RISK COMMUNICATION FOR GOVERNMENT PRACTITIONERS: An Annotated Bibliography

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Attachment 1

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INTRODUCTION[1]

Like people in industry, people in government often feel frustrated when they try to communicate about risk. To help reduce this frustration, the University of Wisconsin-Madison Center for Human Performance in Complex Systems has prepared this annotated bibliography, assisted by a cooperative agreement with the U.S. Nuclear Regulatory Commission (NRC). Nearly 40 references are included.

This bibliography is intended as a supplement to an earlier bibliography published by the Society for Risk Analysis (SRA)--A. Fisher, S. Emani, and M. Zint, "Risk Communication for Industry Practitioners: An Annotated Bibliography," August 1995. As such, it does not attempt to be comprehensive. Rather, it focuses on areas not covered in detail in the earlier document. In particular, this bibliography reviews general risk communication literature published in 1995 or later (which could not be included in the earlier document), and also focuses on government risk communication--both risk communication to government decision-makers and government risk communication to the public (covered only incidentally in the earlier document).

A brief section on credibility and trust in risk communication is provided (supplementing the references provided in the earlier SRA document), mainly because the issue of trust is one of the key reasons for the emphasis on stakeholder participation processes as a mechanism for risk communication and risk management. A section on stakeholder involvement processes is also provided; this topic again was covered only incidentally in the earlier SRA document, but has received increasing prominence in recent years. In this section, the emphasis is on general-purpose discussions of stakeholder processes, rather than manuals or guides developed by particular government agencies.

Finally, a section on technical communication and science education is also included. Because of the voluminous literature in this area, this section focuses primarily on summaries of the field (especially summaries intended for risk communication practitioners), and applications of ideas from this field (in particular, the idea of "mental models") to problems of environmental risk. References are listed alphabetically by author under each topic.

Relevant risk communication research findings are published in journals in the fields of risk analysis (e.g., *Risk Analysis*; *Reliability Engineering and System Safety*; *Human and Ecological Risk Assessment*; *Environment*; *Risk: Health, Safety and the Environment*) and communications (e.g., *Journal of Applied Communications*; *Journal of Applied Communication Research*; *Communication Yearbook*). In addition, an increasing number of reports are being published electronically, on sites such as RiskWorld (http://www.riskworld.com/) or the National Environmental Publications Internet Site (http://www.epa.gov/ncepihom/nepishom/).

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GENERAL RISK COMMUNICATION LITERATURE (1995 OR LATER)

Fischhoff, B. 1998. Communicate unto Others... *Reliability Engineering and System Safety* 59: 63-72.

This short article discusses some of the challenges involved in risk communication across a wide range of situations and contexts. In particular, the author describes the bases for creating trust either among colleagues (e.g., professionals in the same field) or with the public, and the types of information most likely to be needed for well-structured versus ill-structured decisions. The need to carefully select which information to include in risk communication messages is also highlighted. As noted by the author, "All too often...it is hard to know why particular facts were chosen for risk communications...Commonly known facts may be repeated, while potentially useful ones are presented without necessary context."

Flynn, J. 1996. Constructing and Reconstructing Respondent Attitudes During a Telephone Survey. American Statistical Association 1996 Proceedings of the Section on Survey Research Methods 2: 895-899, Alexandria, Virginia: American Statistical Association.

This paper is a brief discussion of the "decision pathways" survey method discussed in more detail in Gregory et al. (1997); see below. The paper also includes a good discussion of open issues regarding the use of this survey methodology. In particular, the author notes that it is still unclear whether the method generates "a better response" than traditional survey techniques, or even how one should judge the answer to that question.

Gregory, R., J. Flynn, S. M. Johnson, T. A. Satterfield, P. Slovic, and R. Wagner. 1997. Decision-Pathway Surveys: A Tool for Resource Managers. *Land Economics* 73(2): 240-254.

This paper presents a novel technique for performing public opinion surveys. The method is based on the assumption (confirmed by empirical research in the area of decision theory) that people often do not have well-formed and stable beliefs about complex subjects. Therefore, results obtained using traditional survey instruments may be heavily influenced by minor changes in question wording, and may be quite unstable over time. Instead, the authors propose the use of a structured "decision pathway" questionnaire designed to help respondents think about complex topics. It is hoped that the results obtained using this process will be more informative for policy purposes (since they will contain more information about the reasons for people's opinions), and will also be more stable (since subjects must think in depth about the issues in responding to the survey). The paper also describes an application of the proposed method to study attitudes towards forest management (e.g., use of herbicides to reduce undesirable vegetation). The data from the pilot application revealed five different groups with significantly different attitudes towards vegetation management. Opinions covered a wide range of viewpoints, from those who distrust the ability of forest management professionals to make

reasonable decisions given the complexity of the problem (and therefore would prefer that no action be taken), to those who support aerial spraying of herbicides.

Heath, R. L. 1995. Corporate Environmental Risk Communication: Cases and Practices Along the Texas Gulf Coast. *Communication Yearbook* 18: 255-277.

This article summarizes the results of five chemical-industry case studies "featuring successful and unsuccessful communication efforts." The cases include the use of "citizens' advisory councils," provision of risk communication training to subject matter experts, and strategies that were either successful or unsuccessful in building and maintaining public trust.

Lundgren, R., and A. McMakin. 1998. Risk Communication: A Handbook for Communicating Environmental, Safety, and Health Risks. Columbus, OH: Battelle Press.

This is the second edition of a "manual" for how to plan and implement risk communication efforts, and perhaps the best single reference book for people who want a quick, practical overview of the field. The book includes detailed chapters on a number of topics, including possible goals of risk communication, how to assess the knowledge and background of risk communication audiences, how to design brochures and other written materials, how to manage "stakeholder participation," and how to evaluate risk communications. Each chapter includes a brief list of helpful references. In addition, each of the chapters that discusses specific tools and techniques of risk communication (rather than general background material) also includes a "checklist" of issues to be addressed by people planning to use those techniques. Topics whose coverage has been substantially expanded since the first edition (published in 1994) include stakeholder participation, evaluation of risk communications, and the use of computer methods such as web pages and e-mail.

The Presidential/Congressional Commission on Risk Assessment and Risk Management. 1997. Final Report. Volume 1: Framework for Environmental Health Risk Management; and Volume 2: Risk Assessment and Risk Management in Regulatory Decision-Making. http://www.riskworld.com/Nreports/nr5me001.htm.

This electronically published report summarizes the results and findings of a recent government commission. Chapter 3 of Volume 2 includes a brief discussion on risk communication that emphasizes the importance of public participation, the role of risk comparisons, and the need for greater comparability between estimates of risk from carcinogens vs. other chemicals. However, due to the wide range of topics covered in the report, no specific aspect of risk communication is covered in much detail. Thus, the report represents a useful summary of current thinking, but is not a substitute for more detailed reference material.

Slovic, P. 1997. Trust, Emotion, Sex, Politics, and Science: Surveying the Risk-Assessment Battlefield. In M. H. Bazerman, D. M. Messick, A. E. Tenbrunsel, and K. A. Wade-Benzoni (eds.), Environment, Ethics, and Behavior: The Psychology of Environmental Valuation and Degradation. San Francisco, CA: The New Lexington Press, pp. 277-313.

This survey article summarizes the results of recent research regarding the factors influencing public attitudes to risk. The author discusses gender and racial differences in risk perceptions; e.g., "the finding that men tend to judge risks as smaller and less problematic than do women." The influence of more general attitudes such as fatalism, individualism, and support for use of advanced technology is explored; for example, research results have shown that egalitarians are generally anti-nuclear, while fatalists and individualists are more likely to be pro-nuclear. The positive and/or negative connotations associated with a particular technology were also noted as influences on risk perceptions. Finally, empirical research on the types of events that contribute to increased or decreased trust in an organization's risk management capabilities are discussed. The author concludes that due to the subjective nature of risk perceptions, methods of decision-making that involve active stakeholder participation are likely to enhance their acceptance of the resulting decisions.

Stern, P. C., and H. V. Fineberg. 1996. Understanding Risk: Informing Decisions in a Democratic Society. Washington, D.C.: National Academy Press.

This frequently cited report discusses how to integrate the detailed technical information needed for risk management decisions with input from the people affected by those decisions. In particular, the report distinguishes the roles of public deliberation and technical analysis, and discusses options for how to better integrate these two aspects of the decision making process. It also presents case studies illustrating some of the ideas discussed in the report (including applications to power plant siting and nuclear waste cleanup, among other topics), and discusses some common methods for facilitating public involvement in decision making.

Thompson, K. M., and J. D. Graham. 1996. Going Beyond the Single Number: Using Probabilistic Risk Assessment to Improve Risk Management. *Human and Ecological Risk Assessment* 2(4): 1008-1034.

This article advocates the use of uncertainty analysis in risk assessment, and discusses some of the issues that decision-makers must address in interpreting the resulting risk analyses. These issues include: comparing an uncertain risk with other risks or with a regulatory standard; judging the cost effectiveness or benefit-cost ratio associated with an uncertain risk reduction option; and determining when it is worth deferring a decision until more information is available to reduce the level of uncertainty. As such, it can be helpful to government decision-makers attempting to use complex risk assessment results in decision making. The authors also include a brief discussion of the difficulties in communicating uncertain risk analysis results to the general public, including the possibility that presenting uncertainties may reduce public credibility in some situations.

GOVERNMENT RISK COMMUNICATION

Risk Communication to Government Decision-Makers

Balch, G. I., and S. M. Sutton. 1995. Putting the First Audience First: Conducting Useful Evaluation for a Risk-Related Government Agency. *Risk Analysis* 15(2): 163-168.

This short and informal article (co-written by a marketing researcher and a government risk communicator in the U.S. Department of Agriculture) discusses how risk communicators in government agencies can better serve senior managers accomplish their goals of avoiding crises and obtaining better control over their interactions with the public. The recommendations are grouped into ten categories: "Be knowledgeable" about management priorities and the potential uses of risk communication. "Be prepared" with information on risk communication techniques that are likely to be used. "Be relevant" to senior management and other stakeholder concerns. "Be flexible" to accommodate the differing needs at different stages of a risk communication program. "Be proactive" about potential problem areas and successful solutions. "Be visible" so that others become aware of relevant risk communication capabilities within the agency. "Be opportunistic" by targeting the issues where risk communication can do the most good. "Be understandable" so that managers can easily grasp what is presented. "Be consistent" in always presenting a positive image to other team members. Finally, "Be realistic" about what can be accomplished in both the short and long term.

Bloom, D. L., D. M. Byrne, and J. M. Andresen. 1993. Communicating Risk to Senior EPA Policy Makers: A Focus Group Study. Washington, D.C.: Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency.

This report documents the results of a focus group of eleven senior managers at the U.S. Environmental Protection Agency. The group summarized the key issues they consider when making policy decisions. These include the legal requirements, the possible adverse effects of the particular hazard being regulated, the available options for reducing that risk, the extent of concern about the issue on the part of various groups, and the reliability of the information on which the decision is based. The group also discussed the types of information that they would want to receive in a briefing. Those include both quantitative and qualitative descriptions of risks, and descriptions of the uncertainty (e.g., about the dose-response relationship, about the number of people exposed, about the costs and effectiveness of the risk management options, and any significant gaps in the available information base). Finally, the group rated several different information formats (including verbal, graphical, and tabular presentation formats); some were viewed as being highly effective, while others were seen as overly complex or simplistic. The report concludes with recommendations on how to structure briefings to decision-makers, based on the results of the focus groups. Some of the issues addressed in this document (e.g., dose-response relationships, number of people exposed) may be specific to the regulation of hazardous chemicals, but many of the more general policy issues could apply to almost any type of safety or environmental regulation.

Brown, R., and J. W. Ulvila. 1987. Communicating Uncertainty for Regulatory Decisions. In V. T. Covello, L. B. Lave, A. Moghissi, and V. R. R. Uppuluri (eds.), Uncertainty in Risk Assessment, Risk Management, and Decision Making. New York, NY: Plenum Press, pp. 177-187.

This brief article discusses the issue of how to communicate uncertainties in risk analysis results to regulators, from a decision-theoretic perspective. It summarizes early work on this issue supported by both the National Science Foundation and the Nuclear Regulatory Commission (in particular, the Division of Risk Analysis and Operations). The paper first distinguishes between "outcome uncertainty" (i.e., "what might actually happen and with what probability") and "assessment uncertainty" (i.e., how much the results of the analysis might change with additional information). The authors note that outcome uncertainty is the primary concern of a decision-maker who must reach a final decision immediately, while assessment uncertainty is of interest to decision-makers who have the option of collecting more information before deciding. With regard to assessment uncertainty, the authors distinguish between the effects of "unlimited information" versus information that might result from a realistic research effort, and address the issue of how much the new information might reduce the outcome uncertainty (rather than only shifting the central estimate of the outcome). Possible graphical representations of these various types of uncertainty are suggested, although no empirical results about their effectiveness are provided. The authors conclude that information on uncertainties is difficult to communicate, but is an essential input to regulatory decision making.

Improving Risk Characterization: Summary of a Workshop held in Washington, DC on September 26 & 27 1991. 1992. Washington, D.C.: American Industrial Health Council, Center for Risk Management (Resources for the Future), and U.S. Environmental Protection Agency.

Risk characterization is defined here as "the integrative description of the results of hazard, dose-response and exposure evaluations." Several recommendations for improving the quality of risk characterization are proposed. First, it is recommended that "potential users of the information" (including not only government decision-makers but also other stakeholders) and the decisions to be made should be identified as early as possible, so that the risk analysis can be designed to address all of the major issues of concern. Next, the risk characterization should be "relevant... timely and comprehensible," and should provide a variety of risk measures (e.g., both societal and individual risk estimates) as well as a clear statement of uncertainties. Finally, the need for "two-way communication between assessors and users" is emphasized. The workshop report also lists research needs, including the relative effectiveness of different risk communication strategies, methods for enhancing the "risk literacy" of decision-makers, and methods for integrating "technical information about risk with information on other social values."

Presentation of Risk Assessments of Carcinogens: Report of an Ad Hoc Study Group on Risk Assessment Presentation. 1989. Washington, D.C.: American Industrial Health Council, U.S. Environmental Protection Agency, Department of Health and Human Services, and Society for Risk Analysis.

This study reports on the results of a multi-organization task force that discussed methods for improving the format of cancer risk assessments. The group reviewed ten published risk assessments, and developed a list of "desirable attributes" for presentation formats. Many of these attributes (e.g., guidelines for explaining the derivation of the dose-response relationship) are not specific to cancer risk assessment, and could be usefully applied to analyses of other health effects.

Government Risk Communication to the Public

Chess, C., K. L. Salomone, B. J. Hance, and A. Saville. 1995. Results of a National Symposium on Risk Communication: Next Steps for Government Agencies. *Risk Analysis* 15(2): 115-125.

This article briefly summarizes the results of a symposium on government risk communication to the public held in 1994. The agencies participating in the symposium included the U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers, the U.S. Department of Agriculture, the U.S. Department of Energy, and several state agencies. Key points highlighted in this summary include the issues of: "integrating outside concerns into agency decision-making; communicating with communities of different races, ethnic backgrounds and incomes; and evaluation of risk communication."

Fischhoff, B. 1995. Risk Perception and Communication Unplugged: Twenty Years of Process. *Risk Analysis* 15(2): 137-145.

This brief and highly readable article traces the evolution of government risk communication to the public from the early stages in which just presenting quantitative risk estimates was assumed to be adequate, to more recent thinking regarding the public as partners in risk-related decision making. Although the article reflects the somewhat idiosyncratic thinking and experiences of the author, it can be helpful in alerting risk communicators to potential pitfalls, such as misguided use of risk comparisons, and to the importance of communication skills and demeanor in affecting public perceptions.

Fisher, A., R. King, W. Hewitt, D. J. Epp, K. Finley, J. L. Brown, and A. N. Maretzki. 1992. Understanding Food Safety Policy Issues--Report on Model Materials. University Park, PA: Department of Agricultural Economics and Rural Sociology, Pennsylvania State University.

This study dealt with risk communication to the public regarding food safety, with application to a specific example; namely, control of Salmonella. The study addressed communication efforts intended both to explain to the public how food safety decisions are made by the responsible agencies, and also to support individuals' ability to make better decisions about food safety in their own lives. Results suggested that the information materials led to greater confidence both in regulatory policy decisions regarding food safety and in individuals' ability to prepare food safely. The ability to achieve greater public understanding of regulatory decisions could be beneficial, for instance, in preventing public pressures to ban or restrict beneficial foods. Both computer and paper versions of the risk communication materials were compared. Respondents generally found the paper version to be more convenient, and learned about the same amount of information from both versions. Asking respondents to answer factual questions about food safety before reading the informational materials did not significantly increase learning.

Fisher, A., R. King, D. J. Epp, J. Lynne Brown, and A. N. Maretzki. 1994. Evaluating Alternatives for Communicating about Food Risk. *Journal of Applied Communications* 78(2): 1-11.

This article is a briefer, more accessible summary of the above-mentioned research report.

Johnson, R., A. Fisher, K. Smith, and W. H. Desvouges. 1988. Informed Choice or Regulated Risk? Lessons from a Study in Radon Risk Communication. *Environment* 30(4): 12-15, 30-35.

This article describes the results of a study undertaken by the U.S. Environmental Protection Agency to study the effects of alternative risk communication formats for educating the public about the risks of radon in their homes. In particular, the study compared quantitative and qualitative formats for presenting risk information (e.g., the "lifetime risk of dying from radon" for individuals with a particular radon level in their homes is in the range of 60-210 out of 1,000, or the risk is comparable to "working with asbestos"). The study also compared "command" and "cajole" formats for encouraging particular risk reduction actions. Stating that "You should act to reduce these levels, preferably within several months," is an example of a command message for a household with a very high radon level. A more complex "cajole" recommendation might suggest that individuals take into account factors such as the amount of time spent at home in making decisions about whether to reduce radon levels. Results were mixed; different message formats performed well depending on the criterion used. For example, "the command-qualitative version increased learning about the health effects of radon," "the quantitative...booklets [led] to greater consistency between perceived and objective risk," and "the cajole-qualitative version had a positive effect on the likelihood of one's making an appropriate recommendation" about radon reduction to one's neighbor. The study also found that "different groups (for example, older people) respond to the same message differently." Thus, while this study showed that "differences in information treatment do influence learning,

formation of risk perceptions, and intended or recommended behavior," it did not yield conclusive results as to which format is "best" overall.

Hance, B. J., C. Chess, and P. M. Sandman. 1988. Improving Dialogue with Communities: A Risk Communication Manual for Government. Trenton, NJ: Division of Science and Research, New Jersey Department of Environmental Protection.

This highly readable and interesting manual, prepared for the Division of Science and Research of the New Jersey Department of Environmental Protection, was based in part on interviews with representatives of the U.S. Environmental Protection Agency, other federal agencies, state agencies, industry, academia, and citizen groups. The issues addressed include the treatment of uncertainties, dealing with community anger, identifying and dealing with different audiences (e.g., "environmental groups, civic organizations, industry..., health organizations, local government agencies, local elected officials, local businesses, trade organizations, and so on"), and how to actually plan and hold public meetings. The discussion of each issue includes "common-sense guidelines" (e.g., "Listen to what various groups are telling you," "Find out from communities what type of involvement they would prefer"), and addresses the reasons that "these...guidelines are routinely violated in agency practice" (e.g., beliefs that "Communities worry about the 'wrong' risks").

CREDIBILITY AND TRUST IN RISK COMMUNICATION

Kasperson, R. E., D. Golding, and S. Tuler. 1992. Social Distrust as a Factor in Siting Hazardous Facilities and Communicating Risks. ***Journal of Social Issues*** **48(4): 161-178.**

This article discusses the impact of trust (or the lack thereof) in environmental management decisions such as siting of hazardous facilities. The authors include a framework for a proposed risk communication program specifically designed for situations where trust is lacking. The first step in that process is "needs assessment," defined here as gathering information about what various members of the public would like to know about the risk at hand. After needs have been assessed and the scope of the discussion has been defined, the next step is to design the actual process to be used for risk communication. As noted by the authors, "The key to...a process geared to social distrust is the sharing of power, that is the empowerment of risk bearers, in the management of the risk or the facility." The paper also discusses the need for multiple risk communication messages and strategies to reach a wide variety of audiences--especially the need for special efforts to involve disadvantaged groups who may otherwise be unable to participate. Finally, the central role of "monitoring and evaluation" in rapidly changing and controversial situations is also highlighted.

Kunreuther, H., P. Slovic, and D. MacGregor. 1996. Risk Perception and Trust: Challenges for Facility Siting. ***Risk: Health, Safety and the Environment*** **7:109-118.**

This paper discusses the barriers to siting of hazardous waste treatment facilities due to public distrust in decision making institutions. It then describes an investigation of twenty-nine facility location decisions, and reveals that the factors most predictive of a successful siting decision included "a broad-based public participation process," and a perception that the proposed facility would solve a waste problem affecting the local community. The authors go on to develop recommendations for facility siting processes, including the need for "earlier involvement of the public."

STAKEHOLDER INVOLVEMENT PROCESSES

Bingham, G. 1986. Resolving Environmental Disputes: A Decade of Experience. Washington, D.C.: The Conservation Foundation.

This book explores in detail one class of methods for achieving stakeholder involvement; namely, mediated dispute resolution and related approaches (i.e., "negotiation, mediation, consensus building, policy dialogue"). As suggested by the title, the book includes brief discussions of numerous cases of dispute resolution in areas including land use planning, management of public lands, energy generation, and air and water pollution, among others. The author discusses the extent to which dispute resolution has been effective at resolving debates over environmental issues, the factors that appear to influence the success of dispute resolution in particular cases, and the cost of implementing a dispute resolution process.

Center for Strategic and International Studies (CSIS). 1997. The Environmental Protection System in Transition: Toward a More Desirable Future--Final Report of the Enterprise for the Environment. Washington, DC: CSIS Press.

This is the final report of a two-year stakeholder process in which representatives of industry, government, academia, and environmental groups developed recommendations to improve environmental decision-making. In particular, the report strongly recommends greater use of public stakeholder participation, along with risk-informed, performance-based decision-making and economic incentives for risk management. These approaches were viewed as leading to greater consensus among industry, government, and the public regarding risk management decisions. However, because of the wide range of subjects discussed, the report does not provide much detail on specific technical issues (e.g., the design of stakeholder involvement processes).

Federal Facilities Environmental Restoration Dialogue Committee. 1993. Interim Report of the Federal Facilities Restoration Dialogue Committee: Recommendations For Improving The Federal Facilities Environmental Restoration Decision-Making and Priority-Setting Processes. Washington, DC: U.S. Environmental Protection Agency.

This report, sometimes called "the Keystone report" (since it was facilitated by The Keystone Center), summarizes the recommendations of a committee made up of numerous federal regulators, as well as representatives of a number of state and local regulatory agencies, tribal governments, environmental groups, and others. The primary charge of the committee was to improve the process of decision making with regard to environmental restoration at the thousands of federal facilities around the country (owned primarily by the Departments of Defense and Energy). One key recommendation deals with the allocation of cleanup budgets among the various sites (especially in cases of budget shortfalls). However, the report also includes detailed recommendations regarding risk communication ("the process of disseminating and exchanging information with affected stakeholders") and stakeholder participation ("the process of soliciting input from affected stakeholders"). In particular, the report recommends that agencies develop explicit "information dissemination policies" to ensure that key documents

are widely available, and establish "site-specific advisory boards" as a mechanism of stakeholder participation in actual decision making.

Federal Facilities Environmental Restoration Dialogue Committee. 1996. Final Report of the Federal Facilities Restoration Dialogue Committee: Consensus Principles And Recommendations For Improving Federal Facilities Cleanup. Washington, DC: U.S. Environmental Protection Agency.

This follow-on report provides additional detail and recommendations on the issues discussed in the above document. In particular, the committee gives recommendations on "community involvement" (defined broadly as "the process of information dissemination and exchange"), and on the use of "advisory boards" as a mechanism for accomplishing one part of that goal. With respect to community involvement, the report notes the need to assess stakeholder needs and resources before designing a risk communication program, and also the need to proactively solicit involvement by all affected stakeholders; it also recommends the use of local news media where appropriate. With respect to the use of advisory boards, the report provides general recommendations regarding their establishment, scope of responsibility, membership, operation, and funding, as well as more specific recommendations on issues such as the possible need for training or technical assistance for board members to ensure their effective participation.

Lynn, F. M., and G. J. Busenbert. 1995. Citizen Advisory Committees and Environmental Policy: What We Know, What's Left to Discover. *Risk Analysis* 15(2): 147-162.

This article reviews fourteen empirical studies on the use of Citizen Advisory Committees (CACs) as a means of providing public input into risk management decisions. Due to the wide diversity in the designs of CACs (as well as the limited number of empirical studies), the article reaches few definitive conclusions, other than the observation that "the influence of CACs on policy outcomes have [sic] varied from case to case." The article also calls for more research on "membership selection processes, the role of facilitators, the methods by which agendas are set... the role of independent experts, methods by which a CAC can be held accountable to the public, methods of feedback from sponsor to CAC, and the purpose of CACs as perceived by members and sponsors."

Renn, O., T. Webler, and P. Wiedemann. 1995. Fairness and Competence in Citizen Participation: Evaluting Models for Environmental Discourse. Dordrecht, The Netherlands: Kluwer.

Although highly academic in tone, this book is an invaluable resource for its detailed descriptions of a wide variety of different models for public participation. The edited volume includes discussions of the strengths and weaknesses of each approach, the types of problems to which each method is best suited, and some representative past applications, with different authors providing arguments for and against each approach. The specific models considered here include (among others) citizen advisory committees, Citizens Juries, regulatory negotiating committees, and mediation. The wide range of models considered makes clear that there are

many different forms of public participation, and the discussion is helpful in identifying the advantages and disadvantages of the various approaches.

Susskind, L., and J. Cruikshank. 1987. Breaking the Impasse: Consensual Approaches to Resolving Public Disputes. New York: Basic Books.

This book reviews consensus approaches to decision making (including "unassisted negotiation," mediation, facilitation, and non-binding arbitration) in a variety of contexts, including but not limited to environmental decision making. The authors postulate several criteria for judging whether a particular dispute resolution process is successful. These criteria include: "fairness"; "efficiency"; "wisdom" (i.e., whether the process was informed by sufficient foresight about the acceptability of particular outcomes, and by all relevant sources of information); and "stability." They also discuss obstacles to successful dispute resolution, including a reliance on voting and majority rule, the inability of some organizations (including the government) to make credible long-term commitments, and the technical difficulty of many of the issues to be addressed by dispute resolution. Finally, the authors discuss the conditions needed for dispute resolution to be successful--e.g., the ability to identify the relevant stakeholders and engage them in discussion, the availability of a spokesperson able to present the views of each stakeholder group, and sufficient time for the process to unfold. Case studies are presented to illustrate the key points.

Yosie, T. F., and T. D. Herbst. 1998. Using Stakeholder Processes in Environmental Decisionmaking: An Evaluation of Lessons Learned, Key Issues, and Future Challenges. http://www.riskworld.com/Nreports/nr5me001.htm.

This electronically published report, supported by the American Industrial Health Council, the American Petroleum Institute, and the Chemical Manufacturers Association, is a worthwhile and highly readable reference summarizing the state of the art on stakeholder participation processes. The report discusses how the design of stakeholder processes may vary depending on the goals of the process, and also outlines the questions and tasks that must be addressed in planning a stakeholder involvement process. As such, it is likely to be extremely useful in needs assessment and planning for agencies interested in making more extensive and/or more effective use of stakeholder participation. The report also includes an appendix presenting five brief case studies of stakeholder participation processes, including processes undertaken by private companies, by a city government, and by a non-profit institute with federal government sponsorship.

Rowan, K. E. 1991. Goals, Obstacles, and Strategies in Risk Communication: A Problem-Solving Approach to Improving Communication about Risks. *Journal of Applied Communication Research* 19: 300-329.

This paper discusses four typical goals for risk communication efforts--"creating awareness..., enhancing understanding..., developing agreement..., and motivating action." It then discusses strategies for accomplishing these goals. Recommendations for creating awareness are drawn from research in fields including: "graphics and document design..., consumer behavior..., social cognition..., media effects..., and readability research." Recommendations for enhancing understanding are drawn from the fields of "instructional design..., educational psychology..., science education..., and applied linguistics." Strategies for obtaining agreement on a course of action are based on literature in the area of persuasion. Finally, recommendations for motivating action are drawn from "disaster research..., health education..., occupational safety..., and consumer behavior."

Rowan, K. E. 1992. Strategies for Enhancing Comprehension of Science. In B. V. Lewenstein (ed.), When Science Meets The Public. Washington, D.C.: American Association for the Advancement of Science, pp. 131-143.

In this article, the author summarizes research results in the areas of technical communication and science education. The article begins by identifying three barriers to comprehension of difficult subjects: lack of understanding of a particular concept or term; the lack of a mental model relevant to the subject at hand; or the existence of an inaccurate mental model. The author goes on to discuss specific strategies for overcoming each of these obstacles, and the criteria needed for those strategies to be successful. For example, an explanation designed to clarify the meaning of a particular term should ideally include not only a definition, but also a variety of examples illustrating what the term does and does not mean. In more complex situations, an explanation may need to provide not only a definition and examples, but also a description of a particular process (i.e., a simple mental model), in which case highlighting of key concepts has been found to be helpful. Finally, when the audience already has a flawed mental model, simply presenting an improved model is unlikely to be very successful if one does not also point out why the original model may seem intuitively plausible, why it is in fact flawed, and why the improved model is actually superior.

Rowan, K. E. 1995. What Risk Communicators Need to Know: An Agenda for Research. *Communication Yearbook* 18: 300-319.

The author cites five goals of risk communication: establishing the credibility of the communicator; creating awareness of the problem or issue being discussed; enhancing the audience's understanding of the issue; obtaining a satisfactory resolution of the issue (e.g., agreement on a course of action); and implementing the resulting decision. The paper highlights the need for research in several areas to support these goals. First, the author argues that there is

a need to develop "a systematic philosophy of risk communication" to integrate the sometimes-competing concerns of "scientific knowledge and social justice." Detailed studies comparing effective and ineffective risk communication strategies (e.g., "citizens' advisory councils," etc.) would clearly also be valuable. Further research is needed on the effects of "social factors such as occupation, race, schooling, [and] socioeconomic status." Finally, the author also suggests additional research on some of the specific skills useful in risk communication--e.g., "listening, credibility management, informing-explaining, persuading, and motivating action."

Shymansky, J. A., and W. C. Kyle, Jr. 1998. A Summary of Research in Science Education -- 1986. 2.0 Learning and the Learner. *Science Education* 72(3): 276-340.

This is the second part of a voluminous (150-page) survey of the state of the art in science education as of 1986, and reviews some 175 references on "the nature of learning" about science. Some of the topics addressed here (e.g., intellectual development of children, characteristics of students at different stages in their school careers) are not directly relevant to the challenges of risk communication to adults. However, other issues (e.g., "Does the way in which new material is presented to students enhance their learning?"; "Is it necessary to take into account the ideas and beliefs that learners bring to their formal study of science?") may be quite relevant. For example, the authors briefly summarize the results of half a dozen references showing that the use of "concept maps" (similar to mental models) to organize and present information leads to improved learning, and also an improved ability to remember what was learned. The authors also cite several dozen references addressing the effects of prior misconceptions on student learning. While many of these studies simply document the widespread existence of such misconceptions about science, some studies do provide empirical evidence that "the use of instructional strategies...especially designed to focus the students' attention on misconceptions" leads to improved learning.

Mental Models of Environmental Risks

Atman, C. J., A. Bostrom, B. Fischhoff, and M. G. Morgan. 1994. Designing Risk Communications: Completing and Correcting Mental Models of Hazardous Processes, Part I. *Risk Analysis* 14(5): 779-788.

Drawing on research in the area of "text comprehension" (i.e., how people interpret written material), this article discusses how to use information on audience mental models to help design risk communication messages. In an application to the task of educating lay people about the risks of radon in their homes, brochures designed using the mental models approach covered roughly the same material as a brochure prepared by the U.S. Environmental Protection Agency (EPA) in fewer words, but in a clearer manner. Perhaps more importantly, the mental models brochures specifically refuted common misconceptions about radon, such as the idea that radon can result in long-lasting contamination of homes, or that radon causes birth defects or forms of cancer other than lung cancer.

Bostrom, A., C. J. Atman, B. Fischhoff, and M. G. Morgan. 1994. Evaluating Risk Communications: Completing and Correcting Mental Models of Hazardous Processes, Part II. *Risk Analysis* 14(5): 789-798.

This follow-on study evaluated audience responses to the EPA brochure on radon as well as the two mental models brochures developed previously. Subjects expressed a larger number of negative comments about the EPA brochure, suggesting that they may have found the format and presentation boring, confusing, and/or frustrating. Subjects who received the mental models brochures appeared to have more accurate knowledge about radon, and particularly about how to mitigate problems with radon in homes. The authors note that the EPA has redesigned its radon communications brochure in response to the results presented in this paper.

Bostrom, A., M. G. Morgan, B. Fischhoff, and D. Read. 1994. What Do People Know About Global Climate Change? Part 1: Mental Models. *Risk Analysis* 14(6): 959-970.

This study used open-ended interviews to assess knowledge about climate change on the part of the general public, as well as a highly educated university sample. Both groups were found to have incomplete and/or incorrect knowledge about global warming, including misconceptions about the relative importance of various causes (e.g., relatively minor causes such as spray cans or deforestation, vs. more significant causes such as fossil fuel use). The authors note that such misperceptions may adversely affect subjects' ability to participate effectively in societal decisions about how to effectively reduce global warming, and may also make the results of public opinion surveys about environmental concerns difficult to interpret.

MacGregor, D. G., P. Slovic, and M. G. Morgan. 1994. Perception of Risks From Electromagnetic Fields: A Psychometric Evaluation of a Risk-Communication Approach. *Risk Analysis* 14(5): 815-828.

This study confirmed earlier work showing an increase in concern about the potential hazards of electromagnetic fields (EMF) after receiving information about the subject. This result was obtained despite the fact that the brochure used in this study stressed the weak and speculative nature of the evidence for health effects caused by EMF. The authors note that these results may be problematic for risk communicators who wish to educate the public about potential hazards, but avoid raising high levels of concern until it is known definitively whether a problem exists.

Maharik, M., and B. Fischhoff. 1992. The Risks of Using Nuclear Energy Sources in Space: Some Lay Activists' Peceptions. *Risk Analysis* 12(3): 383-392.

This paper presents information on the mental models held by anti-war and environmental activists concerned about space uses of nuclear energy. The results showed that although the subjects surveyed in this study knew quite a lot about nuclear energy, their knowledge tended to be incomplete, inaccurate, and not very detailed. Based on these results, the authors propose recommendations for how to more effectively communicate about the risks of space nuclear power to similar audiences. In particular, the authors assert that "a detailed description of

laypeople's mental models is essential to designing effective risk communications. Without it, one may waste their time telling them things they already know, miss the opportunity to build on those correct beliefs, and fail to address misconceptions that can misdirect their inferences."

Maharik, M., and B. Fischhoff. 1993. Risk Knowledge and Risk Attitudes Regarding Nuclear Energy Sources in Space. *Risk Analysis* 13(3): 345-353.

This study investigated the correlation between the degree of knowledge subjects had about the use of nuclear energy in space, and their attitudes towards it. The results revealed that greater knowledge was generally correlated with more favorable attitudes among members of the general public, but not among activists (who were generally opposed to space uses of nuclear energy regardless of their knowledge levels) and engineers (who were generally in favor regardless of their knowledge levels). This suggests that "uninvolved people listen to the evidence," while those with stronger preconceived opinions are less susceptible to changing their views based on information. Follow-on work confirmed that providing additional information did generally lead to more favorable responses. A risk communication brochure specifically designed to address observed weaknesses in understanding was also compared against a brochure developed by the National Aeronautics and Space Administration (NASA) to promote space uses of nuclear energy. The brochure based on the observed mental models was more effective at conveying new knowledge than the NASA brochure, but no less effective at inducing favorable responses to space uses of nuclear energy, even though it was designed to be neutral in tone.

Norman, D. A. 1983. Some Observations on Mental Models. In D. Gentner and A. L. Stevens, Mental Models. Hillsdale, New Jersey: Lawrence Erlbaum Associates, pp. 7-14.

This article provides a brief overview on mental models in general (rather than the application of mental models to environmental risks in particular). The author distinguishes between the mental models used by lay people and the "conceptual models...invented by teachers, designers, scientists, and engineers" in order to accurately describe a particular system. He also outlines some general properties of mental models, including the observations that they tend to be incomplete, change over time, and include "superstitious" or "unscientific" elements.

Read, D., A. Bostrom, M. G. Morgan, B. Fischhoff, and T. Smuts. 1994. What Do People Know About Global Climate Change? Part 2: Survey Studies of Educated Laypeople. *Risk Analysis* 14(6): 971-982.

This follow-on study extended the results of the previous study on knowledge about global warming, using fixed-response questionnaire surveys rather than open-ended interviews. The results confirmed that even well educated respondents often did not understand key concepts, such as the role of fossil fuel use as a primary cause of global warming. The authors therefore conclude that risk communication messages about global climate change should be designed to clarify common misconceptions.

Waltar, A. E. 1995. America the Powerless. Madison, WI: Cogito Books.

Although not specifically described as an application of mental models to risk communication, this book discusses a number of common misconceptions about the risks of commercial nuclear power in the U.S., and attempts to systematically address those views. Therefore, it may be a valuable reference in helping to identify some of the misunderstandings and mental models that may be encountered by risk communication messages dealing with nuclear power safety.