

Structured Decision Making

A Practical Guide to Environmental Management Choices

R. Gregory, L. Failing
M. Harstone, G. Long, T. McDaniels, D. Ohlson

 WILEY-BLACKWELL

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A John Wiley & Sons, Ltd., Publication

This edition first published 2012

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Blackwell Publishing was acquired by John Wiley & Sons in February 2007. Blackwell's publishing program has been merged with Wiley's global Scientific, Technical and Medical business to form Wiley-Blackwell.

Registered Office

John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

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Library of Congress Cataloging-in-Publication Data

Structured decision making : a practical guide to environmental management choices / R. Gregory ... [et al.].

p. cm.

Includes index.

ISBN 978-1-4443-3341-1 (hardback) – ISBN 978-1-4443-3342-8 (paper)

1. Environmental management–Decision making. I. Gregory, Robin (Robin Scott)

GE300.S7834 2011

333.7–dc23

2011038034

A catalogue record for this book is available from the British Library.

Set in 10/12pt Photina by SPi Publisher Services, Pondicherry, India

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Foreword

This book is about the creative and messy process of making environmental-management decisions. The approach we describe is called Structured Decision Making, a distinctly pragmatic label given to ways for helping individuals and groups think through tough multidimensional choices characterized by uncertain science, diverse stakeholders, and difficult trade-offs. This is the everyday reality of environmental management, yet many important decisions currently are made on an ad hoc basis which lacks a solid value-based foundation, ignores key information, and results in selection of an inferior alternative. Making progress – in a way that is rigorous, inclusive, defensible, and transparent – requires combining analytical methods drawn from the decision sciences and applied ecology with deliberative insights from cognitive psychology, facilitation, and negotiation. We review key methods and discuss case-study examples based in our experiences in communities, boardrooms, and stakeholder meetings. Our goal is to lay out a compelling guide that will change how you think about making environmental decisions.

We gratefully acknowledge partial funding support from the Decision, Risk and Management Science program of the US National Science Foundation (Award No. 0725025). We also acknowledge intellectual support from many colleagues and clients over the years who – through a mix of interest, curiosity, and frustration with conventional methods – have seen fit to work with us on a wide range of environmental-management problems, including Joe Arvai, Trent Berry, Cheryl Brooks, Mark Burgman, Bob Clemen, Jean Cochrane, Alec Dale, Nate Dieckmann, Daryl Fields, Baruch Fischhoff, Bill Green, Nicole Gregory, Paul Higgins, Dan Kahneman, Jack Knetsch, Howard Kunreuther, Sarah Lichtenstein, Lynn Maguire, Steven Morey, Ellen Peters, Mike Runge, Terre Satterfield, Basil Stumborg, William Trousdale, Nancy Turner, Terry Walshe, Carl Walters, Tim Wilson, and Kristin Worsley. Many of you (along with Rachel Flood and Leisha Wharfield) also helped by commenting on draft chapters of this book, for which we (and our readers) send thanks. We also thank the editorial staff at Wiley-Blackwell, which has been helpful, professional, and efficient. We take full responsibility for any errors or confusion in how these ideas and case studies are presented, but we recognize and appreciate the many contributions of your clear thinking and practical insights.

This book is dedicated to Ralph Keeney and Paul Slovic. Your enthusiasm for improving how society addresses environmental and risk-management decisions, and your continuing excitement over each new opportunity to learn a little more about how people join emotions with reason to make tough choices, informs and inspires us. Without your friendship and guidance, this book would not exist.

Preface

This book is about decisions. More specifically, it is about making decisions concerning the management of environmental resources. By ‘decision’ we don’t mean a routine i-dotting and form-filling exercise to fulfill an administrative requirement. We mean clear and considered decisions generated through working as part of a team to develop a resource-management plan, prepare an environmental assessment, design a policy framework, propose an infrastructure project, or engage in a host of other activities that may significantly influence the use or protection of valued natural resources.

Our goal in writing this book is to reset the guideposts – even, we might boldly hope, to propose a standard – for what constitutes defensible decision making for the management of environmental resources. In so doing, we are divulging a well-kept secret: there are ‘best practices’ in decision making. Every decision context is different. Yet there is an emerging consensus about what constitutes a responsible and defensible approach to difficult decision making about environmental resources. This book sets out a guide for people who want to lead or be part of such decision processes – whether as managers, facilitators, technical experts, decision makers, community residents, resource users, or as members of non-governmental organizations or interest groups.

The approach we describe is called *Structured Decision Making* (hereafter SDM). It is a distinctly pragmatic label that we believe captures the essence of the approach. We could equally have called it ‘a useful way to think about addressing tough environmental choices’, but this abbreviation would be unwieldy. An SDM approach combines analytical methods from the decision sciences and applied ecology with insights drawn from cognitive psychology and the experience of facilitators and negotiators. People use SDM methods to organize complex issues in ways that help individuals and groups build common understanding, identify relevant information, and find innovative solutions to difficult environmental-management problems.

SDM is particularly helpful for *groups* of people working together on *solutions* in a way that is *rigorous, inclusive, defensible and transparent*. This framing profoundly changes how decisions are approached: who is involved, how the purpose is defined, how attention and resources are applied across different issues, and how success is gauged.

One of the distinguishing features of SDM is that it gives attention to both the values of people affected and factual information concerning the potential consequences of actions. This dual focus is the foundation of defensible decisions: explicit value-based choices based on the best available information. SDM neither should nor can ‘make’ decisions, but by linking values and facts it provides enormous insight to those charged with this task. To this end, we will introduce methods developed in the decision sciences, but tested and implemented in communities, boardrooms, and stakeholder meetings over the past decades in Canada, the United States, and other parts of the world. We emphasize how the fundamental goal of SDM processes – providing clear insights about possible courses of action

to those charged with making a decision – can still be achieved in the midst of deadlines, resource constraints, limited attention, and overworked people with diverse perspectives.

Although we have a range of research and academic credentials, we are primarily practitioners and our experience is in applying SDM to environmental problems in the real world. Thus our approach in this book is unapologetically practical. Our goal is to bridge the gap between theory and practice in environmental decision making. We've tried to synthesize an enormous amount of thinking by minds greater than ours into a volume that will be understandable and useful in the real world. To keep us grounded, we've used an abundance of examples to illustrate both the pros and cons of suggested methods. We include success stories from our own work and the work of others, as well as some of our favorite mistakes – from which we like to think we've learned a great deal.

Who should read this book? Our comments are addressed to a broad audience of resource managers, risk analysts, land-use planners, industry leaders, environmental NGOs, facilitators or negotiators, and government decision makers as well as concerned resource users and the residents of potentially affected communities. In our experience, all of these people can and should have the opportunity to participate in meaningful and productive decision-making processes about environmental resources that lead to the implementation of recommended actions. This book also is intended to be appropriate as supplementary reading for university courses in environmental decision making or for courses in planning, ecology, resource economics, and environmental management, at either advanced undergraduate or graduate levels.

Despite the emphasis on methods, this is not primarily a how-to text. It's meant to introduce you to a new way of thinking about problem solving and accountability in decisions that involve public resources and multiple interests. You don't need to master any fancy mathematics or complex technical tools to benefit from SDM. You may need to change how you think about choices. We hope this book provides a guide to this new way of thinking and gives you a set of tools that are useful for finding solutions to tough environmental-management problems, particularly those that involve multiple stakeholders and choices over diverse and conflicting interests.

Structured Decision Making contains 12 chapters. The first documents why a new approach to environmental decision making is needed. The second outlines the philosophical and theoretical underpinnings of SDM, just enough to thank our predecessors and mentors and to allay any fears that we've made it all up. Chapter 3, on decision sketching, introduces the idea of structuring your resource management problem as a decision from the start. Chapters 4 through 9 cover core methods, emphasizing the role of behavioral considerations as well as analysis and deliberation. Chapter 10 discusses critical concepts of iteration, learning, and monitoring – keys to responsive decision making under uncertainty. Chapter 11 provides a reality check, meant to keep our feet on the ground and focus on what is possible in terms of people, institutions, legal constraints, information, and politics. The final chapter briefly summarizes key points. At the end of most chapters we also list key readings that provide additional details on concepts and methods.

Case studies are included in every chapter. These demonstrate SDM methods in practice and provide ideas, based on our collective experience, about which analytical techniques will work under what circumstances and how to deal with decision makers or other participants who may be hostile, bored, inflexible, or looking for miracles. Despite our emphasis on environmental-management problems, SDM is fundamentally about working with people. If a process to aid resource decision making and environmental management is going to be effective in this modern world of participatory democracy and stakeholder involvement, then it must be understandable and responsive to the needs of the participants.

The bottom line is that SDM, done properly, can help to clarify values, build a common understanding of the best available information, improve the quality of deliberations, and help to identify and implement better management alternatives. It can also save time and money, and – to the extent that the application of SDM methods helps resource management agencies to avoid litigation, lengthy negotiations, or costly remedial efforts to overcome management failures – these savings can be substantial. An SDM process requires knowledge of a mix of analytical and deliberative techniques, along with a willingness to learn and to be both frustrated and delighted by how people address tough environmental and societal choices. It also requires that the minds and hearts of participants (including SDM analysts and their clients) be open to restructuring environmental issues in ways that can lead to new and broadly acceptable management opportunities.

Structuring Environmental Management Choices

In late 1999, 24 people representing a variety of interests, perspectives, and agencies signed off on a consensus agreement that fundamentally changed water flows on a disputed stretch of a managed river in British Columbia, Canada. Up until then, hydroelectric facilities on the river had been operated primarily for power production, with limited consideration given to effects on fisheries, wildlife, recreation, and local communities. Relationships among the diverse stakeholders (BC Hydro, which produces electricity from the dam, the federal Department of Fisheries and Oceans, the provincial Ministry of Environment, and community members) were strained. Court actions were threatened by both the local aboriginal community and the federal Fisheries regulator. From the utility's perspective, water management options were complicated by an unclear regulatory environment that offered little guidance about how to involve other stakeholders, how to address trade-offs affecting water flows, or how to adapt management practices to public values that had changed over time.

Conventional thinking suggested a choice between negotiation and litigation. Instead, the utility, along with provincial and federal regulators, collaboratively developed and adopted a structured decision making (SDM) approach. In addition to achieving consensus agreements at all but one of 23 facilities, the SDM process produced

a common understanding among key stakeholders about what could and couldn't be achieved with different management alternatives, about which trade-offs were acceptable, and about which uncertainties were most important. By focusing on mutual learning, it built trust and stronger working relationships among key stakeholders, and institutionalized a commitment to improving the information available for decision making over time. The process won a range of international awards for sustainability.

Although there are many reasons for the remarkable success of water-use planning in British Columbia, one key factor was the use of SDM methods to guide both analysis and deliberations¹. Over 10 years later, SDM continues to play a prominent role in framing important environmental management decisions in the province. The provincial government regularly requests the use of SDM to help guide environmental assessment and project or program planning efforts. BC Hydro, the government regulated provincial energy utility, uses SDM approaches to assess its electricity generation options and incorporates SDM in its triple bottom-line approach to corporate purchasing policies. In both BC and the adjacent province of Alberta, several indigenous communities are using SDM as part of environmental management and ecosystem restoration initiatives²; one has adopted

its own SDM guidelines as the overarching framework for planning and negotiations in its territory with the provincial and federal governments³. The federal fisheries regulator wrote SDM-based procedures into its Wild Salmon Policy⁴ and has used the process to produce an interim agreement on the management of a widely recognized threatened species⁵. Forestry practitioners in western Canada recently used SDM to help assess climate-change vulnerabilities and adaptation options for sustainable forest management⁶.

In the United States, the Fish and Wildlife Service (USFWS) has adopted SDM as a standard of practice and is using SDM methods in a variety of environmental management contexts. In its technical guide for the conduct of adaptive management, the US Department of the Interior (USDOI) states that 'Adaptive management is framed within the context of structured decision making, with an emphasis on uncertainty about resource responses to management actions . . . '⁷.

This interest in SDM is not limited to North America. In Australia, the Department of Agriculture, Fisheries and Forests has a community of practice in SDM and is using it to develop an approach to the management of agricultural pests and invasive species. SDM approaches have been used in New Zealand to aid recovery of the endangered Hector's dolphin⁸ and the country is debating use of an SDM approach to help develop a risk framework for management of genetic organisms, with a special emphasis on ways to integrate concerns of the aboriginal Maori culture alongside concerns developed through western scientific studies.

Why all the interest? What's different about SDM? Fundamentally, SDM reframes management challenges as choices; not science projects, not economic valuation exercises, not consultation processes or relationship builders. You have a decision (or a sequence of decisions) to make. The context is fuzzy. The science is uncertain. Stakeholders are emotional and values are entrenched. Yet you – or someone you are advising – has to make a choice. This decision will be controversial. It needs to be informed, defensible, and transparent. This is the reality of environmental

management. It has been said that reality is what we deal with when there are no other options. We think that SDM is a useful way to deal with the realities of everyday environmental management.

1.1 Three typical approaches to environmental decision making

Let's look first at three dominant paradigms that guide how environmental management decisions are conventionally made: science-based decision making, consensus-based decision making, and analyses based in economics or multi-criteria decision techniques.

1.1.1 Science-based decision making

A file arrives on the desk of a resource manager working in government. A biologist by training, she learns that a species recovery plan for the recently listed split-toed frog will need to be in place in 18 months. This is a priority issue and she has been given lead responsibility. She pulls together an inventory of all the science on split-toed frogs and launches a science review and planning team. Within a few months, work is underway to produce a comprehensive risk assessment and a state of the art habitat model. The modeling is completed within 15 months, an extraordinary accomplishment. Our scientist heaves a big sigh of relief and settles down to develop a plan. Two months later, however, she is disillusioned, attacked by angry environmental activists who reject the recommended captive breeding options on ethical grounds, by local tourism operators who claim that the proposed road closures will ruin their businesses, and by frustrated recreationists who demand that recovery funding be used instead for the protection of more visible species. Faced with the impending deadline, her embattled boss pushes through a band-aid solution that slightly soothes stakeholders' ruffled feathers but will never protect the frog. Everyone is frustrated and disillusioned with a world where, once again, politics trumps science.

This scenario is (perhaps) a little exaggerated, but it illustrates the deep-rooted reliance on science of many decision makers and resource managers and their desire to produce 'science-based' decisions. When a solution supported by scientific experts fails to receive wide support, environmental managers often throw up their hands and decry the vagaries of 'irrational' social values and power politics. The problem is not with the science: sound science must underlie good environmental management decisions. The problem is with society's tendency to ask too much of science in making decisions and to leave out too many of the other things that matter to people. First of all, science is not the only credible or relevant source of knowledge for many environmental management decisions. Secondly, social considerations and ethics and the quality of dialogue play important roles in shaping environmental management choices. Most importantly, rarely is there a single objectively right answer and science provides no basis for dealing with moral or value-based choices. The biologist Jane Lubchenco, in her Presidential Address to the American Association of the Advancement of Science, reminded the audience (in the context of environmental planning) that 'Many of the choices facing society are moral and ethical ones, and scientific information can inform them. Science does not provide the solutions . . . '9.

There is increasing recognition that when management choices are characterized by a high degree of stakeholder controversy and conflict, the decision process must address the values held by key participants¹⁰. Unfortunately, most resource management agencies have little knowledge about how to deal constructively with value-based questions. Nor is it generally recognized that many so-called environmental initiatives also will have implications for economic, social, and other considerations. If a narrow, environmentally focused agency mandate means that these related concerns have not been identified carefully, then progress in implementation may be blocked. The frequent result is an 11th-hour, behind closed-doors, largely ad-hoc capitulation

to vaguely defined 'social values' and 'political' pressures – as in our scientist scenario.

One of the things we want to do in this book is to help scientists and scientifically trained managers figure out how to contribute usefully to public policy decisions that are as much about values as about science. Making good choices requires the thoughtful integration of science and values – the technical assessment of the consequences of proposed actions and the importance we place on the consequences and our preferences for different kinds of consequences – as part of a transparent approach to examining a range of policy options. While credible environmental management relies on carefully prepared technical analysis, it also relies on creating a deliberative environment in which thoughtful people can express their views in a collaborative yet disciplined way. Science alone will not make good environmental policy choices. But a values free-for-all will not get us there either.

For some types of problems the objectives are simple and clear, the range of alternatives is well understood, and the evaluation of them involves few and relatively uncontroversial value judgments. For example, if a policy decision has been made to reduce waste or emissions by 30%, then the task of deciding how to achieve that target might be quite technical, largely driven by cost-effectiveness or least-cost analysis (implement the lowest cost alternatives up to the point where the target is reached.) Scientific or technical analysis can perhaps provide 'answers' in this constrained decision context, with scientists acting as 'honest brokers'¹¹. For other, morally charged questions – regarding genetically modified foods, the hunting of baby seals, or lethal predator control, for example – beliefs are so deeply entrenched that the influence of scientific or technical information on decisions may be small. These choices often end up in the hands of political leaders who will make a value-based choice with little reference to scientific information.

The problem for environmental managers is that the vast majority of environmental decisions fall into a messy middle ground where science

plays a bounded but critical role and values and preferences, often strong and initially polarized, are also critical but not fixed. Research in behavioral decision making emphasizes that, particularly in less-familiar evaluation contexts, preferences are often 'constructed' based on information gained during a process¹², rather than uncovered or revealed as fixed pre-existing constructs. Factual information will never, by itself, make a decision, but it informs and shapes values, which do determine choices.

This clearly implies that what is needed is a framework for making environmental management choices that deals effectively with both science and values. Yet when managers and scientists – and most other people as well – talk about values, they find themselves tip-toeing around, more than a little uncertain how to proceed. Most often, efforts to resolve value-based conflicts focus on bargaining and negotiation or on consensus building. Unfortunately, an over-emphasis on process, dialogue, and consensus can create its own problems.

1.1.2 *Consensus-based decision making*

As the name suggests, consensus-based decision-making processes are those that focus on the endpoint of bringing a group to a consensus agreement.

What could possibly be wrong with this? As an outcome, nothing; we're fans of consensus, just as we're fans of laughter or happiness. Our criticism arises whenever consensus is a *goal* of group deliberations, because we've often seen an emphasis on consensus take environmental management processes in the wrong direction. The biggest problem is that the group will often push too soon, too hard toward convergence, at the expense of a full exploration of minority views and creative solutions. An approach based on building consensus presumes that people have a good idea at the start of what they want to see happen, and that this reflects a good understanding of what the various alternatives

will deliver. When addressing tough environmental management problems, this is rarely the case. Whenever decisions are characterized by multiple and conflicting objectives and a complex array of alternatives with uncertain outcomes – a nearly universal situation in environmental management – people are likely to enter into a decision-making process with plenty of emotions and strong positions but a poor understanding of relationships between actions and consequences. And as we discuss more fully in Chapter 2, it is naïve and misleading to assume that working with people in a group is a simple cure for the shortcomings of individual decision makers.

In addition, insufficient attention typically is given to dealing with uncertainty in the anticipated consequences of actions and to what this means for establishing an effective and robust management strategy. Although in some cases significant reductions in uncertainty are possible, at other times key sources of uncertainty will be irreducible, at least with available resources and within the time scale of management concern. Reaching agreement in these cases necessarily involves tackling directly the thorny issue of risk tolerance – how much risk people are willing to accept and to which of the things they value. Recovery plans often bring these issues into the fore: with the split-toed frog, it's likely that some stakeholders will be highly risk averse ('we must guarantee long-term survival') and others will be more risk neutral ('we need to improve chances of survival'). Bargaining and negotiation frameworks offer little that will help groups work through these issues in a constructive and collaborative manner.

Finally, because of the emphasis on consensus as such, it is tempting for both participants and facilitators to ignore difficult trade-offs and to favor vaguely defined or relatively safe solutions so long as everyone agrees to them¹³. Questioning the motives or aspirations of the group, reminding them of the larger problem context, or introducing participants to demanding – albeit appropriate and insightful – analytical methods,

is rarely attempted because the fragile consensus might well be upset. Little is done to combat insidious 'decision traps' that (as we'll discuss later) have been shown to foil the judgments of even sophisticated decision makers¹⁴. From a decision-making perspective, however, the goal is to reach beyond the least common denominator of a universally supported plan and, instead, to deliver one that is creative and demonstrably effective, that will survive further scrutiny from a wider audience, and that is likely to prove robust (to changing values, circumstances, and politics) over time. This requires that conflicting views be viewed not as problems to be hushed or appeased but as opportunities to clarify the reasons behind apparent differences in values and the various interpretations given to factual information.

1.1.3 Economics and multi-criteria analysis

Imagine if the split-toed frog project had landed on the desk of an economist rather than a scientist. An economist might immediately see the need for a quantitative analysis that will yield a summary calculation showing the ratio of costs to benefits of the alternative courses of action. He is likely to take the list of initial management alternatives he's been given, calculate the expected values of key effects, and begin the process of monetizing a long list of ecological and social impacts. Knowing that this is a complex and controversial task, he is likely to allocate his 18 months to conducting benefit transfer studies, or perhaps to initiate a travel-cost study or contingent valuation survey¹⁵ – tools that help to assign monetary values to non-monetary effects. There will be little constructive debate about the science and the uncertainties underlying estimates of ecological effects, as discussions are dominated by defense of the controversial monetization techniques. The final results are subject to wide-ranging criticism, as various participants either disagree with the monetization efforts or protest that important values

have been left out of the analysis because they are too difficult to quantify. In the meantime, no alternative solutions have been generated.

This scenario demonstrates a more technocratic approach to decision making. The focus is on finding a formula that will calculate a summary answer: the analyst wants to do the right thing, but above all seeks a method that will yield a number (e.g. a net present value or a benefit-cost ratio) and provide the required answer. For the economist, the primary techniques are monetization, benefit transfer studies, and cost-benefit analysis, informed by a variety of specialized non-market valuation methods. This scenario could equally feature a decision analyst; the tools would be multi-attribute utility functions, normalization, weighting, and related techniques. Yet the effect would be the same – a formula-based score that identifies the preferred solution.

What is lost with these technocratic approaches is the focus on making sound decisions. If you're a manager, you need solutions – creative solutions – that are directly responsive to stakeholders' perceptions and concerns and that are developed with their collaboration and support. Instead, a technocratic approach reduces the management task to a project valuation and selection exercise. The essence of good decision making lies in understanding the problem, gaining insight into what matters to people, and then generating responsive alternatives. In a cost-benefit process, there is little room for these tasks. The emphasis is on analyzing one preferred solution: rarely are alternatives compared explicitly or broken down into their components in hopes of combining elements to develop a new, better (i.e. more effective or cheaper or quicker or more widely supported) management alternative. As we discuss further in Chapter 2, economic and multi-criteria approaches might produce a decision, but it may not be one that addresses the real problem at hand and, without the involvement of key parties in a creative problem-solving process, it's unlikely to enjoy broad-based support. Of course there are experienced practitioners in

both economics and multi-criteria decision analysis who emphasize the need for good problem structuring, creative thinking and mutual learning. But in their conventional applications, both cost benefit analysis and multi-criteria methods lack the structuring and deliberative aspects of SDM and, to the extent that they represent expert-driven processes, are unlikely to generate broad-based community or stakeholder support.

1.2 Structured decision making

1.2.1 *What is structured decision making and where does it come from?*

We define SDM as the collaborative and facilitated application of multiple objective decision making and group deliberation methods to environmental management and public policy problems. It combines analytical methods drawn from decision analysis and applied ecology with insights into human judgment and behavior from cognitive psychology, group dynamics, and negotiation theory and practice. The primary purpose of an SDM process is to aid and inform decision makers, rather than to prescribe a preferred solution.

In more everyday terms, we think of SDM as an organized, inclusive, and transparent approach to understanding complex problems and generating and evaluating creative alternatives. It's founded on the idea that good decisions are based on an in-depth understanding of both values (what's important) and consequences (what's likely to happen if an alternative is implemented). Designed with groups in mind, it pays special attention to the challenges and pitfalls that can trap people working together on emotionally charged and technically intensive problems – mental shortcuts and biases, groupthink, positioning, and a host of difficult group dynamics and communication challenges. Because it has decisions about public resources in mind, it emphasizes decision structuring approaches that

can contribute to consistency, transparency, and defensibility, particularly in the face of technical and value-based controversy.

Although SDM approaches could be applied to a range of public policy and management applications, our focus in this book is on problems involving environmental management and policy choices¹⁶. The examples we discuss span challenges related to the management of competing water uses, air quality, climate change, species at risk, pest outbreaks, cumulative effects, wildfire risks, parks and recreation, fish and wildlife harvest policies, oil and gas development, mining, water supply options and infrastructure investment. An SDM process can't guarantee great outcomes – both politics and uncertainty will influence what takes place – but it provides a sensible decision-making process for multi-dimensional choices characterized by uncertain science, diverse stakeholders, and difficult trade-offs.

Decision-making methods are often grouped into three categories¹⁷. 'Normative' methods define how decisions should be made, based on the theory of rational choice. The problem, of course, is that only rarely are people truly rational; instead, decisions usually reflect a mix of cognitive and intuitive or experiential responses. 'Descriptive' methods describe how people actually make decisions. They provide helpful insights about how and when decision-making processes need to be modified in light of how people typically form and express judgments. 'Prescriptive' approaches, such as SDM, suggest ways to help individuals or groups to make better decisions, based on decision theory but adapted for the practical needs and constraints facing real decision makers operating in the real world. This emphasis on practical, real-world solutions – to ensure concepts are understood, or analyses are undertaken promptly, or recommendations are implemented rather than stalled or ignored – is a theme that will recur throughout the book.

Although there are different types of environmental management decisions and different

deliberation contexts, the use of an SDM approach usually requires that each of the following questions is addressed:

- 1 What is the context for (scope and bounds of) the decision?
- 2 What objectives and performance measures will be used to identify and evaluate the alternatives?
- 3 What are the alternative actions or strategies under consideration?
- 4 What are the expected consequences of these actions or strategies?
- 5 What are the important uncertainties and how do they affect management choices?
- 6 What are the key trade-offs among consequences?
- 7 How can the decision be implemented in a way that promotes learning over time and provides opportunities to revise management actions based on what is learned?

None of this should look surprising – you may recognize these as the most basic of steps in developing or evaluating almost any significant choice: from buying a home, to choosing a name for a company, to developing effective public policy. The difference with an SDM approach is that each of these steps is undertaken formally, openly, and in a way that supports collaborative learning and defensible decision making.

In SDM, these core steps are used to structure and guide thinking about complex choices. Sometimes, the steps are used quite literally as a guide: an explicit step-by-step process that a group agrees to follow. This has the benefit of ensuring that everyone knows where they are and what comes next. At other times, they are used just to inform constructive thinking about complicated management problems – an individual manager or stakeholder with these steps in mind, learns to ask ‘what are our objectives?’, and so on.

The steps are supported by structuring tools and techniques that have been developed in the decision sciences over the past 50 years. These

structuring tools are designed to help individuals and groups deal with technically complex decisions and difficult group dynamics. Key SDM structuring tools that are almost universally applicable (and discussed later in this book) include objectives hierarchies, means-ends diagrams, influence diagrams, consequence tables, and elicitation protocols. Other analytical tools, such as Bayesian belief networks, strategy tables, decision trees, value of information calculations, or multi-attribute trade-off techniques are critical to some decisions but typically see more limited application. Economic methods (such as cost-benefit analysis), technical models (such as life cycle analysis or ecological risk assessment and modeling), or statistical uncertainty techniques (such as Monte Carlo simulation or sensitivity analysis), can all play a role in informing a decision, but do not of themselves constitute the decision-making framework.

What exactly is done at each step of an SDM process, to what level of rigor and complexity, will depend on the nature of the decision, the stakes and the resources, and timeline available. In some cases, the appropriate analysis may involve complex modeling or data collection spanning months or years. In others, it will involve elicitations of experts’ judgments conducted over several days or weeks. At other times, a half-day workshop to carefully structure objectives and alternatives may be all that is needed to clarify thinking about a particular decision. A key point is that structured methods do not have to be time consuming. Even very basic structuring tools and methods can help to clarify thinking, minimize judgmental biases, and improve the consistency of decision-making processes and the quality of their outcomes.

There are no ‘right’ decisions. The goal of SDM approaches is to clarify possible actions and their implications across a range of relevant concerns. In the context of environmental management, clarity is achieved by sound technical analysis, informed and transparent value judgments, and a process that engages people in recognizable best practices with respect to decision making.

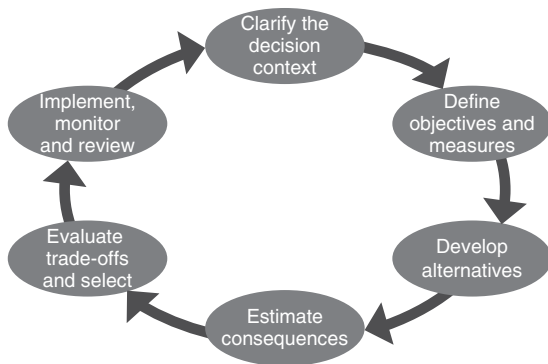


Figure 1.1 Steps in structured decision making.

1.2.2 What does a structured decision making process look like?

There are six core steps in SDM that usefully can be applied to nearly any environmental management decision, as shown in Figure 1.1. What exactly is done at each step will vary depending on the decision context. One of the most important lessons we have learned is the value of iteration. Get started, keep moving, and come back to refine previous work when you need to.

To help to familiarize you with the terminology we will use when discussing these steps, we'll refer to the simple and familiar situation of buying a flight ticket. We know this isn't really an environmental management question, but real problems quickly get complicated and our purpose here is primarily to establish a basic working vocabulary.

Clarify the decision context

This step involves defining what question or problem is being addressed and establishing the scope and bounds for the management decisions. At this early stage, it is important to answer three initial questions:

- 1 What is the decision (or series of decisions) to be made, by whom and when?
- 2 What is the range of alternatives and objectives that can be considered? – not the details

at this stage, just the general range and bounds: what's in and what's out.

- 3 What kind of decision is it and how could it usefully be structured? What kinds of analytical tools will be needed? What level and kind of consultation is appropriate?

This initial problem-structuring phase of SDM lays out a road map for the deliberations that follow so that all parties understand what will happen and when. A key technique at this point is 'decision sketching' – working quickly through the first steps of SDM at a scoping level to clarify what the decision is about and what will be required to make an informed choice. This is the focus of Chapter 3.

Define objectives and performance measures

Objectives concisely define 'what matters' about the decision; performance measures are specific metrics for assessing and reporting how well an

Text box 1.1: Example: buying a flight ticket

Suppose that, for whatever reason, you need to purchase a flight ticket from Vancouver to New York.

There is a surprising amount of additional information you need to know about the context of the trip before running to Expedia: *When is the trip? How flexible are the dates? Who's paying? Is there a travel budget?* You could also challenge constraints: *Do I really need to go – perhaps I could teleconference instead? Maybe we could meet halfway?* All of these details (and many more) need to be addressed in the 'clarify the decision context' phase of the process. Neglect these and other important questions, and your entire analysis could end up being useless.

For now, let's assume it's a personal trip – so you're paying, dates are somewhat flexible, you don't need to consult other family members, and teleconferencing isn't an option.

alternative performs with respect to an objective. Together, objectives and performance measures do two critical things: they drive the search for creative alternatives and they form a consistent and transparent framework for comparing them. They define key concerns related to ecological, social, cultural, economic, or health and safety considerations, to the extent that these might be affected by alternatives under consideration. They include important but hard-to-quantify values and outcomes as well as those more easily quantifiable.

Objectives and their corresponding performance measures must be carefully defined and accepted by key stakeholders as the basis for evaluating management alternatives. It's understood that different parties will attach different importance to different objectives, but weighting is not addressed at this stage; it will be addressed if and only if it's found to be necessary and useful as part of a later trade-off analysis. The goal of this initial stage is for participants to agree on what things matter and need to be assessed in order effectively to compare alternatives.

Of course, the word 'objective' is in wide use, and everyone thinks they have their objectives pretty well figured out. But to be useful for decision making, objectives need to follow a few simple but important rules. We provide some guidance and useful tools in Chapter 4. We devote an entire chapter (Chapter 5) to the development of performance measures, a reflection of how critical they are to a successful decision process.

Develop alternatives

In some decision contexts (like our flight ticket for example), identifying alternatives is a fairly passive affair – the alternatives are discrete things that are 'out there' waiting to be picked from a shelf. In many environmental management contexts, however, things are not so straightforward. Alternatives are usually complex sets of actions that need to be created rather than discovered. That act of creation is what SDM is all about – the

Text box 1.2: Example: buying a flight ticket

Still not ready for Expedia. Ask yourself: 'what do I care about in a flight ticket?' – perhaps it's one that leaves at a convenient time, flies directly, is inexpensive and comfortable. Maybe you'd avoid an airline with a dodgy safety record, or are interested in cancellation flexibility or reward miles? You could probably list dozens of items. But after reflection, suppose these boil down to three fundamental objectives that you'd base your decision on:

- 1 Minimize cost.
- 2 Minimize travel time.
- 3 Maximize comfort.

Now for performance measures: of your three objectives, cost should be straightforward to estimate (in dollars), as should travel time (in hours). Comfort is a bit trickier, so you'd need to come up with a scale that incorporated aspects of comfort that concerned you (e.g. legroom, in-flight entertainment options, etc.). Let's say we come up with a scale of 1 to 5, where 1 is the least comfortable, most basic seat you can imagine and 5 is the most luxurious surroundings you could expect for your budget and for the airlines flying this route.

development of creative alternatives that are responsive to the defined objectives. In contrast to economic or scientific approaches that focus primarily on valuation or risk, the focus in SDM is on identifying, comparing and iteratively refining alternatives. Alternatives should reflect substantially different approaches to a problem based on different priorities across objectives, and should present decision makers with real choices. In most environmental management contexts, it is important to search for alternatives that are robust to key uncertainties or that are likely to reduce them over time.

Text box 1.3: Example: buying a flight ticket

OK, now to the Internet. Let's suppose your search yields three candidate flights that could work within the dates that you want to travel.

With the alternative flights sorted out, we now have a start on a 'consequence table', which compares the alternatives in terms of the specified objectives and performance measures.

Objectives	Performance measures	Flight 1	Flight 2	Flight 3
Minimize cost	\$			
Minimize time	Hours			
Maximize comfort	Scale (1 = uncomfortable, 5 = luxury)			

In Chapter 7, we describe some methods for developing alternatives in the context of multi-stakeholder, multi-issue environmental management problems. In these situations, the number and diversity of alternatives can be overwhelming. And for decision makers some of them are scary – there is a fear of unrealistically raising both expectations and the costs associated with evaluating a large number of alternatives. SDM includes methods for both helping groups come up with a range of creative alternatives, organizing them to facilitate effective evaluation, and then iteratively simplifying and improving them.

Estimate consequences

At this step, the consequences of the alternatives on the performance measures are estimated. This is a technical task, undertaken by 'experts'. Who's an expert depends on the nature of the task, but for any given decision may include a combination of scientists (which we define broadly here to include natural and social scientists, economists and engineers) and local or

traditional knowledge holders. The presence of uncertainty complicates the assessment of consequences, as does the presence of multiple legitimate forms of expertise. Groups involved in an SDM process will need to be prepared to learn, to explore competing hypotheses, and to build a common understanding of what constitutes the best available information for assessing consequences. An honest and accurate representation of uncertainty based on a diversity of expertise will be essential. Consistent with the project goals, timeline and resources, attempts to reduce uncertainty may include collecting additional information, developing predictive modeling tools, or eliciting judgments about the range of potential outcomes from experts. Particular emphasis is placed on building an understanding of uncertainty as it affects the evaluation of alternatives. (Are some alternatives more uncertain or less well-understood than others? If so, how might these sources of uncertainty be addressed? Are management actions sufficiently flexible to incorporate what is learned over time?)

A useful tool for summarizing consequences is a 'consequence table'. Variouslly termed a decision table, objectives by alternatives matrix, or facts table, this deceptively simple tool presents the consequences of policy or management options in a matrix with objectives and performance measures on one axis and the alternatives on the other. In each cell of the matrix is an estimated value or impact score for the measure – the impact or distribution of impacts that is predicted to occur under that policy alternative – not unlike a consumer report comparison of stoves or vacuum cleaners. The level of rigor involved in estimating consequences can vary considerably depending on the nature of the decision. Some major decision processes may have months or even years of supporting analyses; others may require nothing more sophisticated than a one-to-five point scoring system sketched on a flipchart.

We discuss uncertainty in detail in Chapter 6, and key considerations in estimating consequences in Chapter 8. This book is not meant to

provide detailed technical guidelines on estimation methods; rather, we focus on approaches to developing a decision-relevant information base. In the context of environmental management problems, expert judgments will almost certainly play an important role. We provide guidance on how to elicit judgments from experts using best practices that minimize the effects of known biases, aggregate the judgments of multiple experts, and improve the consistency and transparency of judgments. We explore some ways to present probabilistic information and explore decision makers' risk tolerances. We'll touch on issues related to 'best available information', including practical ways to address calls for the democratization of science. We'll also discuss some of the difficulties that arise when seeking to evaluate consequences using information from both scientists and community (including

aboriginal) resource users, and we review considerations for leveling the playing field between these two important sources of knowledge. Here again, the treatment of facts versus values plays a central role.

Evaluate trade-offs and select

The goal of this fifth step is to choose an alternative (or set of alternatives) that achieves an acceptable balance across multiple objectives. Although an SDM process often delivers win-wins and synergies, most decisions will nevertheless involve trade-offs. Choosing a preferred alternative will involve value-based judgments about which reasonable people may disagree: are the incremental health benefits from cleaning up a contaminated site worth the incremental costs?; do the greenhouse gas reductions from a 'green' energy project outweigh its noise and visual impacts?; does improved protection from wildfires in a rural community offset losses in forest biodiversity that would result from proposed wildfire management actions? SDM promotes exposing and facilitating an open dialogue about these trade-offs.

Methods for making choices should allow participants to state their preferences for different alternatives based on credible technical information about the estimated consequences. There are a range of structured methods for this, some quantitative and some less so. Where the potential outcomes of choices are significant and controversial, formal multi-attribute methods can be used to bring clarity, consistency, and transparency to decision making. However, for most environmental management choices, decision makers will retain the discretion and responsibility for making difficult choices; although quantitative trade-off methods can be helpful aids, they should not serve as formulas to prescribe an answer. Further, for a large proportion of environmental management decisions, thoughtful structuring of the problem (in terms of the fundamental objectives and alternatives), sound estimates of consequences and associated

Text box 1.4: Example: buying a flight ticket

Describing consequences requires researching the best available information. The ticket prices should be easy enough, but what about the flight times? Do we believe the airlines' published figures? Is there some uncertainty (as shown for Flight 3) about the actual flight times? Perhaps we could do some digging around in travel forums to see how reliable they are. The comfort scale might also be a bit tricky to populate; can we find a suitable expert (e.g. an experienced traveler on this same Vancouver – NYC routing) to help us out? Even so, the comfort ratings might also be subject to some uncertainty.

Objectives	Performance measures	Flight 1	Flight 2	Flight 3
Minimize cost	\$	2000	1200	600
Minimize time	Hours	6	5	10–12
Maximize comfort	Scale (1 = uncomfortable, 5 = luxury)	3	2	1–3

uncertainties, and structured deliberations about key trade-offs will result in wise, well-informed choices without explicit weighting or formal quantitative trade-off analysis. And because SDM clarifies areas of agreement and disagreement among stakeholders and the reasons for these disagreements, the results of an SDM process are useful to decision makers whether a consensus is reached or not.

In Chapter 9 we discuss different approaches to making trade-offs and provide examples showing how groups have successfully used both quantitative and qualitative methods to aid their understanding. We also do a little myth-busting

Text box 1.5: Example: buying a flight ticket

Although we know that comfort is important to us, the consequence table shows that because of uncertainty it's not possible to know if there's any difference in the performance of alternatives. Unless we can refine this information, comfort can't help us decide anything. On the remaining two objectives, Flight 2 outperforms (dominates) Flight 1 because it's both quicker and cheaper. So, unless there are any other factors we're missing – and, at this point, it's always sensible to pause and ask yourself this question, whether something vital has been omitted from the analysis – we should eliminate Flight 1. Flight 3 takes between five and seven hours longer than Flight 2, but is \$600 cheaper. So the real choice comes down to this: is avoiding five to seven hours in an airplane worth \$600 to you?

This, of course, is a value question that will depend on your personal preferences and finances. Some people will prefer Flight 2, others Flight 3: the use of SDM approaches won't 'make the choice' for you, but they have successfully identified the key trade-off and laid out a consistent, defensible process for making this decision.

in this chapter as we show that there are rigorous ways to deal with values, and that you can – respectfully – ask people to justify, reflect on, and (at times) revise their expressed preferences.

Implement, monitor, and learn

A structured decision process should promote learning and build management capacity to make better decisions in the future. This learning may be related to technical understanding (for example, reducing uncertainty in the estimation of consequences), human resources (for example, training local community members in monitoring methods) or institutional capacity (for example, building trust and partnerships and/or developing systems for tracking and storing data).

Making decisions about things we care about can be hard at the best of times, and it's even more difficult if we're very uncertain about the outcomes. In such cases, an emphasis on learning over time, accompanied by a formal commitment to review the decision when new information is available, can be the key to reaching agreement on a controversial management strategy.

Particularly when resources are limited, it's necessary to focus on the most important sources of uncertainty, those for which reductions would be of greatest value. As discussed in Chapter 10, in SDM, monitoring programs are designed to address those uncertainties that are thought to be the greatest barrier to making an informed choice. To ensure their relevance to the choices facing decision makers, the results of learning should be closely linked to the objectives and performance measures used to evaluate management alternatives.

Learning in SDM doesn't just occur at Step 6. We believe that the ability of an SDM approach to facilitate mutual learning throughout the process – about both facts and values – is one of the key factors in its success. In Chapter 10 we emphasize the central role of learning throughout the SDM process and introduce some ideas for encouraging learning as part of the application of SDM to applied problems.

Text box 1.6: Example: buying a flight ticket

As noted, there is insufficient information to know which of the alternatives might be better for comfort, our third objective. If this was a one-off flight, there might not be much we could do about it. However, if we regularly traveled on the same route, we might want to purchase tickets on a different airline once in a while in order to learn more about the relative comfort ratings for each of the three flight alternatives. With uncertainty reduced, comfort might well come back into play and change which flight we prefer to take from then on. But would the price we pay for this additional learning really be worth it?

1.2.3 Who ‘does’ structured decision making?

As the case studies presented in later chapters will demonstrate, there is no standard formula for deciding who gets together to ‘do SDM’ or how many sessions should be held. SDM is a way of thinking and talking your way through complex choices and can be applied informally, with a few colleagues and a flipchart, or formally in high stakes decisions using advanced computer software and state-of-the-art technical analysis.

SDM approaches most often are used to structure decisions involving a group of 10–20 people who agree to work iteratively and collaboratively through the SDM steps in a sequence of perhaps three to eight meetings. In some cases, all of the participants are highly trained and may have worked together for years. In other cases, groups involve a mix of experts and non-experts who may or may not have met each other prior to the start of the process. There might be additional technical working groups or expert panels who provide input to the main group. There might be auxiliary public

Text box 1.7: What’s an ‘SDM practitioner’?

Often in this book, we refer to ‘SDM practitioners’. What we mean is anyone who wants to organize and lead a sound public decision process, participate meaningfully in it, or simply know whether it’s being conducted according to a reasonable standard of care. Often these people will be environmental managers or other decision makers, but the reference also covers any other government, city or industry employee, local resident, resource user, or interested party who is either directly involved in the environmental management process or concerned about its outcome and potential effects. There’s no single right way to conduct a decision process, and every process is limited by resources and timelines. But the methods in this book describe a sensible approach that can be used (and, as the case studies will attest, currently is being used) under a wide variety of conditions by people with varying degrees of experience and interests and training.

meetings or sessions with aboriginal groups or senior elected officials that take place in parallel. But there is an assumption that a core group of people is getting together repeatedly to work through a complex problem. Who are these people and how long does the sequence of meetings last? It depends. It could take a few weeks, with meetings attended by individuals within a single agency, corporation, or NGO. Or it could be an inter-agency group or a full multi-stakeholder contingent, with members coming from several regions or countries for meetings that span several months or even years. The key is that we envision a group of people who agree to work together, who seek to build a common understanding of a complex issue, and whose goal is to develop good solutions that can be implemented.

Text box 1.8: The language of environmental something

Sometimes the language commonly used in the world of resource management can inadvertently be off-putting people who have come to participate in a decision. Here are a few examples, based on our own experiences when words that we introduced with confidence were met, to our surprise, with frustration or anger:

- 1 *Resources*. To some, this word denotes a commodification of the natural world. Trees, water, and wildlife are not resources, they are the essence of life.
- 2 *Management*. To some, this word denotes failure¹⁸. The only reason we need management is to try new approaches to make up for past mistakes, but why should our current attempts be any more successful? Planning can have a similar connotation.
- 3 *Choices*. To some, a choice is very limiting; decisions can be wide open, but once the language of choice is introduced it means that someone already has limited the options or presented an ultimatum.
- 4 *Process*. To some, saying SDM is a process means that we're introducing yet another long-winded, self-serving, convoluted approach that might work elsewhere but won't work here. As we've been told by stakeholders on several occasions at the start of our work, 'we already have been processed to death – what we want now are results'.
- 5 *Analysis*. To some, introducing the word analysis means that decision-making power will be taken out of their hands. Analysis is seen as another way that outsiders seek to control resource decisions and to be secretive about what is really taking place.
- 6 *Trade-off*. To some, the word trade-off doesn't mean careful value-based balancing but, instead, is synonymous with an imposed loss or sacrifice. It means something of value is about to be stolen from individuals, their community, or the natural environment in which they live.

Anyone who has worked with multi-interest stakeholder groups on environmental issues could add to this list. Our intent is not to be comprehensive; instead, we emphasize the need to be sensitive to the prior experience of participants and ready to be flexible in the terminology that's used.

1.3 Case study: using structured decision making to develop and evaluate creative water-use strategies

In the beginning of this chapter we described the water-use planning process in British Columbia, Canada. Twenty-three water-use plans were developed at large and small facilities throughout the province, all using an SDM process. Each one progressed a little differently. Some were developed over the course of three or four meetings in four to six months. Others required a dozen or

more meetings over one to two years. Here we describe one typical example, with the goal of demonstrating how the steps of SDM just outlined are applied in a situation much more complex than buying an air ticket. It's an example involving a great deal of technical analysis of the consequences of alternatives. For an example of a more qualitative application of SDM, see the case study at the end of Chapter 11, where SDM is used to help communities in a rural African community to choose drinking water filters. Other case studies demonstrating particular steps of SDM are included throughout the book.

1.3.1 *Decision context*

Consider a large hydroelectric facility located in a rural part of British Columbia, Canada¹⁹. A dam forms a large reservoir, and power generation operations affect both the water level of the reservoir and water flows in the river below the dam. There are longstanding conflicts about how water should be managed at the facility. Competing interests are related to fisheries (in the reservoir and the river), wildlife (especially wildlife that uses the riparian areas along the river and reservoir), revenues from power production (which flow through the crown-owned utility to the provincial government), cultural sites located in the drawdown zone of the reservoir, and opportunities for recreational use and quality (boating, bird watching, picnicking, etc.) at sites along the river or reservoir.

Facing public controversy and impending court challenges about how facilities are operated, the utility invites a diverse range of people to participate in a SDM process to explore and make recommendations about alternative ways to manage water at the facility, with the ultimate goal of finding a better balance among competing interests. Participants include the energy utility, the provincial and federal regulators for fish and wildlife, the provincial treasury board, local communities and the First Nation²⁰ on whose territory the facilities lie. A set of 'water-use planning guidelines' prepared by the utility in partnership with the provincial and federal governments establishes the ground rules for this consultative process, outlines the SDM process that will be used in a multi-stakeholder context to develop recommendations, and describes how those recommendations will feed into formal regulatory approval and water licensing processes²¹. The mandate is to identify and evaluate 'water-use' alternatives at the hydroelectric facility – that is, alternatives related to the elevation of water in the reservoir and the timing and magnitude of flow releases from the dam. Alternatives related to structural changes to the facilities or upstream watershed management

activities (such as land use or forestry practices) are therefore out of scope. At minimum, the multi-stakeholder committee is required to evaluate and address the impacts of proposed flow changes on electricity revenues, fisheries, flooding and First Nations communities; other items can be considered at the discretion of participants, but these four items are required. A budget and timeline for the process is established. An SDM facilitator and analyst is selected who is responsible for ensuring that all the essential elements for an informed decision are addressed, with emphasis on the effective integration of technical analysis into the deliberative multi-stakeholder process.

1.3.2 *Objectives and performance measures*

Participants arrive at the first consultative committee meeting with a messy and emotionally charged list of issues and concerns. One of the first tasks is to turn these into a set of fundamental objectives and associated performance measures that can be accepted by all participants as the basis for identifying and evaluating alternatives.

By emphasizing careful structuring, especially the separation of 'means' and 'ends', and the development of a common vocabulary so that people can communicate effectively, the group relatively quickly reaches agreement on a set of fundamental objectives. While they almost certainly don't agree on the relative importance of these objectives, they don't need to. They all agree that these are important considerations when choosing among water-management alternatives – establishing this common ground helps to create a more collaborative environment.

The discussion turns to defining performance measures – specific metrics for assessing and reporting the effects of alternatives on the objectives. This is a complex task, requiring both technical and value-based judgments, and takes substantially more time. Upon conclusion, the group has a clear set of objectives and performance

Table 1.1 A clear set of objectives and performance measures to serve as the basis for identifying and evaluating alternatives.

Objectives	Measured by
Maximize the abundance and diversity of fish in the reservoir	Primary productivity, in tonnes of carbon per year
Maximize abundance and diversity of fish in the river	Spawning habitat, in square meters
Maximize the quality of riparian habitat for wildlife	Frequency of stranding events (days per year)
	Inundation duration of riparian zone in days per year (during the growing season only)
Minimize losses in the value of power	Annual revenue from electricity sales in levelized dollars per year
Maximize access to culturally significant sites	Frequency of access, in days per year
Maximize quality and quantity of recreational opportunities	Quality-weighted annual recreation days (where quality weights were assigned by recreational users as a function of reservoir levels)
Minimize flood damage to infrastructure	Return period of a 'major' flood in years (where major is a flood that will affect infrastructure in a nearby community)

measures that all agree will serve as the basis for identifying and evaluating alternatives (Table 1.1 above).

1.3.3 *Alternatives and consequences*

To generate alternatives thought to be worth considering, the consultative committee breaks into subgroups. They use an approach called value-focused thinking to generate 'bookend' alternatives. The subgroups include people with diverse backgrounds and world views – fish and wildlife biologists, power engineers, local residents, traditional knowledge holders. Working through the objectives one at a time, they generate alternatives that would be good for that objective alone – without consideration of the trade-offs that might be required to balance with other objectives. Initially, this generates some alternatives that are quite polarized – a 'fish friendly' alternative for example and a 'power friendly' one. While these aren't very good candidates for a balanced solution as-is, they generate creative ideas, especially when combined with the cross-disciplinary thinking as a result of participants having a range of technical backgrounds. Some of these creative solutions ultimately form the basis for

unexpected win-win opportunities – water use changes that simultaneously benefit *both* power and fish, for example²².

The generation of alternatives progresses through several 'rounds'. Elements of the initial bookend alternatives are combined with other ideas to create hybrid alternatives that seek a balance among all the competing alternatives. Models are developed to predict the consequences of each alternative with respect to each performance measure and the results are summarized in a consequence table. Alternatives are iteratively refined, eliminated and re-combined by the committee to form new and better alternatives. In some cases this process results in eliminating apparent trade-offs and replacing them with win-wins; in other cases, it exposes irreducible trade-offs. As inferior alternatives are eliminated, some of the performance measures initially identified become irrelevant – they are no longer affected by the refined alternatives and can be eliminated from subsequent analyses. This allows participants to focus in on key trade-offs. Flooding for example in this case is eliminated early as none of the proposed alternatives affect it. Wildlife concerns and recreational opportunities were initially very useful for helping to design good