



Can behavioral decision theory explain risk-averse fire management decisions?

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Abstract

Organizations managing forest land often make fire management decisions that seem overly risk-averse in relation to their stated goals for ecosystem restoration, protection of sensitive species and habitats, and protection of water and timber resources. Research in behavioral decision theory has shown that people faced with difficult decisions under uncertainty and decisions with multiple and conflicting objectives adopt mental shortcuts that systematically bias decision-making. Fire management decisions exhibit exactly the characteristics that are likely to trigger such mental shortcuts. Cumulative and unwitting use of mental shortcuts can lead to fire management decisions that are excessively risk-averse, to the point of jeopardizing stated management goals. It can also cause retrospective analyses of fire decisions to focus inappropriately on placing blame for bad outcomes and fail to scrutinize the quality of the decision itself. Excessive risk aversion is evident in the behavior of individual land managers, land management organizations, regulatory agencies that review land management decisions, and the general public and its agents in the media, courts and legislature. Remedies to excessive risk aversion include: (1) wider use of structured decision processes designed to counteract the mental shortcuts that plague human decision-making, (2) structural and educational changes within and between organizations to change perverse incentives that reward risk aversion and discourage adaptive management, and (3) locally focused collaborations among land management agencies, regulatory agencies, and citizens to build trust and to enhance understanding of forest management goals and practices.

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1. What is going wrong with fire management decisions?

Managers of both public and private forest land have pledged to use prescribed fire, in conjunction with other silvicultural treatments, to reduce the risk of wildfire, improve forest ecosystem health, and restore habitat for endangered species (National Fire

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Plan, <http://www.fireplan.gov/>; Christensen, 2003). Yet both public forest management organizations, such as the USDA Forest Service and USDI Bureau of Land Management, and private forest management organizations, such as The Nature Conservancy, have fallen far short of their goals for treating forested areas with prescribed fire (Christensen, 2003; <http://www.fireplan.gov/reports/1-1-en.pdf>). Observers of recent fire management decisions have charged that both the land management organizations and the regulatory agencies that review their decisions (e.g., US Environmental Protection Agency, USDI Fish and Wildlife Service) have become overly risk-averse, in the sense that the actions they are taking do not make good sense in relation to their stated management goals. Stankey et al. (2003) reviewed progress toward implementing the Northwest Forest Plan in the United States and reported that both the land management agencies and the regulatory agencies were making overly risk-averse decisions about silvicultural treatments, including fire, to the point of jeopardizing the very values toward which management actions should be targeted. Similar criticisms have been made of The Nature Conservancy, which actively espouses forest and range management through prescribed fire but fails to achieve its own burn targets due, at least in part, to fears about using prescribed fire (Christensen, 2003).

What factors can account for apparently systematic deviations of organizational decision-making in the direction of excessive risk aversion? Psychologists who study human decision-making have identified decision heuristics, or mental shortcuts, that can systematically bias decisions that are difficult because of (1) uncertainty about outcomes and (2) multiple and conflicting objectives (Tversky and Kahneman, 1974; Camerer and Kunreuther, 1989). The primary purpose of this paper is to examine fire management decisions using insights from behavioral decision theory to identify factors operating at both the individual and the organizational levels that could contribute to overly risk averse decisions. The secondary purpose is to use this analysis to suggest changes both within land management and regulatory organizations and in the interactions among organizations and their larger social contexts to counteract the systematic biases that lead to excessive risk aversion. Our goal is not to argue for any particular set of forest

management goals or to advocate any specific means of achieving them.

2. What is a “good” decision in an uncertain and complex world?

The world of fire management is highly uncertain. Social, biological and physical factors beyond the control of forest managers can affect the outcome of fire management decisions concerning wildfire or prescribed fire. In particular, actions taken (e.g., igniting prescribed fires, pre-emptive fuel management, suppressing wildfire, deciding not to suppress wildfire or escaped prescribed fire) have the potential to harm the features of forest landscapes that are valued, including human lives and property, endangered species, sensitive habitats and water resources. The best a manager can do when making decisions in an uncertain environment is to use available information wisely and act consistently with the multiple goals that underlie forest management (e.g., ecosystem health, water quality and quantity, protection of endangered species and their habitats, economic well-being of resource-dependent communities, protection of human life and property). Using information wisely means collecting and analyzing information relevant to predicting likely outcomes of management actions within time and budget constraints, and pressing for extra time and resources when initial analyses suggest especially uncertain and risky outcomes. Adhering to stated goals means choosing actions that enhance the likelihood of achieving desired future conditions, that minimize the risk of undesirable consequences, and that trade off among competing objectives according to stated priorities. Following these guidelines for good decisions will not necessarily satisfy critics who want to pursue different goals and different priorities, but should guard against charges of failing to use appropriate information.

The field of decision analysis prescribes a set of analytical tools that help decision makers achieve these desirable characteristics of good decisions (e.g., Clemen, 2001). In an uncertain world even a “good” decision can have a bad outcome, so it is not appropriate to judge such decision-making on the basis of outcome alone. Rather, it is necessary to examine decisions for consistency with the facts

known at the time of the decision and the management goals that the decision is intended to advance. When there is a systematic mismatch between decisions taken and the facts and goals, as has been suggested for many forest management decisions (Stankey et al., 2003), including use of prescribed fire (Christensen, 2003), then the decision-making process can be considered flawed, calling for analysis of what is going wrong and how to improve it.

3. What leads to “bad” decisions in an uncertain and complex world?

Failure to gather relevant information and draw appropriate conclusions about what is likely to happen and failure to articulate the goals underlying management decisions can certainly compromise good decision-making. But, beyond these obvious errors, there are psychological barriers to making good decisions in complex and uncertain situations, and these are the focus of behavioral decision theory (von Winterfeldt and Edwards, 1986). These psychological barriers lead to (1) systematic errors in estimating the likelihood of uncertain events; (2) mistakes in manipulating probabilities, including failure to combine probabilities properly over space and over time; (3) misinterpretation of the meaning of probabilistic relationships (e.g., independence of events, “runs” of the same outcome in small samples); (4) mistakes in identifying and assessing values underlying decisions;

and (5) failure to combine information about probabilities and values in a coherent way. Any or all of these biases can threaten good decision-making.

We will illustrate these biases with decisions about use of prescribed fire in forest management, although the same mental shortcuts affect other forest management decisions (e.g., wildfire suppression, use of silvicultural treatments such as thinning), as well as other types of resource management decisions (e.g., decisions about manipulation of endangered species, including capture, translocation, and habitat restoration), so the conclusions of this paper apply more broadly than just to prescribed fire. We will examine the impact of biases on retrospective analyses of fire management decisions as well as on prospective decision-making (i.e., decisions where uncertainty about outcomes has yet to be resolved).

4. Framing prescribed fire decisions

Prescribed fire decisions are often described as a risky choice (prescribed fire) versus a certainty (status quo management). The decision tree in Fig. 1 shows the choice between these two management actions (branches at the square node) and the random events that influence how the use of prescribed fire will turn out, whether or not the fire escapes from its intended extent and intensity (branches at the circular node). The decision is hard because prescribed fire can fail to achieve its land manage-

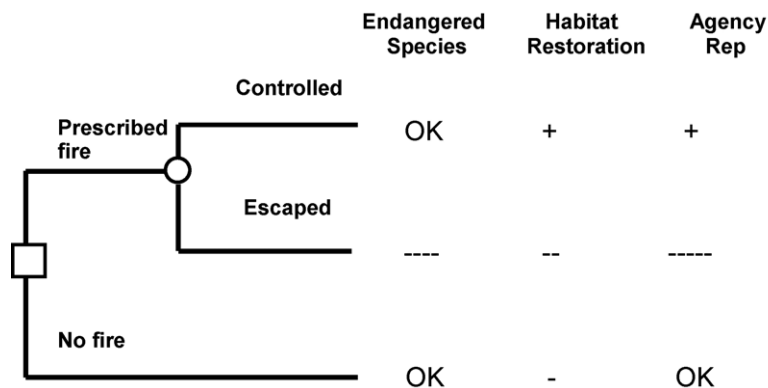


Fig. 1. The “precautionary” approach to fire management, expressed as a choice between the risky alternative of prescribed fire and the certain alternative of status quo management. Pluses and minuses indicate qualitative changes in the outcome measures from conditions at the time the decision is made.

ment objectives, and most particularly, it can harm the very values it is intended to promote (e.g., ecosystem health, endangered species and their habitats). Prescribed fires that escape can threaten endangered species populations and sensitive habitats, set back habitat restoration (at least temporarily), threaten human life and property, and damage agency reputations. Making a good decision about use of prescribed fire requires the decision maker to estimate the likelihood the prescribed fire will escape and do harm and weigh that potential against the benefits to forest habitats (and perhaps to endangered species) from successful use of prescribed fire (Fig. 1). To use the formal tools of decision analysis to help make such a decision, an analyst would help the decision maker assign numerical values to the likelihood of escape and to the various costs and benefits of escaped prescribed fire, successful prescribed fire and continuation of the status quo. Under standard methods of expected utility (or value), the best decision is then the one with the highest expected value, where the probabilities associated with random events are used to weight the positive and negative impacts on management goals. In this example, the desired goals include endangered species, habitat restoration and agency reputation, but similar decision dilemmas would arise if human life and property were substituted for (or added to) endangered species concerns.

5. Certainty bias and the “precautionary principle”

In evaluating prescribed fire decisions according to the framework in Fig. 1, land managers and regulatory agency personnel often invoke the “precautionary principle,” preferring the supposedly certain alternative of “no fire” to the alternative that carries a significant risk to both resources that are valued and to agency reputation. However, framing prescribed fire decisions as a risky choice (prescribed fire) versus a certainty (status quo management) reflects a mental shortcut termed the “certainty bias” (Kahneman and Tversky, 1979). People appear to have a strong urge for certainty, and they struggle to describe decisions so that at least one alternative looks “safe.” They are reluctant to acknowledge that, seen broadly and over a long enough timeframe, most alternatives carry their own set of risks, necessitating risk–risk trade-offs among the uncertain costs and benefits of alternative management actions (Graham and Wiener, 1995). In the case of prescribed fire decisions, the status quo alternative to prescribed fire carries its own risk of increased likelihood of wildfire over time (Fig. 2), unless other management actions are taken to reduce wildfire risk. Mischaracterizing prescribed fire decisions as a risky choice versus a certainty (Fig. 1), rather than more accurately as a choice between two risky alternatives (Fig. 2), fosters an inappropriate

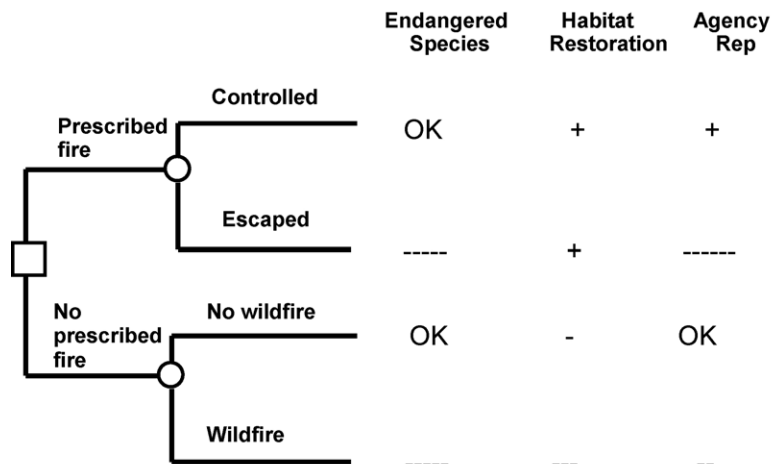


Fig. 2. Fire management decisions re-cast as a choice between two risky alternatives, prescribed fire and no use of prescribed fire. Pluses and minuses indicate qualitative changes in the outcome measures from conditions at the time the decision is made.

application of the precautionary principle in fire management decision-making, leading managers to reject use of prescribed fire more often than would be justified by a true weighing of costs and benefits of all management options.

6. Status quo bias

Recasting the prescribed fire decision as a risk–risk decision alleviates some, but not all, of the mental biases leading to overly risk-averse fire management decisions. Samuelson and Zeckhauser (1988) have proposed a “status quo bias” where traditional responses continue, even if they can be demonstrated to be suboptimal. Camerer and Kunreuther (1989) suggest that decision makers (1) feel less responsible for negative consequences of failing to take action than they do for negative consequences of a deliberate intervention (Corbin, 1980), and (2) view foregone gains as less serious than potential large losses (Thaler, 1980). In the prescribed fire case (Fig. 2), fire damage to sensitive habitats or human property resulting from wildfire is viewed as less serious than the same damage arising from an escaped prescribed fire. In a dramatic demonstration of this effect, staff of the Prescott National Forest in Arizona told Cohan et al. (1984) to weight the dollar value of structures lost to escaped prescribed fire much more heavily than the same losses resulting from wildfire, due to the higher political and legal impact of escaped prescribed fire. The commonly expressed preference for “hands-off” management, or “letting nature take its course,” may also be an example of status quo bias.

The second feature of status quo bias, where foregone gains pale in comparison to potential large losses, applies to prescribed fire decisions, too, since the future gains to habitat and ecosystem health are overshadowed by the potential for large losses from escaped fires. This feature of decision-making may also explain why regulatory agencies that must comment on or approve proposals by land management agencies to use prescribed fire can be even more risk-averse than the land management agencies themselves. Since the regulatory agencies (such as USDI Fish and Wildlife Service, which engages in

consultations regarding actions that could affect listed species, or the US Environmental Protection Agency, which oversees proposals for actions by federal agencies) are charged with environmental protection, not with ecosystem management, potential gains to habitat quality appear to the regulatory agencies even less consequential in relation to immediate threats to species, property and air quality than they do to the land management agencies.

7. Discounting

Other mental shortcuts afflicting prescribed fire decisions reflect people’s difficulties in making both values trade-offs and probability manipulations over an extended time horizon. One of the mental shortcuts that can exaggerate the risks of prescribed fire, in comparison to the risks of status quo management, is “discounting” of future consequences. Although discounting is an accepted way to express commonly observed preferences for “a bird in the hand versus two in the bush,” in this case discounting can cause the immediate negative effects of escaped fire on agency reputation and endangered species to loom unduly large in comparison to the more delayed, as well as uncertain, benefits of fire for habitat restoration. Stankey et al. (2003) used much the same language to describe why land managers implementing the Northwest Forest Plan in the northwestern United States often failed to carry out silvicultural treatments that were part of an adaptive management scheme: “. . . the asymmetry between the economic, political, and personal costs of experimentation (often immediate and obvious) and the benefits (often displaced to the future and problematic) can act to suppress investments in knowledge acquisition and distribution” (p. 41). Repeated application of the precautionary principle, expressed in this way, can actually jeopardize the values management is intended to protect (e.g., endangered species, human property) (Stankey et al., 2003). Camerer and Kunreuther (1989) describe people as being “impatient about the near future and myopic about the distant future,” inhibiting short-term expenditures that would help achieve long-term benefits, such as habitat restoration, or avoid long-term risks, such as the increasing risk of wildfire in some unmanaged forests.

8. Bias in cumulative probabilities

People have difficulty accurately projecting probabilistic events over a period of time, which can lead them to make decisions that appear rational in the short-term but which, accumulated over a longer term, run counter to stated goals. Viewing the prescribed fire example over the short-term, rejecting the use of prescribed fire seems to be a sensible way to guard against the risks of escaped fires. Over the longer term, the probabilities of wildfire (lower branch in Fig. 2) are likely to increase as fuels accumulate. In addition, conditions for endangered species may deteriorate in the absence of fire, so that taken cumulatively, the expected value of not using prescribed fire declines over time. Because the management agencies, and even more so the regulatory agencies, see the decision only as a snapshot at a particular point in time, these cumulative probabilities and cumulative consequences of no fire are less obvious than they should be. Land management agencies and the regulatory agencies that review their activities do recognize that effects of management decisions accumulate over space and over time (e.g., US National Environmental Policy Act guidance, <http://ceq.eh.doe.gov/nepa/ccenepa.htm>), but it is hard to overcome the psychological barriers to evaluating them properly.

Other mental shortcuts bias the way people combine probabilities of separate events and ascribe meaning to combinations of random events. People are apt to miscalculate the probabilities of sequences of random events, such as believing that another wildfire could not follow soon after a recent fire, even in landscapes where conditions suitable for wildfire occur regularly and may not be diminished by a recent fire (Cortner et al., 1990; Gardner and Cortner, 1988). People also misconstrue the meaning of a series of unfortunate events, such as a string of wildfires, assigning unwarranted significance to a small sample of events that may be independent (Tversky and Kahneman, 1971).

9. Biases in probability estimation: availability and optimistic bias

Two types of mental shortcuts that can influence prescribed fire decisions pertain to probability estima-

tion, e.g., assessing the likelihood that a prescribed fire will escape and cause damage. The “availability heuristic” suggests that recent, and especially dramatic, emotionally charged events artificially inflate subjective estimates of the likelihood of such events (Tversky and Kahneman, 1973). Homeowners who had experienced an escaped prescribed fire that caused extensive damage in Michigan thought that prescribed fire was both likely to escape and dangerous, despite the fact that more than 99% of prescribed fires proceeded without incident (Winter and Fried, 2000). Disproportionate media coverage of fire disasters feeds the availability heuristic. It is no accident that a controversial bill to increase spending for and reduce regulatory oversight of forest thinning passed the United States Congress in 2003 shortly after catastrophic wildfires in southern California killed people and damaged property (Healthy Forest Restoration Act of 2003, Public Law 108–148).

Operating in the opposite direction, an “optimistic bias” (Weinstein, 1980) can lead people to underestimate the likelihood of adverse events and exaggerate the likelihood of favorable events, perhaps illustrating the “it couldn’t happen to me” approach to decision-making that leads to risk-taking behavior (e.g., building in fire-prone areas, failing to secure a defensible space around forest homesites). The observed phenomenon of ignoring risks with probabilities below some threshold may also explain such risk-taking behavior (Slovic et al., 1977).

10. Values trade-offs: “mental accounting”

Even when fire decisions are properly re-cast in a risk–risk framework (Fig. 2), there are still impediments to weighing the costs and the benefits of the risky alternatives. People engage in “mental accounting” (Thaler, 1985), where different types of gains and losses seem to be maintained in separate “accounts,” and it is distasteful, or even morally repugnant (see Tetlock et al., 2000, on “taboo trade-offs”) to think of trading off costs and benefits between different types of accounts. One everyday example is the observed reluctance to assign an explicit dollar value to human lives, even though such a value is assigned implicitly whenever decisions are made about expenditures for gains in human health and safety. In the prescribed fire

context, land managers and regulators may be reluctant to make explicit trade-offs between benefits to habitat restoration and ecosystem health versus costs to endangered species or, even worse, to human life and property. However, such trade-offs are being made implicitly whenever a choice is made to use prescribed fire (or another treatment to modify wildfire risk) or not.

11. Retrospective analyses

In addition to the mental shortcuts that can bias decisions about future actions, mental shortcuts can derail retrospective analyses of decisions that have already been taken. Retrospective analyses are an essential part of adaptive management, checking to see whether the results of actions taken are those that were anticipated and using discrepancies to refine future predictions (Holling, 1978). In addition, when things go wrong and the results of actions taken are both unexpected and disastrous, retrospective analyses are mandatory, both for the purpose of assigning blame and exacting compensation for damages, if warranted, and for the purpose of improving future decisions. There is a built-in bias to retrospective analyses in that they are disproportionately analyses of decisions that have gone awry rather than those that have turned out well. To a point, it makes sense to analyze decisions with unfortunate outcomes because situations with the biggest discrepancies between expectation and result can offer the greatest potential for learning, but this legitimate reason for retrospectively analyzing disasters is often overshadowed by the desire to assign blame.

Mental shortcuts threaten the quality of retrospective analyses and diminish the learning that could take place. Those demanding retrospective analyses of decisions that have turned out badly often focus too intensely on the outcome rather than on the decision process, forgetting that, in an uncertain world, even good decisions will sometimes have bad outcomes. Decision makers can and should be held accountable for making decisions that use available information wisely and are consistent with stated goals. Attempting to hold decision makers accountable for outcomes, which may be wholly or partially beyond their control, only reinforces overly risk-averse mental processes that can compromise good decision-making.

12. Hindsight bias

Even retrospective analyses that focus appropriately on the decision process, rather than just on the outcome, can fail to be informative due to what Fischhoff and Beyth (1974) have termed “hindsight bias.” Once a decision has “turned out,” and especially if it has turned out badly, people feel a compelling need to re-cast the decision situation so that the actual outcome appears inevitable. They retrospectively overestimate the probabilities of the events that actually did happen, elaborate an explanatory story that ties together all the events that did occur, and focus only on the costs and benefits of the results that did occur, to the exclusion of the costs and benefits of other results that might have occurred (Camerer and Kunreuther, 1989). Once a prescribed fire has escaped and damage has been done, the benefits of prescribed fire frequently disappear from consideration. An undue focus on a single outcome, from amongst the array of outcomes that were possible at the time the decision was made, cannot give good insight into the decision process and will not help make better decisions in similar situations in the future.

13. Regret theory

The cost side of decisions that have turned out badly looms very large and focuses attention on choices that have the potential for bad outcomes. Bell (1982) has proposed “regret theory” to explain why people appear to often choose alternatives on the basis of minimizing the potential for loss rather than maximizing the expected net value of gains and losses. In this kind of decision-making (minimizing regrets, rather than maximizing expected value), decision makers focus on the random events that have the worst outcomes (e.g., the escape of a prescribed fire), to the exclusion of the other events that are possible, thus assuming that the worst will occur with certainty. Risk assessments by agencies such as the US Environmental Protection Agency often purposely incorporate a conservative bias as the prudent way to evaluate policy alternatives in order to guard against the possibility that circumstances will turn out worse than anticipated (Environmental Protection Agency, 1998).

14. Missing goals

Retrospective analyses can go astray when the results of actions taken are evaluated according to a suite of goals that is narrower than those in play at the time the decision was made. It is easy to criticize land management organizations like the US Forest Service or The Nature Conservancy for failing to meet their own targets for areas to be treated with prescribed fire, or other wildfire reduction measures, but sometimes failure to keep up with a planned schedule has more to do with competing demands on limited budgets than on unwillingness to undertake the planned actions. For example, in 2002 unusual wildfires on federal lands in the United States monopolized financial and human resources that might otherwise have been used to implement fire treatments that were part of the National Fire Plan (<http://www.fireplan.gov/reports/1-1-en.pdf>). In addition, restrictions on prescribed burning to protect air quality may have inhibited implementation of prescribed fire programs.

15. Organizational risk aversion and its remedies

The mental shortcuts described here cause systematic biases in decision-making. In addition, it appears that most of the time, although not always, those systematic biases are likely to be in the direction of excessive risk aversion, in the sense of avoiding risky outcomes to a degree that appears inconsistent with an organization's stated goals. Criticism of excessive risk aversion has been levied at public and private land management organizations alike (Christensen, 2003; Stankey et al., 2003).

Failings of individual decision-making can induce failings at the level of the whole organization. Heath et al. (1998) describe the need for both "cognitive repairs," designed to avoid and counteract the biases of flawed reasoning, and "motivational repairs," designed to fix flawed incentive structures that may mistakenly reward flawed reasoning or fail to reward improved reasoning. We will discuss both kinds of repairs here, mentioning first structured decision processes that are designed to remedy the mental shortcuts that lead to biased decisions and then structural changes, both within and between organiza-

tions, to rectify a perverse set of incentives that discourage individuals from pursuing better decision processes. In practice, it is probably the case that most remedies blend cognitive repairs and motivational repairs to achieve better performance by both individuals and organizations.

16. Structured decision processes

Part of the solution to excessive risk aversion arising from mental shortcuts is use of structured procedures for estimating probabilities for random events, for assessing values associated with management outcomes, and for integrating both probabilities and values in fire management decision-making. The first step in such procedures is to frame decision problems explicitly in terms of alternative actions, random events that can affect how these actions turn out, and criteria for evaluating how well various combinations of actions and random events satisfy the underlying goals of management (as in Figs. 1 and 2). The next steps are to use accepted protocols for estimating the likelihood of random events and for describing preferences for possible outcomes. These procedures are standard repertoire for decision analysis (e.g., Meyer and Booker, 1991, for elicitation of probability estimates from experts, Keeney, 1992, for articulation of preferences for various outcomes); they are designed to counteract the systematic biases that result from common mental shortcuts. The final steps are to integrate information on probabilities and preferences by applying a decision rule such as maximizing expected utility, as has been demonstrated for forest fire management decisions by Cohan et al. (1984).

17. Incentives for individual decision makers

Making better use of structured decision-making procedures is only part of the story. It neglects the organizational framework in which land management, particularly public land management, decisions take place. The mental shortcuts that lead to overly risk-averse decisions affect all levels of organizational structure, from individual decision makers to the interactions among land management agencies, regulatory

agencies, the public, the media and the courts. At the individual level, land managers may be reluctant to make decisions that could turn out poorly in part because they fear criticism, or even job loss. This charge has been made repeatedly in qualitative analyses of land management decisions based on semi-structured interviews and informal observation (e.g., Christensen, 2003; Stankey et al., 2003), although a survey of US Forest Service land managers in which they were asked to make hypothetical decisions concerning fire risk found little evidence that fear of criticism or of job loss influenced their decisions (Taylor et al., 1988). It would be interesting to know if 15 years of additional appeals and litigation over fire management on public lands have changed managers' attitudes in that regard, or if the discrepancy between anecdotal reports and survey results can be attributed to different responses to hypothetical situations than to actual ones (List and Gallet, 2001).

Poorly done retrospective analyses, which focus on assigning blame for bad outcomes rather than on the quality of the decision itself, particularly those that scapegoat lower-level managers, create organizational disincentives to creative management that exacerbate the mental shortcuts leading to excessive risk aversion. When employees perceive that undertaking risky decisions could expose them to disciplinary action, job loss, or even personal liability, it becomes rational for an individual employee to be very risk-averse, to the detriment of the land management goals with which the organization is charged by the public. Stankey et al. (2003, p. 43) interviewed forest managers in the Pacific Northwest and found that “coordinators and line officers cited few incentives to undertake adaptive approaches, arguing that experimentation and risk-taking are not standards against which they are evaluated. They described their organizations as risk-averse (i.e., concerned with minimizing the possibility of harm occurring [Wildavsky, 1988]) but acknowledged that such behavior is rational and appropriate in a world where the burden of proof has shifted to land managers to provide rigorous evidence that any proposed action (including experimentation) will not lead to adverse consequences for threatened and endangered species (Lee, 1993).”

Only by changing the reward structure within the organization, so that taking risks that sometimes result in bad outcomes is not routinely punished, will

excessive risk aversion be alleviated. Christensen (2003) suggests that higher-level decision makers in The Nature Conservancy must provide incentives for crews to set more prescribed fires to counteract their fears that they might lose their jobs if a prescribed fire gets out of control. Stankey et al. (2003) quote Kotter (1995, p. 60), saying that changing a dysfunctional organizational structure requires making “... the status quo seem more dangerous than launching into the unknown.” In the case of fire management decisions, permission to fail (i.e., have a bad outcome from a prescribed fire) is essential to counteract excessively risk-averse decision-making.

18. Incentives at higher organizational levels

Structural incentives and disincentives similar to those affecting management decisions at a particular time and place also influence policy- and program-level decision-making in land management agencies. And, the same considerations influence interactions between the land management agencies and the regulatory agencies, as well as the relationships among the agencies and the public, the media, and the courts. Land management agencies perceive the regulatory agencies as requiring an impossible level of assurance that adverse effects will not occur, inhibiting the experimentation and learning that might result from innovative management (Stankey et al., 2003). When the USDI Fish and Wildlife Service undertook consultations with the USDI Bureau of Land Management and the USDA Forest Service concerning potential impacts to endangered species under the Northwest Forest Plan, the regulatory decisions were “highly risk-averse,” requiring that management actions never result in “taking” (i.e., killing) endangered species, although project-level decisions for specific small scale activities were somewhat more lenient (Burton, this volume).

Both land management and regulatory agencies perceive the public as overwhelmingly critical of management decisions that turn out badly. The media play into this culture of risk aversion by focusing investigation and coverage on laying blame for adverse events. The courts and even the legislative branch participate in creating a culture of risk aversion via damage awards and congressional investigations

prompted by injured publics. There is a legitimate need for these legal and legislative interventions in a democratic society, but when decisions under uncertainty are poorly understood by the general public and by many professionals, and when mental shortcuts exacerbate risk-averse decision-making, sound land management decision-making can be threatened. Changes to the incentive structures both within and between organizations are needed in order to counteract disincentives to risk-taking that arise in interactions between land management agencies and regulatory agencies, and between regulatory agencies and the public and its agents in the legislature and the courts.

19. Risk education

Are there other solutions to these structural problems that lead to excessive risk aversion? One possibility is education of both the general public and those in various professions (natural resources, regulatory, legal, media) about decision-making in an uncertain world. Being able to distinguish good decisions from good outcomes and being able to recognize the effects of mental shortcuts on decision-making might alleviate some of the inappropriate blame-seeking when resource management decisions turn out badly and might increase tolerance for undesirable outcomes.

It is difficult to be sanguine about the potential for public education, however. The mental shortcuts that have been identified by behavioral psychology are fascinating in part because they are so compelling; even experts well trained in probabilistic forecasting fall prey to these mental shortcuts (Tversky and Kahneman, 1983). And, given the high level of litigation to recover damages in so many venues in United States society, it is hard to imagine persuading individuals who believe they have been harmed by fire management decisions to forego opportunities for legal redress. However, it might be possible to budget for compensation to harmed parties as part of fire management decisions, as both private conservation organizations, such as Defenders of Wildlife, and public agencies, such as USDI Fish and Wildlife Service, have done in funding compensation programs for farmers and ranchers who have lost livestock to

depredation by recovering predator populations. In some areas, such compensation programs have significantly disarmed critics of predator conservation (Mech, 1995).

20. Locally based initiatives

Although counteracting excessive risk aversion through education and changes in organizational structure seems daunting when viewed on a broad scale, local initiatives have been successful. Steelman and her students have studied wildland fire management in selected communities of the southwestern United States (<http://www.ncsu.edu/project/wildfire/>). Local efforts by land management agencies, such as the USDA Forest Service and USDI Bureau of Land Management, to create collaborative relationships with citizens and to educate citizens and local government officials about wildland fire risks, and ways to ameliorate those risks, have paid off in terms of greater public acceptance of prescribed fire (e.g., La Plata County, Colorado, http://www.ncsu.edu/project/wildfire/Colorado/la_plata/lp_reduce.html). These efforts have included explicit targeting of local media to educate them about prescribed fire and to recruit them to publish articles in support of wildland fire management (http://www.ncsu.edu/project/wildfire/Colorado/la_plata/lp_improve.htm), instead of focusing solely on fire disasters.

21. Trust and cooperation

Land managers rate public trust as an important influence on their fire management decision-making (Taylor et al., 1988), and Stankey et al. (2003) have identified enhancing the level of trust and cooperation between land management agencies and regulatory agencies as part of the solution to excessively risk-averse management decisions that inhibit adaptive management and learning. The need to enhance trust and cooperation extends to interactions among agencies, the public, the media and the courts as well. Changing the rules for civic engagement in fire management decisions from a system that emphasizes suspicion and avoidance of criticism to one that emphasizes open acknowledgment of risks and

tolerance for unfortunate outcomes, combined with accountability for good decision-making, could go a long way toward countering the excessive risk aversion that seems to grip fire management decisions today.

22. Reducing risk

Although the focus of this paper has been on the mental shortcuts that can bias fire management decision-making and how to counteract them, any comprehensive approach to improving decision-making in risky circumstances should also include management actions to reduce risk substantively. The potential for negative consequences of both prescribed fire and wildfire to human life and property can be reduced by decisions made by individual homeowners to build houses outside of fire-prone areas and to choose building and landscaping materials to deter the spread of fire. These individual decisions can be influenced by local zoning ordinances and by the rate structures for homeowners insurance (Winter and Fried, 2000). Similarly, the potential for adverse effects of fire on endangered species and sensitive habitats, including riparian zones, has been elevated by decades of management decisions that have fragmented and degraded forest landscapes, pushing ecosystems to the point where levels of disturbance typical in those systems historically (including fire) cannot be accommodated (e.g., Reiman, this volume). Land management that reconnects fragmented landscapes and boosts endangered species populations away from the brink of extinction may reduce the risks from fire, whether prescribed or naturally ignited. Reducing actual risk will feed back positively into the decision process, since land managers will not be so wary of adverse outcomes and the mental shortcuts leading to biased decision-making will not be triggered so strongly.

23. Summary and conclusions

Both structured social science investigations and anecdotal reports suggest that current fire management decisions for forest land are often excessively risk-averse, to the point of imperiling the natural and human resources they are intended to protect. Fire

management decisions are fraught with uncertainty and with the need to balance conflicting objectives. People faced with such decisions often resort to mental shortcuts that lead to systematic biases. The cumulative effect of such mental shortcuts in fire management decision-making can be the sort of excessive risk aversion that has been observed in the behavior of both individuals and organizations. These mental shortcuts also affect retrospective analyses of decisions that have turned out badly, where it is too common to focus on assigning blame for a bad outcome and too rare to focus on whether available information was used wisely in pursuit of a carefully identified suite of goals.

In order to counteract these mental shortcuts and encourage fire decisions that are more consistent with the stated goals for forest land management, remedies must address both the cognitive limitations of human decision-making and the incentive structures that influence behavior within and between organizations. Structured decision processes for handling uncertain information and for making trade-offs among conflicting objectives can help avoid some of the cognitive difficulties. Education about decision-making under uncertainty and about the prevalence of mental shortcuts that cause biased decision-making can help managers, regulators and the public become more tolerant of occasionally bad outcomes without diminishing accountability for good decision-making. Changing the incentives that encourage excessive risk aversion, as well as enhancing trust and cooperation between land management and regulatory organizations, can also help remedy current problems with fire management decision-making. More far-reaching remedies include engaging the public, the media, the courts and the legislature in a revised style of civic engagement in fire management, starting with education and cooperation at the local level.

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References

- Bell, D., 1982. Regret in decision making under uncertainty. *Operations Res.* 30, 961–981.
- Camerer, C.F., Kunreuther, H., 1989. Decision processes for low probability events: policy implications. *J. Policy Anal. Manage.* 8 (4), 565–592.
- Christensen, J., 2003. Auditing conservation in an age of accountability. *Conserv. Pract.* 4 (3), 12–19.
- Clemen, R.T. (with Reilly, T.), 2001. *Making Hard Decisions*, second rev. ed. with DecisionTools. Duxbury Press, Pacific Grove, CA.
- Cohan, D., Haas, S.M., Radloff, D.L., Yancik, R.F., 1984. Using fire in forest management: decision making under uncertainty. *Interfaces* 14 (5), 8–19.
- Corbin, R., 1980. Decisions that might not get made. In: Wallsten, T.S. (Ed.), *Cognitive Processes in Choice and Decision Behavior*. Erlbaum, Hillsdale, NJ.
- Cortner, H.J., Gardner, P.D., Taylor, J.G., 1990. Fire hazards at the urban-wildland interface: what the public expects. *Environ. Manage.* 14 (1), 57–62.
- Environmental Protection Agency, 1998. *Guidelines for ecological risk assessment*. U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC, EPA/630/R095/002F (<http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=12460>).
- Fischhoff, B., Beyth, R., 1974. I knew it would happen. remembered probabilities of once-future things. *Org. Behav. Hum. Perform.* 13, 1–16.
- Gardner, P.D., Cortner, H.J., 1988. An assessment of homeowners' perceptions of wildland fire hazards: a case study from southern California. In: Whitehead, E.E., Hutchinson, C.F., Timmerman, B.N., Vardy, R. (Eds.), *Proceedings, Arid Lands: Today and Tomorrow*, 20–25 October, Tucson AZ. West View Press, Boulder, CO, pp. 643–657.
- Graham, J.D., Wiener, J.B. (Eds.), 1995. *Risk Versus Risk: Tradeoffs in Protecting Health and the Environment*. Harvard University Press, Cambridge, MA.
- Heath, C., Larrick, R.P., Klayman, J., 1998. Cognitive repairs: how organizational practice can compensate for individual shortcomings. *Res. Org. Behav.* 20, 1–37.
- Holling, C.S., 1978. *Adaptive Environmental Assessment and Management*. John Wiley and Sons, New York.
- Kahneman, D., Tversky, A., 1979. Prospect theory: an analysis of decision under risk. *Econometrica* 47, 263–291.
- Keeney, R.L., 1992. *Value-Focused Thinking*. Harvard University Press, Cambridge, MA.
- Kotter, J.P., 1995. Leading change: why transformation efforts fail. *Harvard Business Review*, March–April, pp. 59–67.
- Lee, K.N., 1993. *Compass and Gyroscope: Integrating Science and Politics for the Environment*. Island Press, Washington, DC.
- List, J.A., Gallet, C.A., 2001. What experimental protocol influence disparities between actual and hypothetical stated values? *Environ. Res. Econ.* 20, 241–254.
- Mech, L.D., 1995. The challenge and opportunity of recovering wolf populations. *Conserv. Biol.* 9 (2), 270–278.
- Meyer, M., Booker, J., 1991. *Eliciting and Analyzing Expert Judgement: a Practical Guide*. Knowledge-Based Systems, vol. 5. Academic Press, London.
- Samuelson, W., Zeckhauser, R., 1988. Status quo bias in decision-making. *J. Risk Uncertainty* 1, 7–59.
- Slovic, P., Fischhoff, B., Lichtenstein, S., Corrigan, B., Combs, B., 1977. Preference for insuring against possible small losses: insurance implications. *J. Risk Insurance* 44 (2), 237–258.
- Stankey, G.H., Bormann, B.T., Ryan, C., Shindler, B., Sturtevant, V., Clark, R.N., Philpot, C., 2003. Adaptive management and the Northwest Forest Plan: rhetoric and reality. *J. Forestry* 101 (1), 40–46.
- Taylor, J.G., Carpenter, E.H., Cortner, H.J., Cleaves, D.A., 1988. Risk perception and behavioral context: U.S. Forest Service fire management professionals. *Soc. Nat. Res.* 1, 253–268.
- Tetlock, P.E., Kristel, O.V., Elson, S.B., Lerner, J.S., 2000. The psychology of the unthinkable: taboo trade-offs, forbidden base rates, and heretical counterfactuals. *J. Pers. Social Psychol.* 78 (5), 853–870.
- Thaler, R.H., 1980. Toward a positive theory of consumer choice. *J. Econ. Behav. Org.* 1, 39–60.
- Thaler, R.H., 1985. Mental accounting and consumer choice. *Marketing Sci.* 4 (3), 199–214.
- Tversky, A., Kahneman, D., 1971. Belief in the law of small numbers. *Psychol. Bull.* 76 (2), 105–110.
- Tversky, A., Kahneman, D., 1973. Availability: a heuristic for judging frequency and probability. *Cogn. Psychol.* 5, 207–232.
- Tversky, A., Kahneman, D., 1974. Judgment under uncertainty: heuristics and biases. *Science* 185, 1124–1131.
- Tversky, A., Kahneman, D., 1983. Extensional versus intuitive reasoning: the conjunction fallacy in probability judgment. *Psychol. Rev.* 90 (4), 293–315.
- von Winterfeldt, D., Edwards, W., 1986. *Decision Analysis and Behavioral Research*. Cambridge University Press, Cambridge, UK.
- Weinstein, N.D., 1980. Unrealistic optimism about future life events. *J. Pers. Social Psychol.* 39, 806–820.
- Wildavsky, A., 1988. *Searching for Safety*. Transaction Publishers, New Brunswick, NJ.
- Winter, G., Fried, J.S., 2000. Homeowner perspectives on fire hazard, responsibility, and management strategies at the wildland–urban interface. *Soc. Nat. Res.* 13, 33–49.