.

In firefighting, risks and decision-making are inextricably linked. How decisions are made about whether risk is acceptable or not is a vital part of the process and is tied to understanding the true risk consequences (Treasurer 2003). The firefighting risk models used in Australia, which will be discussed below, use such phrases as "we will risk a little to save a lot" with no clear direction on what is acceptable. Fischhoff et al. (1981) describe the acceptable risk decision process as comprising five interdependent steps:

1. Specifying the objectives by which to measure the desirability of consequences;
2. Defining the possible options, which may include "do nothing";
3. Identifying the possible consequences of each option and their likelihood of occurring should that option be adopted, including risky consequences;
4. Specifying the desirability of the various consequences; and
5. Analyzing the options and selecting the best one. (p. 2)

These five steps already occur during the development of wildland fire incident control plans. Incident management teams use the options analysis process to systematically identify and define what is acceptable for a given scenario. One of the incident management team's first activities is to create objectives (step one)—for example, to establish a control line at a specific place, say, Smiths Track. Next, identifying the available options will provide a number of decision choices (step two). In this example, the options may be

a) to burn out an area from Smiths Track, b) to create a mineral earth break at Smiths Track, or c) to undertake a direct attack at Smiths Track. Third, as part of this process, it is vital to understand the possible consequences of selecting each option in order to make decisions about risk (step three). For example, the fire activity may be too intense for a direct attack or back burning. The fourth and fifth steps require incident managers to look at the desirability of the various options' consequences and then make a decision about the course of action based on that information. For example, based on the resources on scene, the terrain, available fuel, and weather conditions, the best option of the three mentioned above for Smiths Track may be an indirect attack using a mineral earth break.

The risk assessment process relies heavily on good intelligence from the fire-line to understand the actual risks. Since most models for determining acceptable risk "are based on probabilistic calculations of a statistical likelihood of an occupational risk occurring" (Holgate and Clancy 2007, p.1), skilled personnel must be involved in the process. Because a range of risks and possible outcomes exist in most wildland firefighting situations, a risk-rating matrix is sometimes used. These matrices include information about the likelihood that specific possible events will occur and information about the potential consequences.

As stated earlier, the concept and perception of risk are subjective. What one person perceives as a risk will not necessarily be identified as such by another person. Even when the likelihood of an incident or of a risk's coming to fruition is low, the margin for error is often slim and in firefighting the consequences can be devastating. There are many limitations and difficulties in quantifying wildfire risks given the diverse range of variables that will affect control options and help define acceptable risk. As Fischoff et al. (1981) suggest, for firefighters and fire managers alike, acceptable risk will often be the same thing as the most acceptable option.

2.1 The "Safe Person" Model

In Australia, many fire agencies and other emergency service organizations have developed wildland fire programs based on a British model introduced in the mid-1990s. Called "Safe Person Approach and Dynamic Risk Assessment," this model details both organizational and individual responsibilities for managing safety. It has proven to be a useful approach to addressing risk but can lead to problems when it is misapplied. The model is useful in that it defines clear expectations for an organization, such as the need to provide training, equipment, and risk information, to select appropriate personnel for particular roles, and to have safe systems of work. It also defines what is expected of individuals in the organization—for example, that they will not undertake tasks for which they are not trained and that they work as a member of a team and within accepted guidelines.

This approach has the potential to fail when an organization has all its requirements in place and something goes wrong. Failures can often be traced back to a specific human action or inaction that was not accounted for in the planning. However, just identifying human errors is not enough; the organization also must understand why the person who made the error thought that the action or inaction was acceptable. Thus, one key to understanding why firefighters behave in a particular way is having knowledge in the field of human factors. In the past decade, fire agencies have gained a stronger understanding of human performance, particularly under time-pressured constraints in situations where information can be ambiguous or incomplete. Understanding human frailties in identifying, assessing, or defining risk and the limitations of human performance in complex situations will aid in making risk decisions.

Wildfire agencies in the United States have proactively developed the field of human factors in order to better understand why failures occur and how best to train personnel. Supporting meetings have included the Wildland Firefighters Human Factors Workshop from June 12-16, 1995 and then a follow-up 10 years later

at the 2005 International Wildland Fire Safety Summit. Other areas that have been developed include the application of the human factors analysis classification system as a tool for assessing wildland fire accident investigations (Ryerson and Whitlock 2005). Research in recent years by the Bushfire Cooperative Research Centre in Australia has also increased the body of knowledge about human factors and helped the discipline to grow.

While empirical data are not available on the impact of introducing the safe person approach and dynamic risk assessment, this author believes that this approach has raised safety awareness among firefighters in Australia. The Country Fire Authority (CFA, Victoria), for example, lost 13 firefighters during the 1983 Ash Wednesday fires. Another five firefighters perished during the Linton fires of 1998 under conditions that were considered benign (Johnstone 2002). The CFA introduced the "Safe Person Approach and Dynamic Risk Assessment" program after the Linton fire tragedy. Ten years later, on Feb. 7, 2009 (which has become known as "Black Saturday"), 173 civilian fatalities occurred under the worst fire conditions in the nation's history. Although casualties and injuries to firefighters did occur, there were no firefighter fatalities. Empirically, this outcome supports the notion that significant progress has been made in raising safety awareness among Australian firefighters over the past few decades.

2.2 Criticisms of the Dynamic Risk Assessment Model

The dynamic risk assessment model used in Australia follows the five key steps of its British predecessor: 1. Evaluate the situation or person at risk; 2. Select tactics; 3. Conduct a risk assessment of the tactics; 4. Determine whether the risks are proportional to the benefits; and 5. Decide whether additional control measures can be introduced. At steps four and five, the decision-maker has several pathways (options), including "do not proceed," "reassess tactics," and "proceed with the task." Because of the number of steps, the additional option decision points, and the inclusion of a risk assessment, it is reasonable to anticipate that the limitations of working memory would be exceeded in complex situations (Clancy 2005). The author has observed that the application of the dynamic risk assessment varies across different jurisdictions in Australia; agencies further develop the model, in most cases to simplify the process. This approach has often failed to account for human limitations in the decision-making process as the model has been developed solely to be applied as a cognitive process.

Dynamic risk assessment has also been criticized for its lack of empirical support. Tissington and Flin (2005) state: "Perhaps the most serious area of criticism of this model – or indeed any other description of risk assessment as a clear step by step process – is that dynamic risk assessment is inextricably linked with decision making" (p. 50). Since dynamic risk assessment is a cognitive process, it is unlike the safety processes with which many people are familiar, such as filling out a form or completing a checklist. Instead, dynamic risk assessment relies solely on individuals to acquire and process information cognitively.

Tissington and Flin (2004) also criticize the dynamic risk assessment model for not being evidence-based and for being "the product of the expert view of a small number of fire officers which, given the expert nature of risk assessment, is on the face of it appropriate. However, no replicable methodology is reported for the organisation of the model nor has it (to date) been tested empirically" (p. 51).

Clancy and Holgate (2008) assert: "Any attempt to model risk assessment must take into account the limitations of human information processing and, in particular, the limitations of working memory" (p. 2). Since dynamic risk assessment is a cognitive process, this observation highlights the need to understand factors that influence our ability to process information. Working memory, theorized to be seven items plus or minus two items under ideal conditions, has the potential to impede the risk decision-making process (Miller 1956).

In fire situations, the fire ground is complex and the environment is constantly changing. There are often time pressures, and available information can be ambiguous. Therefore, it is reasonable to expect that working memory will not perform optimally. Cognitive biases also play a key role in our decision-making process and our ability to determine acceptable risk. For instance, how information is framed will determine how an individual reacts to it; this factor is an important part of providing briefings to crews prior to entering the fire ground (Sadler et al. 2007).

Procedure-based approaches, where performance relies on individuals applying entrenched methods or processes, have long been the norm in managing components of firefighter safety. These approaches include the 10 Standard Fire Orders and 18 Watch-outs that have been adopted internationally and are used to guide risk assessment in wildfires. These tools or methods greatly exceed the limits of working memory capacity (Braun et al. 2001), especially when the fire situation becomes complex. An example of this situation is the 1994 South Canyon fire in Colorado, where firefighters pursued the firefight after breaking 13 of the 18 Watch-outs and being overrun by fire (McLean 1999). Fourteen firefighters died as a result.

3.0 TOWARD A NEW DECISION MODEL

Following an extensive review of the theoretical and applied literature and research, Clancy and Holgate (2008) developed a decision model that attempts to address the lack of empirical support for existing models of dynamic risk assessment. This model was developed based on the need to simplify the complex area of cognitive psychology theories by providing solutions that can be understood by the general firefighting community. The Clancy and Holgate model consists of two components, a simplified risk-rating matrix, which limits the choices available in assessing risk, and a decision model that highlights cognitive biases.

Based on risk-rating models that agencies are currently using, for example, a four-by-four matrix provides the operator with 16 risk-level points. Clancy (2005) applied this model to a specific wildfire scenario where participants assessed the same risk scenario and found that the assessment of risk "varied considerably and had little consistency among participants" (p. 74). In this research, 11 of the 16 potential categories were chosen by participants, highlighting the subjectiveness of the risk assessment process and demonstrating the challenges faced in obtaining accurate assessment of risk. In the Clancy and Holgate (2008) risk-rating matrix, the choices are the likelihood of the risk occurring (either likely or unlikely) and whether the consequences are minor or major. Using a simple traffic light approach, the operator can determine rapidly when the risk is high (and therefore specific actions should not proceed and alternative options should be found), medium (and therefore caution must be exercised, possibly including additional risk controls), or low (and activities can proceed but should be monitored). See Figure 1.

The dynamic cognitive risk assessment model in Figure 2 provides a snapshot of cognitive biases that can occur at each decision point. Key biases and strategies can be applied to manage the factors that affect the frailty of the human mind. The first step is to evaluate the environment to understand what is occurring. Prior assumptions about the incident are a bias that can reduce the effectiveness of the assessment and reduce the desire to undertake a full analysis of the situation. An effective strategy is to take sufficient time to evaluate the situation; this is a cognitive process and can occur very quickly.

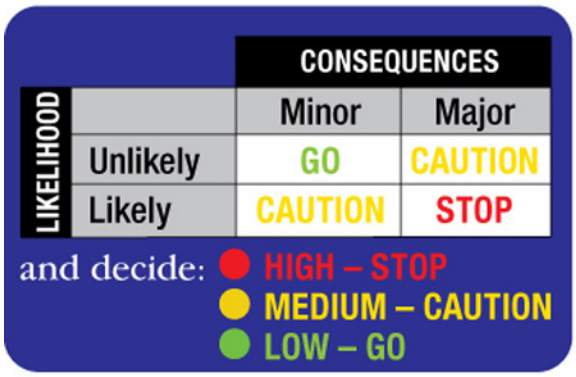

Figure 1.—Simple likelihood x consequences matrix with stoplight coding. From Clancy and Holgate (2008).

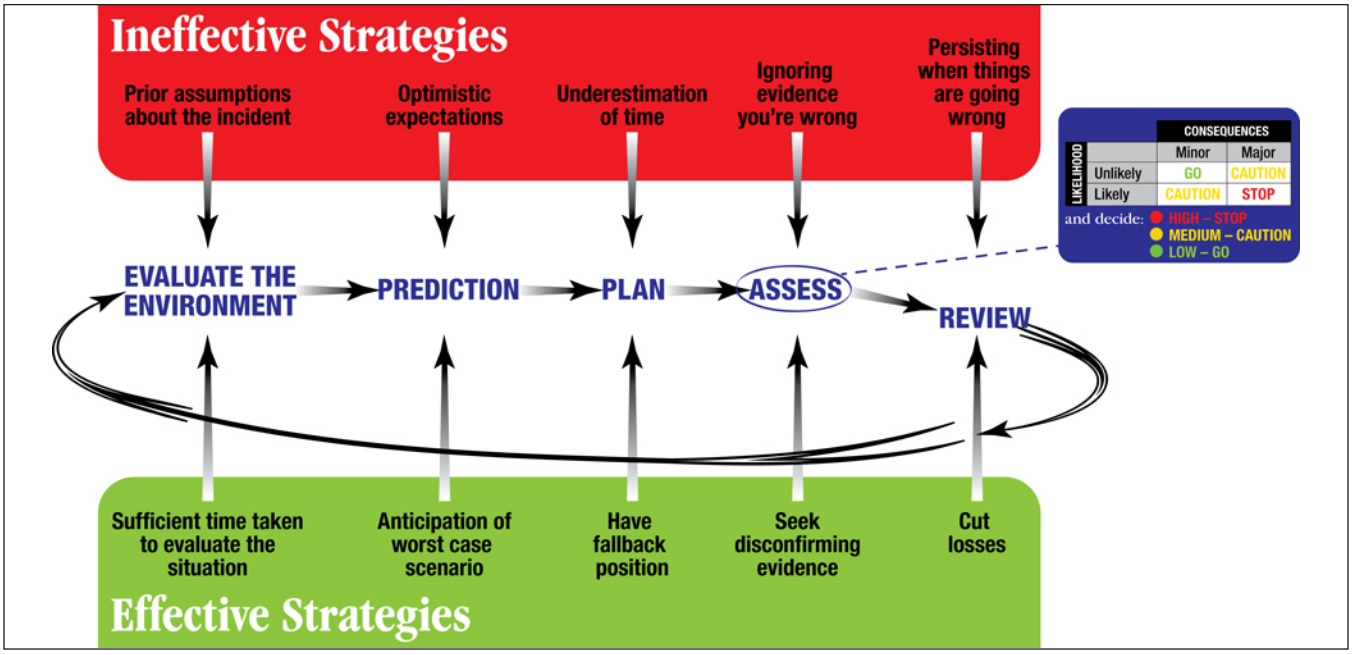

Figure 2.—Dynamic cognitive risk assessment model. From Clancy and Holgate (2008).

The second step is to attempt to predict what may occur; for this step, it is vitally important to have as much information as possible to make a value judgment on what actions should be taken. Optimistic bias is an impediment to effective prediction here. Optimistic bias occurs when people are overconfident of their skills and abilities or underestimate the challenges they face, whereas good risk assessors will always exercise caution and review the situation, thinking of the worst-case scenario. By anticipating the worst-case scenario, people are positioned to deal with changes as they occur and are aware of risks in the environment.

The third step is to develop a plan of action. A key bias that will reduce the effectiveness of the action plan is underestimating the time it will take to put the plan into action; for example, individuals may underestimate the time it will take to get resources into place to implement the plan. To counter this bias, fire managers must always have a fallback position. If the situation changes, they must be ready to act based on the changed situation rather than having to develop new plans on the run.

The fourth step is the assessment of the action plan, including understanding what can go wrong, the likelihood that specific things will go wrong, and the consequences of specific things going wrong. There is some risk here of ignoring evidence that the plan is not working and some risk that confirmation bias will interfere with assessing the plan. Confirmation bias occurs when everything that happens seems to confirm that the plan is working and therefore gaps or flaws in the plan go unrecognized. The skilled fire manager will continually look for evidence that things are not going according to plan to ensure that gaps in the process are identified and acted on promptly.

The fifth and final step is part of the continuous process of reviewing how the plan is working. The greatest risk here is persisting with a plan when things are going wrong; as more time and effort are put into a flawed plan, it becomes harder and harder to change direction. The best way to manage a change in the circumstances when the plan is not going as anticipated is by cutting losses, which can be difficult to do. Again, because this is a cognitive process, it occurs very rapidly and in some cases may involve little conscious thought.

4.0 CONCLUSIONS

Fire personnel can use a combination of documented and cognitive models to follow structured processes in determining acceptable risk. Defining what is acceptable has to take into account the variability of the situation and the limitations in human information processing in the complex environment of wildland firefighting.

Many factors affect both the process of defining acceptable risk and the interdependencies of various aspects of the process. In many cases, something going wrong answers the question of whether the risk was acceptable or not.

In firefighting, there needs to be strong emphasis on the risk-assessment process and on risk assessment as a key competency. Training should also include information about the limitations of human information processing since every individual is prone to cognitive biases and will experience these biases while in firefighting roles. Tools such as dynamic risk assessment raise the profile of risk assessment, but further evidence-based research is needed to determine the validity of these tools and to identify opportunities for improving them.

Defining acceptable risk in firefighting is not an easy task; as Fischhoff et al. (1981) suggest, acceptable risk is often closely related to "the most acceptable option" (p. 3) for a given scenario. In some cases, the most acceptable option may be deciding not to undertake an aggressive attack on a fire. Fischhoff et al. (1981) also provide us with an answer to the dilemma of defining acceptable risk: it is unlikely that "acceptable risk" can be determined when fighting wildfire. The reality is that fire personnel will often be forced to choose the least risky option among many.

Tools are available to help in making risk decisions; in many cases, a combination of tools can assist in effective decision-making. Future research should aim to increase risk awareness and reduce variability in the assessment of risk. Importantly, any risk-assessment model must account for human limitations and the variability of a person's perception of risk in order to improve the risk decision process.

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