

**Applying the Science of Decision Making:
A Survey of Use and Needs in the National Forest System**

A USDA Forest Service Joint Internal Report from
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and the Research and Development Mission Area

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FORWARD

This Forest Service Report is part of a series on concepts and use of decision science and structured decision making in the U.S. Forest Service. The work was inspired by the forming of a national Decision Support Science Research Team under the coordination of Monica Tomosy and consisting of invited scientists, researchers, and specialists from US Forest Service's National Forest System and Research and Development, from US Geological Survey, and from academia, principally University of Arizona, Tucson.

The current report presents results from a survey of line officers, planners, and specialists to gain an understanding of how decision support tools and process are used, under what circumstances, and what improvements may be needed. A brief summary of initial results was presented in a previous publication in this series (Thompson et al. 2013). Highlights from this current, expanded analysis of the survey results include:

- * Line officers expressed a desire for a structured decision making framework that is risk-informed, transparent, and adaptable, facilitates evaluation of consequences and tradeoffs, and can be explained to stakeholders.
- * Over 90% of respondents who had used some form of a decision support approach stated they were very satisfied, satisfied, or somewhat satisfied with the outcome.
- * Primary reasons for adopting decision support included improving the decision process and bolstering against potential conflict.
- * Some respondents expressed frustration at not having the funding, time, opportunity, or skills for applying a structured decision science approach.
- * The principal impediment to broader adoption of structured decision making and decision support approaches was lack of knowledge.

The authors conclude that there could be great support for additional training, networking, and science delivery related to the principles and applications of structured decision making, that could importantly bolster the rigor and transparency of natural resource risk analysis and risk management within the agency and beyond.

EXECUTIVE SUMMARY

To determine how decision support tools and methods are being used, and how their use could be improved, we conducted an anonymous on-line survey of 1,738 decision-makers (including staff managers and line officers) and 4,819 analysts (planners and specialists) of the USDA Forest Service's (FS) National Forest System (NFS). More specifically, the purpose of the survey was to determine (1) how techniques and tools for risk analysis are being used within a structured decision making (SDM) framework, (2) the range of natural resource management issues for which they are being used, and (3) what improvements in their use and in user knowledge may be needed. This survey builds on previous work substantiating the utility of the SDM framework for decision-making within NFS.

We received 1,562 responses (24% response rate) from all 9 NFS regions and the Washington D.C. Office. Respondents are involved in a wide range of high priority resource management issues, including forest ecosystem health, soil and water conservation, biodiversity conservation, legal and institutional issues, socioeconomic impacts, and forest ecosystem productivity.

Most (>50%) respondents have used one or more decision-support processes or methods for risk analysis or risk management, particularly modeling to generate or compare alternatives, comparative risk assessment, tradeoff analysis of alternatives, and participatory or collaborative group decision-making methods. Most (69%) respondents said that structured decision-support approaches provided greater clarity or transparency to the decision process, 43% said they helped mitigate controversy and conflict, 43% said they provided protection against litigation, and 24% said they simplified risk management. Of those who had used such an approach, 91% noted that they were very satisfied, satisfied, or somewhat satisfied with the outcome.

Respondents identified several impediments to using structured decision-support approaches, notably knowledge gaps, educational needs, and perceived lack of applicability of those approaches, with very scant concern about additional burdens or making the decision process more open. Patterns of responses did not vary statistically among NFS regions but some responses differed between decision makers and analysts.

Based on these responses, we suggest an array of management problems for which decision support approaches would be helpful, and identify potential challenges to a broader adoption of structured decision-support approaches within the NFS. We conclude with recommendations about potential training, communication, and support for structured decision frameworks.

Keywords:

Structured decision-making
U.S. Forest Service
National Forest System
Risk analysis
Risk management
Decision support

Introduction

Under the National Forest Management Act (1976), the National Environmental Policy Act (NEPA; 1970), and other federal laws, USDA Forest Service (FS) is legally required to manage national forests and grasslands of the National Forest System (NFS) for a wide variety of ecological, economic, and cultural values, and to report on how such management decisions are made. In recent decades, FS management objectives have broadened beyond the agency's original roots of providing water, timber and other basic resources, to increased emphasis on conservation and restoration of healthy watersheds, ecosystem services, historical and cultural sites, biodiversity, support for local economies and communities, educational opportunities, and reduction of adverse disturbance events such as forest pest outbreaks, spread of invasive species, and unwanted wildfire (Butler and Koontz 2005).

NFS managers are facing greater challenges than ever to conduct risk analyses (estimating the probability of various decision outcomes and their utilities or costs and benefits) and risk management (decisions made based on the information supplied from a risk analysis) under a complex array of objectives and across various scales of time and space. One realm of decision-making that they can use to help in their task is the suite of models, tools, and protocols, collectively referred to as the structured decision-making (SDM) framework.

SDM is a well-established framework that decision makers can use to better understand and frame their decision context, clearly and comprehensively identify and evaluate management options, and make informed choices under conditions of complexity and uncertainty (Gregory et al., 2012a). SDM offers a solid platform with which to assess and manage risks, with an explicit focus on identification of uncertainties and outcome probabilities to inform decision-making (Haynes and Cleaves 1999). As examples, SDM approaches have been used to manage invasive species (Blomquist et al. 2010), plan the recovery of endangered species (Gregory et al. 2012b), and anticipate responses to rising sea levels (Martin et al. 2011). More specifically, recent work has helped substantiate the value and utility of the SDM framework for natural resource management decision-making within NFS (Marcot et al. 2012, Thompson et al. 2013).

Adapted from Hammond et al. (1999), the stages of SDM, as used in many applications, include: problem structuring, problem analysis, decision point, and implementation and monitoring (Fig. 1). Each of these stages assumes interaction and collaboration among decision makers, stakeholders, scientists, and analysts. SDM emphasizes the importance of knowing one's location in a decision process, and knowing which tools and approaches are available at each stage.

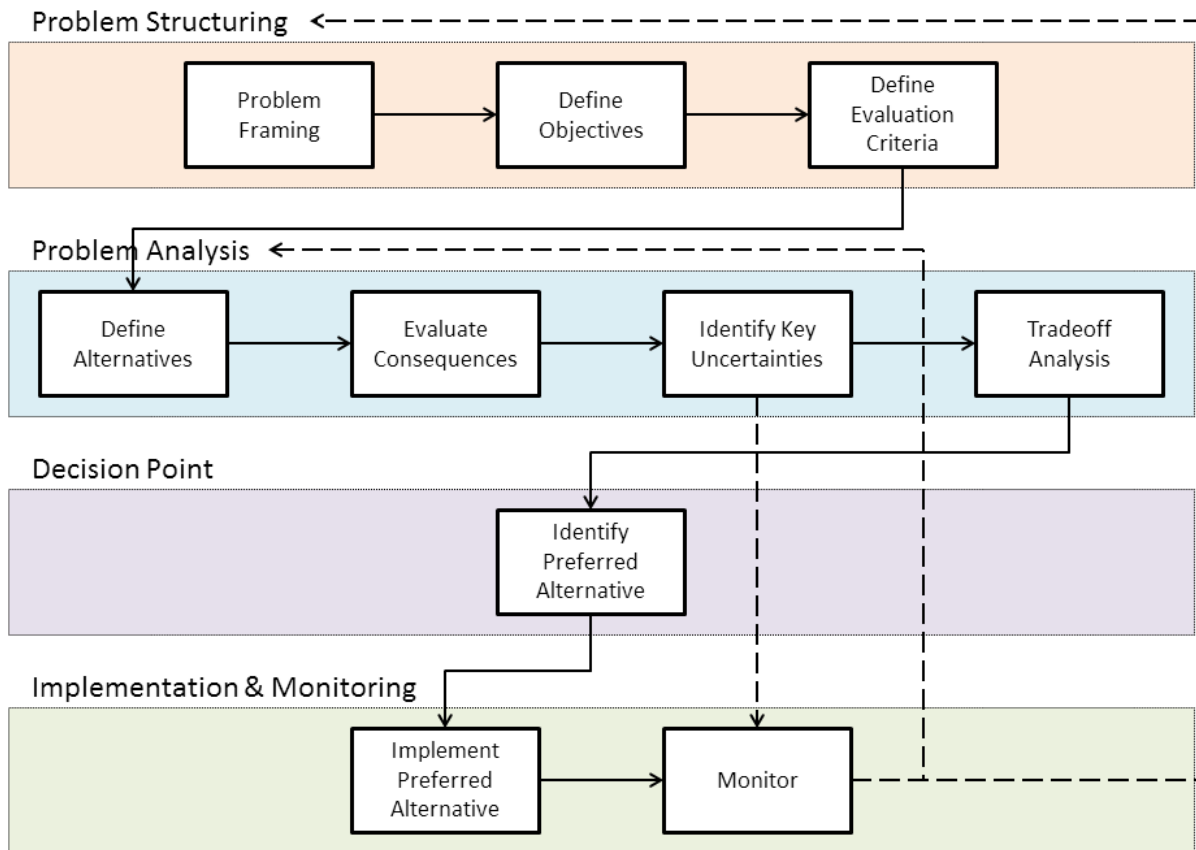


Figure 1. Stages of structured decision-making (after Hammond 1999; source: Marcot et al. 2012).

A national Decision Support Science Research Team of scientists and managers was tasked with summarizing the existing body of research and experience on structured decision-making, and determining its relevance and application to land and resource management decision-making within NFS. The team’s work has been presented in a journal article and FS general technical report (Marcot et al. 2012; Thompson et al. 2013). As part of their tasks, in May-June 2012, the team conducted an on-line survey of decision makers and analysts of NFS to determine (1) how techniques and tools for risk analysis are being used within an SDM framework, (2) the range of natural resource management issues for which they are being used, and (3) what improvements in their use and in user knowledge may be needed. Initial results of the survey were briefly summarized in Thompson et al. (2013); this report provides full details on methods and results with further analyses, and presents implications for resource decision-making within NFS.

Survey Methods

We sent invitations to participate in the survey to 1,738 NFS *decision makers* (including staff managers and line officers) and 4,819 NFS *analysts* (including planners and specialists), as identified from the FS's national NEPA project database (D. Seesholtz, pers. comm.). We chose recipients based on their recent (past 5 years) participation in NEPA projects as decision makers or analysts at local, national forest, and regional-level planning scales. Survey invitees were allowed to remain anonymous to encourage participation without concern that responses would be traced back to individuals.

We developed the survey after consulting with other experts in risk analysis and SDM and with selected agency personnel experienced in producing such questionnaires, and we refined the survey after initially beta-testing it with a small group of invited NFS managers and staff members (see Acknowledgments). To structure, distribute, and conduct the survey, we used the on-line service Survey Monkey (www.surveymonkey.com). The survey was eventually distributed, via email link, through the FS Washington D.C. office, following an initial email from FS leadership to all selected recipients alerting them of the purpose, importance, and need for participating in the survey. Subsequent reminders were sent to recipients to increase the survey response rate.

We analyzed survey results with frequency distributions of number of responses, and with patterns of cross-tabulations of frequencies of respondents by NFS region and position, resource management issues for which they are responsible, and the types of structured decision-making techniques and tools with which they use or are familiar.

The survey consisted of 14 questions (Appendix) covering the following topics:

- NFS region and current position held;
- resource management issues in their area of formal and informal responsibility;
- SDM general processes or methods used for risk analysis or risk management;
- SDM specific models or protocols used for risk analysis or risk management;
- reasons for, satisfaction with, and impediments to using SDM processes, methods, models, or protocols;
- risk management problems requiring support from specific SDM tools, protocols, approaches, or methods; and
- general interest in risk management and SDM science including means and methods for further learning.

In addition to the electronic survey, the team conducted six intensive post-survey interviews with selected respondents to explore in greater depth the key insights and themes gained from the survey. The individual interviews, selected subjectively to provide a cross-section of management levels in the agency and according to the interviewees' availability and interest, were conducted by phone and helped to validate and augment the survey analysis, providing more vivid quotes and illustrations for the general technical report (Thompson et al. 2013).

Survey Results

As noted in the Introduction, initial results from the survey were briefly summarized in Thompson et al. (2012) in the context of a fuller review of SDM methods and approaches. Results presented here greatly extend that previous presentation with further analyses of response rates, comparisons of responses among NFS regions and between decision makers and analysts, and new details on current use of SDM models and procedures in NFS, and on the needs of, and interests in, further training and application.

Survey Response Rate

We received 1,562 responses (24% response rate), of which 13% were identified as *decision makers* (including line officers) and the remaining were *analysts* of various types including 22% planners and interdisciplinary team leaders, 40% specialists or researchers, and 25% otherwise involved in NEPA activities (Fig. 2). Responses were received from all 9 NFS regions and the Washington Office (Fig. 3), and they were roughly in proportion to the total numbers of employees and to numbers in line and staff. Based on the NFS Washington D.C. office experience with national surveys of FS employees, our overall response rate of 24% was considered very good, and, in particular, the absolute number of responses was larger than with most other FS surveys conducted to date.

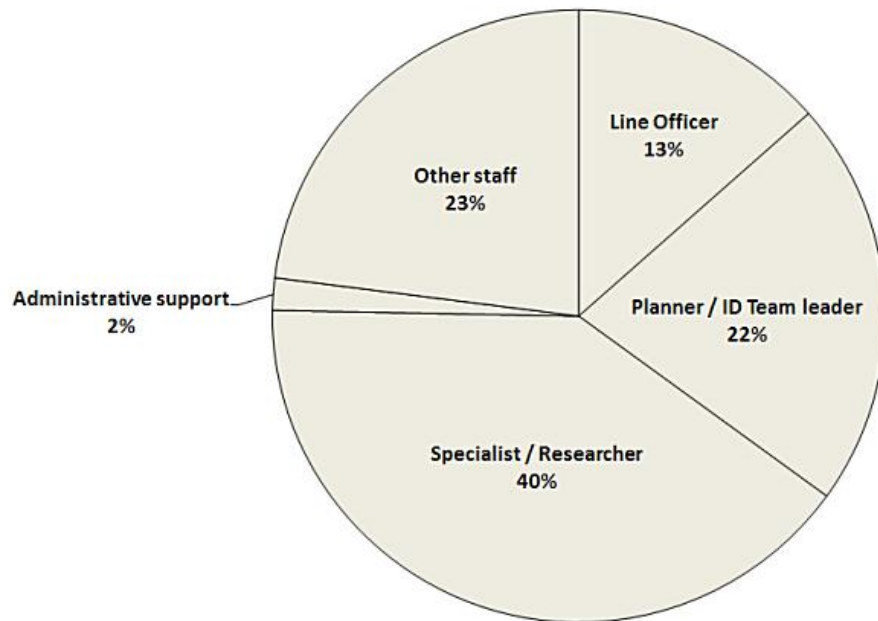


Figure 2. Percent of survey respondents by position.

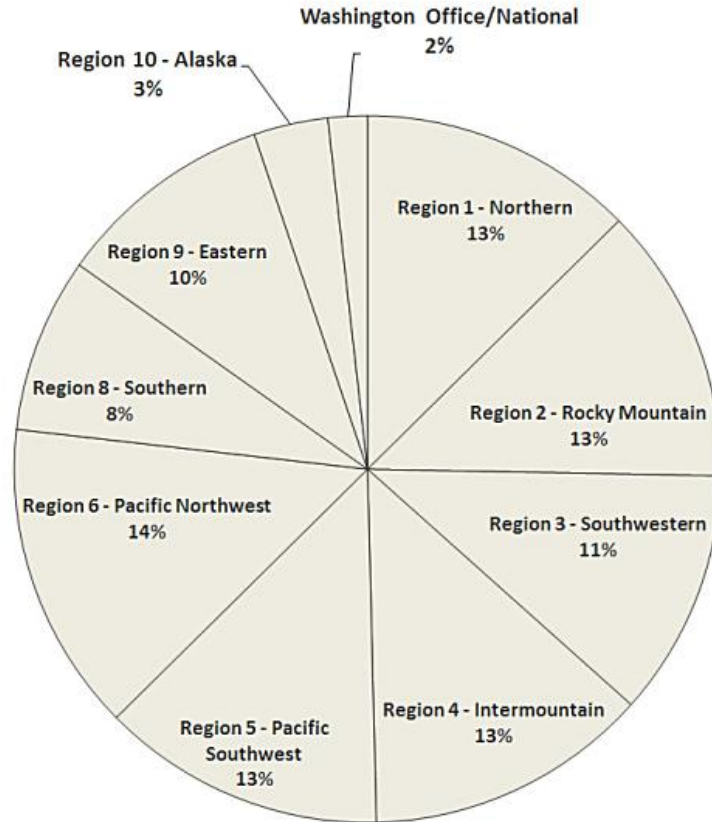


Figure 3. Percent of survey respondents by location.

Respondents' Areas of Responsibility

The survey revealed that respondents were responsible for a wide range of resource management issues including recreation, planning and plan revision, wildlife management, water and watershed management, fire and fuels treatment, silviculture, timber scheduling, wilderness management, public affairs, and other issues (Fig. 4). Most (58-84%) respondents noted that they are dealing with many high priority issues, including forest ecosystem health, soil and water conservation, biodiversity conservation, legal and institutional issues, socioeconomic impacts, and forest ecosystem productivity (Fig. 5, Fig. 6).



Figure 6. Word cloud results from the survey question asking to fill in “other” kinds of resource management issues being dealt with by the survey respondent (survey question 4; see Appendix). See Figure 4 for explanation of word clouds.

Respondents’ Use of SDM Processes, Methods, Models, and Protocols

As described in the introduction, SDM consists of multiple decision stages, and various decision support tools and approaches applied at each stage. Some of these tools and approaches are more appropriately characterized as broad or generalized processes and methods (Appendix, survey question 5), whereas others are models and protocols with more specific uses or realms of application (survey question 6). Both types of approaches – general and specific -- are interrelated. As examples, multi-attribute utility theory and multi-criteria decision analysis (specific models and protocols) can facilitate objectives hierarchy assessment and tradeoff analysis (general processes or methods). (For descriptions and references of these and other SDM approaches mentioned in this paper, see Marcot et al. 2012 and Thompson et al. 2013.) Similarly, influence diagrams and models based on expert judgment typically stem from a formalized expert paneling process, and statistical and simulation models can form the basis for comparative risk assessment or scenario analysis.

When presented with a list of 10 decision-support processes and methods for risk analysis or risk management, half or more of the respondents replied that they have used modeling to generate alternatives, modeling to compare alternatives, comparative risk assessment, tradeoff analysis of alternatives, and participatory or collaborative group decision-making methods (Fig. 7, Fig. 8). In general, respondents were at least familiar with, but half or most have never used expert paneling and scenario planning and analysis, and most were unfamiliar with objectives hierarchy assessment and social choice theory. Few respondents noted that they frequently use

any of the 10 processes or methods, but, on the other hand, very few respondents noted that any of the 10 processes or methods were not relevant to their work.

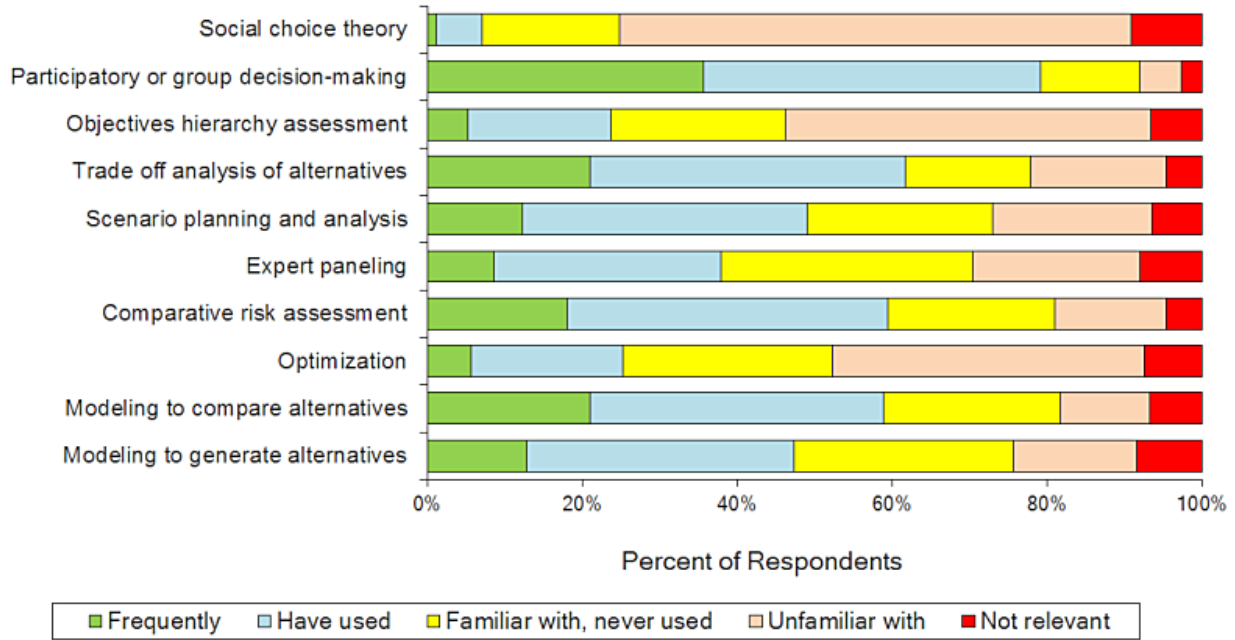


Figure 7. Frequency of use of SDM processes or methods.



Figure 8. Word cloud results from the survey question asking to fill in “other” kinds of decision support processes or methods for risk analysis or risk management as used by the survey respondent (survey question 5; see Appendix). See Figure 4 for explanation of word clouds.

Most respondents had used 4 of 10 listed decision-support models and protocols: models based mostly on expert judgment, simulation models, statistical models based on field data, and decision trees (Fig. 9). Most were unfamiliar with fuzzy logic models, agent-based modeling, influence diagrams, Bayesian tools, multi-attribute utility theory, and multi-criteria decision analysis. Fewer respondents used any of the models and protocols frequently, and even fewer noted that they are not relevant to their work.

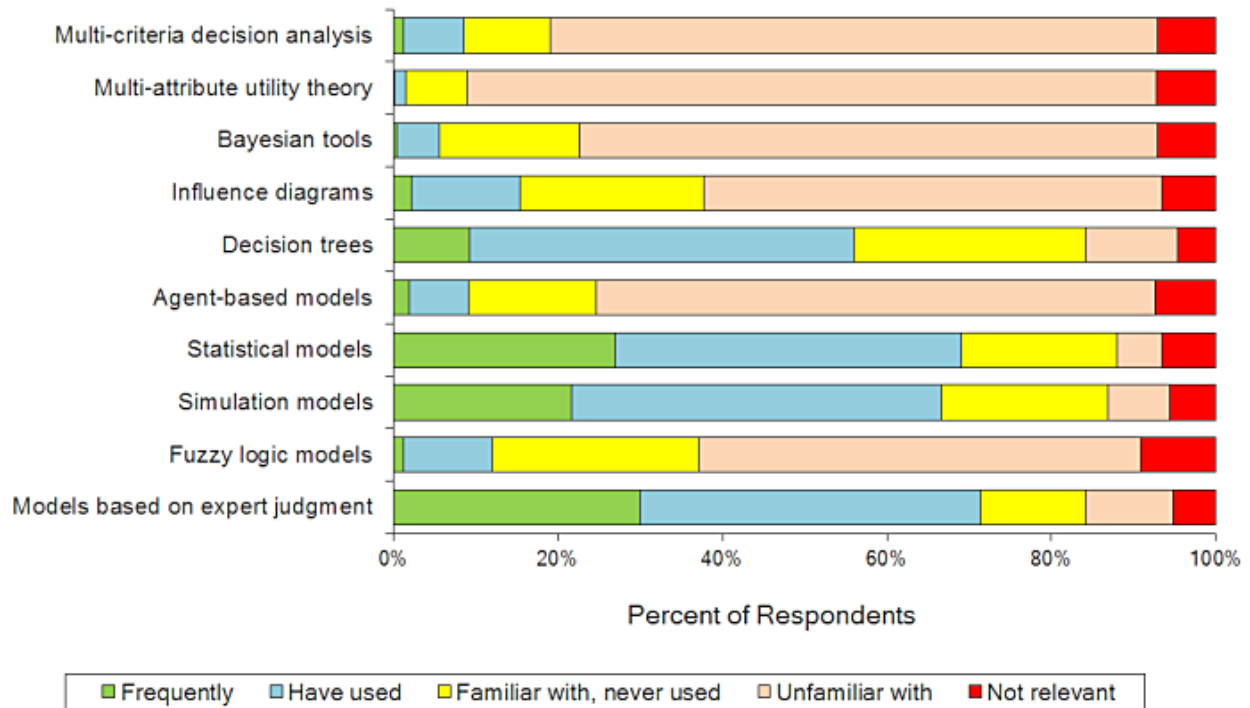


Figure 9. Frequency of use of SDM models or protocols.

Reasons for Using SDM Approaches

We asked the respondents why they have used any of the 10 SDM approaches and allowed them to indicate multiple reasons (Fig. 10). Most respondents (69%) said SDM approaches provided greater clarity or transparency to the decision process; 43% said they helped mitigate controversy and conflict, or provided protection against litigation; and 24% said they simplified risk management. Only 12% of respondents said that they did not use any of the SDM approaches, and only 17% of respondents noted that using them saved time. Clearly, the main reasons for using such SDM approaches pertained to improvement of the decision process and protection against informal or formal conflicts, rather than saving time in the decision process. There was no statistically significant differences in patterns of responses among NFS regions ($X^2 = 44.41$, $df = 63$, $P = 0.96$). Decision makers identified clarity of the decision process, simplifying of risk management, and mitigation of controversy as key reasons more frequently than did analysts ($X^2 = 29.49$, $df = 7$, $P < 0.001$).

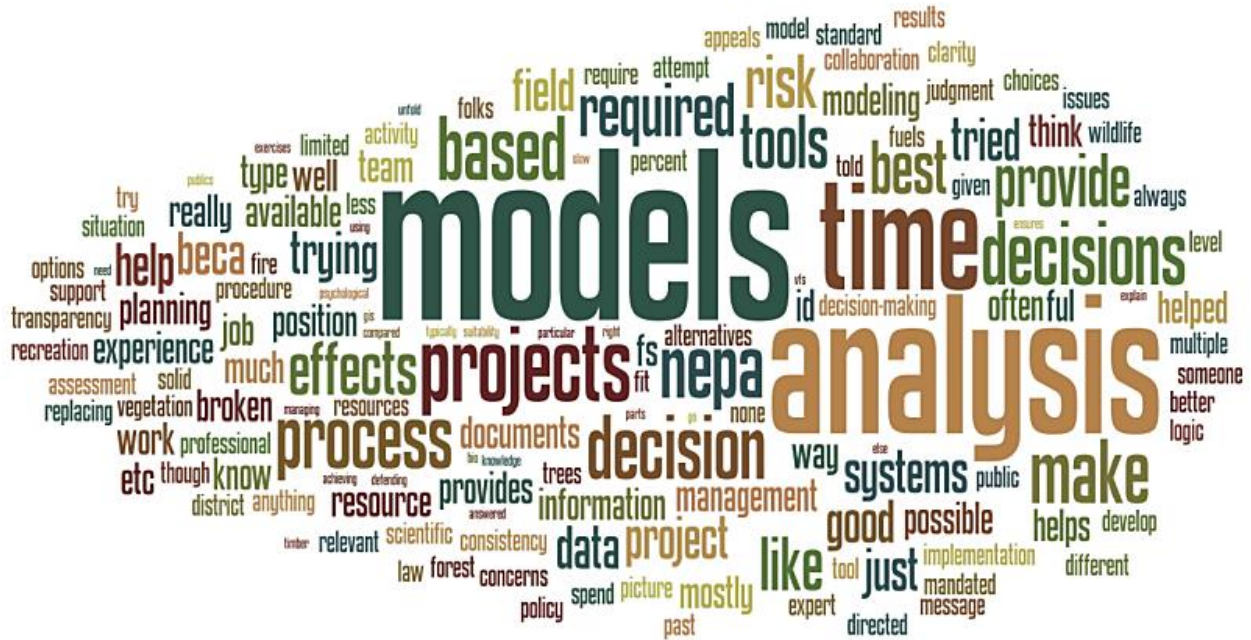


Figure 10. Word cloud results from the survey question asking to fill in “other” reasons that SDM procedures or tools were used by the survey respondent (survey question 7; see Appendix). See Figure 4 for explanation of word clouds.

However, as implied from some respondents’ comments and subsequent interviews, increased time in the decision process may still lead to overall time savings due to reduced time spent in appeals and litigation. Further, of those respondents that had used some SDM approach, a full 91% noted that they were very satisfied, satisfied, or somewhat satisfied with the outcome; this pattern was similar across all regions ($X^2 = 46.02$, $df = 45$, $P = 0.43$). Decision makers and analysts differed somewhat in their responses ($X^2 = 15.71$, $df = 5$, $P = 0.01$) with decision makers reporting a higher rate of satisfaction and analysts reporting a higher rate of not having used SDM approaches. Overall, though, this is strong testimony to the perceived value and utility of SDM approaches.

A few of the categories of decision-support processes, methods, models, and protocols seemed to be used more frequently by, or were more familiar to, respondents with particular areas of responsibility of resource management issues. For example, respondents responsible for issues pertaining to fire management and fuels treatment were slightly more apt to have used modeling to generate or compare alternatives and comparative risk assessment methods than did respondents primarily responsible for other resource management issues. Respondents responsible for public affairs were slightly more apt to have used expert paneling and multi-criteria decision analysis than did other respondents. However, such differences were minor and use of, and familiarity with, SDM approaches did not seem to be particularly influenced by areas of responsibility of resource management issues (multiple X^2 tests, each $df = 32$, $P \gg 0.05$). This lack of influence was likely because many respondents were responsible for some or many of the resource management issue categories, not just one. Specifically, half of all respondents were responsible for >1 issue, about a third were responsible for >2 issues, and the number of resource

management issues for which respondents were responsible averaged 2.7 (minimum =1, maximum =10, SD = 1.7).

Perceived Impediments to Using SDM Approaches

When asked about impediments to using SDM approaches, most (73%) respondents said they did not know enough about the SDM approaches, with fewer (20-30%) stating that it is difficult for the public to understand them, that colleagues are not aware of or are resistant to using them, that in their assessment it does not apply to their work, and that it appears to take too much time. Only 15% of the respondents noted that using SDM approaches is not better than what is done now, and only 2% noted that using SDM approaches makes the decision process too transparent and vulnerable to appeals and litigation. Thus, most of the reasons given for not using SDM approaches pertained to knowledge gaps, educational needs, and perceived lack of applicability of those approaches, with very scant concern about additional burdens or making the decision process too open. This pattern was invariant across regions ($X^2 = 48.73$, $df = 63$, $P = 0.91$) and differed somewhat between decision makers and analysts ($X^2 = 17.01$, $df = 7$, $P = 0.02$) with decision makers more frequently citing difficulty for the public to understand SDM approaches and that their colleagues are not aware of or are resistant to using them, and analysts more frequently citing that SDM approaches did not apply to their work.

The SDM survey results also provided insights into what many respondents noted as high work load and work-related stress that impede interest in, and use of, SDM approaches. Examples of sources of stress included responding to high recreational demands, explaining and/or defending management activities designed to restore forest ecosystems, interacting with adjacent private landowners with potentially conflicting land use objectives, and dealing with political and litigation concerns. Some survey respondents balked at the use of formal SDM approaches simply because they are not part of doing business, there is scant time to learn and use them, they are perceived to pertain to other administrative levels, and/or that the politics will not support the use of rigorous environmental risk analyses. Other respondents perceived that impediments to their use of SDM approaches included lack of funding and supervisory support and interest, that SDM approaches seem more complex than are needed, and that SDM reduces time in the field. Respondents also expressed concerns suggesting that SDM approaches may be overly complex and inappropriately applied to project-scale decisions; that risk analysis is equated with undue constraints on operations because of mandates on safety; and that models in general are inaccurate, are too complex to explain to the public, and are used to justify pre-made decisions.

Sources of Learning About SDM Approaches

We found that the NFS respondents have learned about risk management and decision support procedures and tools from a variety of sources: 68% from on-the-job experience dealing with appeals, litigation, and NEPA procedures; 40% from work-supported training and workshops; 24% from personal interactions with scientists; 15% from webinars; 13% from web sites; and 11% from college courses. Some 18% of respondents noted that they are not familiar with such procedures and tools. Additional learning preferences included: conferences and workshops held by various professional societies, particularly on fire issues; leadership training;

colleagues and networking; and incident management teams and fire management leadership. Patterns of learning sources did not vary among regions ($X^2 = 44.50$, $df = 54$, $P = 0.82$) but they did vary significantly between decision makers and analysts ($X^2 = 36.23$, $df = 6$, $P < 0.001$), with decision makers learning more from work-supported training and workshops and personal interactions with scientists, and analysts more frequently reporting that they were not familiar with SDM approaches.

Needs for Further SDM Education

Respondents noted a wide array of management problems for which SDM approaches would help (Fig. 11). These included:

- evaluating consequences and analyzing tradeoffs of potential management actions,
- monitoring and adapting to results,
- addressing controversy and conflict with stakeholders,
- providing greater credibility to the decision process to reduce the likelihood of litigation and appeals,
- developing decision evaluation criteria and defining management alternatives,
- identifying and framing problems and articulating objectives, and
- identifying uncertainties.

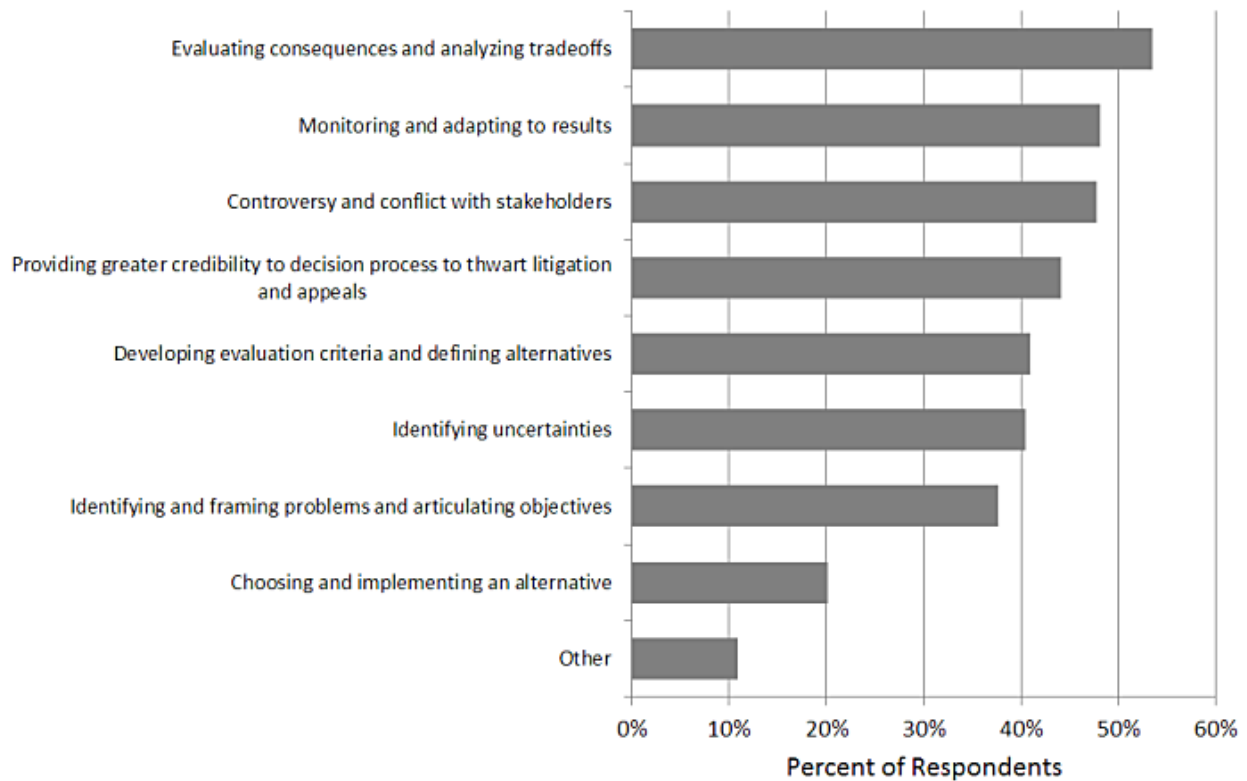


Figure 11. Issues that could benefit from applying SDM approaches.

The least frequent problem noted was choosing and implementing an alternative. This suggests that respondents viewed SDM approaches as potentially more helpful for the early stages of the SDM process and for subsequent monitoring, than for the decision point and implementation stages. The types of management problems for SDM approaches did not differ significantly among regions ($X^2 = 36.30$, $df = 63$, $P = 1.00$) nor between decision makers and analysts ($X^2 = 4.41$, $df = 7$, $P = 0.73$), suggesting that such NFS problems are universal and faced equally by line and staff employees alike.

When asked how they would prefer to learn more about SDM approaches, most asked for work-supported training and workshops (noted by 70% of respondents), followed by on-the-job use (52%), webinars (37%), and web sites (20%). Additionally, some would like to learn through personal interactions with scientists (28%) and a few by taking college courses (9%). Others (10%) noted that they were not interested in learning more about these topics. Respondents also suggested additional ways to learn via: how-to guides; guidance from a knowledgeable mentor; consultation with NEPA coordinators; publications; and terse case studies. Patterns of response to this question did not vary among regions ($X^2 = 48.36$, $df = 54$, $P = 0.69$) and only marginally differed between decision makers and analysts ($X^2 = 12.46$, $df = 6$, $P = 0.05$).

Interpretation, Lessons Learned, and Implications

Survey responses also provided insights into knowledge gaps, needs, desires, and concerns over risk analysis and SDM tools and methods. When asked what decision-support processes or methods for risk analysis or risk management they use in addition to the lists provided in the survey, many respondents suggested that decisions are made without recourse to formal procedures. However, some respondents did note that they use some other formal decision-aiding procedures such as relying on the NEPA framework as a decision tool, use of multi-criteria decision support and ecosystem management decision support procedures for programmatic planning, and using budget modeling of forecasts, management alternatives, scenarios, and economic trade-offs. The distinction of these procedures from NEPA is that SDM provides an explicit structure for informing and supporting the choice (the decision; Gregory et al. 2012a), whereas the NEPA and related procedures, including modeling forecasts and scenario analysis, are more for description and disclosure (Stern and Predmore 2011).

Beyond NEPA, a foundation of SDM can support existing procedures and protocols across a spectrum of other types of decisions. Wildland fire management is one salient example, wherein decisions are recurrently made in dynamic environments, often supported by risk assessment tools within the Wildland Fire Decision Support System (Calkin et al. 2011). Similarly, FS decisions relating to resource management standards, land designations, fleet and facilities management, and environmental engineering, among others, could benefit from adoption of SDM principles.

It is clear from the responses that most decision makers (including line officers) and staff personnel alike have had at least some formal or on-the-job exposure to some of the methods, models, and procedures of SDM. This suggests that NFS personnel understand, and often use,

various approaches to risk assessment and risk management in a structured way. There also appear to be no specific, rigorous SDM procedures imposed by NEPA itself or by the agency's application of NEPA and other planning and evaluation mandates (also see MacGregor and Seesholtz 2008). Not mandating specific SDM procedures allows flexibility to select among the wide array of procedures (Appendix) those most appropriate to specific issues and scales of geography and time.

The survey results suggest several key opportunities for improving the use of decision support in NFS resource management:

1. The agency and stakeholders could do well to recognize and better document when structured approaches to agency resource decision-making have resulted in more timely, efficient, and cooperative decisions. This would help bolster the awareness of and interest in using these tools and approaches, and provide positive reinforcement to those who have successfully implemented such approaches. Success stories also can be shared with stakeholders and the public to help strengthen cooperative planning.

2. We can envision the FS developing a network of SDM practitioners, consisting of decision makers and analysts who have gained experience with successful applications of SDM tools and approaches, and who could provide peer mentoring and consulting assistance. Similarly, we suggest a variety of venues by which the scientists who work in the field of risk management and structured decision-making can be effectively integrated with the managers of forest and grassland ecosystems. One example could be a community of practice for regular forums of scientists and managers via webinars, or face to face, that features real case study situations. Another could be a technical assistance enterprise that matches managers with scientists to structure a decision process for a particular issue.

One possibility from the survey results is for FS Research and Development and EMC to potentially form a national, virtual Center of Excellence for decision science as a science research and development focus, and also as a service to NFS managers. Having this Center of Excellence could support scientific synergy and management effectiveness as it could bring together the diverse array of decision scientists that currently work in this field separately, in fire, economics, wildlife habitat, climate change, recreation, and water management, across diverse ecoregions. Such a center of excellence also could serve as a model for, and involve in partnerships, other agencies and non-governmental institutions.

3. Because most impediments to the further use of SDM approaches pertain to education, it may be important to identify and encourage a range of in-service learning opportunities for FS decision makers and analysts. Given concerns for workload and job-related stress, however, a range of learning options, e.g., formal training events, on-the-job experience, interaction with peers and researchers, and development and use of web sites and webinars with case studies, could be provided to encourage participation. In addition, an initial focus on simpler, more accessible tools, such as influence diagrams and decision trees, could be an effective way for decision makers and analysts to become familiar with portions of the overall SDM process, and once those are understood the next step might be to better understand multi-attribute decision

analysis (see reference examples in the Supplementary Appendix). Additional suggestions and listings of SDM tools were provided by Marcot et al. (2012) and Thompson et al. (2013).

There was no evidence that training in specific SDM approaches, nor in methods of further learning, needs to vary by NFS region, but training could differ for decision makers and analysts, not so much for the type of management problem being faced but more for differences in solving perceived impediments to their use. For example, decision makers might benefit from training in SDM approaches more geared to engaging stakeholders and the public, and in more peer-to-peer sharing of experiences – both successful and unsuccessful. Analysts might benefit from learning about a fuller suite of SDM models and protocols that could more effectively inform decision makers in difficult resource decision problems.

4. Cross-training decision makers and analysts could also enhance the resource decision process by involving decision makers in all phases of the SDM framework (Fig. 1), and by engaging analysts more actively and collaboratively in the decision process, thereby providing stronger support to decision makers (Thompson et al. 2013). As well, results of the survey suggest that some analysts may be less apt to seek and adopt SDM models and protocols, so having analysts and decision makers train together could help enhance not just their mutual communication but could also help analysts better understand the value of specific SDM approaches in informing and advising their decision maker counterparts.

To this end, an on-line “Decision Science for Management” web site has been recently developed (<http://www.eforest.us/group/decision-science>) under the eForest model of The Online Community of NEPA Professionals. The aim of this web site is to improve communication and networking among those who develop tools, knowledge, and application of decision science approaches. The web site is a direct result of the SDM survey presented in this report, to help foster interaction and mutual learning among managers, analysts, and researchers.

5. Research can also play a role in the integration of science, policy, and natural resource management (Pouyat et al. 2010). Users of scientific knowledge, be they decision makers or analysts, are usually more willing to accept ideas and to trust information from scientists they know and work with directly (see Armitage et al. 2009). In an evaluation of the effectiveness of science delivery methods in the Joint Fire Science Program encompassing multiple U.S. federal agencies (<http://www.fire-science.gov>), from the perspective of scientists the most effective methods were direct interactions, consultations, and collaborations with field personnel, as well as workshops, seminars, and meetings conducted by scientists to engage field personnel (Wright 2010). The benefits to management from working with scientists highlights the need for local and more frequency engagement of scientists in the risk analysis parts of the SDM process and for mechanisms to reward and incentivize this engagement for both parties.

6. Similarly, setting strategic short- and long-term agency research agendas could facilitate greater use of SDM principles, specifically to help determine which decision makers need answers, and to what types of priority questions they are facing, to help emphasize place-based research, and to organize research around missions and problems rather than disciplines.

7. Using SDM tools and methods could be of great help in encouraging constructive stakeholder participation in the decision process, potentially enhancing the development and selection of more universally acceptable resource management objectives and decisions, thereby potentially lessening the threat of litigation or appeal. In a separate survey, Predmore et al. (2011) reported that the FS engaged in NEPA public-involvement processes to inform and disclose and to engage sometimes adversarial stakeholders; such disclosure and involvement could be enhanced using SDM approaches. There are many ways that decision makers could apply specifically-designed SDM approaches to improve public engagement and stakeholder participation in risk analysis and risk management (Mendoza and Prabhu 2000).

8. Whereas NEPA and SDM are not synonymous, it is clear that there are both parallels and important differences between NEPA procedures and the SDM process. While NEPA is the formal process that the agency uses to analyze and disclose the environmental effects associated with federal decisions, the structure of NEPA mirrors all stages of the SDM framework, and they are readily integrated. SDM methods can provide a rich structure, protocol, and set of tools for decision making reported under NEPA.

Stern and Predmore (2011) found that FS interdisciplinary team leaders and decision makers differ philosophically in their perceptions of favorable outcomes of applying NEPA procedures, with decision makers more commonly separating the decision from the analysis. Such philosophical differences could prove detrimental to a more tightly integrated approach to risk analysis and risk management. SDM, as a systematic framework, can provide a wealth of models, tools, and protocols for ameliorating such differences and for applying NEPA and other planning evaluations and management decisions.

9. SDM is not a panacea for alleviating all sources of work stress noted by respondents. Initially crafting SDM approaches may indeed entail some demand on time and expertise. In most cases, however, we feel that, with appropriate coordination among administrative levels, and objective application, it can provide ways to ease time demands, involve clients and stakeholders in positive ways, and help explain the basis of decisions. Instead of perceiving SDM approaches as yet more bureaucracy and mandates that take away from field time and face time with others, appropriate use could help resolve such concerns and streamline the overall decision process.

Conclusions

Decision science is solidly grounded in both theory and practice. As decision makers and analysts apply the concepts and tools of SDM, they are rapidly developing sets of best practices for high-quality decision-making. With training and experience, decision makers and analysts could utilize SDM as an overarching framework and a formalized decision structure for decisions, and potentially as a defensible and rigorous means of addressing regulations under NEPA and related directives. While resource management decisions can be, and are, made without explicit recourse to SDM methods and models, the survey results suggest that such tools can well serve risk analysis and risk management in the overall decision process. The SDM approach can help the FS address the complexities of sustainable natural resource management and in general has the potential for providing a high degree of disclosure to, and involvement with, stakeholders and customers. SDM can be a powerful tool in the context of decisions that guide management of public natural resources.

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Appendix. Contents of the Risk Assessment and Management Survey.

WELCOME TO THE RISK ASSESSMENT & MANAGEMENT QUESTIONNAIRE

This 15 question survey (takes about 15 minutes to complete) is part of a U. S. Forest Service Research and Development program working to summarize the risk management and decision-making techniques that natural resource decision makers use as they work to maintain sustainable forests and grasslands.

Through this survey, we are hoping to get a clearer understanding of how tools for risk analysis are used within a structured framework: how they are being used, under what circumstances, and what improvements may be needed. In taking this survey, you will remain anonymous. As we analyze the responses from this survey, we plan to make the results widely available to resource decision makers and scientists, to provide awareness and suggest potential applications of these decision-making tools.

The results of this effort will support and assist Forest Service employees' work toward sustainable forests.

Thank you for taking the time to share your thoughts and experiences.

If you have any questions about this survey or about the work we are doing related to decision-making and risk assessment and management, please contact:

Monica Tomosy
US Forest Service Liaison to USGS National Climate Change and Wildlife Science Center
USDA Forest Service Research and Development
Arlington, VA
Email: mstomosy@fs.fed.us

QUESTIONS

- 1) Please identify your Forest Service region.
 - Northern
 - Rocky Mountain
 - Southwestern
 - Intermountain
 - Pacific Southwest
 - Pacific Northwest
 - Southern
 - Eastern

- Alaska
- Washington office/national
- Other (please specify): _____

2) What is your primary current position within the Forest Service?

- Line Officer
- Planner/ID team leaders
- Specialist/Researcher on staff
- Administrative support/Data management
- Other (please specify): _____

3) What particular resource management issue/s are you responsible for? Check all that apply:

- Planning/plan revision
- Timber scheduling
- Silviculture
- Water/watershed management
- Fire and fuels treatment
- Wildlife management
- Wilderness management
- Recreation
- Public Affairs
- Other (please specify): _____

4) What general kinds of resource management issues are you dealing with in your current position, even if these are issues for which you are not formally responsible (as noted in Question 3)? Please indicate the level of priority for each issue : high, low, or not relevant:

- Biodiversity conservation
- Forest ecosystem productivity
- Forest ecosystem health
- Soil and water conservation
- Forest/global carbon cycles
- Socioeconomic impacts
- Legal/institutional issues
- Other (please specify): _____

5) How often do you use each of the following decision support processes or methods for risk analysis or risk management? For each, please indicate: frequently, have used, familiar with but have never used, unfamiliar with, or not relevant to my work:

- Modeling to generate alternatives
- Modeling to compare alternatives
- Optimization (multi-objective, heuristic, goal programming, etc.)
- Comparative risk assessment

- Expert paneling
- Scenario planning and analysis
- Trade off analysis of alternatives
- Objectives hierarchy assessment
- Participatory or collaborative group decision-making methods
- Social choice theory

Do you use processes or methods not listed above? If so, what are they called, and at what frequency do you use them? _____

6) How often do you use each of the following decision-support models and protocols for risk analysis or risk management? For each, please indicate: frequently, have used, familiar with but have never used, unfamiliar with, or not relevant to my work:

- Models based mostly on expert judgment
- Fuzzy logic models
- Simulation models (e.g., landscape, population, vegetation, disturbance)
- Statistic models based on field data (e.g., standing growth yield models, forest inventory, species distribution)
- Agent-based modeling
- Decision trees
- Influence diagrams (includes mind maps)
- Bayesian tools, including Bayesian network models
- Multi-attribute utility theory (MAUT)
- Multi-criteria decision analysis (MCDA) (e.g., SMART, AHP, SMAA, Kepner-Tregoe, TEP)

Do you use models and protocols not listed above? If so, what are they called and at what frequency do you use them? _____

7) In the last 5 years, if you have used any of the procedures or tools listed in questions 5 and 6, why did you use them? (Check all that apply)

- Saved time
- Provided greater clarity/transparency to the decision process
- Provided protection against litigation
- My colleagues are advocates for its use
- Simplifies risk management
- Helps mitigate controversy/conflict
- It's better than what I used to do
- Did not use any of them
- Other (please specify): _____

8) In the last 5 years, if you have used any of the procedures or tools listed in questions 5 and 6, how satisfied were you with the outcome? Check all that apply.

- Very satisfied
- Satisfied
- Somewhat satisfied

- Not very satisfied
- Not at all satisfied
- Did not use any of them

Please offer any comments to explain your answer: _____

9) What impedes you from using the procedures or tools listed in questions 5 and 6? Check all that apply. (Leave blank if you didn't use any of the procedures or tools).

- Appears to take too much time
- Based on my experience, it takes too much time
- Don't know enough about them
- Colleagues are not aware of or are resistant to using them
- Does not apply to my work
- Not better than what I do now
- Difficult for the public to understand
- Makes decision process too transparent and vulnerable to appeals and litigation
- Other (please specify): _____

10) What risk management problem(s) are you facing for which you need greater support in the way of better tools or a more structured decision framework? Check all that apply.

- Identifying and framing problems and articulating objectives
- Developing evaluation criteria and defining alternatives
- Evaluating consequences and analyzing tradeoffs
- Identifying uncertainties
- Choosing and implementing an alternative
- Monitoring and adapting to results
- Providing greater credibility to decision process to thwart litigation
- Controversy and conflict with stakeholders
- Other (please specify): _____

11) For the problem(s) you provided in the previous question, what tools, protocols, approaches, or methods would you like to have provided or learn more about?

12) If there was anything you wished for from risk management and structured decision-making science, what is it? _____

13) Where are you learning about risk management and decision support procedures and tools? Check all that apply.

- College course
- Work-supported training/workshop
- Webinars
- Personal interactions with scientists

- Web sites
- On the job use
- Not familiar with them
- Other (please specify): _____

14) How would you like to learn more about risk management and decision support procedures and tools? Check all that apply.

- College course
- Work-supported training/workshop
- Webinars
- Personal interactions with scientists
- Web sites
- On the job use
- Not familiar with them
- Other (please specify): _____

Thank you for taking the time to complete the survey.