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A Framework for Understanding and Improving Environmental Decision Making

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ABSTRACT *This paper presents a framework for understanding and improving public sector environmental decision making. Within the framework, four interrelated components are discussed: (1) the environmental and cultural context–understanding this context includes understanding what people consider to be environmental problems, the goals and values that they bring to environmental problems and decision processes, specialized and common knowledge about environmental problems, and the institutional settings within which problems are addressed; (2) planning and appraisal activities—these activities include forecasting and monitoring exercises, evaluations of past decisions, and decisions that processes ought to be launched to solve specific environmental problems; (3) decision-making modes—these include six typical ways of conducting an environmental problem-solving process, modes which, in the framework, are called emergency action, routine procedures, analysis-centred, elite corps, conflict management and collaborative learning; (4) decision actions—these include five generic steps that are undertaken, formally or intuitively, in virtually any decision-making situation: issue familiarization; criteria setting; option construction; option assessment; and reaching a decision. In the course of describing the framework, we show a decision-making process can be adapted to incorporate sustainability concerns, including fostering sustainable environmental and social systems, meeting obligations to future generations, and searching for robust and reasonable (rather than rigidly optimal) decisions. The framework also helps to illuminate intriguing questions regarding institutional responsibility, decision process complexity and paradigms for environmental decision making.*

Introduction

This paper presents a framework for understanding and improving environmental decision making. The framework is designed to help environmental decision makers and planners who work within the public sector at the community, regional, and state or tribal levels, although the framework could be adapted for use by the private sector and by other levels of government. It can be used to address a variety of environmental problems (e.g. from wetlands protection to hazardous waste disposal) and a variety of decision-making settings (Dale & English, 1999). By using a framework analysis, structured thinking can be

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applied to endeavours that often are characterized as random or *ad hoc*, and that may be conflict-ridden, inefficient and ineffective.

The framework described here can improve environmental decision making in several ways. First, the framework comprehensively lists the elements and activities that either do, or should, compose an environmental decision-making process. Environmental decision makers can refer to the framework to make sure that they are not neglecting any important steps. They can also use it to better comprehend the decision-making processes for which they are responsible. People involved in environmental decision making often do not understand what their responsibilities are or what is likely to happen when (Feldman, 1997). The framework can be a useful tool to enlighten participants about where, in the overall scheme of things, their process stands.

Second, the framework can improve a decision maker's understanding of how public participation should be integrated into the decision process. Disagreements in this regard are often painted in black and white: While some people view the public as swayed by emotions rather than facts and believe that environmental decision making should be the domain of experts using analytical methods, others view bureaucrats as attentive to special interests rather than the public interest and believe that the public should be intensely involved in all environmental decisions. Nevertheless, public participation should not be seen as an 'either–or' proposition. Within the decision modes described in the framework, the public can be involved to different degrees and in different ways. Understanding differences among decision-making modes will help environmental decision makers to choose both the appropriate mode for their problem and the appropriate approach to public participation.

Third, environmental decision makers must frequently deal with conflicts concerning not only process values (such as those that arise concerning public participation) but also outcome values (Keeney, 1992). As an example of the latter, conflicts often arise over whether environmental decision outcomes should favour nature (e.g. protection of species) or present-day human concerns (e.g. protection of economic growth). Using the framework, the ways in which values influence the entire environmental decision-making effort can be better understood, as can ways to manage value conflicts during the process. Improved understanding and management of value conflicts may also help reduce the cynicism and lack of credibility that has plagued environmental decision making (Tonn & Peretz, 1997).

Fourth, the framework ties together process issues with sustainability concerns. Spurred by the Brundtland Commission's vision of sustainable development—"Development that would meet the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development (WCED), 1987)—and by subsequent calls for sustainability, many communities, regions and states are adopting sustainability principles such as prescriptions for limiting resource use, reducing pollution, adopting recycling programmes, protecting biodiversity and conserving land.[1] However, much less attention has been devoted to incorporating sustainability into the *process* of environmental decision making. To address this lack, this paper interweaves sustainability concepts into the comprehensive framework presented here.

The framework presented below draws upon the existing academic literature and the experiences of actual environmental decision makers and planners. It

was developed by distilling and synthesizing concepts and ideas from a number of fields—including planning, sociology, psychology, economics, decision analysis, evaluation, public administration and futures studies—and then examining those concepts and ideas in the light of everyday experiences. Through numerous discussions with environmental decision makers in various settings—interviews, focus groups and workshops (Gray *et al*., 1996; Tonn & Peretz, 1997; Wolfe & Schweitzer, 1997; Dobson *et al*., 1998; Schexnayder, 1998; Dale & English, 1999; and Tonn *et al*., 1999)—we have determined that environmental decision making does, in fact, include all of the aspects contained in the proposed framework, although that underlying structure is often not apparent when in the throes of a decision-making process.

By design, the framework is both descriptive and prescriptive. It describes the underlying structure of environmental decision making, but it is also intended to enlighten decision makers about both what they are doing (or not doing) and how they could improve their decision processes. We do *not* believe that environmental decision making is doomed to be forever chaotic, and we *do* believe that the self-awareness and insights enabled by the framework can improve environmental decision making. We do not have any proof that our framework is the best or the only one that could be fashioned from the ideas and observations which we have distilled. In the third section of the paper, however, we do present a few examples found in the literature that comment upon improvements made in environmental decision making processes that have been incorporated into this framework.

Whenever new ideas are introduced, new questions arise. The development of the framework has spurred questions concerning institutional capability and responsibility for environmental decision making, the complexity of environmental decision making and the appropriateness, for environmental decision making methods and goals, of current disciplinary and public policy paradigms. These issues are addressed in the concluding section of this paper.

Decision Process Framework

The framework is illustrated in Figure 1. We begin by discussing the most encompassing of the framework's four elements: the environmental and social context within which a decision is made. Second, we discuss planning and appraisal activities that should precede and follow decision making. Third, we introduce six typical decision-making modes. Finally, we discuss the decision actions themselves.

It must be emphasized that the framework, while necessarily presented in a linear fashion in this paper, is actually quite dynamic. As shown in Figure 1, there are feedback loops within and among the elements of the framework. Moreover, Figure 1 only begins to capture the complex interactions among the framework's elements, as will become apparent in the ensuing discussion.

Environmental and Social Context

Environmental decision making takes place within the context of environmental and social realities. The environmental context includes the past, present and expected state of various aspects of the environment—e.g. drinking water supplies, air quality, soil quality, endangered species, waste disposal, wilderness

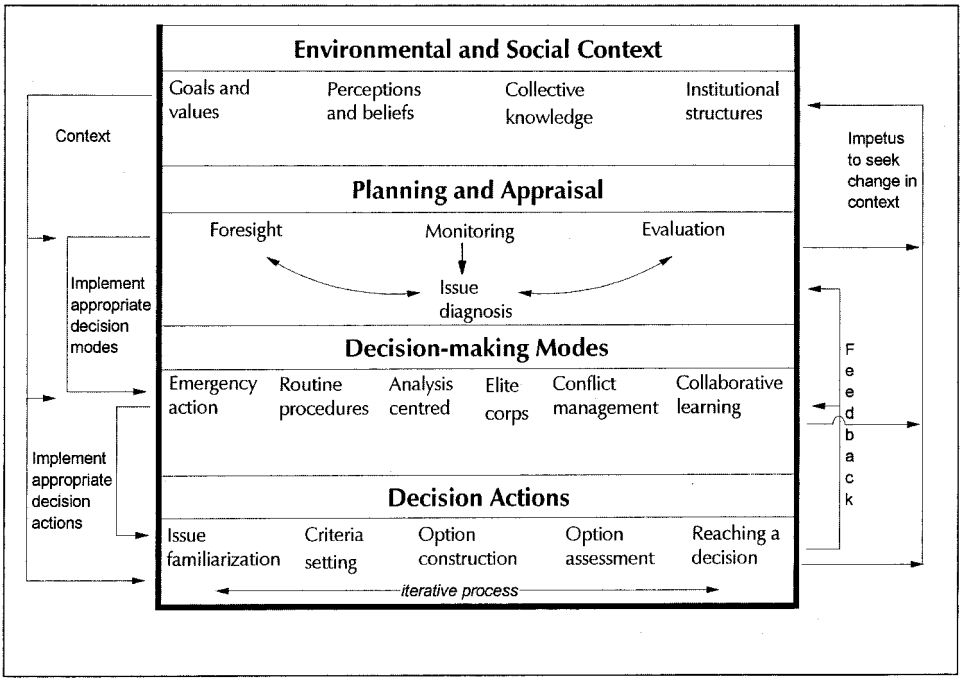

Figure 1. Environmental decision-making: a process framework.

protection—for the locale that the environmental decision will address. While the natural environment is contextually important, the built environment may be also. But environmental decision making is contextually rooted, not simply in the physical world, but in the social world as well. Regarding the latter, cultures, religions, political institutions and other organizations, economic systems, communities and individuals all may help to shape the social context within which an environmental decision-making process is carried out. Change in both the environmental and the social context is inevitable. Changes in the physical world occur naturally or through human interventions (deliberate or inadvertent); changes in the social world sometimes are deliberate but often occur because of complex, unplanned interactions among people, and between people and their physical environments.

To understand environmental decision making, it is important to understand that we see the physical and social world around us through the prism of social construction. In other words, what we know as reality is filtered through socially-acquired concepts, words, values and beliefs. For example, it has been argued that people socially construct what constitutes an environmental problem (Hannigan, 1995). Through social construction, we collectively become aware of and label various problems—for example, solid waste disposal, indoor air pollution, global warming—that may have existed for years but hitherto went unrecognized and unnamed. As yet, we are less aware collectively of process issues that underlie environmental problem-solving, although there too social construction is at work (for example, in shaping our collective awareness of 'alternative dispute resolution' or 'stakeholders' or 'environmental justice'). One purpose of this paper is to help raise our collective consciousness about other,

as yet little-recognized aspects of environmental decision making—in effect, to help socially construct systematic thinking about environmental decision-making processes.

Within the framework, we identify four contextual components that help to shape environmental decision making. These are discussed below.

Goals and values. Goals and values "refer to preferences for states or things" (Keeney, 1988). Goals may be outcome-oriented (e.g. economic growth, reduced pollution, community stability), or they may be process-oriented (e.g. public participation, efficiency analyses, conformance with rules). Underpinning goals are values concerning such issues as economic progress, social equity and environmental stewardship. We argue that, while goals may change over time, for a system to be sustainable, fundamental values favouring sustainability must remain relatively constant.

Perceptions and beliefs. Perceptions and beliefs shape people's conceptions of their environmental and social contexts; in effect, their views of how the world works. Seminal research in psychology has found that people's perceptions and beliefs are often at odds with scientific data, and their decision-making heuristics are often at odds with theories about how decisions *ought* to be made (Combs & Slovic, 1979; Kahneman & Tversky, 1979; Tversky & Kahneman, 1981; Kahneman *et al*., 1982). These findings help to explain why environmental decision making is often so difficult: a common understanding often is lacking of both the factual basis for, and the appropriate means of, making environmental decisions.

Collective knowledge. Collective knowledge includes common as well as scientific knowledge about the environment and society. Through a process called 'social learning', improved scientific and common knowledge accrues. As discussed in the next section, evaluatory activities are expressly designed to foster social learning.

Institutional structures. Most broadly understood institutions are simply patterns of expected human behaviour which are enforced by both positive and negative social sanctions (Bellah *et al.*, 1992). Our formal and informal political, legal, economic and community institutions all help to shape the context of environmental decision making.

This paper is, in part, an attempt to change how our society collectively thinks about environmental decisions. In addition to providing the means for a new understanding of the *process* of environmental decision making, we seek to promote sustainability as an overriding *goal* of this process. To accomplish this, new knowledge must be developed, collective knowledge must be applied and environmental decision-making institutions must become more self-aware and resilient.

More specifically, we believe that environmental decision making should ensure that environmental and social systems have long term stability.[2] By 'stability', we mean that neither environmental nor social systems should be pushed into situations that could lead to total system collapse. Good environmental decision-making processes will be able to detect threats to these systems, identify decision options that will keep the systems within safe ranges, and allow people the freedom to choose among the 'safe' decision options according

to their present-day goals, values, perceptions and beliefs, while not jeopardizing future sustainability.

In a sense, then, we see sustainability as a complex archetypal myth. Whereas present-day concerns represent the dynamic vibrancy of human society, the archetypal myth of sustainability is a permanent part of the human psyche, one related to other archetypes such as "the journey" and "mother earth" (Campbell, 1986).

Planning and Appraisal

This element of the framework addresses the need for oversight and guidance functions for the entire environmental decision-making enterprise. These functions promote sustainability but should also be responsive to present-day concerns. The functions include foresight, monitoring, evaluation and issue diagnosis. The first three functions help to articulate the fourth, as illustrated in Figure 1, and also help to determine which decision mode is chosen.

Foresight. Foresight is important to ensure that environmental decision making is future-oriented, with adequate anticipation of possible environmental and social systems. Foresight entails imagining possible future worlds and assessing opportunities and threats that characterize those worlds. Scenario building, conducting scans of environmental, technological and other trends, and Delphi processes are all widely used foresight techniques discussed in the futures research and planning literatures (Schwartz, 1991; May, 1996). Using foresight techniques, environmental decision makers can assess whether current issues may heighten or diminish in importance. Foresight can also reveal new issues and potential events that environmental decision makers need to consider. Given these aspects of foresight, it is clear that foresight is not about predicting *the* future; instead, it is about "opening to the future with every means at our disposal" (Slaughter, 1995).

Results of foresight activities can be used to guide monitoring activities, by collecting data and other information to detect when opportunities and threats are imminent. If the results are compelling, they can be used as a primary basis for issue diagnosis: in other words, they can draw the attention of environmental decision makers, forcing them to consider whether and how an environmental issue needs to be resolved. Well-conceived foresight activities also can contribute to the growth of collective knowledge, and they can help people reflect on how their goals and values shape the future, for better or for worse.

Monitoring. Monitoring is seemingly a very straightforward task: to track environmental and social conditions in order to warn of emerging, potentially detrimental situations. Nevertheless, many practical questions arise with monitoring: what data need to be collected, how often, in how many places, using what means? Are computer resources capable of storing, processing and retrieving large amounts of data flexibly and efficiently? While efforts to monitor the environment have improved, they often are hampered by financial and administrative constraints, as are efforts to monitor social conditions. Moreover, efforts to monitor social conditions are constrained by other considerations, such as privacy issues.

Evaluation. Evaluation is essential if environmental decision making is to be improved over time. Every aspect of the decision process—from the usefulness of foresight activities to the effectiveness of monitoring schemes to the appropriateness of various decision modes and activities—requires keen evaluation. Insights gleaned through evaluation can feed back into foresight, monitoring and diagnostic activities to enrich the imagination, refine monitoring strategies and sharpen diagnostic capabilities. Learning through evaluation also can inform and enrich the environmental and social context within which decisions are made.

But evaluation activities themselves require evaluation. Numerous evaluation methods are available. The problem is choosing the right one for the task at hand and then making sure that its results actually make a difference in subsequent decision-making activities and processes. Another problem concerns time: many evaluations could extend over years before firm conclusions are reached, yet mid-course corrections may be needed before the final evaluatory results are in. For this reason, while long term studies may be needed to confirm scientific and policy predictions, models and counterfactual analyses are also needed to probe hypothetical consequences, including the consequences of paths not taken. Apart from these formal evaluatory methods, informal, on-going evaluations can be conducted as people learn from the experience of participating in various decision-making processes. For both formal and informal learning from evaluation to be of greatest value, it must become institutionalized: in other words, it must be passed on so that succeeding generations build on the painfully gained wisdom of their predecessors.

Issue diagnosis. Results from foresight, monitoring and evaluation are inputs for issue diagnosis: this information is used to: (1) identify situations that require action: and (2) identify an appropriate mode for decision making (see below). Many psychologists argue that diagnosis is fundamental to human intelligence (Anderson, 1982; Newell, 1990). Ancient professions such as medicine and law are organized around the basic concept of diagnosis and treatment, and most expert systems use *if-then* frameworks.

While seemingly straightforward, the concept of issue diagnosis is not easily implemented within environmental decision making. The most pressing difficulties are, first, that the issue at hand (e.g. groundwater contamination) may not be clear, in that it may be interconnected with other issues such as urban growth or forestry practices; and second, that even if the issue is clear, how it should be handled—using what decision mode, with what decision actions—is often opaque. Especially in the latter regard, environmental decision making is considerably more complicated than decision making in, say, medicine, where a diagnosis is much more likely to lead to a clear set of treatment options. Thus, an important research task for environmental decision making is to build a compendium of environmental issue diagnoses or syndromes, using 'symptoms' that are directly related to the environmental and social contexts of the problem at hand (Travis *et al.*, 1997), and then to build a set of viable 'treatment' options. Within environmental decision making, while many diagnoses would likely be made with respect to pressing contemporary problems, if environmental and social sustainability is accepted as an overriding goal, a diagnosis that sustainability is threatened would also then require some corrective action.

Decision-making Modes

In this subsection, we discuss six typical decision-making modes: emergency action; routine procedures; analysis-centred; elite corps; conflict management; and collaborative learning. These are 'ideal types' in that, in reality, none is likely to exist in pure form; instead, an environmental decision-making process is likely to incorporate aspects of more than one mode, simultaneously or over time. Nevertheless, each mode has distinctive characteristics that typify different approaches to decision making, and by understanding these six modes and their characteristics, decision makers can make more informed judgements about whether the mode that they have adopted (perhaps unconsciously) is appropriate for the issue at hand. Moreover, as will be discussed in the following subsection, decision actions are likely to be implemented in different ways depending upon the mode, and more informed choices about these decision actions also can be made by being conscious of the mode of decision making (Dale & English, 1999).

Emergency action. Emergency managers within the decision-making organization make rapid decisions concerning a crisis situation (e.g. involving a natural disaster such as a hurricane or a technological disaster such as a chemical plant explosion). Knowledge of the situation is gathered quickly and may be incomplete. Of necessity, predetermined procedures and 'seat of the pants' judgement are used. While other people and organizations may participate in emergency preparations or mop-up activity, only a few designated people participate in decisions concerning the emergency action itself.

Routine procedures. Administrative or technical staff within the decision-making organization follow predetermined procedures to make day-to-day decisions concerning familiar, routine situations. The decisions typically require well-specified, standardized information. Making a decision may require experience and common sense but does not require extensive or unique training or capabilities in policy analysis. Any given decision is not likely to lead to substantial social conflict requiring intervention by high-level administrators and elected officials. The environmental and socio-economic consequences of any given decision are also not likely to be substantial (although they may be, when the routine decisions are taken in the aggregate). Although others within and outside the decision-making organization are likely to have participated in establishing the policies and procedures that led to these routine decision-making procedures, few people other than administrative or technical staff are involved in implementing the procedures.

Analysis-centred. Analysts within the decision-making organization develop carefully-crafted technical or policy recommendations for the ultimate environmental decision maker (typically, the head of the organization, such as the mayor or the governor). Issues requiring an analysis-centred mode are more complex than routine technical decisions, have not been addressed many times before, entail potentially high environmental and social consequences, and may pose some threat of social conflict. The analysis may be required within hours but is more likely to take weeks, months or even years. Quantitative information often is preferred, and elaborate methods for considering components of the

situation and then weighing alternatives often are employed. While other people internal or external to the decision-making organization may participate in the decision process, they typically do so only by providing input on their goals and values. The analysis-centred mode of decision making has been the major focus of research on decision making and public administration in recent decades; it is also tends to be the fall-back position of decision makers when faced with complex, potentially contentious problems.

Elite corps. Issues tackled in an elite corps mode typically have major consequences for the decision-making organization. Staff presentations are followed by discussion and negotiation among senior members of the organization; 'bottom line' information is sought, including information about the views of special interests. But while these views may figure importantly, outsiders typically do not participate in an elite corps decision process. Instead, senior members within the organization reach either agreement or a majority view on the issue at hand.

*Conflict management. S*taff or leaders within the environmental decision-making organization seek to resolve a controversial issue using a decision process that is open and often lengthy. The process typically begins with a meeting of people internal and external to the organization who represent various sides of the conflict. The process may be kicked off with issue immersion (i.e. discussion of the nature of the problem), which may itself be a source of disagreement. Typically, information is presented by a variety of people, followed by discussion and negotiation. This may lead to more information being sought, leading to further discussion and negotiation, and so forth. Thus, conflict management may entail repeated, protracted iterations of the five decision action steps discussed in the next section. Alternative dispute resolution methods such as mediation and arbitration may be used to settle conflicts. A conflict management mode is needed in those cases where knowledge of the issue at hand is extensive but not necessarily shared, and where the consequences of the decision are large, with substantially different effects on different groups. Under these circumstances especially, conflict management is gaining popularity as a decision-making mode (Coughlin, 1995).

Collaborative learning. Various people internal and external to the environmental decision-making organization work together as equals to address an issue that is widely acknowledged to be neither well-understood nor easily addressed. The process is likely to be long and iterative. As information is obtained, people are encouraged to revisit their original goals and beliefs, and the nature of the issue may be collectively rethought. This mode is often anxiety-provoking, as its goal is to force people to seriously consider the issue and ultimately to consider changing their values to accommodate new realities. A collaborative learning process takes time and leaders who know when to push and when to be patient. Decisions are subject to change over time as new collaborative learning occurs. Collaborative learning is an essential decision-making mode for sustainable societies, since it is a preferable means for evolving and improving our collective understanding of complex environmental problems.

These modes of decision making are not unique to environmental issues; furthermore, they all take place within the larger context of institutional and

Table 1. Matching decision-making modes to criteria for their implementation

Decision-making mode/ implementation criteria	Emergency action (EA)	Routine procedures (RP)	Analysis centred (AC)	Elite corps (EC)	Conflict management (CM)	Collaborative learning (CL)
Knowledge of problem	Very low to very high	High to very high	Very low to medium	Medium to high	Medium to very high	Very low to low
Potential for conflict	Very low to very high	Very low to low	Medium to very high	Very low to medium	Medium to very high	High to very high
Magnitude of consequences	Medium to very high	Very low to low	Medium to very high	High to very high	Medium to very high	High to very high
Response time	Immediate to days	Immediate to days	Weeks to years	Days to months	Weeks to years	Months to years

societal culture, particularly the individual values and beliefs as well as the collective norms and knowledge of those most interested in the decision at hand. The decision-making modes also are affected by (and in turn may affect) the structures of the institutions participating in the decision, as well as contextual institutional activities such as retrospective evaluation or foresightful planning. And, as noted above, none of the modes is likely to exist as a discrete type; instead, various modes are likely to act in combination, simultaneously or over time. For example, an analysis-centred mode may be in support of an elite corps mode, which may in turn precipitate a conflict-management mode. Nevertheless, despite the fluid nature of modes of environmental decision making, this typology is a useful construct for clarifying not only where environmental decision making is today but where it is likely to go in coming years.

Over the past several decades, the first four modes—emergency action, routine procedures, analysis-centred and elite corps modes—have been dominant. Among these modes, the analysis-centred and elite corps modes have been preeminent for controversial issues with potential high and long term consequences. While these four modes are not likely to disappear, the last two modes are gaining in importance. Since the early 1980s, conflict management increasingly has been recognized as a vital part of environmental decision making in a pluralistic society that strives to be open and participatory. And now, in the late 1990s, the concept of collaborative learning—also called adaptive work or transformative facilitation,[3] depending upon the emphasis—is receiving widespread attention as a way to deal with highly complex issues where values are diverse and knowledge is limited.

Table 1 illustrates how to dissect environmental issues in a fashion that can lead to improved understanding of the most appropriate decision mode for a particular problem. The first column lists four dimensions of the issue, or problem: knowledge of the problem; potential for conflict; magnitude of consequences; and response time. Across the first row are the six decision-making modes. Each cell of the matrix contains the conditions under which a decision mode might most appropriately be selected. For example, routine procedures might be the best mode for problems where knowledge is high, potential conflict is low, magnitude of the consequences is low, and response time is short. We should note, however, that Table 1 is based on casual observation and that

further, more systematic research is needed to identify the salient dimensions of issues and their implications for preferred decision modes.

Decision Actions

These constitute the actual activities that lead to environmental decisions. The five steps listed below are comparable to other such formulations found in the decision-making literature (Chechile, 1991). There is a major difference, however: most formulations concentrate on the decision steps themselves and tacitly assume a methodical, analytical, 'number crunching' approach to decision making. Here, in contrast, these steps are nested within the larger framework described above, and we also note ways in which the steps might be carried out differently, depending upon the decision mode.

Issue familiarization. This first step often is called 'problem identification'. That is, to begin a decision-making process, the problem requiring attention must be clearly and explicitly stated.

Merely identifying the problem is often not enough, however. Thus, this step focuses on getting all of the decision-making participants familiar with the issue at hand. If the framework described above has been followed, problem identification has already been conducted as part of the issue diagnosis activity (see above). Often, however, especially in very open, highly participative decision-making processes, many more people will (or should) be involved in the issue familiarization step than were involved in prior issue diagnosis activity. Thus, many new people may need to become introduced to, and immersed in, the issue under consideration. They will need to have their basic questions answered. People from different perspectives will need to develop a common language to discuss the issue. One point which must be clarified and agreed upon by participants in the decision process is whether the problem primarily involves present-day concerns or future sustainability concerns.

All of these activities may result in the issue being redefined slightly or significantly. For this reason, the prior 'issue diagnosis' activity should be seen as a preliminary starting point, not as definitive.

Criteria setting. This step involves specifying criteria to evaluate various options. We would argue, as previously noted, that one important criterion is the sustainability of the environmental and social system—in effect, whether obligations to future generations can be met. In addition, however, the criteria need to address present-day concerns. Those constructing the set of criteria should consider identifying the relative weights of various criteria, to enable more precise option assessment. (The topic of weighting criteria has received considerable attention in the decision-making literature—see Keeney & Raiffa, 1995.) Criteria setting should precede option construction, discussed immediately below, in order to avoid consciously or unconsciously favouring certain options in developing the criteria.

Option construction. This step involves identifying decision options. For familiar issues, the range of feasible options may already be fairly well-known. For less familiar issues, options may be 'borrowed' from other, somewhat similar situa-

tions. Sometimes, however, the issue may be so complex and unique that brainstorming may be virtually the only way to generate options.

In constructing options, preference should be given toward options that are: (1) reversible; (2) robust and multi-pronged (i.e. a portfolio of actions that will enable learning over time and will guard against unexpected events); and (3) incrementally integrated. To explain the third point further: especially with issues of great uncertainty and potentially grave consequences, the options should reflect an incremental strategy—one that entails small steps, monitoring, reassessment, adjustments as necessary, additional small steps, and so forth. This philosophy toward options will help to ensure that the options result in system sustainability.

Option assessment. This step involves evaluating how well each option satisfies the previously established criteria. Options that do not meet thresholds established for the criteria should be modified or dropped from consideration. For familiar, relatively simple issues, experience may substitute for formal option assessment. For very complex problems, more formal analytic assessment may be required. Numerous operations research and economic methods are available to assist quantitative assessments of options. Options assessments should be qualitatively or quantitatively explicit, not just about what is known, but also about uncertainties; it may be that 'don't know' or 'can't know' is an important part of the assessment.

Reaching a decision. After options are assessed, a decision must be reached. There are numerous methods for making decisions. The appropriate one depends on the institutional context, the decision-making mode and who has the ultimate decision-making authority. For example, in a conflict management situation, a decision is reached when parties come to a negotiated agreement. Voting can be used to reach decisions in many situations, from citizen referenda to boards of directors. Citizen juries are an innovative possibility for reaching decisions in some situations (Brown *et al*., 1995; Crosby, 1995).

Summary

As indicated in Figure 1, the five decision actions described above do not necessarily proceed in a tidy, linear fashion; at times, it may be necessary to backtrack. For example, if none of the options satisfies the criteria, then new options may be needed or the criteria may require rethinking. Moreover, discussions about the criteria, the options and their assessments may reveal that participants in the decision process do not share a common understanding of the issue, which may necessitate revisiting the issue familiarization action.

As Figure 1 also suggests, it may become apparent that a different decision mode is needed: for example, an issue initially seen as a problem for analysts may entail much more uncertainty, conflict and grave consequences than originally thought, in which case, a conflict management or collaborative learning mode may be more appropriate. Changing the decision mode can radically affect how the decision steps are carried out. Table 2 links the five decision steps with each of the six decision modes. While there are some similarities in the way the steps are conducted, there may also be significant differences depending upon the mode. For example, roughly similar option construction and option assess-

ment approaches might be used in each mode but methods for public interactions and reaching decisions would be expected to differ greatly.

The environmental decision-making framework depicted in Figure 1 is thus composed of four dynamic, interactive processes. To illustrate this, take the case of community-level environmental decision making. Environmental and social contexts shape the community's notions of environmental problems and guide community planning and appraisal activities, which in turn prime monitoring and foresight activities. The community uses this information to ascertain whether a pressing problem exists, and if so, what decision mode should be adopted to reach a decision. The mode drives the 'who, what, when, where, and how' of the decision-making process. Decision actions constitute the everyday activities leading to a decision and can be quite iterative and intense.

But the interaction among the four levels of the framework is not simply top-down; it is also bottom-up. For example, feedback from the decision actions may lead to a change in decision mode: e.g. it may become apparent that a routine procedures mode is inappropriate because of a high level of community interest as well as new information about the problem, and a collaborative learning mode should be adopted instead. A change in the decision mode may lead to the development of new, hybrid decision modes and improvement in how decision actions are implemented; it may also lead to a change in planning and appraisal activities. These activities can, in turn, lead to changes in environmental and social contexts, including values and goals as well as perceptions, beliefs and collective knowledge. Moreover, when taken cumulatively, environmental decision-making processes can fundamentally alter our institutional structures.

In considering this interactive framework, however, it is important to step back from details about the modes and methods of reaching a decision. The multi-dimensional aspects of the issue under consideration, including questions of uncertainty, must be understood. Moreover, a test of *reasonableness* should guide those reaching the decision. 'Reasonableness' should not be confused with optimality. Tests of optimality often are used to guide decisions dominated by present-day concerns, but optimality, as a concept, is much less appropriate for decisions that are intended to promote environmental and social sustainability.

There is no single, optimal 'environment' or 'society'. Instead, there are many acceptable future states of the environment and society. The strategy should be to move from one acceptable world to another, all the while working to increase the 'option space' of acceptable worlds for present and future generations, rather than limiting the latter's option space. Granted, optimality can be relevant to present-day concerns, where cultural norms dictate the optimization of decisions according to one or a few criteria (e.g. cost, time). If taken too far, however, optimization may work against the long term survival of societal and environmental systems.

The Framework in Action

The ultimate value of this framework will rest on its ability to improve environmental decision making. To make this assessment, it would be necessary to collect data from numerous environmental decision-making situations, some of which followed the path set out above and some which did not. Hypotheses would need to be developed to predict the outcomes of the decision processes,

Table 2. Decision actions for each decision-making mode

Decision modes/ decision actions	Emergency action (EA)	Routine procedures (RP)	Analysis centred (AC)	Elite corps (EC)	Conflict management (CM)	Collaborative learning (CL)
Issue familiarization	In real-time, decision makers immerse themselves in the problem, assemble support staff	Technical staff assemble relevant information about the problem	Analysts collect existing information on the problem, immerse themselves in the the viewpoints	Elite corps is briefed on problem, extended discussions ensue	Opposing parties discuss and agree to problem definition	Public is actively involved in discussing situation and forming consensus on problem statement
Criteria setting	Use pre-set criteria (e.g. human safety)	Criteria are known; efficiency is important	Policy is used to guide criteria setting; maybe survey public	Organization mission and values used as guides	substantive public participation used to set criteria; disagreement, confusion and iteration expected	
Option construction	Follow emergency procedures	Use known alternatives, incremental change	Use brainstorming and other such techniques, iterate as necessary, construct in accordance to applicable laws and regulations; situation could dictate incremental, evolutionary or even revolutionary change; look for reversibility and flexibility in the alternatives			
Option assessment	Use experience, intuition and real time models	Results of decisions already known with high certainty	Use available and applicable environmental, economic, social, transportation, etc. models; employ appropriate visualization techniques; consider uncertainty; with few exceptions, satisficing strategies take precedent over optimization strategies			
Reaching a decision	Made by emergency team leader	Made by technicians	Made by administrator	Rendered by elite corps, using voting, consensus or other means	Rendered according to agreement; arbitration, citizen jury …	Rendered as community consensus (e.g. direct democracy; by a new group)

given the extent to which the framework was implemented. This is, at a meta-level, exactly the type of long term evaluation that this paper advocates.

Unfortunately, the data do not currently exist that were collected expressly to test specific hypotheses derivable from the framework that could lend support to or refute the major elements of this framework. Instead, our belief in the fundamental strengths of the framework rests for now on what we have gleaned from the literature and what we have observed of the experiences of environmental decision-making practitioners. We are, in effect, theory-building; it would take many years to rigorously test the theoretical framework proposed here. Nevertheless, setting forth the framework now will allow practitioners to apply it and researchers to test it.

There is not, however, a complete lack of information very relevant to understanding the framework in action. One excellent, highly relevant case study is included in a book by Ronald Heifetz entitled *Leadership Without Easy Answers* (Heifetz, 1994). Heifetz documents an environmental decision-making situation in the 1980s in Tacoma, Washington, concerning a copper plant that was emitting a potentially carcinogenic level of arsenic into the air. The US Environmental Protection Agency (US EPA), under the leadership of administrator William Ruckelshaus, was responsible for determining what to do with the plant. Heifetz explains how Ruckelshaus decided that the typical decision mode that the US EPA would apply in these types of situations, an analysis-centred mode, would be inappropriate and that the EPA would need to implement a collaborative learning mode, where for all intents and purposes the decision about what to do with the plant would rest in the hands of the community. Heifetz concludes that the collaborative learning process (which he refers to as an adaptive work process) was extremely successful and a better choice than the traditional analysis-centred mode.

A more recent example for which more documentation exists concerns a complex environmental decision making process implemented in the late Spring of 1995 (see Keating & Farrell (1999) for an excellent 'case essay' about this process). This process came to be known as OTAG, which stands for the Ozone Transport Assessment Group. OTAG was formed to try to resolve ozone pollution problems in the eastern half of the US. A major point of contention in ozone policy making is the transport of ozone precursors, especially NO_x, across state borders; 37 states participated in this process, representing up-wind and down-wind states. Also participating in the process were the US EPA, industry (lead by the electric power companies whose fossil fuel power plants were significant emitters of NO_x), and to a lesser extent, scientists, environmental advocates, legislators and the public. All told, over one thousand people participated in the OTAG process.

The goal of OTAG was to come to interstate agreements to solve the ozone transport problem. OTAG is an excellent example for this paper because it represented an attempt to use a different set of decision-making modes to tackle this problem. Prior to OTAG, given the framework jargon developed above, ozone decision making had the characteristics of a joint elite corps—conflict management process. By law, the US EPA would request from states documents known as state implementation plans (SIPs), which would detail how a state intended to meet ozone National Ambient Air Quality Standards (NAAQS). Although the standards themselves could be viewed as being set by an analytic centred decision mode, the US EPA, at least to outsiders, acted in an elite corps

mode as it developed guidelines for the SIPs and judged whether the SIPs were satisfactory. Because the vast majority of the SIPs could not meet ozone NAAQS for many states due to the transport of ozone precursors from neighbouring states, many conflicts ensued between US EPA and the states, downwind and up-wind states, and between electric power companies and these parties. The courts were routinely called upon to manage these conflicts.

As discussed above, it is desirable to continuously evaluate the decision modes being used to ascertain whether they are working and whether it might be worthwhile to switch decision modes. In the Spring of 1995, such a situation existed. A new Republican Congress was then in power. This Congress did not favour federal environmental regulation but did favour environmental federalism (i.e. returning power to the states). The US EPA, as recounted by Keating and Farrell, came to believe that it could not continue along its path of requesting SIPs, judging them to be not in compliance, and then issuing possibly draconian orders to states to reduce the emissions of ozone precursors without potentially putting the entire federal air quality control effort in jeopardy. Thus, the US EPA decided to change its mode of operation to support a collaborative learning decision-making process involving the states which would be supported by a substantive analysis-centred activity. To give this effort the best chance of success, the US EPA suspended its SIP-related activities and environmental groups agreed not to take the US EPA or the states to court during the two-year OTAG lifetime.

OTAG was designed to arrive at consensus decisions by the affected states and other parties about what to do about ozone in the eastern US. The process was lead by state environmental commissioners and the state air quality agencies, with the US EPA playing an active role in the background. OTAG was organized into several groups. The Policy Decision Group took the lead and eventually issued the final report. Supporting the Policy Decision Group were several ozone modelling groups, a group that studied emissions trading and incentives, and a technical integration group. According to Keating & Farrell (1999), "throughout the OTAG process, decisions were made on the basis of consensus, somewhat loosely defined" (p. 103). The analysis groups had to overcome many internal disputes concerning what analyses should have been done under what assumptions, but in the end did provide a great deal of useful information.

Keating & Farrell report that OTAG did reach consensus on many points, although they argue that no tough decisions were made. The most meaningful decision was to recommend that NO_x emissions fall somewhere between *status quo* standards and an 85% reduction. The Policy Decision Group also came to other recommendations concerning the need for additional regional modelling and analysis, continuing the use of reformulated gasoline, establishing Ozone Action Days to increase public awareness of ozone and the establishment of an NO_x emissions trading system.

The fact that OTAG did not reach any tough decisions should not, however, indicate that the combination of collaborative learning and analysis-centred modes was unsuccessful or inappropriate. The OTAG process yielded much new analysis and information. The multi-state consensus process improved communication among stakeholders and among scientists and decision makers. Keating & Farrell concluded that the ozone assessment process promoted learning among all parties, which is an important goal of the collaborative

learning mode of environmental decision making. Had OTAG continued beyond two years, it might have evolved into a more permanent, consensus-based yet multi-mode and multi-level environmental decision-making process that could have eventually yielded more substantive decisions. Keating & Farrell note that, by 1999, the OTAG collaborative learning–analysis-centred modes had been replaced by the familiar elite corps behaviour of the US EPA and conflict management through the courts and that the collaborative networks that had been established were quickly eroding.

This case highlights several important points. First, collaborative learning processes can serve as anchors to highly complex, multi-modal environmental decision-making processes. Second, in some cases, it may be necessary to continue collaborative processes for long periods of time in order to not to lose communication and other benefits. Third, it is apparent that analysis-centred activities can well complement collaborative learning processes. Fourth, both the OTAG case and the case described by Heifetz indicate that the choice of a decision mode can make a big difference in both the quality and the outcome of the environmental decision-making process.

Lastly, it must be noted that, in increasing numbers, other decision makers are opting for collaborative learning processes, Nationwide, there is a growing cadre of facilitators who are trained in managing these processes. In areas as diverse as Oak Ridge, Tennessee, and the Gray Ranch in New Mexico, on problems as diverse as mercury contamination and habitat protection, people are participating in collaborative learning processes. Additional research is needed to evaluate the success of this newest and most innovative mode of decision making, for example, research on whether the mode was used in appropriate situations, how well it worked and how it can be improved. Thus far, however, the evidence tends to support the validity, not only of collaborative learning as a distinct and promising mode of environmental decision making, but also of other parts of the framework.

Concluding Comments

This paper presents a framework for understanding and managing environmental decision making. The discussion above is partly descriptive, partly prescriptive. It is descriptive in that many of the activities discussed above do take place to some degree, but rarely fully or systematically. It is prescriptive in that it recommends a more conscious, well-considered approach to environmental decision making than is typical today.

For example, foresight is practised, although not often or well; monitoring programmes are in place in many instances, but they often have little effect on subsequent decisions; evaluations of environmental decisions are conducted, but not nearly as frequently as needed. Moreover, these activities—all of which are under the direct control of the decision making organization (unlike some of the other components of the framework)—are often not well-coordinated and do not systematically feed into issue diagnosis.

All of the decision modes described in the framework are used in the US, with the more participatory modes—alternative approaches to conflict management and collaborative learning—on the ascendency. Nevertheless, the choice of decision mode often appears to be haphazard—a matter of habit or personal preference—rather than resulting from a systematic assessment of which mode

is most appropriate for the situation at hand. There are no well-recognized methods for choosing the most appropriate decision mode. Decision actions are being implemented in roughly the sequence described in the framework, but in many situations there still appears to be a lack of clarity about how, precisely, they should be undertaken, particularly given the decision mode that has consciously or unconsciously been chosen.

We recognize that the framework which we have laid out could be called Utopian and that numerous hurdles must be overcome before it can be realized. For example, who should have responsibility for:

- determining whether thresholds have been (or could be) exceeded with respect to environmental and societal systems sustainability;
- operationalizing criteria that define the space of acceptable environmental decision options;
- conducting foresight and monitoring activities;
- conducting evaluations;
- rendering environmental issue diagnoses;
- choosing which decision modes to implement; and
- managing conflict management and collaborative learning decision modes?

There are also numerous geographic scale issues that complicate environmental decision making. For example, how might criteria for evaluating options be scaled to be relevant to both national and community level environmental decision making? How should foresight efforts be co-ordinated across geographic scales and regions of the country? How can numerous community-level and private-sector environmental decisions be aggregated for comprehensive assessment of environmental decision options? Does a larger scale inhibit the use of participatory decision modes?

In addition, these issues are complex because of their temporal dimension: the issues are often pressing, but a well-integrated long view is required. How should communities, for example, go about managing numerous decision modes at once? They do so now, either in a fog or in a crisis atmosphere, but explicit implementation and management of the modes requires a more systematic approach. The changing nature of how environmental problems are socially constructed, as well as the interdependence of environmental problems, significantly complicates the picture. Sometimes the solution of one problem will be conditional on the solution of other, seemingly unrelated problems; sometimes the solution of a problem requires the solution of numerous subproblems and moreover; sometimes different decision modes will be required for each of the problems.

Evaluation presents further challenges. Evaluation of environmental decisions is methodologically quite difficult: Environmental decision making is an ongoing process: Many decisions are actually composed of many sub-decisions, made at different points in time and sometimes revisited. What, then, is the decision being evaluated? How can one draw bounds around it? For example, in choosing a bounding time frame, should it be five years, ten years, a century? Each passing day further complicates the evaluation, making it more difficult to attribute the contribution of past decisions to today's situation. These methodological difficulties can be confronted, but only through concerted, long term efforts.

Another problem is decision making's analogy to the uncertainty principle: the more one focuses on certain decisions, the less one knows about what could have happened if other decisions had been made. One can learn from both good and bad decisions, but it is difficult to tell whether unchosen options might have fared better. Physicists and other natural scientists have the luxury of being able to control their experiments, manipulating variables one at a time and playing out any number of experimental scenarios. Researchers concerned with decision making do not have that luxury. Few practitioners are willing to 'experiment' by purposely choosing an option which they think will not work but which may provide an excellent learning opportunity. Current collective knowledge may persistently guide people toward the same flawed decisions in case after case, because the results of no other decision options are experienced. It literally could take generations for humans to learn how to improve environmental decision making.

Of course, there will always be people who will try something different. The question then becomes whether these new initiatives will be evaluated. If formal evaluations cannot take place, perhaps the participants in the experiment will be around long enough to learn from, and communicate about, the results of the innovative process. But turnover, especially in government, is endemic. Passing on new knowledge about environmental decision making becomes accordingly more difficult, unless those who have gathered new knowledge and insights incorporate those insights into their new work situations. What then can be hoped for is not so much the transformation of particular institutions as a gradual, more general transformation of the culture of environmental decision making.

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Notes

1. For examples, see Robinson (1989); Daley (1990); Meadows (1996); and Holmberg *et al.* (1996) (about The Natural Step).
2. What constitutes a sustainable society is a philosophical question of practical importance. It can be argued that, in order to carry out long term stewardship of the environment, societies need: stable communities (e.g. no mass relocations and migrations); stable economies; and the ability to learn over time—see Tonn & White (1996).
3. Adaptive work is a central concept in Heifetz (1994). Transformative facilitation is a key concept in Maser (1996).
4. A designation used by Leakey (1981); Maxwell (1984); and Campbell (1988).

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