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SUMMARY REPORT:
**Developing a Users' Needs Survey Focusing on
Informational and Analytical Environmental
Decision-aiding Tools**

by

Amy K. Wolfe, Oak Ridge National Laboratory
Susan M. Schexnayder, University of Tennessee
Mark Fly, University of Tennessee
Christa Furtsch, University of Tennessee

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University of Tennessee

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NCEDR

314 UT Conference Center Building

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For more information, or additional copies, contact:

The National Center for Environmental Decision-making Research

NCEDR

314 Conference Center Building

Knoxville, Tennessee, 37996-4138

Phone (423) 974-3939, Fax (423) 974-4609

www.ncedr.org

SUMMARY REPORT:

Developing a Users' Needs Survey Focusing on Informational and Analytical Environmental Decision-aiding Tools

SUMMARY

This document describes efforts to develop a survey of needs that participants in the environmental decision-making process express for informational and analytical environmental decision-aiding tools. Further, it summarizes the results of a literature review, small-group sessions, and telephone interviews conducted as part of the process of survey development. Literature related to environmental decision-making tended not to address users' needs for environmental decision-aiding tools. Rather, the literature more often described certain types of tools and, perhaps, the degree to which the use of those tools was successful in particular circumstances. Information about the uses and needs for informational and analytical environmental decision-aiding tools was elicited from 18 participants in two small-group sessions and 24 telephone interview respondents. Participants in small-group sessions, though drawn from the eastern Tennessee area, deliberately were selected to represent a wide diversity of environmental issues and decision-making roles. Although telephone interviewees played a variety of roles in environmental decision making, we narrowed the environmental topics of concern to natural resource management, solid waste management, and growth management/infrastructure development.

Because of the small sample size, the results of these elicitations are not generalizable. However, they provide a starting point for additional investigation.

Respondents provided a considerable amount of information during small-group sessions and telephone interviews. Preliminary findings from these elicitations are summarized here. Rather than undertake exercises to identify goals and values, several respondents indicated that they see regulations, long-term planning documents, and the like as specifying their operating goals and values. Our questions focused primarily on informational and analytical tools; yet, virtually *no* respondents highlighted the need for those sorts of tools. In telephone interviews, several respondents stated that they most need *communication* tools in response to a question that asked them to specify the *informational and analytical* tools the most need. The most pressing needs, as expressed by our respondents, were the following:

- ❖ for access to a wide range of tools, such as databases and models, where "access" incorporates financial, technological, and other dimensions;
- ❖ for assistance in determining *how* to use the sometimes overwhelming amount of information that either already exists or that is generated through problem-specific analyses; and
- ❖ for assistance in determining *what* information is needed to help generate an informed decision, and, therefore, in determining what tools should be selected for use.

Survey development proved to be deceptively difficult for several reasons. First, commonly used language—terms like "environmental decision making," "tool," and "user"—lacked the precision necessary for use in a survey. Second, the wide diversity of types of participants in environmental decision making and of environmental issues created the following three major difficulties:

- ❖ developing a survey whose language would be understandable to a broad array of respondents and that would mean roughly the same thing to those respondents;
- ❖ developing a survey whose results are meaningful—results should be somewhat context-dependent (not extremely broad generalizations) but not so situation-specific that they have no relevance to most participants in environmental decision making; and
- ❖ developing a “tight” survey whose results will achieve specific goals, which means that it is essential to determine in advance the kind of information the survey should provide to whom.

1. INTRODUCTION

This document summarizes efforts to develop a survey of users' needs for informational and analytical environmental decision-aiding tools. “Users” refers to participants in the environmental decision-making process. Our goals for this effort were to develop and preliminarily test a survey that later could be implemented on a large scale. We anticipated that the information obtained through the survey would provide some indication of what decision-aiding tools currently are in use and, more importantly, the needs that users identify for additional or more refined tools. The National Center for Environmental Decision-making Research (NCEDR) could then use the information supplied by respondents to undertake selective tool-development and tool-access initiatives.

Conceptually, it is relatively simple to develop a users' needs survey. However, in practice, it was an extremely challenging task because of the complexity of the environmental decision-making arena. Part of this summary document discusses the fundamental issues raised during the course of the project. We also summarize the process we used to develop the survey and the preliminary findings from its initial implementation regarding users' needs and the utility of the survey instrument.

In brief, the project consisted of a literature review, informal small-group sessions with participants in the environmental decision-making process, the development of a draft survey instrument, and testing and refinement of that survey instrument as it was implemented through telephone interviews. Because the time frame for the project was limited (from May through October, 1996), to test the survey instrument team members selected telephone respondents who were involved with the following three different environmental decision-making topics for investigation: solid waste management, natural resource management, and growth management and infrastructure development. These topics were selected to provide some diversity of (a) environmental decision-making issues, (b) decision makers, and (c) likely use of, and need for, informational and analytical environmental decision-aiding tools. In addition, team members' previous experience allowed them to identify quite readily a list of potential interviewees involved with these particular issues.

The project was conducted under the auspices of the National Center for Environmental Decision-making Research (NCEDR). Established in 1995, NCEDR seeks to improve environmental decision making at local and regional levels through collaborative research, education, and outreach. NCEDR focuses on the range of issues, approaches, tools, and processes that constitute environmental decision making. The Center is funded by the National Science Foundation, with additional support provided by its three parent institutions, Oak Ridge National Laboratory, Tennessee Valley Authority, and University of Tennessee. This effort—part of a larger NCEDR focus on

the use, improvement, and development of environmental decision-aiding tools—was conducted by two anthropologists (Wolfe and Schexnayder); a recreation resource specialist (Fly); a forestry, wildlife, and fisheries graduate student (Furtsch); and a student who was an environmental studies major (Lawson).¹

2. FINDINGS

The project resulted in three categories of findings. First, it raised a number of issues basic to the development of a survey on users' needs for decision-aiding tools. Second, it produced some preliminary information about the decision-aiding tools used or needed by people involved in the environmental arenas we targeted. Third, it provided an indication of the usefulness of the survey instrument we developed. All three sets of findings are presented in the following sections. The latest iteration of the interview protocol we used in conducting telephone interviews is attached as an appendix to this document (see Appendix B).

2a. Literature Review on the Use and Need for Environmental Decision-aiding Tools

We conducted a literature search¹ of environmental citations, using a wide diversity of key words on which to search. We limited the search primarily to 1985–1996, concentrating on post-1990 citations. Among the many key words used were variants of “decision making,” “decision tool,” and “environmental decision,” as well as a host of more specific tools such as “geographic information system” and “database.” Through this process, we had over 100 “hits,” from which we selected approximately 40 for more serious attention. We judged these 40 to have the most relevance for this project. Nevertheless, there were few documents that bore directly on our survey development activities. Literature related to environmental decision-making typically described certain types of tools, usually in terms of the ability of a certain tool to provide a certain kind of result or in terms of how a user *might* use the tool. Occasionally, authors addressed the degree to which the use of those tools was successful in particular circumstances or acknowledged that the tools were tested among potential or prototypical users *to assess the degree to which the tool “worked.”* Authors did not assess the degree to which the tool was compatible with the needs of real-world participants—either researchers/analysts or decision makers—in the environmental decision-making process. “Needs” typically were defined from an analysts' perspective. As a rule, the literature did not address users' needs for environmental decision-aiding tools from the users' (in particular, decision makers') perspectives. See Appendix A for more detailed information on literature review findings.

2b. Tools that Participants in the Decision-making Process Use and Need

We elicited information from a relatively small number of participants in environmental decision-making processes. A total of 18 people participated in the small group sessions, and we conducted a total of 24 telephone interviews. Participants in the small group sessions were drawn from the eastern Tennessee region, primarily from the Knoxville-Oak Ridge vicinity. These individuals deliberately were selected to represent a wide variety of environmental resource areas and environmental decision-making roles. As examples, participants included environmental specialists from large local industries,

¹ Monica Lawson (University of St. Thomas) largely was responsible for conducting the literature search; we much appreciate her efforts.

a local utility board decision maker, local government representatives, private environmental analysts, members from local advocacy groups, and members of local environmental advisory groups.

The telephone interview respondents were involved in decision making in one of the three areas in which we focused our efforts—natural resource management, solid waste management, and growth management/infrastructure development. These areas were selected to provide a diversity of input with an associated indication of the degree to which the survey structure and results apply in different environmental decision-making contexts. In addition, project staff's familiarity these topics and with individuals involved in environmental decision making facilitated the identification of potential interview respondents.

The number of respondents is far too small to provide statistically valid or otherwise generalizable information. However, we report patterns of findings from our elicitations to provide an indication of what environmental decision-aiding tools are used and needed.

We asked about tool use and needs within the organizational framework of eight functional categories of decision making developed by NCEDR's Toolkit Team (Mary English, Virginia Dale, Claire Van Riper-Geibig, and Wendy Hudson Ramsey). These functional categories are identifying goals and values; characterization of environmental, economic, social, regulatory, and political settings; information integration, futures forecasting, assessment/refinement/narrowing of options; and post-decision assessment. The preliminary survey emphasized the characterization categories more than the other functional categories.

Functional categories of decision making
Identifying goals and values
Characterization of environmental setting
Characterization of economic and social setting
Characterization of regulatory and political setting
Information integration
Futures forecasting
Assessment/refinement/narrowing of options
Post-decision assessment

Identifying Goals and Values. Many participants in the groups sessions are involved in what they characterized as "problem identification." Some include problem identification as part of "identifying goals and values," while others see it as a separate, preliminary step in decision making. Persons who are involved in problem identification tend to "use their experience" to define problems. Regulations are identified as tools to identify problems, and regulatory compliance often constituted the environmental decision-making goal. Other frequently mentioned tools to identify goals and values involved plans, advisory committees, boards of directors, and direct contact with the public and other stakeholders. Among natural resource managers and land use and urban planners, previous environmental decision processes, many of which involved interested parties, had resulted in mid- or long-range plans which, in turn, specified the decision-making goals and values that they weigh their day-to-day environmental decisions against.

Characterization. Preliminary findings indicate that there is a considerable amount of characterization activity, although some respondents would not have described the work they do in terms of "characterization." Respondents indicated that there is considerable information available about the environment, and about social, economic, and legal settings, and that they know how to conduct characterizations. Many commented that the internet has made characterization information available to them,

whereas information previously would have been difficult to identify or obtain. A few complained that they were overwhelmed by information, and some, e.g., persons involved in community development and redevelopment and those involved in solid waste management decisions who are not expert in the solid waste management field, would like a tool to help them identify relevant information (including regulations) or choose which information is most salient, and most credible for their needs. In general, information was gathered through different vehicles, including surveys of residents, Census data, and databases. However, the methods for integrating various sources of information into social setting or natural resource characterizations, for example, often were not given formal labels (e.g., the x method; the y equation) by respondents.

Some respondents reported that timing can be a characterization issue. These respondents said that when groups are asked to do a characterization, it is too late—either a decision already has been made or, because funding was allocated for conducting an assessment, an impression is given that a decision was made. Also, some respondents indicate that even a wealth of information and improved characterization tools would not necessarily improve their decisions and decision processes because insufficient resources (e.g., the time to read reports or pull data from databases or the money to hire consultants to help them retrieve and understand the information) may hamper their ability to make use of the information.

Small group sessions indicated that users need access, expertise, and aids to help them communicate their interpretations of information (obtained and massaged via tools) to upper levels of management, to shareholders, and to the public and other stakeholders. "Informational tool" seems to be interpreted differently by different respondents—as tools to collect information, as tools to convey information, and as resources/expertise to help interpret information. In fact, many interviewees, when asked about tools to acquire, manage, and analyze information, mentioned communicating with their stakeholders (the public, their boards, etc.). Virtually *no one* said that he or she needs a new or better analytical tool. From what small-group-session participants have said, existing analytical tools are adequate (though they always can be improved); the problems center more around (a) the lack of access (technological, financial, etc.) to informational and analytical tools, (b) *how* to use the sometimes vast amount of information that either already exists or that is generated through problem-specific analyses, and (c) the lack of knowledge about *what* information is needed to help generate an informed decision and, by extension what tools should be selected for use to acquire that information.

Information Integration. There were different levels of information discussed explicitly or implicitly by respondents. One level of integration was discussed under "Characterization," in which different sources of information were integrated into, for example, a "social characterization" or an "ecological characterization." However, a higher level of integration consists of using social, ecological, human health, economic, etc. information together in the course of making decision making. Few formal methods for this kind of information integration were mentioned by respondents. Instead, tools consisted of "common sense," "professional judgment," "experience," "trying to figure out what people would value," and the like. Based on the responses about what integration "tools" people use, this higher level of information integration seems to be an area ripe for tool development. However, virtually *no one* said they needed integration tools. Furthermore, one respondent explicitly stated that he did *not* want a tool—a "black box"—that integrated disparate kinds of information because he needed to be able to understand, justify, and communicate his reasons for making a certain decision. If he did not understand or could not communicate adequately the underpinnings of and

processes within the black box, he could not rely on it to help him make or justify his decisions.

Futures Forecasting. A number of respondents said that they did not engage in future forecasting. However, among the biologists who made predictions, their tool of choice was models (e.g., river models). Planners involved with economic development and infrastructure issues said that they want credible and reliable population and economic forecasting data and methods.

Assessment/Refinement/Narrowing of Options. Participants in natural resource and growth management decision making gave two kinds of responses to this inquiry. Some said that they take all available information and make their best judgment. Others involved in natural resource management reported that they take that information to experts to make these judgments. In contrast, respondents who were involved in growth management and solid waste management identified cost-benefit analyses and the National Environmental Policy Act (NEPA) process as the preferred methods for conducting these kinds of assessments.

Participants in one of the small group sessions disagreed about when assessment/refinement/narrowing of options actually occurs in environmental decision making. For some participants, especially those who work regularly under NEPA, alternatives are identified before characterization activities begin. Often the "preferred alternative" is identified at that early stage. (Note that identification of alternatives is not listed as one of the functional categories of environmental decision making and that respondents have linked identifying alternatives to problem identification.) Participants in other kinds of decision-making processes thought that identifying alternatives occurs later (after characterization), and that the identification of alternatives may instigate a new cycle of characterization.

Post-decision Assessment. The most typical response to questions about this functional category of environmental decision making is that funds are insufficient to allow post-decision assessment and that the implementation of decisions can take so long as to make post-decision assessment infeasible. Perhaps these sentiments are the reason no one identified a need for a post-decision assessment tool. Biologists and natural resources managers, however, reportedly used some of the same methods they used for characterization (e.g., conducting inventories or monitoring) when conducting post-decision assessments. Persons involved in solid waste management used "results-based" assessment measures, e.g., determining the volume of waste diverted from a landfill, while persons involved in growth management and infrastructure decisions used public comments and informal "on-the-spot" observations to assess the effects of the decisions.

Other findings from interviews and small group sessions.

- ❖ Small group session participants made the point that "middle" organizations that conduct research may have access to fine tools, etc., but that the decision makers who direct those middle organizations may not know what questions are best to ask. Further, those decision makers may not have the time or money necessary to obtain appropriate data or use particular tools, and the tools and data that exist may not mesh with the kinds of questions asked by decision makers.
- ❖ Small group session participants gave us the general impression that what is needed is better access to tools, better information about what tools exist, and better ways

to communicate the results of analyses to others...*not* better analytical tools. This point was reinforced in telephone interviews when respondents said that the tools they most need are *communication* tools, even when they were asked to specify the *informational and analytical* tools they most need.

- ❖ Time can be an issue in the use of environmental decision-aiding tools, particularly if it takes a long time to access information.
- ❖ Money, too, may be an issue. Costs may prohibit (or encourage) access to certain tools or sets of information.
- ❖ For participants in the environmental decision-making process who take a minimalist approach to regulatory compliance—doing only what is necessary to achieve compliance—few decision-aiding tools may be used even if such tools are readily available.

2c. Survey Development

The process of conducting small group sessions and telephone interviews identified some ways in which the survey could or should be improved. Among the difficulties we encountered was that some of the people interviewed said that they do not *make* environmental decisions and were, therefore, reluctant to respond. Those concerns generally were alleviated when interviewers reiterated that we want to survey participants in environmental decision-making processes.

Although we used input from small-group sessions to refine our terminology, there still is room for improvement. At the most basic level, the word "tool" is problematic. The first small-group session did not like the word "tool" because it implied a tangible "thing" and their "tools" included processes like discussions, meetings, and the like. Those participants suggested "aids to environmental decision making." In the second small group session, we started by using that phrase but participants found it too vague, and preferred "tool." In the telephone interviews, a number of respondents thought of tools only as tangible "things," which may be too narrow a view of tools for the purposes of the survey. In addition, some respondents explicitly desired tools (processes) that would help their problems (e.g., environmental controversies) go away.

As another example of terminology problems, the word "characterization" proved to be a term that a number of respondents found difficult to interpret. Alternatives like "assessment" or "description" may convey different meanings.

During telephone interviews, a number of respondents seemed distracted. Some of the reason for that distraction may be the length of the survey. We should develop a more succinct survey. Given the issues discussed below, making the survey more succinct is an enormous challenge.

3. UNDERLYING ISSUES: SURVEY DEVELOPMENT

Survey development and implementation requires specific knowledge about many items, including the desired use of the information obtained from the survey, the population that should be sampled, and what questions are salient to that group. In developing this users' needs survey, we found these items were not easy to specify. Moreover, definitions of terms fundamental to the topic were ambiguous. Some of the major issues raised in determining specifically what we were trying to accomplish and how to achieve those goals are described below. These issues are critical to consider when discussing environmental decision making broadly, and when focusing more precisely on environmental decision-aiding tools.

3a. Definitions

What do the terms "environmental decision making," "tool," "decision-aiding," and "user" mean?² These terms may "make sense" in everyday conversation, but they mean quite different things to different people. For instance, indications from both the small group sessions and the survey responses (and questions posed by the respondents) are that informational and analytical "tool" and "decision-aiding" are terms too ambiguous to elicit a response from some persons involved in environmental decision making, while other persons have specific, yet quite different, internalized definitions of these terms. Respondents' answers to survey questions differ according to their conceptions of these terms. In a survey, the terms must be used (and, perhaps, defined) precisely—in ways that are clear and that are interpreted similarly by the set of potential respondents. This precision is necessary both for writing questions that respondents understand as well as for interpreting survey results.

3b. What to Ask to Whom?

Small group sessions indicated that (a) researchers' or analysts' needs for tools differ substantially from decision makers' needs and (b) knowledge about informational and analytical tools likewise diverge. Researchers and analysts typically use informational and analytical tools. Small-group-session participants indicated that this subset of users may need quicker, cheaper tools as well as communication tools to provide and justify their results to upper management levels and to decision makers. In contrast, decision makers typically do not use the same kinds of data gathering and analytical tools; they generally need and use tools to help them sort through a sometimes overwhelming amount of information and to help them communicate more effectively. These decision makers may not have the knowledge base to allow them to answer questions about informational and analytical tools effectively. Moreover, they may not have a direct interest either in the existence of, or in the relative merits of, such tools.

Respondents thought that decision makers who have the least experience or knowledge of environmental issues or decision processes may most need tools or information about tools. This "neediest" group of users was thought to have few or no resources with which to learn about or use tools. There are at least two survey-related issues here. First, people who have little knowledge about what tools exist are likely to have difficulty responding to questions about what tools they need, especially if queried about specific tool types. Second, people may neither think of nor label the "things" they use as "tools." For example, respondents may not identify "process" tools as such because they believe that what they are doing is "common sense," "brainstorming," and

² Although the leaders of NCEDR's overall focus on environmental decision-aiding tools and other members of their team have grappled with these definitional issues and crafted definitions (English *et al.* 1997), those definitions were not developed in time to contribute to the users' needs survey development project.

“talking about it.” Unless the survey format allows for in-depth exploration, these needs may not be identified adequately or correctly.

In developing the survey, it is crucial to distinguish categories of respondents, whose needs and perspectives may differ. Should we identify decision makers' needs or analysts' needs, for example? Needs for tools could vary tremendously according to one's role (e.g., a relatively small proportion of environmental decision makers is likely to use a database or econometric model directly in making decisions). Further, the individuals within organizations who use informational and analytical tools are not necessarily the people who make environmental decisions. Initially, we decided to target individuals in “middle-level organizations” who supply analyses and information to decision makers. This decision proved problematic during our small group sessions. Virtually every participant in the small group sessions fell into a middle category—nearly all both made decisions based on information and analyses provided to them by others and provided information and analyses to others to inform their decisions. There was no easy resolution of the dilemma of to whom we should ask what question.

3c. What Kind of Decision?

The total set of environmental decisions is vast, both in terms of scale and topic. For example, they range from individuals' decisions about lawn-mowing (or whether to grow grass), to planned housing developments, to municipal solid waste facilities, to shoreline development, to large hydro-electric plants, to regulations governing ground-level ozone. If environmental decisions are considered broadly, it is difficult to determine what is excluded from the domain of environmental decision making. Nevertheless, not all decisions are the same; nor do they require the same tools (even within the same “functional category” of tools). Different kinds of decision makers make different kinds of decisions, based on different kinds of information, using different kinds of tools, with different kinds of potential implications. Further complicating this issue, in many settings there is not a single decision point; rather there are series of decisions made at different phases and by different organizational levels, in a seemingly never-ending process.

Determining the kind(s) of decision on which to focus is essential for asking questions that are meaningful to respondents and for determining, ultimately, what tools users need. What level of specificity is optimal, or at least useful? To state that participants in the environmental decision-making process use or need tool *x*, without indicating the environmental decision-making context within which that tool is used, is too broad a statement to have practical value. This assertion was supported by the participants in the two small group sessions we held, who told us that “environmental decision making” is too broad a phrase to use. But, to narrow the focus to a particular category of participants in the decision-making process, one environmental issue, and one stage of the decision-making process may provide information that has relevance to a relatively small group. The key is to determine what level to target in the continuum between the two extremes of absolute specificity and very broad generality. This determination should be made according to the value of the information gained. We need to ask ourselves what is the value of knowing that people need or use categories of tools like databases, surveys, geographic information systems (GIS), risk analysis, life cycle analysis, etc. Likewise, we need to know the value of learning very specifically which life cycle analysis model, which GIS package, which atmospheric deposition model, etc. people use and need.

Further, for survey development, what methods should be used to provide a reasonably specific link between types of environmental decision making and the tools that respondents use and need? If we provide a scenario to establish a common

decision-making context to anchor respondents' thinking about tools, that scenario may be irrelevant to many respondents. If we preface tool-related questions with a request to fill out a pre-determined categorization (checklist) of kinds of environmental decision making, respondents may have difficulty placing their work in a particular box (especially if they do multiple things). If we ask them to specify the x environmental decisions they have worked on in the past year so that we can assess the kinds of tools used in different circumstances, we run the risk of intimidating some respondents and losing others (e.g., if they are involved day-to-day in environmental decision making and make so many decisions that it is impractical to specify just a few). If we ask respondents involved in various kinds of environmental decision making to answer tool-related questions in light of just one of those kinds of decision making, then we introduce a bias that would be difficult to identify both its form and its meaning when we analyze survey results.

3d. What Kind of Information Should the Survey Provide to Whom? Why?

Part of the reason that the level of specificity is of such great importance in developing the survey is because the desired level of specificity is related directly to the goals of the survey. It may be interesting to learn what kinds of decision-aiding tools are used and needed, but the ultimate use of such information should be determined. Our initial goal was to identify where gaps exist in the current informational and analytical "toolkit" of participants in the environmental decision-making process. Based on that information, NCEDR or other organizations could develop needed tools or refine existing tools. When operationalizing this goal through survey development, the goal became ambiguous. One reason for this ambiguity is that gap identification may depend on one's perspective; what may appear as a chasm to those involved in assessing the current state of the environment, for example, may not be apparent at all to decision makers who use the results of a variety of analyses (and who frequently may make decisions without the luxury of complete information). Further, gap size may vary in importance according to the topic, type of decision maker, and potential consequences of the decision.

4. A POSSIBLE FUTURE DIRECTION

Not surprisingly, our initial research suggests that there is a diversity of people and professions involved in environmental decision-making processes who are associated with a wide range of environmental issues using terminology that is not always common across disciplines. The knowledge and skill level of people involved in environmental decision making also varies a great deal. One way to explore these and other salient issues in detail is to conduct a series of face-to-face interviews. Interviewers would need to be knowledgeable of the subject matter and skilled in qualitative research methods. Trained interviewers would be able to explain and probe as necessary to address the level of detail needed to communicate with and understand the true needs and concerns of participants in environmental decision-making processes. Initial efforts might focus on a particular topic of environmental decision-making, such as solid waste management, forest management, or growth management. For exploratory purposes, it might be possible to treat one geographic region as a microcosm of the kinds of issues, interests, and needs environmental decision makers face nationwide. Among the criteria for selecting a specific region are the following: participants in the environmental decision-making process could be drawn from local, state, and federal levels; the region contains a range of urban and rural settings; and decision makers in the region face a diversity of environmental issues.

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Appendix A.

Literature Review on the Use and Need for Environmental Decision-aiding Tools

Literature Review on the Use and Need for Environmental Decision-aiding Tools

We conducted a literature search³ of environmental citations, using a wide diversity of key words on which to search. We limited the search primarily to 1985–1996, concentrating on post-1990 citations. Among the many key words used were variants of “decision making,” “decision tool,” and “environmental decision,” as well as a host of more specific tools such as “geographic information system” and “database.” Through this process, we had over 100 “hits,” from which we selected approximately 40 for more serious attention. We judged these 40 to have the most relevance for this project. Nevertheless, there were few documents that bore directly on our survey development activities. Literature related to environmental decision-making typically described certain types of tools, usually in terms of the ability of a certain tool to provide a certain kind of result or in terms of how a user *might* use the tool. Occasionally, authors addressed the degree to which the use of those tools was successful in particular circumstances or acknowledged that the tools were tested among potential or prototypical users *to assess the degree to which the tool “worked.”* Authors did not assess the degree to which the tool was compatible with the needs of real-world participants—either researchers/analysts or decision makers—in the environmental decision-making process. “Needs” typically were defined from an analyst’s perspective. As a rule, the literature did not address users’ needs for environmental decision-aiding tools from the users’ (in particular, decision makers’) perspectives.

Categorizing the literature reviewed is a somewhat arbitrary process because the kinds of categories can vary tremendously (e.g., by type of tool, by environmental topic, by stage of decision making) and the categories overlap. We chose to categorize the literature by broad tool types. Regardless of the tool type, many articles suggested tools for helping to reconcile multiple, possibly competing or conflicting, attributes (or criteria, objectives, etc.). Multi-attribute utility theory or analysis (labeled as such by the authors), for example, was described for acid rain (Anandalingam 1989), energy and environmental modeling (Huang, Poh, and Ang 1995), and nuclear waste repository siting (Merkhofer and Keeney 1987). Huang, Poh, and Ang, investigating actual tool usage among energy planners and analysts, found that multi-attribute decision theory was used most widely for power-plant site selection and environmental control and management. Merkhofer and Keeney found that, though their application of a multi-attribute utility approach was lauded by a National Academy of Science panel, the Department of Energy’s ultimate short-list of potential repository sites did not mesh with the results of their analysis. The authors suggested a number of possible reasons for that situation, including the possibility that their approach evaluated each site *individually*, but that the Department of Energy wanted the *set* of sites to encompass certain criteria.

A variety of multi-criteria or multi-objective tools were described for water-related issues (e.g., Shafike, Duckstein, and Maddock 1992 on groundwater contamination management; Harboe 1992 and Roy, Slowinski, and Treichel 1992 on supply systems) and for energy conservation and supply (Hobbs and Meier 1994; Koundinya, Chattopadhyay, and Ramanathan 1995). Hobbs and Meier tested a variety of multi-criteria decision-making techniques in a workshop setting, evaluating participants’ preferences for different techniques and the understandability and usability of those techniques. The authors focused primarily on how the weighting of different criteria was accomplished via the different techniques. They found that the use of the techniques increases participants’ confidence in their decisions. But, because different techniques

³ Monica Lawson (University of St. Thomas) largely was responsible for conducting the literature search; we much appreciate her efforts.

could yield considerably different decisions and no method clearly was superior, they suggest using multiple approaches. Despite their attention to the potential usability of the multi-criteria techniques, the authors did not address the extent to which the participants did, might, or would like to use the techniques in a real-world setting.

Other decision frameworks addressed in the literature include decision hierarchies for fishery management (DiNardo, Levy, and Golden 1989); decision analysis for hydrogeological monitoring (Jardine, Smith, and Clemo 1995); and non-specific decision frameworks for forest management (Haight 1995) and ecological restoration (Wyant and Meganck 1995). In focusing on environmental decision-making analysis for environmental engineering when there is considerable uncertainty, Jennings, Mehta, and Mohan (1994) state that approaches can be based on absolute or relative, probabilistic, or multi-attribute utility analysis.

Quite a few articles discussed decision support systems, which authors tended to define as computer software that allows one to access, retrieve, integrate, and generate information. These systems often rely on a variety of information sources, including models and databases, and they often are built using some form of expert system. They have been described for water quality management (Arnold and Orlob 1989), air quality monitoring (Calori, Finzi, and Tonezzer 1994), multiresource management including forestry or land use (Covington *et al.* 1988; Linehan and Corcoran 1994; MacLean 1995; Wadsworth 1992), hazardous waste management (Frysiner, Thomas, and Parsons 1993), and general environmental decision making (Greathouse, Clements, and Morris 1989; Malczewski and Ogryczak 1995). Decision analysis is described for groundwater contamination (Massmann *et al.* 1991) and hydropower-related power, recreation, and environmental objectives (Owen, Flug, and Gates 1995). Again, most citations focus on the potential usefulness of the tools for balancing different needs, rather than their real-world application and utility. Malczewski and Ogryczak make the point that the decision support system they are developing may provide little support to decision makers when it generates a set of efficient solutions. Their reasoning is that the percentage of information used by individuals tends to decrease as the amount of available information increases.

Wadsworth (1992) discusses the use of potential users in the iterative process of developing a decision support system. In this case, the potential users are diverse—general public, farmers, landowners, developers, policy makers, and academics. The timing of consulting potential users is important: "If we go too early, we run the risk of wasting their time, of being unable to demonstrate the potential to help them. If we go too late, making radical changes will be difficult" (pp. 88–89).

Resource economics tools were combined with cost-benefit analyses, and decision analysis techniques to create software for helping decision makers make tradeoffs between competing interests (Sullivan, Birk, and Rice 1995). Lave and Gruenspech (1991) critique the ability of a variety of economic tools to assist in air and water pollution control policy making, noting that the lack of consensus on goals and tradeoffs and uncertainty complicate their use.

Some tools were described as group decision-making techniques or dispute resolution techniques (Coughlan and Armour 1992; Crowfoot and Wondolleck 1990; Friend 1993; and Maguire and Boiney 1994). Of these documents, only one (Friend) discusses field-testing the tool with a panel of prospective users in a workshop setting. The panel helped refine the tool; the author did not address the extent to which potential users actually might use the product. These tools overlap to some degree with those that might be categorized as "process" tools or approaches. Process tools or approaches include risk communication (e.g., Vaughan 1995), public participation and conflict management (Wiedemann and Femers 1992), eliciting (via Delphi methods and citizen panels) and

classifying concerns (Webler *et al.* 1993), inter-organizational decision making (Deyle 1995), and generalized approaches (Beazley 1985). Last (1995) investigated county zoning committee members' decision-making behavior. He found that these decision makers are risk-averse because they want near-certain, low risk decision outcomes. Last suggests that these county-level decision makers make incremental decisions. That is, they rely heavily on their previous experience, considering only those courses of action that do not differ much from previously taken actions. According to Last's model of decision-making behavior, decision behavior is a function of the following five variables: (1) the decision criteria used; (2) traits of the decision issue; (3) characteristics of the decision maker; (4) decision information; and (5) the decision-making forum and format. The author does not address tools *per se*. In discussing decision information, he describes it in terms of its type and amount, source, accuracy, and utility. He does not address how information might be obtained or synthesized.

Some tools, such as geographic information systems (described by Kliskey 1995 as a decision support tool), scenario planning (Earle and Rhodes 1995), and probabilistic risk assessment (Timm 1995) were discussed primarily in terms of planning and forecasting activities. Remote sensing and geographic information systems were used to assess environmental impacts (Nobre, Romana, and Ramos 1994). Computerized operator decision aids were described for use by nuclear power plant operators (Long 1984).

In summary, the literature reviewed describes a diversity of tools intended to enhance environmental decision making. Most tools are described from an analyst's or researcher's perspective, where both the need for the tool and its potential utility are delineated by the researcher. Very few tools are considered in terms of the extent to which decision makers (rather than analysts or researchers) express either a need for the tools or an indication of the circumstances under which they do, or are likely to, use the them.

Appendix B.

The Environmental Decision-making Interview Protocol Used During Telephone Interviews

ENVIRONMENTAL DECISION-MAKING INTERVIEW PROTOCOL

The National Center for Environmental Decision-making Research is working to determine what decision-aiding tools people who are involved in environmental decision making need or need access to. To help in this determination, we are contacting people who are in some way involved in the environmental decision-making process. We are particularly interested in talking to people who may or may not be environmental professionals, but who "help" or assist others in making environmental decisions. This category of individuals may include people who typically make recommendations to decision-makers.

The purpose of our interview is to determine how you are involved in environmental decision making and what informational and analytical methods (e.g., information, processes, techniques, and tools) you use in environmental decision making. We particularly would like to know what tools you need to help you improve your environmental decision making.

Would this be a good time to talk or would another time be better for you? [Specify _____]
Your participation is voluntary and everything that you say is confidential and will not be associated with your name.

1. First, I would like to get [or verify] some basic background information.

Name: _____

Organization, Company, Government: _____

Job Title: _____

2. It is our understanding that you are involved in [natural resource, solid waste management, growth management/infrastructure development] issues. Specifically, what role do you play in environmental decisions about [natural resource management, solid waste management, growth management/infrastructure development]? [We are interested in the organization's decisions (community groups, businesses, governments), not in individuals' decisions.]

3. What are the main ways you acquire, analyze, and use information for environmental decision making? (i.e. information, processes, techniques, and tools)

Now I'll ask you a series of questions to determine whether you are involved in particular environmental decision-making activities.

4. **Are you involved in characterizing natural environmental settings?** (e.g. inventory, monitoring, and description of the environment or ecological systems)?

[IF YES]

What methods (i.e. information, processes, techniques, and tools) do you use in characterizing environmental settings?

What methods (i.e. information, processes, techniques, and tools) do you *need* to help improve your ability to characterize environmental settings?

5. **Are you involved in characterizing economic settings?** (e.g. cost-benefit analysis)?

[IF YES]

What methods (i.e. information, processes, techniques, and tools) do you use in characterizing economic settings?

What methods (i.e. information, processes, techniques, and tools) do you *need* to improve your ability to characterize economic settings?

6. **Are you involved in characterizing social settings?** (e.g. collecting or analyzing demographic data or doing social impact assessment)

[IF YES to c. social settings]

What methods (i.e. information, processes, techniques, and tools) do you use in characterizing social settings?

What methods (i.e. information, processes, techniques, and tools) do you *need* to improve your ability to characterize social settings?

7. **Are you involved in characterizing regulatory settings** (e.g. regulations, legal cases, legislative acts)?

[IF YES to d. regulatory settings]

What methods (i.e. information, processes, techniques, and tools) do you use in characterizing regulatory settings?

What methods (i.e. information, processes, techniques, and tools) do you *need* to improve your ability to characterize regulatory settings?

8. **Are you involved in characterizing political settings?** (e.g. identifying stakeholders)

[IF YES]

What methods (i.e. information, processes, techniques, and tools) do you use in characterizing political settings?

What methods (i.e. information, processes, techniques, and tools) do you *need* to improve your ability to characterize political settings?

9. **There are other ways one could be involved in environmental decision-making. How, and to what extent, are you involved in each of the following, if at all: [take one at a time]**

a. Identifying goals and values

b. Information Integration (e.g. integrating ecological data, combining social and ecological data sets)

c. Futures Forecasting (e.g. modeling)

d. Assessment/Refinement/Narrowing of Options

e. Post-Decision Assessment

10. **Considering the information, information management, and information analysis aspects of your role in environmental decision making, how could your environmental decision-making process be improved? What types of information, processes, techniques, and/or tools would you like to see developed, use, or have access to?**

11. Are there other comments that you would like to make about your involvement in environmental decision-making?

We have a checklist to help us determine more specifically the decision-making tools or aids you use and need in your environmental decision making. We are particularly interested in tools or aids you use for informational and analytical purposes. The checklist should take no more than 5 minutes for you to complete. We would like to fax this page to you, and have you return it to us as soon as possible.

What is your fax number? _____

THANK YOU VERY MUCH FOR YOUR TIME!!!!

Please return to: _____

Fax number: _____

Phone number: _____

continued from preceding page

Tools	I use this tool	Persons who help me in my decision making use this tool	I would use the tool if I had access to it	I would direct persons who assist me to use the tool if they had access to it	I am not familiar with this tool / term	The 5 tools I need most
time-series forecasting						
uncertainty characterization						
integrated assessment						
risk assessment						
life-cycle assessment						
environmental impact assessment						
socioeconomic impact assessment						
cost-benefit analysis						
knowledge-based systems (e.g., expert systems)						
optimizing/satisficing methods						
multi-attribute utility analysis						
monitoring						
verification						
performance assessment						
other (please describe)						
other (please describe)						
other (please describe)						
other (please describe)						
other (please describe)						

Thank you for your help and cooperation.