Frey, B.S. 1992. *Economics as a Science of Human Behavior.* Boston: Kluwer Academic Publishers.

Frey, B.S., and F. Oberholzer-Gee. 1997. "The Cost of Price Incentives: An Empirical Analysis of Motivation Crowding-Out." *American Economic Review* (87), 746–755.

Habermas, J. 1972. *The Legitimation Crisis.* Boston: Beacon Press.

Hartman, H. 1996. "Myths and Realities of the 'New' Green Economy." *Environmental Quality Management* (6), 11–22.

Keeney, R.L. 1992. *Value Focused Thinking.* Cambridge, Mass.: Harvard University Press.

Kleindorfer, P.R., H.C. Kunreuther, and P.J.H. Schoemaker. 1993. *Decision Sciences: An Integrative Perspective.* New York: Cambridge University Press.

Kunreuther, H.C., and D. Easterling. 1996. "The Role of Compensation in Siting Hazardous Facilities." *Journal of Policy Analysis and Management* (15), 601–622.

Kunreuther, H.C., A. Onculer, and P. Slovic. 1997. "Time Insensitivity for Protective Investments." Working paper, Wharton Center for Risk Management and Decision Processes, University of Pennsylvania, Philadelphia.

Maslow, A.H. 1954. *Motivation and Personality.* New York: Harper & Row.

Miceli, T.J., and K. Segerson. 1993. "Regulating groundwater contamination: a comment." *Journal of Environmental Economics and Management* (25), 196–200.

Ruderman H., M. Levine, and J. McMahon. 1987. "Energy Efficient Choice in the Purchase of Residential Appliances." In *Energy Efficiency: Perspectives on Individual Behavior,* eds. W. Kempton and M. Neiman. Washington, D.C.: American Council for an Energy-Efficient Economy, 41–50.

Schwartz, J. 1990. "Earth Day Today." *American Demographics* (12), 40–41.

Segerson, K. 1990. "Liability for Groundwater Contamination from Pesticides." *Journal of Environmental Economics and Management* (19), 227–243.

Simon, H.A. 1957. *Models of Man.* New York: John Wiley.

Tversky, A., and D. Kahneman. 1981. "The Framing of Decisions and the Psychology of Choice." *Science* (211), 453–458.

Weaver, R.D., J.K. Harper, and W.J. Gillmeister. 1996. "Efficacy of Standards vs. Incentives for Managing the Environmental Impacts of Agriculture." *Journal of Environmental Management* (46), 173–188.

CHAPTER 3

# Environmental Decision Making by Organizations: Choosing the Right Tools

Mary R. English

Different types of environmental decisions involve different participants and different modes of decision making. Each day in the United States literally millions of environmental decisions are made, consciously or unconsciously, as individuals decide where to live, which products to buy, whether to drive or take the bus to work, and so forth. These individual decisions are often nested within the environmental decisions of organizations such as public agencies and private businesses. In organizational decision processes, the ultimate decision maker may be the head of a public agency or private corporation; however, he or she rarely acts alone. Instead, environmental decisions by organizations usually involve many people, including staff, special interest groups, regulators and other public agencies, and individual citizens. In the interactions leading up to a decision, one or more modes of decision making may be adopted, ranging from following routine procedures to conducting elaborate analyses to engaging in conflict management.

Most environmental decisions faced by organizations are complex. As a result, a number of tools may be used to aid the decision process. The idea of "tools" is broad and includes everything from physical tools to computer software to methods and processes. To date, many of the tools to aid environmental decisions have been developed with an analytic mode of decision making in mind. These tools differ in their tasks and in the way they frame the issue. Nevertheless, all are based on the principle that systematically gathering and analyzing information is the best route to an optimum decision. Often that may be the case, but not always. Other modes of decision

making suggest the need for new or modified tools suited to their somewhat different processes and to use by a variety of participants.

The chapter begins by synopsizing decision-aiding tools as they have evolved within the realm of information gathering and analysis. The discussion then turns to the importance, in selecting tools, of understanding the context of an environmental decision—specifically, the nature of the substantive issue at hand and the social setting in which the decision is to be made. Both of these discussions draw on work of the National Center for Environmental Decision-making Research.[1] The discussion concludes with comments about the pros and cons of tools available today and suggests criteria for judging their appropriateness and efficacy.

## Today's Tools

To date, the development of tools for information gathering and analysis has received the greatest attention and financial support. For this reason, these tools are arguably the best developed and most used aids to environmental decision making. Less developed but no less important are tools for involving people in the decision process, brainstorming about the issue and decision options, and communicating the results of steps in the decision process (Wolfe et al. 1997). These other tools are likely to be used in modes of decision making that, while they may include analysis, are not *centered* around analysis. Some such tools have been developed—for example, a number of tools for stakeholder involvement are now available (English et al. 1993)—but tools outside the realm of information gathering and analysis remain a new, largely unexplored frontier.

Within the realm of information gathering and analysis, tools can be grouped into eight functional categories that mirror eight steps of a decision process (English et al. 1998). These steps (shown within boxes in Figure 3.1) support the central decision actions of precisely specifying the issue at hand,[2] identifying options, and making a decision.

The process is depicted linearly for simplicity's sake, but its steps often are iterative and interdependent. Other somewhat different categories and configurations also might be used. Nevertheless, the basic functions described here—articulating values and specifying goals; gathering information about the existing situation, integrating this information, and anticipating the future; weighing options; and conducting postdecision evaluations—are likely to be undertaken, intuitively or explicitly, in virtually all environmental decision processes.



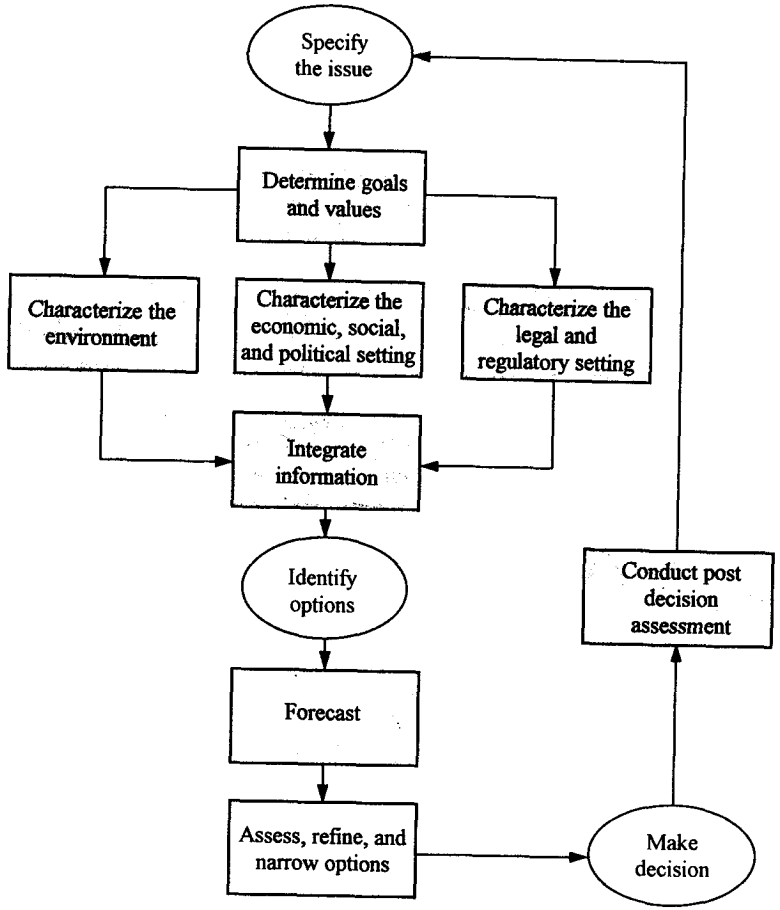


**Figure 3.1**
Steps in an Environmental Decision-Making Process

The information gathering and analysis tools that have been developed as aids to these eight steps vary widely: from devices to monitor the environment (such as a pH meter), to software programs to manage large, multifaceted data sets (such as a computer-based geographic information system), to methods for eliciting people's views (such as a random-sample survey), to broad conceptual tools (such as cost-benefit analysis) supported by other tools (such as an econometric model). They also vary from the simple to the complex but have tended toward the latter.

The eight categories of tools were reviewed recently by the National Center for Environmental Decision-Making Research (Dale and English 1998). As the centerpiece of this review, national experts

were commissioned to prepare papers on decision-aiding tools for each of the eight categories in Figure 3.1.[3] Although each author had a somewhat different slant on environmental decision making, each had the same charge: to describe characteristic tools within their respective categories and then, for each characteristic tool, to address a common set of themes, in particular: What questions does the tool address, and how does the tool frame these questions? How are answers reached? What type of knowledge is gained? What are the tool's strengths and limitations? Examples of tools analyzed in this review are synopsized in Table 3.1.

These tools, taken singly and together, provide a wealth of opportunity to improve environmental decision making. They are not always put to good use, however, due partly to barriers such as time and budget constraints and deficiencies in knowledge and training. Moreover, as the following discussion suggests, they may not be ideal for some environmental issues, some decision settings, and some modes of environmental decision making.

## Context Counts: The Multiple Dimensions of Environmental Decisions

The context of an environmental decision can be divided into two major domains: the substantive issue and the social setting in which decisions about the issue are made. Both of these domains have multiple dimensions, and both help to determine the mode of decision making, which in turn affects the types of tools that are or should be used.

### *Domain A: The Issue Itself*

Issues—environmental or otherwise—can be parsed in any number of ways, and while examining the constituent elements of an issue can bring clarity it also can constrain insights. With that warning, let us consider three aspects of any environmental issue: the type of issue, its spatial dimension, and its temporal dimension. Understanding both the obvious and the more subtle ramifications of an environmental issue is an essential first step in the decision process. Conceptual tools can help, but ultimately this understanding depends on individual reflection and the exchange of ideas among people.

#### The Type of Issue

Virtually everything we do has environmental consequences, even the relatively simple decision of whether to buy a new or a used car.

**Table 3.1** Information-Gathering and Analysis Tools for Environmental Decision Making

| *Functional Category* | *Examples of Tools* |
|---|---|
| Determine Goals and Values | Market-based approaches (e.g., restoration/replacement costs, travel costs, hedonic or characteristics-based pricing, and damage schedules) |
| | Expressed-preference surveys (e.g., opinion surveys, contingent-valuation techniques, constructed preferences, conjoint analysis, image-based techniques, value integration surveys, decision-pathway surveys, and referenda) |
| | Small-group elicitation (e.g., advisory committees, focus groups) |
| Characterize the Environment | Devices to enhance senses (e.g., sight, listening, and olfactory enhancement devices) |
| | Measurement devices (e.g., tape measures, pH meters, and global positioning satellites) |
| | Models (e.g., heuristic, physical, and mathematical models) |
| Characterize the Economic, Social, and Political Setting | Secondary/archival techniques (e.g., by comparisons to similar situations, and by gathering standard data and statistics as well as other source material) |
| | Primary/fieldwork techniques (e.g., surveys, interviews, and participant observation) |
| Characterize the Legal and Regulatory Setting | Printed materials (e.g., books and journals written for lawyers and law students, books for managers of businesses, and books on regulatory policy) |
| | Computer-based materials (e.g., computerized legal research services, CD-ROMs, and the Internet) |
| Integrate Information | Geographic information systems |
| | Spatial decision support systems |
| Forecast | Judgmental methods (e.g., analogies and expert expectation surveys) |
| | Extrapolation |
| | Econometric models |
| Assess, Refine, and Narrow Options | Probabilistic risk assessment |
| | Cost-benefit analysis |
| | Decision analysis |
| Conduct Post-Decision Assessment | Goal systems |
| | Indicator systems |
| | Budget accountability systems (e.g., zero-based budgeting and goal-based budgeting) |

Yet until these consequences are widely recognized, such decisions are not thought of as "environmental" decisions. Gradually, as the consequences become known, a given issue may become environmental. For example, draining land for agriculture is now clearly an environmental decision subject to federal wetlands regulations, whereas it used to be solely a private business decision of the farmer. Like other issues, environmental issues are socially constructed; that is, they are the product of society's changing collective consciousness (Hannigan 1995). Thus, the substantive issues addressed in environmental decision making are dynamic, not static. Moreover, these issues are multifaceted and complex—an issue that appears to be about transportation can also be about air pollution and urban sprawl.

The list of ten types of issues in Table 3.2 can help specify the issue at hand and also can help to uncover its relevance to related issues. Inevitably, as this list suggests, virtually no environmental issue is purely "environmental" in the sense that it only has to do with nature. Instead, all environmental issues involve, to varying extents, aspects of the natural environment and the anthropogenic environment. The mixture can vary greatly. On the one hand, the issue may be mainly about human effects on the natural environment (such as the effects of low-flying aircraft on wildlife); on the other hand, it may be mainly about the environment that humans have, over time, fabricated for themselves (such as preservation of an old mill building).

### Spatial Dimension

Some environmental decisions focus on specific places, such as decisions about how to clean up a particular Superfund site. Others concern broad policies; for example, the Congressional decision expressed in the 1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, the Superfund law) to apply strict, joint and several liability principles when determining responsibility for contaminated site cleanup. Regardless of whether the issue concerns a place or a policy, its spatial scale can vary. Some Superfund sites involve thousands of acres; others, less than one acre. Some wilderness areas encompass hundreds of square miles and extend across state boundaries. In contrast, an urban park may consist of only one small lot. Similarly, policies may be national or local in scope depending on their origin.

But as with the distinction between the natural and the anthropogenic environment, characterizing an environmental issue as small or large in spatial scale can be difficult. Cleanup of industrial pollution in the Great Lakes, for example, has involved both an international accord and hundreds of small, local actions. The point is not to precisely pin down the spatial dimension, but rather to recognize that a given issue may have previously unrecognized spatial ramifications that should be taken into account in the decision process.



**Table 3.2** Ten Typical Categories of Environmental Issues

The following list of issues is drawn from English, Dale, et al. 1998. The list is similar to other contemporary lists of environmental issues.

*Air quality control:* Issues concerning indoor and outdoor air pollution, including, for example, criteria pollutants, chlorofluorocarbons, and greenhouse gases.

*Critical natural areas:* Issues concerning the protection of areas such as coastlines, floodplains, wetlands, ecological bio-reserves, parks, and the habitats of endangered species.

*Energy production and distribution:* Issues concerning conventional energy sources (e.g., coal-fired, gas-fired, nuclear, and hydro plants), alternative energy sources (e.g., solar, wind, geothermal, biomass), and energy conservation.

*Green technologies:* Issues concerning technologies and practices used in manufacturing, construction, etc. that are less environmentally burdensome than conventional approaches.

*Historic, cultural, and aesthetic resources:* Issues concerning the protection of historic buildings and districts, archeological artifacts, and sacred places, as well as "viewsheds" and other aesthetically sensitive areas.

*Natural resource management:* Issues concerning the use of plants, minerals, soils, water, fish, and wildlife for purposes such as food, manufacturing materials, and recreation.

*Urban infrastructure and growth management:* Issues concerning infrastructure, such as utilities and transportation systems, as well as the type, intensity, and distribution of urban land uses.

*Waste management:* Issues concerning the management (reuse, recycling, treatment, storage, disposal, cleanup, etc.) of solid waste (garbage, yard wastes, construction and demolition material, etc.), chemically hazardous waste, and low- and high-level radioactive waste, including spent nuclear fuel.

*Water allocation:* Issues concerning aquifers, aquifer recharge areas, reservoirs, rivers, dams, and water use rights and responsibilities.

*Water quality control:* Issues concerning point-source and nonpoint-source contaminants in groundwater and surface water, as well as related issues such as sewage treatment and thermal discharge.

### Temporal Dimension

Persistence, reversibility, and cumulative effects are three important temporal aspects of an environmental decision. Some environmen-

tal decisions may strive for but not achieve permanent outcomes. Red wolves have been reintroduced into the Great Smoky Mountains but so far have not successfully multiplied there. Other environmental decisions are intended to be experimental and reversible but may be permanent. Kudzu, an exotic plant introduced into the southeastern United States to prevent soil erosion, has grown out of control, covering in some places not only the ground but also trees, telephone poles, and buildings. Still other environmental decisions may have unanticipated cumulative outcomes. The decision to adopt strict, joint and several liability principles as part of Superfund's legal framework has led to transaction costs (legal and other non-cleanup costs) that, taken in the aggregate, are far higher than foreseen when the law was enacted.

The decision on a given issue should be seen as part of a stream of past and future decisions. No crystal ball can give a clear picture of the future, nor can the past be completely known. Nevertheless, understanding the past and anticipating the future are necessary parts of framing the issue to be decided.

### *Domain B: The Decision-Making Setting*

As with understanding the substantive nature of an environmental issue, understanding the social decision-making setting is necessary for choosing the right tools for the decision process. An environmental decision-making setting can be classified in many different ways. Here, I suggest three attributes, or dimensions: the key decision maker, key participants in the decision, and the urgency of the decision.

#### Key Decision Maker

Environmental decisions are made by people as individuals and as members of organizations. A CEO, having done a good deal of "fact-finding" on solar water heaters, decides to install one in her home. On the same day, she decides on behalf of her manufacturing company to revamp its production process to reduce its electrical bills. The decision maker in the latter sense, as a member of an organization, is the focus of interest here. With decisions made by organizations, however, it is not always clear who the decision maker is. While the final decision may rest with the CEO, her decision may be supported (or challenged) by advice from the company's vice presidents and by analysis from staff. Part of identifying the key decision maker is knowing both who "signs the paper" and who within the organization that person listens to.



#### Decision Participants

On many environmental issues, especially controversial issues, people external to the organization(s) responsible for the decision also may become involved in the decision process. This is especially the case because environmental impacts do not respect property or jurisdictional lines, and they often tap into deep-seated values that may not be universally shared.

Individuals from one or more of the following broad groups are likely to participate in environmental decisions:

- Legislative and judicial branches of federal, state, or local government, as well as their executive branches, with public agencies whose missions concern environmental protection, public health, parks and recreation, transportation, and so on
- Regional governmental organizations, such as watershed commissions, regional transit authorities, and regional governments
- National, regional, state, local, or neighborhood citizen groups that focus on issues such as human health and the environment, parks and greenways, neighborhood protection, regulatory impacts, property taxes, and so on
- Associations of businesses, such as chemical manufacturers associations, dry cleaners associations, as well as individual large and small businesses and related labor unions

Often the lines between groups are blurred, especially with formal coalitions and informal alliances (including unexpected alliances of, say, environmental and business organizations). In addition, not all groups will be involved in an issue at the same time or to the same extent, and over time new groups may become more or less involved. For example, groups representing the environmental justice concerns of low-income people and racial minorities are far more engaged in public discourse and debate about environmental issues than they were twenty years ago (Dunlap and Mertig 1992; Hofrichter 1993).

#### Urgency of the Decision

A chemical spill may have occurred. A forest fire may be spreading. In cases such as these, the time period for a decision may be very short, even if the ultimate decision is to take no action. In contrast, especially if the decision involves a complex policy, the time period leading up to the decision may be months or years. The initial Super-

fund legislation was enacted quickly in a crisis atmosphere in the wake of publicity about Love Canal. Its reauthorization (and possible amendments) has been debated for years. But as with the other dimensions discussed here, the "urgent" versus "deliberative" distinction is not absolute. Deliberative issues often become more pressing as the need to reach closure draws near, and a decision about how to manage a forest fire or a chemical spill is made within the context of past and future decisions concerning emergency preparedness and postcrisis follow-up.

## Different Modes of Decision Making for Different Issues and Settings

Domain A (the substantive issue) helps to determine Domain B (the decision-making setting), which in turn helps to determine the mode of decision making that is adopted. Consider, for example, the siting of a new municipal solid waste landfill. If the landfill is to serve only the municipality where it is sited, its impacts are more likely to be predictable and local in scale than if it is to take regional and out-of-state waste as well. In the former case, the decision-making setting is likely to involve primarily the waste management company that will operate the landfill and local government officials (acting in consultation with affected individuals and groups, one hopes), whereas in the latter case, others such as officials from surrounding counties and from the state government are also likely to be involved. In the former case, the decision process may entail some analysis but is likely to rely heavily on informal discussions among local leaders. In the latter case, the process is likely to entail more detailed analysis as well as heightened conflict and more extended, formal, multilateral discussion.

Conceptual work done by researchers at the National Center for Decision-making Research has led to the identification of six characteristic modes of environmental decision making (Tonn et al. 1998). These six modes can be described in terms of the three dimensions of the decision-making setting discussed above—the key decision maker, the decision participants, and the urgency of the decision—coupled with other factors such as the extent of knowledge of the situation and the potential consequences of the decision. Briefly, the six modes are as follows:

- *Emergency action.* Preappointed emergency managers within the responsible organization(s) make a rapid decision concerning a situation with potentially high consequences. Complete knowledge of the situation may be lacking. Predetermined procedures are used, along with "seat of the pants" judgment. Few groups external or internal to the organization participate in the decision process, although a number may participate in related decisions prior and subsequent to the emergency action.
- *Routine procedures.* Administrative and technical staff within the responsible organization(s) make an unhasty but not highly deliberated decision concerning a familiar situation whose individual consequences are not high. While full knowledge of the situation's particulars may not be available, the decision requires specified, standardized information. Predetermined procedures are used. Few groups external or internal to the organization participate in the decision process, although a number may have participated in setting the policy that has led to the routine procedure.
- *Analysis-centered.* Technical and policy analysts within the responsible organization(s) make a carefully deliberated recommendation concerning a fairly well-specified issue whose consequences, taken in the aggregate over time, are potentially high. Full knowledge (including predictive knowledge) of the issue is sought, although it is not always available. Quantifiable information is often preferred. Systematic methods for considering components of the issue and then weighing decision alternatives are used. People internal or external to the responsible organization may participate in the decision process, typically by providing input on their values and goals concerning the outcomes of the decision. The final decision is usually made by the head of the responsible organization.
- *Elite corps.* Senior members of the responsible organization(s) reach a consensus (or a majority/minority view) on a specified issue whose consequences, especially taken in the aggregate over time, are potentially high. Depending on the initial level of agreement within the elite corps, the decision process may be rapid or protracted. "Bottom line" knowledge of the situation is sought, including information about the views of special interests. Formal information presentations from subordinates are followed by discussion and negotiation among the elite corps. The views of people outside the elite corps may or may not be sought, but they do not participate in the decision process

itself. The final decision is usually made by the head of the responsible organization.

- *Conflict management.* Selected staff members of the responsible organization(s) seek to resolve a controversial issue, the consequences of which are potentially high but are not agreed upon. The decision process is likely to be protracted. Extensive information about the issue is sought, but what counts as appropriate and sufficient knowledge may itself be a subject of debate. The process often is begun by calling a meeting of the people who are seen as representing various sides of the conflict. They may be external or internal to the organization. The process may begin with a scoping of the issue, which itself may be a source of disagreement. Information is presented by various people, including but not limited to those participating in the meeting, followed by discussion (especially discussion about goals, values, and the validity of the information presented) and negotiation. The process is often highly recursive: As discussion and negotiation occur, more information may be sought, leading to further discussion and negotiation, and so on. If agreement cannot be reached on the issue, it may be resolved ultimately by a directive from the head of the organization (if the dispute is internal) or in a judicial or quasi-judicial setting (if the dispute involves multiple organizations).

- *Collaborative learning.* Various members of the responsible organization(s), working as equals with each other and, possibly, with external participants, tackle an issue that is widely recognized as being neither well-understood nor easily resolved. The process of addressing the issue is likely to be lengthy and highly deliberative. As information about the issue is obtained, the nature of the issue may be rethought. Similarly, people are encouraged to reconsider their goals and values concerning the issue as new information is obtained and as they hear from one another. The process is iterative: It includes exploration, information exchange, discussion, challenge, and synthesis. Decisions are reached through widespread agreement but may be formalized by the head of the responsible organization. Decisions are provisional and subject to change over time as new learning occurs.

These six decision-making modes are not unique to environmental issues, nor is any one mode likely to be mirrored as a pure type



in actual practice. Real decision making on a particular issue is a messy business, influenced by an organization's history, by other issues that the organization may be tackling, and by external events. The actual decision-making process may involve a combination of two or more of these modes, concurrently or over time. Thus, the six modes noted earlier should not be seen as depicting what actually happens in an environmental decision-making situation, but rather as the "ideal types" of Max Weber (1949, 90). In other words, these six modes are constructs to analyze both what is occurring and what should occur. As such, they suggest (1) that environmental decision processes, while they share certain attributes, are not alike in some crucial respects; and (2) that decision processes may be altered out of a need or desire to find better, more workable approaches. As discussed below, differences among these modes also suggest that new or modified tools to aid decision making may be required.

## Pros and Cons of Today's Tools

One message came through clearly in the assessments of information-gathering and analytic tools done under the auspices of the National Center for Environmental Decision-making Research: Each tool, perhaps inevitably, has pros and cons. A number of the tools examined—for example, surveys, models, and decision support systems—often have several favorable characteristics, such as providing a means to systematically organize and document information, identify both central tendencies and dispersion, and facilitate the comparison of options as well as the tracking of results. These tools, however, also may have the less desirable characteristics of being expensive and time-consuming to implement, entailing special expertise or equipment, requiring extensive and precise data if gross inaccuracies are to be avoided, and ignoring special factors as well as specialized or local knowledge that might be relevant. In addition, these tools may need to be tailored to the issue at hand, leading to further demands on time, budget, and expertise, especially if the tool in question is a complex computer-based model. And because of the complexity of many of these tools, their results, as well as the means by which they were reached, may be difficult to communicate.

Other tools—for example, small-group preference elicitations and judgmental forecasting methods—can be fairly inexpensive to implement, have limited data input requirements, result in useful insights, and be fairly easily comprehended by a broad spectrum of people. Tools such as these, however, are often susceptible to bias, may fail to

capture important factors, can lead to results that can be interpreted in different ways, or, if they lack repeatability, can fail to establish a track record that can be reexamined if the decision is revisited.

Today's information-gathering and analytic tools share another limitation as well. Many were developed with certain types of environmental issues in mind, particularly issues involving risks to human health and, to a lesser extent, the environment. These include issues within areas such as waste management, air and water pollution, natural resource management, and critical areas protection. Less well-trodden areas, such as growth management, green technologies, water allocation, and the protection of historic, cultural, and aesthetic resources—areas that do not typically involve direct, obvious assaults on the health of humans and other species but do involve important values such as "quality of life," stewardship, and distributive justice—have tended to receive less attention in the development of decision-aiding tools. Taken as a whole, today's tools are less useful for grappling with less tangible yet important values and effects than they are with more tangible values and effects. They also are less capable of distinguishing cumulative impacts, spatially and over time, than they are of giving a snapshot of the present.

In addition, the decision-aiding tools that have been developed to date have, in general, been developed for an analysis-centered mode of decision making. They have tended to be developed *by* analysts *for* analysts, who in turn use the tools in preparing carefully crafted, well-documented recommendations for a key decision maker, typically the head of a federal agency or a large corporation, on an issue of potentially large import. These tools are not always well-suited to the other modes of decision making discussed above: the less typical modes of emergency action, conflict management, and collaborative learning, as well as the more commonplace modes involving routine procedures or an elite corps. These other modes have different attributes from an analysis-centered mode. The key decision maker and the decision participants may be different, as may their methods of interacting. Also, there may not be time to gather extensive information about the situation and possible consequences of the decision alternatives. What is more, if the key decision maker is a small business owner or the head of a local government agency, he or she may not have the luxury of using an elaborate decision-aiding tool, yet the organization may still face important environmental decisions.

This is not to say that the analysis-centered mode is never used in combination with other modes; indeed, it often is. The point, though, is that currently available information-gathering and analysis tools



may not be sufficient in all situations. These tools may require adaptation to make them useful when the other, non-analysis-centered modes are being pursued, and altogether new tools may be needed for functions unique to these other modes.

What might new tools look like? As an example, Robin Gregory (1998, in press) refers to an experimental technique called a decision-pathway survey that, by providing a set of linked questions, encourages respondents to self-select a response pathway that reflects their thinking about an environmental decision option. By emphasizing reasons why alternative options might matter, the questions encourage respondents to address potential values conflicts and to come to grips with the relative costs and benefits of alternative options. Tools of this sort are particularly useful to a conflict management decision mode: Not only can they clarify areas of disagreement, they also can help to uncover common ground that may provide the basis for reaching an acceptable decision. Another example are tools that enable small groups to construct bounding scenarios of "future worlds" (both possible and preferred) concerning an environmental issue. These can be especially helpful in a collaborative learning mode, especially where the issue is highly complex and uncertain. Tools such as these do not reject the need for systematic information gathering and analysis, but they place a new emphasis on the interactions—emotional as well as intellectual—of participants in the decision.

## Criteria for Choosing Tools

Given the range of environmental decisions being made by organizations today, as well as the range of available tools to aid those decisions, it is difficult to specify universal criteria for choosing among tools. Nevertheless, a few can be stated. These criteria apply not only to the information-gathering and analysis tools referred to above but also to other tools, such as tools to promote communication, interaction, and involvement. They are grouped below into two categories—essential and desirable criteria—followed by a cluster of factors that, depending on the situation, could necessitate additional criteria for choosing tools.

### *Essential Criteria*

- *Honesty.* While the results produced by tools should be as error-free as possible, they should not convey a false sense of precision, which may lead to unfounded confidence in an "answer"

that turns out to be wrong. Instead, the results should be accompanied by explanations of their degree of certainty and factors that could cause them to change.

- *Freedom from bias and "tunnel vision."* Tools should not be used unthinkingly; they should be accompanied with what William Freudenburg (1998) has termed "gaps and blinders" techniques—those that help reveal the full range of effects of a decision, including effects on subpopulations or aspects of the environment that otherwise might be ignored. While any one tool may not be able to meet this criterion, the suite of tools used in a decision-making process should.
- *Intelligibility.* The tool results—and the process of reaching those results—must be intelligible to those who are or should be participating in the decision process. Even when support tools for communication are used, and even when participants in the decision process have received training about the tool, some tools and their results may be too complex to be understood by all participants. The decision setting and mode will determine who should be taken into account in deciding whether the tool meets the criterion of intelligibility, but those selecting the tool must be prepared for the possibility that the setting and mode may change during the decision process. For example, what started out as a small group of like-minded participants may become a large and diverse group, and what began as a routine procedure may become conflict management.

### *Desirable Criteria*

- *Complementarity.* A tool should be complementary to other tools being used in the decision process. For example, the tool's output should serve as input to other tools, or vice versa.
- *Proportionality.* A tool should not require substantial inputs (large quantities of precise data) that are out of proportion to the likely value of the tool results.
- *Flexibility.* Virtually all tools have *some* use; otherwise, they would not have been created. But, other things being equal, it is better for a tool to be able to be used again in similar or somewhat different situations, if only to get more return on the investment made in developing the tool.



### *Situation-Dependent Factors*

The following factors depend on the specific decision-making situation at hand. If relevant, they may lead to the addition of other essential or desirable criteria.

- *Time.* Some tools may require months or years to produce results, especially if their inputs are extensive. They obviously will not be feasible with an emergency action decision mode. They also may not be appropriate with other modes, such as an elite corps mode, where the decision is to be made at the next board meeting, whether or not the tool results are available.
- *Cost.* Use of some tools—especially those that require extensive expertise and tailoring to a particular situation—may not be feasible for some organizations with small budgets, and, even if the funds are there, they may not be appropriate if they don't add value in keeping with their cost.
- *Training.* Some tools are easy to use and do not require a specialized background. Others are much more complicated. While opportunities are increasing for various participants in environmental decision processes to receive training in the use of decision aids, these new opportunities are still not likely to totally overcome all hurdles (for example, the lack of time or ability to acquire the necessary new skills or knowledge). Such hurdles may be much more formidable with some modes of decision making, especially inclusive modes that have a variety of participants, such as conflict management or collaborative learning. They also may lead to personnel problems with other modes (routine procedures, emergency action), if existing staff are unable to learn how to use a complex new tool.
- *Equipment.* Given the dramatic change over the past few years in the availability of high-powered, fairly inexpensive personal computers and software, this factor has declined in its importance but is often still relevant for some (especially smaller) organizations. Furthermore, while many of today's decision-aiding tools require only a computer as equipment, others entail other gadgets as well, which may raise barriers concerning not only cost, training, portability, and so on but also flexibility for use in other situations.

## Conclusions

All of the criteria discussed earlier cannot be fully met in a given environmental decision. Trade-offs inevitably must be made in selecting tools. These trade-offs need to be made with a keen awareness of the particular dimensions of the situation at hand, including its dimensions as both an environmental and a social issue. In addition, no tool should be considered in isolation: It should be treated as part of a larger package called the decision process, which may also lead to trade-offs among tools. No tool is likely to be ideal. Instead, an affordable and workable set of tools may be the best pragmatic answer.

In choosing the right tools to aid a decision process, it is important not to reach automatically for a familiar tool or set of tools and assume that it is appropriate for the situation at hand. Instead, a crucial first step—and one that should be periodically repeated—is to critically assess the big-picture context of the situation. What is *really* at issue? What is the social setting? Who will and who should participate in the decision process? How will the decision process be conducted, and how *should* it be conducted? Depending on the answers to these questions, some tools may be valuable aids to the decision process while others may turn out to be impediments.

### NOTES

1. The National Center for Environmental Decision-making Research is a center created with funds from the National Science Foundation and administered by the University of Tennessee, the Oak Ridge National Laboratory, and the Tennessee Valley Authority as an activity of the Joint Institute for Energy and the Environment.

2. Note that I avoid using the term "problem" here, preferring "issue" instead (Keeney 1992). While nearly everyone would agree that some issues are problems, other issues are problems to some people but not to others. Even highly radioactive spent fuel, which is regarded by most people as posing a disposal problem, is regarded by some people as offering a potential resource.

3. The authors and their topics were as follows: Robin Gregory of Decision Research and Value Scope Research, tools for identifying environmental values; Virginia Dale and Robert O'Neill of Oak Ridge National Laboratory, tools for characterizing environmental settings; William Freudenburg of the University of Wisconsin, tools for understanding socioeconomic and political settings; Mary Lyndon of St. John's University School of Law, tools for characterizing legal and regulatory settings; Jeffrey Osleeb of Hunter College and Sami Kahn of Rutgers University, tools for integrating information; Scott Armstrong of the University of Pennsylvania's Wharton School, forecasting tools; Miley (Lee) Merkhofer of Applied Decision Analysis, tools for assessing options; and Gilbert Bergquist of Florida Center for Public Management and Connie Bergquist of Correctional Services Corporation, tools for conducting postdecision assessments.



### REFERENCES

Dale, V.H., and M.R. English, eds. 1998. *Tools to Aid Environmental Decision Making.* New York: Springer-Verlag.

Dunlap, R.E., and A.G. Mertig, eds. 1992. *American Environmentalism: The U.S. Environmental Movement, 1970–1990.* Philadelphia: Taylor and Francis.

English, M.R., V.H. Dale, C. VanRiper-Geibig, and W.H. Ramsey. 1998. "Tools to Aid Environmental Decision Making: An Overview." In *Tools to Aid Environmental Decision Making,* eds. V.H. Dale and M.R. English. New York: Springer-Verlag.

English, M.R., A.K. Gibson, D.L. Feldman, and B.E. Tonn. 1993. *Stakeholder Involvement: Open Processes for Reaching Decisions About the Future Uses of Contaminated Sites.* Knoxville: Waste Management Research and Education Institute, University of Tennessee.

Freudenburg, W. 1998. "Tools for Understanding the Socioeconomic and Political Settings for Environmental Decision Making." In *Tools to Aid Environmental Decision Making,* eds. V.H. Dale and M.R. English. New York: Springer-Verlag.

Gregory, R. 1998. "Identifying Environmental Values." In *Tools to Aid Environmental Decision Making,* eds. V.H. Dale and M.R. English. New York: Springer-Verlag.

Hannigan, J.A. 1995. *Environmental Sociology: A Social Constructionist Perspective.* New York: Routledge.

Hofrichter, R., ed. 1993. *Toxic Struggles: The Theory and Practice of Environmental Justice.* Philadelphia: New Society Publishers.

Keeney, R.L. 1992. *Value-Focused Thinking: A Path to Creative Decision Making.* Cambridge, Mass.: Harvard University Press.

Tonn, B., M. English, and C. Travis. 1998. *Frameworks for Understanding and Improving Environmental Decision Making.* Draft manuscript.

Weber, M. 1949 [1905]. "'Objectivity' in Social Science and Social Policy." In M. Weber, *The Methodology of the Social Sciences,* eds. and trans. E.A. Shils and H.A. Finch. New York: The Free Press, 50–112.

Wolfe, A.K., S.M. Schexnayder, M. Fly, and C. Furtsch. 1997. *Summary Report: Developing a Users' Needs Survey Focusing on Informational and Analytical Environmental Decision-Making Tools.* Knoxville, Tenn.: National Center for Environmental Decision-making Research, Tech. Rep. NCEDR-97-01.