

Managing Wicked Environmental Problems: Integrating Public Participation and Adaptive Management

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Abstract

It has been over three decades since “wicked problems” first appeared in the literature. However, there are still few viable approaches for confronting wicked problems. The most common approaches include the precautionary principle, adaptive management, and participatory processes. Each has significant limitations.

Building upon the National Research Council’s proposal of a deliberative-analytic process involving multiple stakeholders, we propose a method that augments typical participation with sophisticated modeling of public preferences, thus enhancing both the efficiency and the potential success of public engagement.

To illustrate our proposal, we describe an experiment that we conducted in the Sierra Nevada Forest Plan Amendment context involving the USDA Forest Service, other agencies, advocacy groups, and the general public. The results of the experiment demonstrate how public preferences can be clarified for all parties and then linked to ecological models to better inform and guide decision making in the context of wicked problems.

Keywords

Wicked problems, public participation, learning networks, modeling public preferences.

Introduction

In this paper, we introduce a method for clarifying public attitudes and improving participatory processes. The discussion is based on our work with the Pacific Southwest Region (Region 5) of the USDA Forest Service during 2003 and 2004. The Regional Forester asked us to evaluate the Region's consideration of risk and uncertainty in the development of the Sierra Nevada Forest Plan Amendment (SNFPA). Detailed results of the study are available elsewhere (Stewart et al. 2004; Walters et al. 2003). Here we begin with a brief glimpse into the vast literature on uncertainty and risk. We then discuss the nature of wicked problems and three approaches commonly used to address them: the precautionary principle, adaptive management, and public participation. We conclude that, as currently applied, these approaches are inadequate. We then examine the SNFPA as a wicked problem and describe an iterative, analytic, deliberative, participatory approach for dealing with such problems using the SNFPA as a case study. While we build on existing literature for the background discussion on risk and uncertainty, wicked problems, and the analytic-deliberative process, we believe our proposed method for eliciting and analyzing stakeholder preferences and feeding the results back into the analytic-deliberative process is novel. Our thesis is that while precaution, adaptive management and participation are important, an additional analytic step is essential in addressing wicked problems.

Decision Making under Risk and Uncertainty

In this first section, we consider the risks and uncertainties associated with large-scale environmental dilemmas. Based on this discussion, we argue that in this context the most important immediate risks that public managers face are related more to decision-making processes than to ecological outcomes.

Defining Uncertainty

Uncertainty and risk are defined in various ways both in common language and in the scholarly literature. In some cases, the terms are used interchangeably. In others, the usage depends on the discipline or context. Here, we discuss ways of thinking about uncertainty and risk that may be useful for forest managers facing complex environmental management decisions.

Uncertainty signifies that events, relationships, phenomena, or other important considerations are not precisely predictable. The likelihood of occurrence of a particular event in a given circumstance may be unknown, or may have a distribution of possible values, but it is not under the immediate control of agency decision makers. In this sense, we argue, uncertainty is value neutral. In describing uncertainty as value neutral, we highlight two important points:

- Uncertainty is used to describe probabilistic events, whether or not it is possible to quantify those probabilities. For example, in the context of forest management, the distribution of naturally occurring fire events may be calculable and therefore the probability of fire during a specific time interval may be estimable. In contrast, the likelihood of important budgetary changes resulting from shifts in national public policy priorities over the next 50 years may not be estimable. In both cases, however, "uncertain" is the analytical term used to describe the events.

- Uncertainty does not inherently involve a value position on the part of the analyst or decision maker. The probability of a lightning strike, for example, is independent of attitudes toward fire hazard, owl habitat, or any other value position. In this sense, uncertainty is a neutral concept.

In describing and presenting the uncertainties inherent in the Sierra Nevada management decision, analysts face a dilemma. On one hand, simple and accessible characterizations of the multiple uncertainties are likely to be misleading, biased, or wrong. But the alternative poses its own challenges. Detailed characterizations of uncertainty are likely to be difficult to understand and present, and consequently may not be useful to the public or to decision makers. There is no scientific or technical solution for this dilemma. The resolution focuses on the decision processes employed. To be effective, such processes must tightly integrate analysis and broader deliberation, and should allow all participants to understand where scientists agree, where they disagree, and where their relative certainty ends (Stern & Fineberg 1996).

Defining Risk

Risk is a concept with a long pedigree in a variety of disciplines, but in virtually all technical discussions, risk is represented as having three components:

- one or more potential stressors (sometimes called hazards);
- a probability that these stressors will occur (often called exposure); and
- the likely adverse effect that will result if the stressors do occur (the value of the potential loss).

It is common to compare risks based on the product of the magnitude of the loss that will occur and the probability of its occurrence. Such calculations are referred to as “expected values.” In one recent analysis produced by the National Academy of Public Administration (Fairbanks et al. 2001), however, the NAPA panel finds that many federal risk assessment methods consider mostly the magnitude of hazards. The panel argues that it is necessary to develop methods that clearly include all three components of risk.

An important observation regarding the role of value judgments in assessing risk is also made by Slovic (2000) and is incorporated in a National Research Council (NRC) study (Stern & Fineberg 1996). In any characterization of risk, these studies argue, two critical value judgments are at least implicit. First, there is the judgment that a particular process or outcome merits serious attention. The decision to focus on wildland fire hazards or old growth owl habitat, rather than, say, the economic vitality of adjacent communities or the potential harm to black oaks, is a value judgment made by key actors. Because of the influence of those key actors, one set of values prevails in characterizing the risks in a given decision. Other actors at different times could have made, and have made, different judgments.

Second, there is the judgment about what constitutes an unacceptable level on the outcome dimension. To say that some number of acres of stand-destroying fires is unacceptable reflects again the values of the decision makers. Between these two judgments, there is much room for analysis in modeling, measuring, and calculating, but these important analytical efforts should not obscure the central observation that focusing on some outcomes and not others, and on some

outcome levels and not others, is a reflection of the value judgments and priorities of those making the decision. Again, which perceptions prevail in determining acceptable threshold levels of risk is a function of the influence of key actors. Our point is simply that these choices are neither objective nor purely scientific, nor could they be.

Most forest management decisions can be characterized as having both long-term and short-term risks:

- *Long-term risk*: given observed ecosystem conditions, existing external human factors, and future natural events and processes, the probability that any particular adopted management strategy will result in a preponderance of outcomes judged undesirable by the majority of stakeholders over the long term (for example, beyond 10 years).

- *Short-term risk*: given observed ecosystem conditions, existing external human factors, and future natural events and processes, the probability that any particular adopted management strategy will be seen as undesirable by the majority of stakeholders over the near term (for example, for 10 years or less) because
 - it results in a preponderance of undesirable outcomes; or
 - it violates accepted historical precedents; or
 - it violates widely held principles and standards of practice; or
 - it violates broadly held social preferences.

What emerges from this characterization is the observation that short-term risks involve much more than just concern about uncertain outcomes or the products of the decision. While stakeholders are certainly concerned with ecological outcomes, many are willing to accept modest short-term losses if potential long-term gains are great enough. Further, many of the available ecologically based vegetation or fire projection models used in forest planning do not show a significant difference in ecological outcomes in the short run. If it is true both that stakeholders are willing to consider short-term tradeoffs and that alternatives under consideration are indistinguishable in their short-run outcomes, then the focus of short-term risks must shift to concerns with the decision process itself. Attention must be paid to process, or the decision maker runs the risk of failing to garner public support in the short term even though the likelihood of desirable long-term outcomes is enhanced. And this brings the “risk dilemma” into focus.

Risk assessment is rarely without controversy. How people perceive risk depends on what they value, how the risk is framed, and their level of trust in the responsible organization or institution. Thus every way of presenting risk information constitutes a “frame” that can shape the judgments of participants in a risk decision. If the issue is framed in a positive light, people are more likely to dwell on the positive aspects of the decision, and vice versa. As the NRC report concludes: “Numerous research studies have demonstrated that different but logically equivalent ways of summarizing the same risk information can lead to different understandings and different preferences for decisions” (Stern & Fineberg 1996, p. 57).

Framing is not an issue that can be resolved with better science. There is no scientific way to determine that one summary of risk is more accurate or less biased than another when both

accurately reflect the data. Thus the problem of generating a single unbiased summary of risk information to meet the needs of participants in a risk decision has no purely technical solution.

Consequently, as with efforts to address uncertainty, the decision processes become centrally important. If participants trust the organization presenting the risk information, they are more likely to accept the characterization. And the level of trust is a byproduct of the decision process (Shindler & Toman 2003). Experience in a variety of settings suggests that such trust is easily damaged and difficult to restore.

Defining Wicked Problems

Decision making in the public arena occurs at various levels of complexity. Challenges often include large spatial and temporal scales with varying social and ecological conditions across the scales, multiple stakeholder groups with strongly divergent preferences and values, high levels of perceived risk with risk perceptions across stakeholder groups that are sometimes contradictory, and scientific uncertainty concerning both current and predicted social and ecological conditions. In such circumstances, there may be no clear consensus, among experts or the broader public on either the nature of the problem or what would be an acceptable solution. Such problems have been termed “wicked” (Rittel & Webber 1973).

Table 1 adapted from Committee of Scientists (1999, p. 131) illustrates the distinctions between wicked and tame problems along the dimensions of the level of scientific uncertainty and the level of disagreement over values among stakeholders.

Table 1. Wicked Problems

	Agreement on Values	
State of Knowledge	High	Low
Well Developed	Routine analysis with periodic stakeholder and expert review. <i>Decisions are Easy</i>	Emphasis on stakeholder deliberation with periodic expert review.
Tentative/Gaps/Disagreements/Research Needed	Emphasis on expert deliberation with periodic stakeholder review.	Emphasis on both stakeholder and expert deliberation. <i>Wicked Problems!</i>

Rittel and Webber (1973) identified several distinguishing properties of wicked problems.

1. There is no definitive formulation of the problem; different framings of the problem will lead to different definitions.
2. Every wicked problem is inextricably linked to other problems; efforts to resolve components of a wicked problem will exacerbate other components of the problem or create new problems.
3. There is no stopping rule, or point at which the problem is effectively resolved.

4. Resolutions to wicked problems are not “true or false,” but rather “good or bad” or “better or worse” or, at best, “good enough.”
5. There is no immediate and no ultimate test of the effectiveness of a solution to a wicked problem.
6. Every wicked problem is essentially unique; consequently there is no opportunity to learn by trial and error.
7. The public gives the planner no flexibility to be wrong.

We argue that national forest management in the United States now often falls into the category of wicked problems. Moreover, the “wickedness” of the forest planning decision processes increases as the time horizons and ecological scales increase. In part, this explains why planning efforts get bogged down in uncertain analyses, acrimonious political struggles, and interminable appeals and lawsuits.

Thus in the context of wicked problems when uncertainty cannot be eliminated and perceptions of risk differ profoundly, the most important short-term risks for decision-makers are related to decision processes rather than ecological outcomes. We are not suggesting that forest conditions are unimportant; clearly they are a central concern. Rather, we contend that no progress toward successful implementation of a forest management plan can be expected in the absence of decision-making processes that have broad public support.

In later sections of this paper, we discuss lessons from the scholarly literature and best practice from a number of environmental management arenas indicating that responses to wicked problems must work to integrate multiple methods—including the best scientific analysis and the fullest possible public participation and deliberation—in long-term, iterative, adaptive decision-making processes (Stern & Fineberg 1996). First, however, we review three approaches that have been applied to wicked problems and consider their strengths and weaknesses. These are the precautionary principle, adaptive management, and public participation.

Addressing Wicked Environmental Problems

Precautionary Principle

One possible response to the public manager’s dilemma in the case of a wicked problem is application of the precautionary principle (PP). This proposed approach has engendered considerable controversy. Some scholars and practitioners assert that the PP is a powerful tool for protecting human health and the environment under conditions of uncertainty (Cameron & Aboucher 1991; Raffensperger & Tickner 1999). Others criticize it as ill-defined, unscientific, and of limited value as a concrete guide to policymaking (Manson 2002; Sunstein 2003).

Although the precautionary principle is presented and interpreted in various ways in the literature (Manson 2002), its basic concept is captured in the adages “better safe than sorry” and “above all, do no harm.” The key idea is that technologies or practices that have the potential to harm human health or the environment should be banned or strictly regulated until proven safe. Thus, an essential consequence of the precautionary approach is that the burden of proof is shifted from opponents of a given technology or management strategy, who in other circumstances would have to demonstrate harmfulness, to proponents, who now have to assure safety.

The influence of the PP on environmental policymaking in the United States was first seen in the wave of major, ground-breaking statutes relating to human health and the environment adopted in the 1970s (Jordan & O’Riordan 1999). The National Environmental Policy Act (NEPA), for example, requires that before any proposed government action that may harm the environment can be implemented, environmental impact assessments must be completed and alternatives considered. The Clean Air Act, the Clean Water Act, and the Endangered Species Act all include precautionary language mandating “margins of safety” in health and environmental protection. These ideas were also adopted in strong form in Europe and incorporated into various international treaties, conventions, and declarations (Raffensperger & Tickner 1999).

Over the past twenty years, however, attitudes in Europe and the United States towards the precautionary approach have diverged. In comparison with European and UN institutions, the United States, particularly from the early 1980s on, has been less sympathetic to the PP. Indeed, there has been considerable resistance to the idea at the leadership level both in government and the private sector, with movement instead towards cost-benefit, cost-effectiveness, and other forms of economic analysis. In the context of wicked problems where public stakeholders are active and influential, however, the PP continues to have a significant influence on policymaking in the United States as well. Outcomes in forest planning dilemmas, such as in the Sierra Nevada, are influenced by the precautionary attitudes of important public stakeholder groups. These differences in worldview contribute to the political stalemates that accompany decision making in the context of wicked problems.

Precautionary thinking can clearly make important, positive contributions in focusing attention on the potential for long-term, multigenerational effects of policy decisions; the potential for severe, adverse, unintended consequences; the limitations of cost-benefit and risk assessment methodologies; and the importance of public participation and recognition of diverse values. Nevertheless, the precautionary principle as currently understood cannot in isolation provide an effective, practical guide for policymaking when confronting wicked problems. The PP, for example, does not account for the potential adverse effects of precautionary actions themselves; does not provide unambiguous guidance to policymakers; has become politicized; and in its restrictive forms may stifle innovation and limit the application of adaptive management.

Adaptive Management

The strategy of adaptive management is commonly offered as a means to deal with scientific uncertainties. Twenty-five years of real-world examples as reviewed in Stewart et al. (2004) illustrate varying degrees of success across a spectrum of legacy cases, each of which teaches important lessons for applying this strategy. The basic concept of adaptive management is to “learn by doing.” Thus the approach involves an iterative process of experimentation, evaluation, and adjustment of policies and procedures. Later in this paper we discuss the important role that adaptive collaborative management can play in identifying and developing stakeholder networks that engage all parties in the process of grappling with the impacts of ecosystem management. First, we briefly review the history and definitions of conventional adaptive management that does not address social and political obstacles.

Uncertainty and complexity are central to the concept of adaptive management (Irvine & Kaplan 2001). Unlike non-adaptive management practices, which may attempt to make precise predictions and presume certainty, adaptive management accepts as given the reality of incomplete knowledge, and focuses on building learning opportunities into designing and implementing policies. Therefore, adaptive management emphasizes learning by doing, treating management actions and policies as hypotheses to be tested, and then designing and implementing them to generate critical information about the resources being managed. From the ecological perspective, complexity generally refers to the presence of multiple interconnected relationships and levels. Bormann et al. (1994, p. 3) observe, “Complexity is confronted by increasing effort to understand mechanisms that influence change, by reducing expectations that the future can be accurately predicted, and by reducing risk through diversifying.” If uncertainty and complexity require learning and adjustment, the need for adaptive management seems indisputable (Asher 2001).

Scholars have identified two forms of conventional adaptive management: *passive* and *active* (Wilhere 2002). Passive adaptive management is a scientifically rigorous process of formulating predictive models, making policy decisions based on the models, and revising the models as monitoring data become available. Models are used to predict ecosystem responses and, in theory, activities can be designed to disturb the ecosystem in ways that enhance estimating model parameters. Monitoring and evaluation systems are in place before management begins, but monitoring is conducted without controls, replication, or randomization. Therefore, passive adaptive management cannot establish cause-and-effect relationships between management actions and changes in ecosystem conditions. However, it is relatively simple and inexpensive (Wilhere 2002).

Active adaptive management conducts management actions as deliberate experiments. Alternative policies are viewed as treatments and implemented through statistically valid experimental design. Monitoring is the experiments’ data collection phase. Active adaptive management results in better understanding of how and why natural systems respond to management, and responses to a range of treatments can help develop better policy. However, this approach is more complex and expensive.

These conventional forms of adaptive management address scientific uncertainty but ignore social components. Wicked problems, however, involve not only scientific uncertainty, but also stakeholder conflicts in values and levels of acceptance of risk and uncertainty. Therefore, adaptive management needs to address the social side as well, including institutional barriers. Lee (1993), for example, in listing conditions that favor adaptive management, includes institutional factors such as institutional stability, organizational culture that encourages learning from experience, and sufficient political and administrative commitment of resources. McLain and Lee (1996, p. 437) add an emphasis on diverse sources of information and broad participation arguing that, “To be effective, new adaptive management efforts will need to incorporate knowledge from multiple sources, make use of multiple systems models, and support new forms of cooperation among stakeholders.” Gunderson (1999) finds that in cases of successful adaptive management, informal networks emerge. Such networks are effective because they have political independence and are out of the fray of regulation and implementation. It is these informal groups that explore flexible opportunities for resolving

resource issues, devise alternative designs and tests of policy, and create ways to foster social learning. These newer forms of adaptive management are applying the concept to the public participation process itself through the formation of learning networks (Stubbs & Lemon 2001).

While conventional adaptive management can address issues of scientific uncertainty, it does not produce agreement on policy choices when stakeholders have sharply different priorities and preferred outcomes; adaptive management is not a process for coping with disagreement over management goals and objectives (Johnson & Williams 1999). Other obstacles to using conventional adaptive management effectively include stakeholders failing to agree on the nature of the issue, a lack of flexibility in the power relationships among stakeholders, and a lack of resilience in the ecosystem (Gunderson 1999; Gunderson et al. 1995).

Thus, conventional adaptive management is necessary but not sufficient for coping with wicked problems. It helps resolve issues of scientific uncertainty but does not aid in resolving conflicting values among the various stakeholders. Often, these differences in values will prevent agreement on acceptable solutions and thus will not allow managers to move forward in an adaptive mode. Nevertheless, while few examples of completely successful adaptive management experiences are available, a number of important concepts and recommendations relating to incorporating social and political aspects have emerged from examining case studies (Stewart et al. 2004).

1. Whenever possible, all stakeholders, interested federal, state and local agencies, and decision makers in the responsible organization's chain of command should be involved.
2. There must be agency commitment to the stakeholder engagement and adaptive management processes, including funding for both monitoring and experimentation.
3. There must be an agency cultural shift and stakeholder tolerance for reasonable risk taking.
4. While the precautionary principle is likely to guide short-term decision making in cases of high uncertainty, provision must be made to allow for experimenting.
5. The entire decision-making process must be open and transparent.
6. The presence of endangered species requires active engagement of responsible regulatory agencies, such as the U.S. Fish and Wildlife Service.
7. Using small experiments selected to respond to stakeholder risk and uncertainty preferences should be explored. Such experiments help build learning networks, build trust, provide short-term results critical to maintaining stakeholder interest, solve problems important to the stakeholders, provide lower risk to ecological communities and endangered species, and are easier and less costly to implement.
8. The process must be iterative, incorporating and responding to stakeholder value judgments.

As Bormann et al. (1994, p. 8) note,

Because societal values and ecological capacity must be integrated to achieve sustainability, iterative interaction is required. Defining what is ecologically possible is not efficiently pursued without first knowing what people want; reconciling what is desired with what can be sustained and finding creative solutions require understanding of what is and is not thought to be possible. Thinking about new possibilities does not come easily, and ideas from a broad cross-section of society are needed.

A crucial point, however, even in terms of this broader vision of adaptive management at the ecosystem level, is that complex, large-scale decision making not only imposes enormous

financial burdens (ultimately upon taxpayers) but also simply takes too long. From a practical standpoint, forest planning has become an almost continuous process. Local experimentation and monitoring could feed back into recursive planning processes, perhaps allowing for smaller-scale plan revisions as needed. Projects and experiments are best at small scales, involving local stakeholders [“citizen–agency interaction,” as Shindler and Cheek (1999) call it], with the monitoring and evaluation also at the local level. Such small-scale projects could be extrapolated for landscape-level management decisions at lower cost than large-scale experiments.

Clearly, adaptive management can contribute to national forest ecosystem management, but it is not enough to resolve planning dilemmas. Carefully designed public participation and accountability are equally essential.

Participatory Processes

Public participation lies along a continuum of democratic practice. At one extreme, there is pure representative democracy, in which the electorate selects public officials who, in principle, need report to and consult with the public only at election time. Rare and short-lived are the politicians who follow such a course. At the other extreme lies pure democracy, in which all public decisions are made by the entire electorate’s vote. Only rarely has this extreme proven workable for nation-states. Consequently, in actual practice the level and nature of public participation fall somewhere along this continuum. It is important to note that (1) the amount of participation acceptable in a given context is not static, and (2) over the past decade the level of participation expected by the public has substantially increased.

Participation as used here is a broad-based term describing various communicative processes intended to include the public in analyzing, planning, selecting, and potentially implementing government actions. Some authors distinguish public participation from stakeholder collaboration, with “public participation” denoting democratically involving average citizens in public decision making, while “stakeholder collaboration” signifies involving special interest groups or other populist representatives (Beierle & Cayford 2002). However, this distinction merely identifies different but closely related points along the participation continuum, and consequently we do not differentiate participation and collaboration.

Our approach is similar to Arstein’s (1969) ladder of citizen participation, where the rungs represent the different levels of power citizens have in determining a policy outcome. Arstein asserts that “citizen participation” is merely another term for “citizen control,” as the extent of influence ranges from no authority through full decision-making authority.

Arstein (1969) provides a useful tool to conceptualize participation; however, one should not conclude from her ladder that public agencies should consistently strive for “top rung” participatory processes—processes that grant citizens full decision control. Rather, it is important to achieve balance in participatory objectives and methods. The public does not always seek complete control over every public decision. However, for wicked problems, public agencies have more often than not tended to land on “rungs” that settle for “informing,” “consulting,” or “placating”—when outsiders argue that Arstein’s “partnership” rung has a greater probability of ultimate success.

Lawrence and Daniels (1996) group the goals articulated for public participation into (1) efforts seeking to arrive at decisions that better achieve resource management objectives, and (2) efforts seeking to increase public support for decisions taken. In the context of wicked problems, we argue that the first goal is either unattainable or unknowable due to the nature of the problems. Consequently, public participation aimed at addressing wicked problems must focus on increasing public support for the decisions made. This is not to say that all alternatives are equally viable from a scientific perspective. Rather, we argue that after applying the best available science, multiple alternatives will still remain with uncertain future outcomes, so the choice between these alternatives must be based on non-scientific criteria guided by broadly held public values.

One of the major challenges of participatory efforts can be the problem of identifying groups of stakeholders and bringing these “clusters of shared interests and concerns” together in an environment conducive to learning (Gray 1989; Stubbs & Lemon 2001). Only then, it is argued, can stakeholders transcend their usual boundaries and belief systems to gain greater awareness of other stakeholders’ perspectives and sensitivities and to construct a mutually acceptable understanding of the wicked problem at hand. A common thread across many policy issues today is the growing conviction that public participation is a critical component in achieving any sort of progress with wicked policy problems (Selin et al. 2000). Fischer (1993), for example, contends that “contrary to technocratic expectations,” the right approach to dealing with wicked problems, is “more—rather than less—citizen participation.” In the context of environmental management, Fiorino (2000) argues, “Indeed, the themes of cooperation, participation, integration, ecosystems, and regional/local problem solving define a vision for a new era of environmental management, a vision that is emerging almost case by case across the country.” Findings such as these lead the Committee on Risk Characterization of the National Research Council to strongly advocate a decision process for situations involving risk that tightly integrates both technical analysis and broadly based public participation (Stern & Fineberg 1996).

Thus among many analysts there is growing consensus that addressing wicked problems requires a greater level of public participation than has been the case in traditional analytic approaches (Haight & Ginger 2000; Steelman 2001). Increasing calls for expanded public participation have been attributed to many factors, including a growing distrust of public institutions and officials; increased legislative requirements for public participation; the complexity and uncertainty of contemporary problems; different perceptions of risk; and a common recognition that decisions are never purely scientific—that politics and social values are inherent in all administrative decisions (DeLeon 1995; Durning 1993; Fischer 1993; Slovic 2000; Thomas 1995; Wondolleck 1988).

However, public participation has received mixed reviews from practitioners and evaluators. On the positive side, it has been credited with the ability to facilitate trust and mutual learning, a broad sense of ownership in decision outcomes, reduced conflicts, stronger democracy, and so on (Beierle 2002; Gericke et al. 1992). Conversely, it has been argued that broad participation is associated with intensive resource commitments (e.g., money, time, and human capital), prolonged decision making, decreased stakeholder trust, reduced decision quality, increased

controversy and conflict, and diminished likelihood of successful outcomes (Sample 1993; Steelman 2001).

For wicked problems, there is a substantial consensus across a number of disciplines that broadly based participation from all stakeholders in the decision-making process is essential (Fischer 1993). But a particular problem’s characteristics are not the only considerations that may result in a call for expanded participation. Gray (1989) and Selin and Chavez (1995) list other factors, summarized in Table 2. These factors are grouped into four broader classifications relating to problem characteristics, stakeholder characteristics, the history of the decision, and the particular decision context. As more characteristics from Table 2 are present in a given decision situation, the greater the apparent need for carefully designed and rich public participation.

Table 2. Factors Requiring Expanded Public Participation in Wicked Problem Decision Making

Problem/Issue Characteristics	Both the problem’s definition and solution are illusory (i.e., wicked problems); The problem/issue involves uncertainty and risk.
Stakeholder Characteristics	Various stakeholders have an interest in a problem and cannot achieve a unilateral solution. Stakeholders are not easily identifiable in advance, or well-organized. There is possible disparity in stakeholder power and available resources. Stakeholders have various levels of expertise and knowledge. Stakeholders have different values and interests which have led to adversarial positions on other occasions. A common goal exists between different stakeholders that requires a collaborative effort to fulfill. A network exists, such as a chamber of commerce or community organization, where stakeholders have already forged alliances.
History of the Decision	Incremental or unilateral problem resolutions have not proven successful. Existing methodologies to address the issue have not been successful, and may even have compounded the problem.
Decision Context	A crisis exists where policy action has been paralyzed by adversarial positioning, by legal delay tactics, or where there is immediate danger, such as the need to protect endangered species or ecosystems. A third party is intervening who convenes the stakeholders as a neutral mediator. There is a legal mandate handed down by the legislature or the courts, such as with the National Forest Management Act. A charismatic leader’s enthusiasm and vision persuades others to join in the participatory effort. Incentives for participation exist, such as matching funds for stakeholders to participate.

Adapted by the authors from Gray (1989) and Selin and Chavez (1995).

In the case of wicked problems, as with precautionary approaches and adaptive management, however, it is apparent that while public participation is essential, it is not as currently practiced sufficient for resolving issues of scientific uncertainty and differing stakeholder values.

The Sierra Nevada Case

This assessment of possible responses to wicked problems grew out of our research on the Sierra Nevada Forest Plan Amendment (SNFPA) process, introduced more fully below and used here as an example.

In working to develop and implement a management plan for the Sierra Nevada national forests, Forest Service administrators faced the defining characteristics of wicked environmental problems: a high degree of uncertainty, profound social and political divisions, the impossibility of finding an optimal solution, and the mandate for action despite these unresolved concerns (Allen & Gould 1986).

Managing the Sierra Nevada National Forests

Since the early 1990s, the Pacific Southwest Region (Region 5) of the USDA Forest Service has struggled to develop a broadly acceptable management plan for the Sierra Nevada national forests (USDA Forest Service 2001a). The effort began following the bitter battle in the Pacific Northwest over Northern spotted owls. While the controversy in the Northwest began as a question of how to preserve a particular threatened species, it quickly evolved into much broader struggle over the proper role of the Forest Service in resource management—whether for example the Forest Service should follow its traditional practice of managing timber harvests, or whether it should instead reshape its policies to emphasize the goal of protecting old growth forests and associated species.

Region 5 managers recognized that the presence of a closely related species of owl, the California spotted owl, was likely to trigger a similar clash in the Sierra Nevada. Hoping to avoid the intervention of the courts, as had occurred in the Pacific Northwest, Region 5 began an unprecedented effort to marshal the best science and engage the full range of public stakeholders, including timber interests, grazers, recreationalists, environmentalists, local residents, and others. Despite the agency's best efforts over almost two decades, however, the conflict surrounding policy alternatives continues unabated.

Following this extended process, the Regional Forester in the 2001 Record of Decision (ROD) attempted to balance the conflicting management strategies of caution and flexibility (USDA Forest Service 2001b). The selected alternative took a precautionary approach emphasizing fire management near developed areas and a precautionary approach emphasizing preservation of owl habitat outside these zones. The chosen approach also recognized that, because neither management strategies nor forest ecosystems remain static, some form of adaptive management is essential. Thus the ROD attempted, unsuccessfully, to have it both ways: to incorporate precautionary thinking and to implement adaptive management.

In practice, the precautionary practices, particularly in the implementation of the standards and guides that accompanied the ROD, prevented full application of adaptive management. A team appointed by the Regional Forester to review implementation of the decision concluded that the prescriptive standards added to protect California spotted owls and old growth habitat actually reduced the likelihood that the ROD's stated goals could be achieved and that precautionary constraints prevented the opportunity to take advantage of possible tradeoffs of modest short-term losses for more significant long-term gains (USDA Forest Service Pacific Southwest

Region 2003). In a review of implementation of the Northwest Forest Plan in California, former Forest Service Chief Jack Ward Thomas found similar conflicts between use of the precautionary principle and adaptive management (Thomas 2003).

As evidence of continuing profound divisions, the decision was subject to over 200 formal appeals from across the spectrum of external stakeholders and to criticism from Forest Service insiders who argued that it was unworkable. Given this broad dissatisfaction, the Chief of the Forest Service ordered that the decision be reconsidered. After another three years of scientific analysis, public engagement, and policy review, the Regional Forester in the spring of 2004 issued a modified ROD. Although in this paper we focus on the development and subsequent reassessment of the 2001 decision, we note that the 2004 decision has been criticized and appealed by a wide range of interest groups, and it appears that consensus on a management strategy for the Sierra Nevada remains out of reach.

Thus the SNFPA case is clearly a wicked problem (Stewart et al. 2004). It is characterized by multiple and compounding uncertainties and by deep divisions in public values. There is no optimal policy choice. Yet Forest Service officials do not have the luxury of waiting in the hopes that uncertainties will be overcome and political conditions will stabilize. They are required to act despite the remaining irresolvable dilemmas.

Data Collection on Stakeholder Preferences

In our research related to the SNFPA case, to understand the sources of the problem's intractability, we invited stakeholders to participate in a data-gathering and preference-elicitation process.

In a series of workshops, we met with three groups to elicit their opinions on the SNFPA process. In total, 75 people participated. Respondents included:

- The public (47% of the participants belonged to this group), including
 - members of private-sector or business-related organizations;
 - members of environmental or other nongovernmental organizations;
 - individual concerned citizens; and
 - all others not elsewhere classified.
- Government agency employees other than the Forest Service (21%), including
 - municipal or county government employees;
 - state government employees; and
 - federal government employees not with the Forest Service.
- Forest Service employees (32%).

We asked participants to complete two activities to help us measure their attitudes: a survey and a card-sort exercise. The survey was designed to help us identify attitudes toward, and preferences for:

- management priorities for the Sierra Nevada national forests;
- management philosophy;
- risks and tradeoffs;
- management strategies and tradeoffs;

- decision-making processes; and
- qualities of the Forest Service as a management institution.

The survey presented the participants with approximately 50 statements about these topics. They were asked to indicate their level of agreement or disagreement with the statements on a five-point scale ranging from “strongly agree” to “strongly disagree.”

The card-sort exercise was designed to help us determine which factors influenced participant attitudes toward decisions regarding management of the forests. The exercise consisted of each individual being presented with a stack of 23 cards where each card represented a profile of plausible policy choices and possible outcomes (Figure 1). These policy choices were obtained from the Region’s ecological model results. This deck of 23 cards provided a fairly complete set of the range of options under consideration. Each card provided different combinations of:

- total area to undergo fuel reduction through prescribed fires and/or mechanical treatment;
- locations where the fuel reduction would occur, whether inside or outside of the urban-wildland interface (UWI), the area within 1.5 miles of state-identified communities and structures;
- changes in timber and salvage offered for sale;
- the creation of forest gaps or holes (0.25 to 2 acre openings in the canopy intended to facilitate forest regeneration); and
- outcomes, including short-term and long-term changes in habitat and wildfire severity.

Figure 1. Typical Card Showing One of Three Levels on Each of Ten Attributes

<i>Treatments</i>	
Mechanical	5%
Prescribed Fire	8%
<i>Strategies</i>	
Change in Timber	-80%
Forest Holes	0%
<i>Locations</i>	
Defense Zone	90%
Threat Zone	20%
Land outside UWI	2%
<i>Outcomes</i>	
Short-term Habitat	-1%
Long-term Habitat	40%
Wildfire Acres	-50%
SCORE	
1-100	
Acceptable	Y N

Respondents were asked to indicate whether they would consider the combination of actions, locations, and outcomes reflected on a card acceptable (“yes” or “no”) if this combination actually occurred. They were also asked to indicate the strength of their preference by rating each card between 0 and 100.

Findings

The findings presented here are derived from these workshops with external stakeholders and the government employees and from analysis of the participants’ responses to the two exercises. We stress that we collected data only from 75 people, a sample too small to support definitive conclusions. Nonetheless, virtually all of the participants were either directly involved in the SNFPA case or were citizens and government officials with long-term engagement in the Sierra Nevada decision process. As such, their views are important indicators of the views and values that may be held by interested parties in general. We highlight our main findings and summarize the participant responses below. Results of the study are reported in more detail in Walters et al. (2003) and Desai et al. (submitted for publication).

The survey and card-sort exercise led to two sets of related but distinct findings. The survey gave us basic information on the attitudes of participants. Each individual completed the survey independently. For the card-sort exercise, participants first rank-ordered the cards individually, but then repeated the exercise in small groups representing diverse values. Data from the small-group work gave us information we could use to simulate analytically possible areas of compromise that were not revealed in elicitation of individual preferences. In our proposed model for improving public participation, these findings would be reported back to stakeholders to inform their continuing deliberations, perhaps providing opportunities for progress that would otherwise be missed. Here we briefly summarize findings first from the survey and then from the analysis of data from the card-sort exercise.

Selected Survey Results

Willingness to Consider Tradeoffs

Workshop participants were presented with over half a dozen statements describing various management approaches and tradeoffs and were asked whether they agreed or disagreed with these statements. As indicated in Table 3 (next page), responses to these statements regarding risks and tradeoffs inherent in management decisions indicate a sophisticated understanding of underlying issues. Participants acknowledge that management practices that require timber harvesting in the forests will be integral parts of any management decision. They also both acknowledge and demonstrate the willingness to confront related tradeoffs.

Participants seem most willing to tradeoff short-term losses in old-growth forest habitat for a likelihood of long-term gains, but they appear relatively less willing to incur short-term losses in habitat for potential economic gains or fire-safety benefits. Participants also demonstrate a slight preference for the location of fuels treatments, preferring that treatments occur in the urban-wildland interface zones rather than elsewhere. Participants clearly recognize the uncertain nature of outcomes, and yet in general they appear willing to tradeoff short-term losses for potential long-term gains.

Table 3. Tradeoffs

Statement	Public		Other agency employee		Forest Service employee	
	SD/D	A/SA	SD/D	A/SA	SD/D	A/SA
A 3 percent short-term reduction in old forest habitat acreage is acceptable if there is a good chance that over the long-term at least a 10 percent gain in habitat acreage will result.	27%	61%	0%	93%	14%	86%
A 3 percent short-term reduction in old forest habitat acreage is acceptable if there is a good chance that long-term economic benefits to adjacent communities will result.	36%	48%	14%	57%	14%	76%
A 3 percent short-term reduction in old forest habitat acreage is acceptable if there is a good chance that over the long-term safety benefits to adjacent communities from reduced fire hazard will result.	33%	61%	0%	79%	10%	86%
Providing fuels treatments on 1.5 to 2 percent of the forest each year (roughly 150,000 acres) is acceptable if there is a good chance the average number of acres burned will be reduced by 5 to 10 percent per year.	22%	69%	15%	77%	5%	95%
A 3 percent short-term decline in spotted owl nesting habitat is acceptable if there is a good chance the average number of acres burned will be reduced by 5 to 10 percent per year.	31%	56%	23%	54%	13%	74%
A 3 percent short-term decline in spotted owl nesting habitat is acceptable if there is a good chance the average acres in lethal or stand replacing fires will be reduced by 10 to 30 percent per year.	25%	63%	8%	77%	9%	87%
The creation of small openings or gaps in the forest canopy is acceptable if there is a good chance that the long-term effects on forest regeneration and health are positive.	15%	82%	7%	93%	13%	87%

SD=Strongly disagree; D=Disagree; A=Agree; SA=Strongly agree. In all cells, the “neither agree nor disagree” category has been omitted.

Attitudes toward Management Philosophy

Participants believe that given the underlying uncertainties, some form of adaptive management may be the best approach to managing the forests. As Table 4 suggests, they appear willing to accept some adverse outcomes resulting from experimentation with different strategies in order to learn more about the consequences of implementing such strategies.

Table 4. Management Philosophy

Statement	Public		Other agency employee		Forest Service employee	
	SD/D	A/SA	SD/D	A/SA	SD/D	A/SA
When outcomes of management decisions are uncertain, adaptive management is the most responsible approach.	12%	70%	0%	77%	13%	70%
If a management or research “experiment” may damage some habitat for an old-growth forest dependent species, then the experiment should not be allowed.	61%	27%	85%	0%	91%	4%

SD=Strongly disagree; D=Disagree; A=Agree; SA=Strongly agree. In all cells, the “neither agree nor disagree” category has been omitted.

Also as the second statement in Table 4 indicates, workshop participants do not favor strict application of the precautionary principle. In fact, they appear willing to tolerate some risk of

harm in order to learn from experimentation. They also believe that some costs of managing the forests should be recoverable through harvesting of trees and other uses of natural resources. There is general agreement that there are tradeoffs to be made, and most participants appear willing to consider recommendations regarding the nature and extent of these tradeoffs.

Satisfaction with the SNFPA Decision Process

One consistent finding across all groups is a general pessimism about the potential for finding a consensus agreement for managing the Sierra Nevada. Asked to evaluate the statement, “A consensus agreement is possible that would satisfy all participants concerned about management of the Sierra Nevada forests,” 79 percent to 83 percent of the three groups disagree or strongly disagree with the statement.

The evaluation of the SNFPA decision process overall is not highly favorable (Table 5). Nearly half of all participants do not feel that their most important concerns have been adequately incorporated in the process. This feeling of a lack of attention to important concerns is also true for a strong minority of Forest Service employees.

A majority of Forest Service employees and a plurality of the public disagree that the process has afforded adequate opportunity for public involvement. The majority of public participants and a substantial minority of Forest Service employees also disagree that their trust in the Forest Service has increased because of the process. This last finding should be of concern to the Forest Service, which appears to face a loss in trust and confidence in spite of having implemented the best available public participation practices.

Other responses indicate that a majority of participants feel that their personal contributions have made a difference and that the process has been valuable in educating the public, but it seems clear that for many participants the SNFPA process still needs improvement.

Table 5. SNFPA Decision Process

Statement	Public		Other agency employee		Forest Service employee	
	SD/D	A/SA	SD/D	A/SA	SD/D	A/SA
The issues and concerns that I believe are most important are adequately incorporated in the SNFPA decision process.	60%	20%	43%	50%	35%	43%
The SNFPA decision process affords adequate opportunity for public involvement and deliberation in determining the final management goals and priorities.	46%	30%	13%	53%	50%	41%
My trust in the US Forest Service and its management of the Sierra Nevada has increased as a result of the SNFPA decision process.	62%	19%	27%	47%	36%	36%

SD=Strongly disagree; D=Disagree; A=Agree; SA=Strongly agree. In all cells, the “neither agree nor disagree” category has been omitted.

Satisfaction with the Forest Service

In describing their attitudes toward the Forest Service and its capacity to manage the Sierra Nevada, most participants feel that the Forest Service has or can obtain the technical skills necessary to manage the forests (Table 6). However, the majority of respondents outside the Forest Service do not agree that the Forest Service has a good fire management record.

Moreover, there is disagreement about whether the Forest Service can be trusted to protect and restore owl habitat. Thus, while most participants see the agency as competent (or at least potentially competent), outsiders have concerns about both the record of accomplishments to date and the Forest Service’s priorities for the future.

Table 6. Forest Service

Statement	Public		Other agency employee		Forest Service employee	
	SD/D	A/SA	SD/D	A/SA	SD/D	A/SA
The Forest Service has, or can develop, the skills and information necessary for effective medium- to long-range ecological risk management in the Sierra Nevada forests.	8%	67%	14%	71%	22%	70%
The Forest Service has a good fire management record in the Sierra Nevada.	54%	19%	57%	14%	13%	70%
Forest Service personnel can be trusted to protect and restore essential habitat for the California spotted owl and other old forest species.	38%	32%	14%	57%	17%	74%
Unexpected outcomes from management actions are the result of agency failings.	59%	11%	57%	7%	87%	4%

SD=Strongly disagree; D=Disagree; A=Agree; SA=Strongly agree. In all cells, the “neither agree nor disagree” category has been omitted.

Attitudes towards the Role of the Public

Views on the appropriate decision processes to follow in managing the Sierra Nevada national forests are ambivalent (Table 7).

Table 7. Role of the Public

Statement	Public		Other agency employee		Forest Service employee	
	SD/D	A/SA	SD/D	A/SA	SD/D	A/SA
The general public lacks the specialized knowledge necessary to guide management decisions in the Sierra Nevada.	30%	59%	13%	73%	27%	55%
Forest management plans developed by experts are generally more feasible and balanced than plans developed by local participants.	46%	38%	40%	53%	65%	22%
Management decisions in the Sierra Nevada should be guided solely by science and expert opinion.	72%	8%	67%	13%	86%	5%
Broadly held public values should guide management decisions in the Sierra Nevada.	27%	51%	33%	20%	23%	64%
Democratic, participatory processes generally lead to better forest management decisions than processes dominated by experts.	24%	49%	20%	67%	0%	83%

SD=Strongly disagree; D=Disagree; A=Agree; SA=Strongly agree. In all cells, the “neither agree nor disagree” category has been omitted.

Most participants do not feel that the public has the expertise necessary to guide decisions regarding forest management. At the same time, there is substantial disagreement over the role of experts. Over half of all participants disagree with the statement that expert plans are more feasible and balanced than those developed by local participants, and 65 percent of Forest Service employees take this position. In addition, a strong majority of all participant groups disagree that management decisions should be guided solely by science and expert opinion.

With regard to the role for public values and participatory processes, there is agreement that these are important, with the strongest support found among Forest Service employees. On balance, it appears that most participants—while recognizing that citizens must be educated and informed if they are to participate effectively—remain skeptical of claimed expertise and continue to value local stakeholder views and engagement.

Factors Determining Individual Preferences

The large majority of participants demonstrate concern for three broad value foci:

- natural resource production and utilization;
- conservation of old-growth forest species and habitat; and
- responsiveness to legal requirements and popular will.

We stress, however, that in general these are not mutually exclusive or independent concerns.

Relatively few individuals single-mindedly commit to only one set of values. For most participants, these three sets of values are jointly held and competing concerns. Moreover, people are willing to consider tradeoffs above identifiable thresholds.

Participants' top priorities for the Sierra Nevada national forests are (number in parentheses represents the percent of respondents ranking this option either first or second in importance):

- complying with all environmental and legal requirements (64%);
- following a decision process that is open and fair (63%);
- avoiding catastrophic fire losses in communities (63%);
- protecting threatened and endangered species (59%);
- promoting good air quality (55%);
- enhancing healthy and abundant old forest habitat (54%); and
- avoiding catastrophic fire losses in old forests (52%).

Analysis of Data from the Card-Sort Exercise

The card sort exercise yielded additional insights into the tradeoffs the respondents were willing to consider. In general, when we asked participants to compare specific alternatives involving relative treatment amounts, treatment locations, and potential outcomes, we found that three factors are most important in determining individual preferences and attitudes toward tradeoffs:

- *Amount of timber harvesting.* Few people are adamantly opposed to all timber harvesting. But based on conversations and questions we heard, we found that an extremely important aspect of this issue is the maximum diameter of trees to be cut.
- *Potential long-term changes in habitat.* Most participants are willing to accept strategies that would lead to modest short-term habitat losses in return for significant long-term habitat gains. Because of uncertainty in outcomes from the Region's ecological models and lack of trust in the agency, this seems to be an especially productive area for experimentation and building of learning networks.
- *Potential changes in the incidence of wildfires.* Most participants are not willing to compromise on the goal of reducing the long-term incidence of wildfires. Respondents appear strongly supportive of efforts to reduce fire risk.

To move beyond this straightforward overview, however, we apply a novel multi-step quantitative technique combining two forms of analysis that have previously been used

independently to assess subjective information on stakeholder preferences: conjoint analysis (Green & Srinivasan 1978) and Q-methodology (Durning 1999). [Desai, et al. (submitted for publication) presents a more complete technical description of our methods and analysis.] While neither tool, by itself, may help untangle wicked problems, the two in combination may provide useful insights. Q-type analysis allows us to tease out different value orientations present among the stakeholders. Conducting conjoint analyses for each of these value sets provides a spectrum of preference structures that can be used to inform the debate and support an iterative, deliberative decision-making process. The greatest advantage these two techniques offer, when implemented in concert, is their ability to obtain preference structures based on a limited set of choices. Q-type analysis allows us to identify multiple value orientations and conjoint analysis provides us with the information to generate preferred alternatives. These alternatives are potentially viable real-world solutions that can be presented to stakeholders as the foundation upon which to build implementable management plans.

Once again, in a case like the SNFPA the search is for common ground on which to build potential agreement. In this instance, using the combined approach referenced here, we are able to identify six alternatives (out of a possible 59,049 options) which are both technically feasible and likely to have broad appeal to stakeholder groups (Table 8).

Table 8: Attributes and Rank Ordering of Six Options

	Attribute and Level	Option					
		1	2	3	4	5	6
Treatments	Mechanical 10%	x	x	x	x	x	x
	Fire 5%	x			x	x	x
	Fire 8%		x	x			
Strategies	Timber -80%	x		x	x		x
	Timber -50%		x			x	
	Holes 3%	x	x	x	x	x	x
Locations	Defense 85%	x	x	x	x	x	
	Defense 90%						x
	Threat 5%	x	x		x	x	x
	Threat 20%			x			
	UWI 2%	x	x	x			
	UWI 3%				x	x	x
Outcomes	S-T hab -1%	x	x	x	x	x	x
	L-T hab 80%	x	x	x	x	x	x
	Wild fire -50%	x	x	x	x	x	x
	Group 1	3	5	4	2	1	6
Ranks	Group 2	2	4	1	3	6	5
	Group 3	3	2	5	4	6	1

See sample card (p. 15). An x implies that the attribute level is included in the option; %=percent change (negative sign signifies reduction); Holes= clearings to promote forest regeneration; UWI=Urban-Wildland Interface zones including Defense Zones (within ~200' of buildings) and Threat Zones (1.25 mile extended buffer zones around Defense Zones); S-T hab=projected short-term changes to wildlife habitat; L-T hab= projected long-term changes to wildlife habitat.

The Q-type analysis yielded three distinct value orientations among the respondents. The conjoint analysis identified the strength of their preferences for each of the levels of the attributes

discussed earlier. The last three rows of Table 8 show how these six options would be ranked by individuals with the preference structures represented in these three groups.

It is apparent from the analysis that these six options will be somewhat controversial. For example, all six require further reductions in timber harvesting. One clearly identified group will not like this option. On the other hand, all options require maximal use of mechanical thinning, which will not please respondents from a different value orientation. There is still a good deal of negotiating to be done around these options among the groups with identifiable value positions. The point is that each group should find something attractive in each option because these options are selected based on congruence with the exhibited value orientations.

It is important to remember that wicked problems are never solved. Addressing them is an on-going process. Success requires that stakeholders accept the process, that it yield implementable next steps, and that adaptive learning and feedback inform future iterations of the process. This learning will inevitably involve the elaboration and modification of stakeholder values as well as improved scientific and technical understanding. The challenges of scale and duration make this learning about values more difficult in a number of society's more complex problems. Being able to characterize value orientations, link them to plausible management decision scenarios, and explore the implications of values and value conflicts in a timely and yet sophisticated manner will significantly aid participatory processes in confronting wicked problems.

Proposed Analytic, Deliberative Process

Forest management, with its inherent scientific and administrative risks and uncertainties, conflicting economic and societal objectives, varying local and national political considerations, multiple and vocal stakeholders, and cross-generational implications, clearly constitutes a wicked problem. It is not surprising that the Forest Service faces serious challenges. The agency is ultimately responsible for managing these forests but finds itself at a considerable disadvantage in that it is operating from a position of diminished trust. The main problems it faces are not technical or managerial. Our research indicates that the Forest Service receives high marks for competence but suffers from significant recent erosion in public trust. If it is to be an effective arbiter of the public interest and able guardian of these natural resources, the agency's immediate task is to regain that trust. The Forest Service will need to implement processes and practices that help rebuild the trust between it and the various stakeholders (Stewart et al. 2004).

Our participants broadly support stakeholder involvement in decision-making; however, there remain significant differences among stakeholders on values and priorities. The Forest Service can take partial solace in that these diverse stakeholders appear to share some common ground. There is general consensus favoring adaptive management, opposing strict interpretation of the precautionary principle, tentatively supporting fuel treatments including some tree cutting, and acknowledging that short-term losses may be an acceptable price to pay for the potential of long-term gains.

Sentiments in favor of adaptive management suggest support for the design and implementation of localized experiments to explore and study the efficacy of innovative, scale-appropriate forest management techniques. Nevertheless, many problems would remain. Even if the Forest Service

is able to build a fragile coalition around a proposed plan of action, it is easy for a small minority to sabotage such initiatives by mounting administrative and legal challenges. Our findings indicate that there is some room for compromise and progress in the SNFPA process, but that political conflicts and diminished trust in the agency are likely to continue to impede progress.

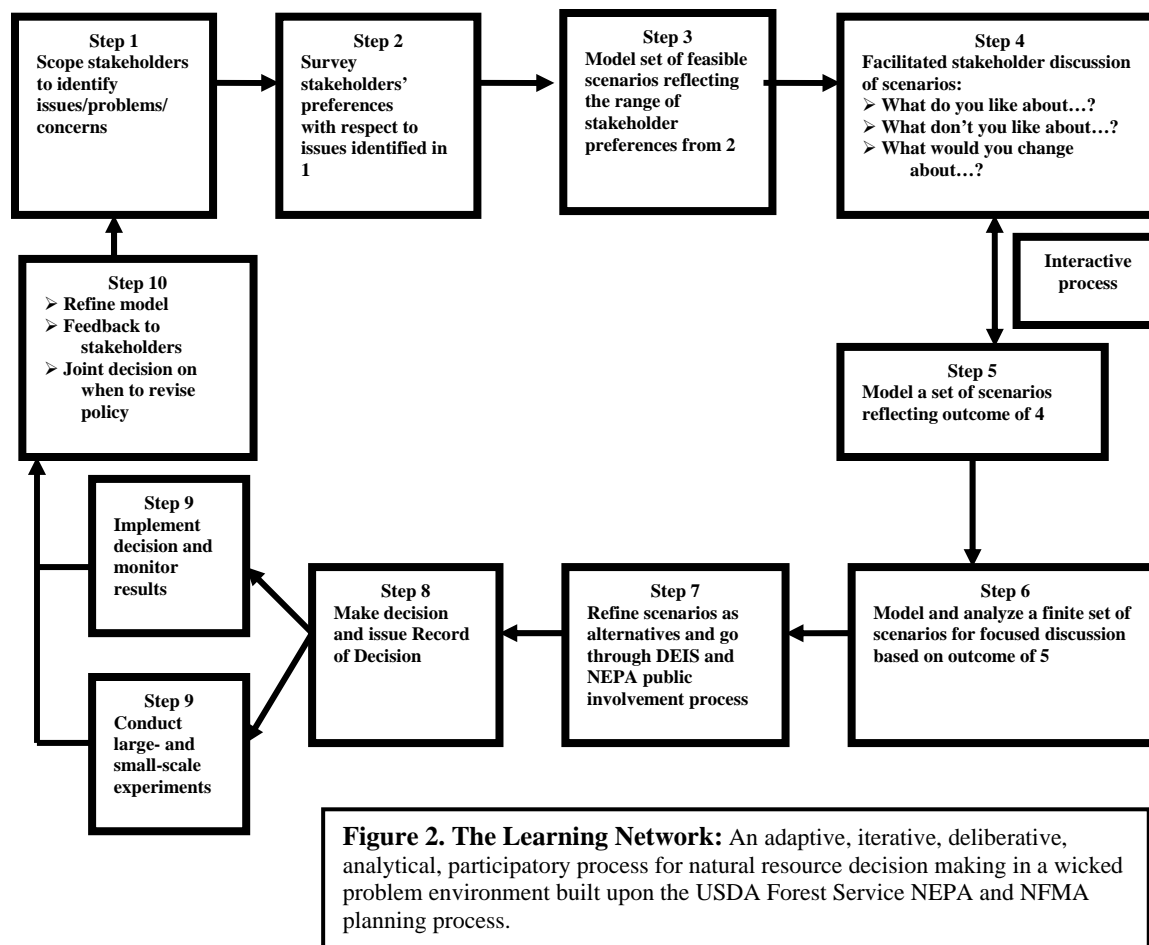
Recognizing that managing the Sierra Nevada is a wicked problem is important to arriving at an appropriate characterization of the challenges facing the Forest Service in the future. One immediate implication is the recognition that there will be no optimal solution to the problems faced. No amount of scientific or analytic effort will produce a solution that addresses, with sufficient certainty, all the critical ecological and political aspects of the management problem for all stakeholders. Instead, the most productive approach for dealing with such problems will be to seek broadly satisfactory, rather than optimal, solutions. A satisfactory solution in this context implies one that is consistent with ecological and legal constraints—and is also acceptable to the public. We characterize this approach as “collective satisficing.”

Since there is no optimal solution to the Sierra Nevada management problem, the Forest Service’s greatest short-term risks are related to decision processes rather than ecological outcomes. The SNFPA dilemma is a wicked problem characterized at all levels by multiple risks and uncertainties. Both the scholarly literature and best practices from a number of environmental management arenas indicate that the best approach for dealing with such decisions is to develop a decision process that tightly integrates the best scientific analysis and the fullest possible public participation and deliberation.

The participatory approach we suggest incorporates the key aspects of the Forest Service’s NEPA and forest-planning processes. The planning process is typically driven by identified issues that determine the scale and nature of the analysis and decision. We illustrate this suggested “learning network” process in Figure 2 (next page).

The process begins with identifying issues (Step 1), but also—at the outset—formally seeks to identify stakeholder values and preferences about these issues (Step 2). The literature clearly indicates that stakeholders must be identified and engaged. Involved stakeholders must represent a broad range of interests, have long-term commitments to the effort, and have credibility with other individuals and interest groups concerned with, but not directly engaged in, the process.

Information about stakeholder preferences and values should then be used as important input in developing a modeled set of alternatives that are environmentally, economically, and technically feasible and also reflect the range of stakeholder preferences and values (Step 3). This step is motivated by the observation that there are generally a very large number of technically feasible potential solutions, not just the relatively small number usually displayed in a draft or final Environmental Impact Statement. Further, since there are no perfect solutions to wicked problems, only those that are more satisfying or more useful than others, it will be important to find solutions that allow the agency to move forward in an adaptive management mode with a broad base of public support. Therefore, the alternatives developed in Step 3 should be analyzed only to the extent that they can be useful to stakeholders in further refining their preferences in Step 4.



Stakeholder reactions to the alternatives can then feed back into an iterative, analytic process to define a small set of feasible alternatives, perhaps three to five, that best satisfy public preferences and values (Step 5). This set of alternatives could then be fully analyzed and subjected to the NEPA process, and a decision made (Steps 6, 7, and 8). These steps would take advantage of the simulation of alternatives through the conjoint and Q-type analyses of stakeholder preferences that we describe above.

The decision would then be implemented, and a combination of monitoring results from implementation and small-scale experiments, jointly identified by stakeholders (managers, public interest groups, and scientists) to answer specific questions, could be used to identify new issues and opportunities for further progress (Steps 9 and 10). This would constitute an expanded form of adaptive management allowing opportunities to learn from social, political, and administrative factors as well as from ecological outcomes.

This learning-network process more explicitly models stakeholder preferences, and uses these preferences to develop and assess initial alternatives. Modeling preferences would allow the Forest Service to assess the values and preferences of a broad cross-section of stakeholders. Explicitly linking those preferences to the science models used to generate alternatives will likely sample a much broader range of alternatives and will increase the likelihood of identifying alternatives offering the greatest promise of being broadly acceptable.

Summary, and Four Valuable Lessons

Our argument can be summarized as follows. Large-scale forest management planning falls into the category of wicked problems. Given the context of a wicked problem, the decision-making process is at least as important as the projected outcomes. Practices that have been applied to date to address wicked problems—the precautionary principle, adaptive management, and public participation—cannot in isolation produce broadly acceptable decision processes. An iterative, analytic, deliberative learning network that incorporates the best of these three approaches appears to have some promise for producing more satisfactory results. Finally, we offer a novel method for eliciting and analyzing stakeholder preferences that may provide valuable feedback for participants in the learning network and reveal previously overlooked opportunities for progress.

To conclude, we list four take-home lessons:

1. In the case of wicked problems, it is important to remember that there is no single correct solution—so stop looking for one.
2. While ecosystem sustainability is an essential component of the decision matrix, the process of getting to the planning decision is also critically important.
3. Rarely do people argue their positions overtly on the basis of their values. Instead, they usually resort to using uncertainties in the science as an opportunity to make their points.
4. Current approaches, including conventional adaptive management, are necessary but not sufficient. Developing long-term learning networks appears to be a key step in addressing wicked problems.

In response to the challenge of a wicked problem, the Forest Service often seeks better and better models. These typically fail to produce a solution, both because the science is uncertain and because the problem is as much political as technical. We believe that all stakeholders, including agency personnel, activist groups, and the broader interested public, must work to communicate and clarify their differences in priorities and preferences. Giving some justification for cautious optimism, our initial experiment in the SNFPA case suggests that in some important areas participants may be more willing than they generally believe to compromise and accept tradeoffs.

Literature Cited

- ALLEN, G.M., and E. GOULD, JR. 1986. Complexity, wickedness, and public forests. *Journal of Forestry* 84(4):20-23.
- ARSTEIN, S.R. 1969. A ladder of citizen participation. *Journal of the American Institute of Planners* 35:216-224.
- ASHER, W. 2001. Coping with complexity and organizational interests in natural resource management. *Ecosystems* 4:742-757.
- BEIERLE, T.C. 2002. The quality of stakeholder-based decisions. *Risk Analysis* 22(4):739-749.
- BEIERLE, T.C., and J. CAYFORD. 2002. *Democracy in practice: Public participation in environmental decisions*. Washington, DC: Resources for the Future.

- BORMANN, B.T., P.G. CUNNINGHAM, M.H. BROOKES, V.W. MANNING, and M.W. CALLOPY. 1994. Adaptive ecosystem management in the Pacific Northwest. General Technical Report PNW-GTR-341. Washington, DC: USDA Forest Service.
- CAMERON, J., and J. ABOUCHER. 1991. The precautionary principle: A fundamental principle of law and policy for the protection of the global environment. *Boston College International and Comparative Law Review* 14:1-27.
- COMMITTEE OF SCIENTISTS. 1999. Sustaining the people's lands: Recommendations for stewardship of the national forests and grasslands into the next century. Washington, DC: U.S. Department of Agriculture.
- DELEON, P. 1995. Democratic values and the policy sciences. *American Journal of Political Science* 39(4):886-905.
- DESAI, A., L.C. WALTERS, P.J. BALINT, and R.E. STEWART. Augmenting public deliberation: Wicked analysis for wicked problems (submitted for publication).
- DURNING, D. 1993. Participatory policy analysis in a social-service agency: A case-study. *Journal of Policy Analysis and Management* 12(2):297-322.
- DURNING, D. 1999. The transition from traditional to postpositivist policy analysis: A role for Q-methodology. *Journal of Policy Analysis and Management* 18(3):389-410.
- FAIRBANKS, F., H. GARDNER, E. HILL, K. MULROONEY, C. PHILPOT, K. WEICK, and C. WISE. 2001. Managing wildland fire: Enhancing capacity to implement the Federal interagency policy. Phase 2 Report: Study of the implementation of the Federal Wildland Fire Management Policy. Washington, DC: National Academy of Public Administration.
- FIORINO, D.J. 2000. Innovation in U.S. environmental policy. *The American Behavioral Scientist* 44(4):538-547.
- FISCHER, F. 1993. Citizen participation and the democratization of policy expertise—from theoretical inquiry to practical cases. *Policy Sciences* 26(3):165-187.
- GERICKE, K.L., J. SULLIVAN, and J.D. WELLMAN. 1992. Public-participation in national forest planning: Perspectives, procedures, and costs. *Journal of Forestry* 90(2):35-38.
- GRAY, B. 1989. *Collaborating*. San Francisco: Jossey-Bass.
- GREEN, P.E., and V. SRINIVASAN. 1978. Conjoint analysis in consumer research: Issues and outlook. *Journal of Consumer Research* 5:102-123.
- GUNDERSON, L.H. 1999. Resilience, flexibility and adaptive management: Antidotes for spurious certitude? *Conservation Ecology* 3(1):7.
- GUNDERSON, L.H., C.S. HOLLING, and S.S. LIGHT. 1995. Barriers broken and bridges built: A synthesis. In L.H. Gunderson, C.S. Holling, and S.S. Light (eds). *Barriers and bridges to the renewal of ecosystems and institutions*. New York: Columbia University Press.
- HAIGHT, D., and C. GINGER. 2000. Trust and understanding in participatory policy analysis: The case of the Vermont Forest Resources Advisory Council. *Policy Studies Journal* 28(4):739-759.
- IRVINE, K.N., and S. KAPLAN. 2001. Coping with change: The small experiment as a strategic approach to environmental sustainability. *Environmental Practice* 28:713-725.
- JOHNSON, F., and K. WILLIAMS. 1999. Protocol and practice in the adaptive management of waterfowl harvests. *Conservation Ecology* 3(1):8.
- JORDAN, A., and T. O'RIORDAN. 1999. The precautionary principle in contemporary environmental policy and politics. In C. Raffensperger, and J. Tickner (eds). *Protecting public health and the environment: Implementing the precautionary principle*. Washington, DC: Island Press.

- LAWRENCE, R.L., and S.E. DANIELS. 1996. Public involvement in natural resource decision making: Goals, methodology and evaluation. Corvallis, OR: Oregon State University.
- LEE, K.N. 1993. *Compass and gyroscope: Integrating science and politics for the environment*. Washington, DC: Island Press.
- MANSON, N. 2002. Formulating the precautionary principle. *Environmental Ethics* 24(3):263-274.
- MCLAIN, R.J., and R.G. LEE. 1996. Adaptive management: Promises and pitfalls. *Environmental Management* 20:437-448.
- RAFFENSPERGER, C., and J. TICKNER (eds). 1999. *Protecting public health and the environment: Implementing the precautionary principle*. Washington, DC: Island Press.
- RITTEL, H.W.J., and M.M. WEBBER. 1973. Dilemmas in a general theory of planning. *Policy Sciences* 4:155-169.
- SAMPLE, V.A. 1993. A framework for public-participation in natural-resource decision-making. *Journal of Forestry* 91(7):22-27.
- SELIN, S., and D. CHAVEZ. 1995. Developing a collaborative model for environmental planning and management. *Environmental Management* 19(2):189-195.
- SELIN, S.W., M.A. SCHUETT, and D. CARR. 2000. Modeling stakeholder perceptions of collaborative initiative effectiveness. *Society and Natural Resources* 13:735-745.
- SHINDLER, B., and K.A. CHEEK. 1999. Integrating citizens in adaptive management: A propositional analysis. *Conservation Ecology* 3(1):9.
- SHINDLER, B., and E. TOMAN. 2003. Fuel reduction strategies in forest communities. *Journal of Forestry* 101(6):8-15.
- SLOVIC, P. 2000. *The perception of risk*. Sterling, VA: Earthscan.
- STEELMAN, T.A. 2001. Elite and participatory policymaking: Finding balance in a case of national forest planning. *Policy Studies Journal* 29(1):71-89.
- STERN, P.C., and H.V. FINEBERG (eds). 1996. *Understanding risk: Informing decisions in a democratic society*. Washington, DC: National Academy Press.
- STEWART, R.E., L.C. WALTERS, P.J. BALINT, and A. DESAI. 2004. Managing wicked environmental problems. Sacramento, CA: USDA Forest Service, Pacific Southwest Region.
- STUBBS, M., and M. LEMON. 2001. Learning to network and networking to learn: Facilitating the process of adaptive management in a local response to the UK's national air quality strategy. *Environmental Management* 27(8):321-334.
- SUNSTEIN, C. 2003. Beyond the precautionary principle. Public law and Legal Theory Working Paper no. 38. Chicago: University of Chicago Law School.
- THOMAS, J.C. 1995. *Public participation in public decisions*. San Francisco: Jossey-Bass Inc.
- THOMAS, J.W. 2003. Application of the Northwest Forest Plan in national forests in California. Sacramento, CA: USDA Forest Service, Pacific Southwest Region.
- USDA FOREST SERVICE. 2001a. Sierra Nevada Forest Plan Amendment final environmental impact statement. Vallejo, CA: USDA Forest Service, Pacific Southwest Region.
- USDA FOREST SERVICE. 2001b. Sierra Nevada Forest Plan Amendment record of decision. Washington, DC: USDA Forest Service, Pacific Southwest Region.
- USDA FOREST SERVICE. 2003. Sierra Nevada Forest Plan Amendment management review and recommendations. R5-MB-012. Washington, DC: USDA Forest Service, Pacific Southwest Region.

- WALTERS, L.C., P.J. BALINT, A. DESAI, and R.E. STEWART. 2003. Risk and uncertainty in management of the Sierra Nevada national forests. Sacramento, CA: USDA Forest Service, Pacific Southwest Region.
- WILHERE, G.F. 2002. Adaptive management in habitat conservation plans. *Conservation Biology* 16(1):20-29.
- WONDOLLECK, J.M. 1988. *Public lands conflict and resolution: Managing national forest disputes*. New York: Plenum Press.