

MAKING SMARTER ENVIRONMENTAL MANAGEMENT DECISIONS¹

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ABSTRACT: This paper outlines a sound, practical approach for making more informed decisions about environmental policy choices. It emphasizes the importance of using a structured decision process to specify and organize values, use these values to create alternatives, and assess tradeoffs to help achieve a desired balance across key objectives. Although these decision making steps are based on common sense, they are often neglected or poorly carried out as part of the complex evaluations of natural resource options. We discuss several reasons for this frequent neglect of decision making principles and provide examples from recent water use planning projects to demonstrate some of the benefits of using a structured, decision focused approach: new and better solutions, increased and more productive participation by stakeholders, and greater defensibility and acceptance of the resource management evaluation process and its conclusions.

(**KEY TERMS:** decision making; objectives; tradeoffs; alternatives; environmental management; resource managers.)

INTRODUCTION

Important decisions are made throughout the design, development, and implementation of any action or management policy that influences the use of environmental resources. Resource managers and scientists involved in water management decisions, from fisheries biologists to forest extension agents and restoration ecologists, have a key role to play in many of these choices. The ability to make smart decisions is fundamental to the success of any resource manager.

What tools are available to help managers make good decisions? Most professionals have taken courses in economics, psychology, statistical methods, or project management. However, the elegant ideas encountered in these courses are not used as often as we

think they should be. Instead, the process by which water (and other environmental) management decisions is made often ignores basic principles of sound decision making. Why are insights from the decision sciences largely neglected? There are many possible reasons; here we mention four of the most prominent.

First, many people trained in the natural or physical sciences were taught, whether subtly or overtly, that different standards of logic and proof exist in the social sciences. At its worst, this perspective creates a rift between the “science” practiced by the forester, biologist, or ecologist and the “art” practiced by the psychologist, economist, or policy analyst. One is seen to be hard science, the other soft; one is objective, the other subjective; one is consistent and subject to universally applied standards, the other idiosyncratic and situation specific. It is not surprising that one consequence of this biased point of view is a diminishment of interest on the part of many natural scientists in the methods and techniques of the social scientist, particularly as regards something often considered to be so personal as decision making, choice, or judgment.

Despite this bias, good decision making lies at the heart of good science: No quantitative model can be developed or used without a qualitative foundation that describes what is important to include. As a result, even the most “objective” or “scientific” of decisions rest on a base of subjective choices that are made concerning which data to include, what people to ask questions of, which criteria to use when evaluating alternatives, and what methods to use in a statistical analysis. Typically, many of these choices are made out of habit, because professionals often don't

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recognize that they have the opportunity to make decisions. And many times scientists or managers will disagree about components of these decisions, which is a natural (and healthy) byproduct of differences in the qualitative and subjective assumptions that lie at their core.

A second, and related, reason why decision making techniques are rarely employed is that natural scientists often are exposed only to the traditional literature of the social sciences, which focuses on the development of sophisticated models and a mathematical presentation of concepts, and are not provided with opportunities to study the rich body of more applied social science work. As a result, the vast majority of resource managers do not feel that they have been informed by the underlying social science theory, which is not felt to be operational in the sense of providing useful insights into real problems. Another impression created by this overly theoretical emphasis is that the ideas can only be applied in the real world by employing specialists (e.g., specialists trained in economics, psychology, or negotiations), which (by implication) leaves nonspecialists largely free to ignore them.

Other natural scientists, lucky enough to have some exposure to applied social science findings, may be left with the misperception that social science techniques are largely common sense (and, therefore, not meriting careful study) rather than, as is more correctly the case, reflective of common sense. One reason is that many of the essential insights have been around a long time; those familiar with the work of Charles Lindblom, Gilbert White, Ward Edwards, or Herbert Simon from the late 1950s will recognize many of the concepts basic to policy evaluation approaches used today. Another reason is that many of the basic findings in social science have been popularized (e.g., Lindblom's concept of "muddling through" or Simon's concept of "satisficing") and appear familiar to many people, although, as has been found sadly to be the case in many applied settings, casual familiarity is not a substitute for deep thinking or a thorough knowledge of techniques.

Third, even for those resource managers with some training in economics, psychology, or policy analysis, the dominant model used for purposes of evaluation is that of cost benefit analysis. A cost benefit framework is able to include many facets of a natural resource initiative, but it does so by collapsing the different types of possible impacts into the single measure of dollars. This approach is fundamentally different from one that employs multiple metrics to assess the different dimensions of a problem and explicitly looks at conflicts in achieving these objectives, such as decision analysis or multicriteria decision methods. Such decision focused approaches are particularly useful

for evaluating water management options because a key element of most problems facing managers is the need to deal explicitly with multiple dimensions of the anticipated (or realized) ecological, economic, and social impacts of planned actions in light of the multiple perspectives of resource users.

A fourth reason for the neglect of decision making opportunities by resource managers is more subtle and, in many ways, counter intuitive. The recent popularity of stakeholder participation as part of many resource based decision making contexts has had the unintended result of focusing managers' interest on the outcome of group discussions, negotiations, and dispute resolution processes. One problem is that many resource managers naively assume that a wiser choice necessarily will emerge from a group discussion. Unfortunately, there exists little support for this idea. If individuals within the group are left to make complex choices unaided, then there is no reason to expect clarity to emerge. In fact, a rich body of psychological literature supports the contrary hypothesis, that group participation often encourages people to conform and can result in erroneous choices that fail to address individuals' priority concerns or to explore sufficiently the wisdom of minority views (Russo and Schoemaker, 1989).

A second problem with reliance on stakeholder input is that, in most cases, the lead role in grappling with the inevitable mixture of economic, environmental, and social issues is left to an outside consultant such as a group facilitator or, in some cases, a resource planner. The need for decision making assistance at the individual level is therefore largely neglected, following the premise that the role of the resource manager is to put forth technically competent options while leaving the tough choices and concerns about integrated decision making to others. This division entirely neglects, however, the importance of good individual decision-making skills to the resource manager. It also overlooks the diversity of approaches used in working with stakeholders: just as a water manager's knowledge of the physical sciences will help him or her to select the best consultants in fisheries biology or ecology, so will a basic knowledge of the decision sciences help in selection of the most appropriate group facilitator or resource analyst.

A STRUCTURED APPROACH FOR MAKING DECISIONS

Vast strides have been made over the past 50 years to improve both the theory and practice of decision making. Insights have come from two principal sources, behavioral decision research (BDR) and

decision analysis (DA). The BDR side of this work has taken a descriptive focus and points out many of the reasons why people tend to be “quite bad at making complex, unaided decisions” (Slovic *et al.*, 1976). These results show that individuals systematically employ cognitive shortcuts and have little instinctive ability to structure decision tasks (Simon, 1990), clarify objectives (March, 1978), or recognize the role of contextual or task-related influences on their choices (Payne *et al.*, 1992). The DA side of decision making studies has focused on how prescriptive techniques can be used to improve the quality of individual and group choices. This work includes value structuring approaches based in multiattribute utility theory (Keeney and Raiffa, 1993) that help people to identify key concerns and their relative importance in the context of the problem at hand. This values based information then can be combined with knowledge of the anticipated probabilistic consequences of different actions for each of the identified environmental, economic, social, or other objectives (Von Winterfeldt and Edwards, 1986).

In recent years, several of the leading researchers in decision making have applied these descriptive and prescriptive insights to problems typically faced by individuals and managers. Examples include *Judgment in Managerial Decision Making* (Bazerman, 2002) and *Decision Traps* (Russo and Shoemaker, 1989). Some of the structure of this paper is adopted from the book *Smart Choices: A Practical Guide to Making Better Decisions* (Hammond *et al.*, 1999), which explains and applies structured decision making methods to a variety of personal choice and management problems. Other examples that focus on specific environmental and water management contexts address the development of environmental impact statements (Gregory *et al.*, 1992), energy policy (Keeney *et al.*, 1990), biodiversity issues (Maguire and Servheen, 1992), land use development options

(Gregory and Keeney, 1994), sewage and waste treatment (McDaniels, 1996), and estuary protection (Gregory, 2000).

A common link among all these applications of good decision making approaches is that the essential insights are accessible to all thoughtful resource managers regardless of their specialty. To strike a balance between theoretical rigor and application usefulness, our own work (as reported in this paper) has led us to stress *qualitative* guidance for how to think clearly to make a smart choice rather than *quantitative* analysis to make an optimum decision. We recognize that it is worthwhile to quantify important concepts such as the probabilities of events, desirabilities of consequences, and tradeoffs among competing objectives, and for these aspects of decision analysis specialized techniques are needed. But for nonspecialists the main use of the approach should be to improve thinking and sharpen communication about the critical elements of resource management decisions, rather than to encourage any subsequent mathematical analysis.

A structured decision making approach helps resource managers by splitting a tough decision into its parts (referred to here as “elements”). For many complex decisions, making a better choice requires that eight key elements be considered (see Table 1). The first five elements – Clarifying the Problem, Identifying Key Objectives, Creating Alternatives, Assessing Consequences, and Explicitly Addressing Tradeoffs (leading to the acronym PrOACT, a reminder to be proactive) – constitute the core of a structured approach to decision making (Hammond *et al.*, 1999). The remaining three elements – Uncertainty, Risk Tolerance, and Linked Decisions – are more specialized concepts that are well known to many professional managers (and are not described further here).

It is useful to recognize that most practical problems can be analyzed without going through all the

TABLE 1. Elements to Make Smarter Decisions.

Problem	Define your decision problem to solve the right problem.
Objectives	Clarify what you’re really trying to achieve with your decision.
Alternatives	Create better alternatives to choose from.
Consequences	Describe how well each alternative meets your objectives.
Tradeoffs	Equate the value of different levels of achievement on different objectives.
Uncertainty	Identify and quantify the major uncertainties affecting your decision.
Risk Tolerance	Account for your willingness to take risks.
Linked Decisions	Plan ahead by coordinating current and future decisions.

Adapted from *Smart Choices: A Practical Guide to Making Better Decisions*, by J. S. Hammond, R. L. Keeney, and H. Raiffa, Harvard Business School Press, Boston, Massachusetts, 1999.

eight elements. Often, clear thinking on one element may resolve the decision completely. Sometimes a manager will just need to understand his or her objectives, create a better alternative, get the key tradeoffs straight, or know what the chances of some events really are. Then a smarter choice can be made.

An important observation from our experience with helping to develop and evaluate resource policies is the inadequate attention of almost all managers to establishing a logical foundation for making a good decision. Once you have correctly specified the decision problem, a sound foundation is established for identifying measurable objectives and for creating a wide range of alternatives to consider — the second and third steps outlined in Table 1. When either objectives or alternatives are inadequate, the usual result will be a poor decision. When they are clearly stated and complete, many decisions can be resolved using clear thinking and communication rather than quantitative analysis. In other cases, the objectives and alternatives create the foundation for resource managers to develop an appropriate quantitative model to provide additional insight to guide the decision.

SPECIFYING AND ORGANIZING OBJECTIVES

As Yogi Berra said, “If you don’t know where you’re going, you just might end up somewhere else.” Too often, resource managers don’t specify their objectives clearly and fully. As a result, they (and the community and technical stakeholders affected by the policy choice) fail to get where they want to go. A frequent cause is the piecemeal nature of much environmental management, with physical scientists thinking in terms of good biology or fisheries or forestry outcomes and social scientists thinking in terms of good economic or cultural consequences. Problems frequently arise due to a neglect of the linkages and tradeoffs across these different dimensions and, as a result, a failure to specify the full range of relevant objectives.

An example comes from a recent estuary restoration project at Tillamook Bay, on the Oregon coast (Gregory and Wellman, 2001). The EPA funded group charged with developing the estuary management plan faithfully performed the background scientific analyses they felt necessary and used this information to propose a set of key activities. Unfortunately, many of these actions were opposed by members of the local community due to their worries concerning the resulting nonenvironmental effects (e.g., adverse economic and social impacts) and the lack of specific details regarding implementation strategies. What had occurred was a failure of the resource managers

to properly state all the objectives, which were not only to provide a rigorous scientific plan but also to maximize community acceptance of the proposals and to ensure speedy implementation of the key recommendations. This neglect of both acceptance and implementation objectives led to a plan that showed too little community participation, provided too little rationale for proposed actions, and included too few details about the proposed timetable or responsible implementing agency. As a result, it provides a case of resource managers failing to get where they wanted to go.

Similar situations occur frequently, for three main reasons. First, *many managers spend too little time and effort on the task of specifying objectives*. They feel they already know what is wanted and needed, which is often generally specified by some higher authority (e.g., a regulation or legislation). Without further reflection, they quickly pick an alternative that seems to “solve” their problem and they begin to implement it. Only then do they realize that they didn’t really understand the full set of appropriate objectives after all.

Second, *getting it right isn’t easy*. Objectives don’t just pop up in nice neat lists. While you might think you know what you want, some of the most important objectives may not be at all obvious. In particular, experts brought in from outside a community may not be aware of the past history of similar management efforts or of specific concerns that are held by community members. Only hard thinking, often assisted by a second party and a careful examination of the overall decision context, will reveal what really matters. This kind of selfreflective effort perplexes many managers and makes them uncomfortable. But the more relentlessly you probe beneath the surface of “obvious” objectives, the better the decisions you’ll ultimately make.

Third, *resource managers often take too narrow a focus*. Their list of objectives is limited and may omit important considerations that, perhaps, become apparent only after a decision is announced. There are three concerns here. First, typically resource managers concentrate on the tangible, substantive, and quantitative elements (cost, availability) over the intangible, procedural, and subjective (emotions, community participation, ease of implementation). “Hard” concerns therefore drive out the “soft.” Second, resource managers often define their job in terms of “what” needs to be done — establishment of a cleanup plan for a river, development of revised water flows for a hydroelectric facility, creating new habitat for a threatened fish stock — without paying sufficient attention to “how” the task will be achieved: the procedural aspects of the problem as compared to the substantive or content aspects (Simon, 1990). Third,

management decisions are often framed as one time decisions when, in fact, they involve a sequence of choices made over time. Later decisions should be reexamined in the light of what is learned as a result of the actions taking place earlier in the sequence.

Each of these concerns can be included through the careful definition of objectives; for example, by including process as well as content objectives, and by including flexibility and learning as key dimensions of a preferred plan.

Strategic thinkers since Benjamin Franklin in 1772 have long emphasized the need to clarify objectives as a key step in making informed decisions. More recently, Peters and Waterman (1982) refer to their “one all purpose bit of advice for management” in the pursuit of excellence as “figure out your value system.” However, figuring out a value system requires more than simply listing objectives. Identifying and organizing objectives is in part an art, but it’s an art that can be practiced systematically by following and iterating among these four steps.

Write Down the Concerns You Want to Address

In making your list, don’t worry about including both major concerns and ones that seem trivial. Early in the process, too much orderliness will only inhibit your creativity. Also, it is all right to say the same thing in different ways. Rephrasing the same concern may help you to uncover important nuances. Use as many ways as you can think of to jog your mind about present, future, and even hidden concerns. Useful techniques include:

Composing a wish list – Describe everything that you could ever want from this decision. What would make you (and, in turn, other interested parties) really happy?

Thinking about the worst possible outcome – What do you most want to avoid?

Considering a great alternative, even if it may prove unfeasible – Ask yourself: What’s so good about it?

Thinking about how you would explain your chosen alternative to someone else – How would you justify it?

Talking to people who have faced similar situations and asking what they considered when making their decisions.

When facing a group or stakeholder decision, it is generally best to first have each participant involved follow the above suggestions individually. Then their lists can be combined, using the varied perspectives to expand and refine first take ideas. By initially freeing each participant to search his or her mind without being limited by others’ thoughts, the result will be a more comprehensive list that more accurately reflects everyone’s concerns.

Convert General Concerns Into Succinct Objectives

To become fully operational and ensure they are well understood, general concerns need to be defined succinctly. The clearest and most easily communicated form for objectives is typically a short phrase consisting of a verb and an object, such as “minimize economic costs” or “mitigate environmental damage.” A more complete set of identifying objectives is shown in Table 2, which concerns Land Use Development Options for a proposed development in Sabah, Malaysia.

In our experience, vague expressions of objectives are often a primary reason for frustration among resource managers or stakeholders and can mask unintended differences in meaning. For example, in a project the first author undertook in the early 1990s, two different groups participating in the development of a plan for exploratory drilling of off shore oil and gas reserves in Alaska both cited “jobs” as an important consideration. However, on closer examination one group cared most about the number of jobs (and therefore proposed plans with high numbers of seasonal workers) and the other group cared most about the stability of jobs (and therefore preferred plans with year round employment, even if this meant lower numbers of jobs). Only once this distinction became clear could the two sides talk effectively with each other.

An important consideration for resource managers is to include all relevant objectives as part of the decision, not just those that may be considered legitimate or science based. For example, time constraints may be an important consideration in selecting a preferred alternative, and if not included in a list of program objectives may result in an unsuccessful initiative. Some concerns may be omitted inappropriately because they are considered obvious, such as compliance with local, state, and federal laws. Coordination with the programs of other agencies is another example of an objective that may be important but is often not made explicit.

TABLE 2. Land-Use Alternatives in the Maliau Basin, Sabah, Malaysia.

In the summer of 1992, we conducted a multiple stakeholder workshop in Malaysia to discuss future development options for the Maliau Basin, a pristine area located in the central region of the state of Sabah. The charge given the workshop was to add insight to the choice between two options, a preservation option (conserving the unique natural attributes of the area) and a mining option (developing rich coal reserves). We began the workshop discussions by focusing on the values and concerns of participants, and by the end of the three-day session it became obvious that the two-way framing of future options was extremely limited because better alternatives could be created using the expressed values of participants as a starting point (Gregory and Keeney, 1994).

Fundamental Objectives

Minimize Adverse Social Impacts

- To health
- To culture
- To education
- To crime levels
- To standard of living

Minimize Adverse Environmental Impacts

- To species, flora, and fauna (rare, endangered, threatened)
- To biodiversity and ecological services
- To human experience (scenic beauty, wilderness, noise)

Maximize Direct and Indirect Economic Benefits

- To local area (within 25 kms)
- To region (Kalabakan region)
- To state (Sabah)
- To nation (Malaysia)

Maximize Positive Political Impacts

- To public opinion
- To political stability

Maximize Increase in International Prestige

- Demonstrate commitment to development
- Demonstrate commitment to conservation
- Maintain peaceful relations with neighboring countries

Means Objectives (partial list)

- Increase water quality
- Promote discovery of new drugs
- Minimize land degradation
- Increase industrialization of region
- Maximize resource rents to government
- Protect indigenous cultures
- Maintain water catchment
- Protect endangered species
- Control flow of illegal immigrants
- Diversify economic base
- Minimize transmission of disease
- Minimize foreign control of resources
- Enhance fisheries populations
- Minimize waste products

Separate Ends (fundamental objectives) From Means

Once an initial, rough list of objectives has been drawn up, they will need to be organized so as to distinguish between objectives that are means to an end and those that are ends in themselves. The best way to separate means from ends is to follow the advice of the common Japanese saying, *You don't really understand something until you ask five times "Why?"* Simply ask "Why?" and keep asking it until you can't go any further.

Consider again the land use case study we worked on in Malaysia (Gregory and Keeney, 1994), involving an isolated area that was slated either for preservation (as a pristine tropical rainforest) or for mining (of rich coal reserves). One obvious objective was to "minimize waste material." But was this objective an end or a means? To find out, we repeatedly asked the participating stakeholders "Why?"

So why do you want to minimize waste material?

Because it will reduce emissions to the environment.

Why is this important?

It will limit human and environmental exposure to the materials.

Why is this important?

Because exposure can damage water quality and people's health.

Why is water quality an important concern?

Because it affects biodiversity and the maintenance of ecological services.

Why are biodiversity and ecological services important?

Biodiversity and ecological services just are important.

And why is health damage an important concern?

Health damage just is important.

This conversation shows that biodiversity and ecological services and health damage are fundamental end objectives; the other objectives are means for getting there. Asking "Why?" will lead you to what you really care about – your ends objectives, as opposed to your means objectives. *Means objectives* (for example, water quality) represent way stations in the progress toward a *fundamental objective*, the point at which you can say, "This is important for its own sake." Fundamental objectives constitute the broadest objectives directly influenced by your decision alternatives.

Clarify What is Meant by Each Objective

Once a solid list of fundamental objectives is obtained, it is necessary to refine the list by asking “What do I really mean by this?” Asking “What do I mean?” leads to the development of measures that enable you to identify the components of your objective and better understand it. This in turn will help you to state the objective more precisely and see more clearly how to fulfill it. In addition, when it comes time to choose, you’ll be better prepared to appraise how well the objective will likely be achieved.

For many objectives, the bottom line meaning will be obvious. “Minimize cost,” for example, means just that: Spend the least possible number of dollars. The meaning and measure of other objectives can be more elusive. For example, you may want to “minimize adverse ecological effects” in a lake due to runoff of fertilizers from adjacent agricultural lands. But exactly which ecological effects? To what species: terrestrial or aquatic? Is the concern with threatened and endangered species or is it more broadly focused on biodiversity? And is the concern with ecological services or is it with compliance and the ability to avoid costly shutdowns of operations? Or, as another example, you might want to “promote your company’s (or agency’s, or university’s) image.” But what do you mean by company image? Is it how highly rated your products are in comparison to your competitors? Is it the percentage of sales that enjoy international certification? And what is the intended audience: in whose eyes do you want your image to be promoted? It is important to think hard about such questions to clarify your objectives.

CREATING ALTERNATIVES

Alternatives represent the range of potential options for satisfying the identified objectives. The order is important here: alternatives follow objectives in the sense that they provide a means for achieving what has been identified as important. This value focused emphasis (Keeney, 1992) is in marked contrast to the more usual alternative focused emphasis, in which a decision problem is viewed as a choice between alternatives rather than as an opportunity to think deeply to achieve more of what is desired. Thinking about objectives first can also broaden the range of alternatives that are considered. For example, a new type of seagrass that is more resistant to chemical contamination may be an ideal solution to your fisheries restoration problem, but if you’re unaware of it, you cannot choose it.

The payoff from seeking good, new, creative alternatives can be extremely high. Unfortunately, people don’t tend to think enough about their decision alternatives. As a result, too many decisions miss out on a more favorable set of consequences because they are made from a poor set of alternatives. While the common denominator in all these cases is lack of thought, the essential problem can take many forms.

One of the most common pitfalls is business as usual. Because many decision problems are similar to others that have come before, choosing the same alternative beckons as the easy course. You have been treating disease problems in a hatchery using the same product for five years, so it is easy to keep using it. But should you consider the potential gains of a newly available system? You have been running stakeholder meetings the same way since community participation in resource decision making became the norm. What you’re doing works reasonably well, but could altering your approach work even better? Business as usual often results from laziness and an over-reliance on habit or tweaking the status quo. With only a modest amount of effort and a minimum of risk, and by paying attention to the guiding objectives, attractive new alternatives might be found.

Many poor choices also result from relying on an easily accessible *default alternative*. Suppose you are not particularly satisfied with the data analysis technique you are using for an important part in an ongoing assessment of a field trial. A colleague has been searching for alternatives, but he is busy and knows the current approach is generally satisfactory and also uses a familiar software package. The result: you end up with the default alternative of using the current software. Finding ways to free up your colleague’s time may reenergize the search for a better alternative. In such cases, the default option may look much less attractive once a new, improved alternative is recognized. Every decision problem has multiple alternatives, even if it doesn’t seem to at first. What people really mean when they say “no alternatives” is “no alternatives better than the default option” — *yet*. Creating fresh alternatives requires some time and focused thinking.

The recent case of a relicensing plan for a hydroelectric facility in British Columbia, Canada, provides a good example of creating fresh alternatives (McDaniels *et al.*, 1999). Environmental interests on a representative stakeholder committee wanted to increase water flows over an existing dam to provide better habitat for resident salmonids. Yet the higher the water flow, the higher the cost in terms of the foregone production of electricity. At the flow levels desired initially by environmentalists, costs were considered to be prohibitive by both the community and the local utility. Yet further probing showed that high

water flows were only needed at a few times in the spring and late summer, principally to clean out accumulated silt and debris in the river bottom, whereas moderate water flows were sufficient for salmonid health at other times. As a result, a new alternative was created that allowed for higher, short term seasonal “flushing flows” but otherwise maintained moderate flow conditions.

Choosing the *obvious solution* is another pitfall. Suppose a state fisheries management agency has experienced significant loss of stream cover and a rise in soil erosion because of an increase in the incidence of forest fires. Additions to the equipment fleet could solve this problem, so a decision is made to buy more airplanes and trucks and to hire more pilots and drivers. However, this alternative is very expensive. Perhaps a little more thought would have resulted in the design of a much improved delivery system using existing equipment, or in the adoption of a new detection technique that would help to reduce the incidence of fires, particularly in key portions of the watershed, and also cost much less. As in this example, once one possible solution is found, it is a good idea to always look further so as to generate new alternatives that could lead to an even better solution. Some of the following techniques might be helpful.

Ask How You Can Best Achieve Your Objectives

Because objectives drive your decisions, you also can use them to guide your search for good alternatives by asking, for each individual objective (including both means and fundamental objectives), how they can best be achieved. Just as asking “Why?” distinguished means from ends, asking “How?” leads from ends back to means and eventually to alternatives. In this context, alternatives can be viewed as the ultimate means. *How* would you fulfill the fundamental objective “maximize the percent of total harvest obtained in a sustainable manner”? One answer: by maximizing the amount of money spent in developing promising new techniques for sustainable harvests. *How?* By funding three new researchers who also know local regulations and local sustainability certification requirements. This option then becomes an alternative, established by looking backwards to the organizing objectives.

Challenge Constraints

One of the frequent mistakes made in thinking about decisions is to assume the presence of hard constraints that may, in fact, be either irrelevant or soft

(in the sense that they can be removed or overcome without much trouble). Few constraints are absolute. As a simple example, suppose you’ve set a constraint of once per week for the routine delivery of needed supplies, in large part because you’ve grown accustomed to this timing. But suppose that you locate a high quality, less expensive supplier who can guarantee delivery every 10 days. It doesn’t meet your assumed constraint, but it may encourage you to reexamine your once a week assumption and, in the process, identify a better alternative.

One useful technique is to assume that a constraint doesn't exist and then create alternatives that reflect its absence. A utility company, for example, assumed that its proposed new power plant had to be on a waterway to ensure a sufficient supply of cooling water. Working within this constraint, it found that all of its alternatives would cost more than \$1.5 billion and result in significant environmental damage. Under pressure from environmentalists, the utility removed the waterway constraint and took a fresh look at its alternatives. Freed from its self imposed straightjacket, it identified an inland site that required pumping water a modest 12 miles. The result: a \$1.2 billion facility that caused only minimal environmental damage.

Avoid Common Psychological Traps

Research by cognitive psychologists has uncovered a number of psychological traps that can prevent us from seeing some of the most attractive alternatives (Tversky and Kahneman, 1974). For example, a common psychological trap is anchoring, which involves our tendency to make insufficient adjustments up or down from an initial starting value or mental “anchor” when thinking about numerical quantities and estimates. One implication of anchoring is the unexpected strength of worst case or best case estimates of the effectiveness of an activity or treatment, which may then inadvertently anchor later estimates.

Another frequent psychological trap is thinking about a situation in terms of its most salient example, under the dubious assumption that a situation easily recalled would provide a useful guide to understanding future circumstances. This availability bias leads us to overestimate the probability of highly visible or sensational events (e.g., toxic spills, plane crashes) and to underestimate the occurrence of less dramatic, more routine events (e.g., equipment injury) (Tversky and Kahneman, 1981). A third, and very common, psychological trap concerns sunk costs (Russo and Schoemaker, 1989). This trap occurs when prior expenditures of money, time, or other resources encourage people to make choices that they would

otherwise recognize as not in their best interests. The concern about sunk costs causes us to make choices in a way that justifies past decisions (and their associated sunk costs), rather than admitting – in light of what we know now – that the past choices were a mistake and should no longer guide our actions.

Think First on Your Own

A natural tendency in facing a complex management problem is to share opinions and discuss options with others. However, research in judgment and decision making has shown that it is useful to give your own mind free reign before consulting with others, because some of our most original ideas may be suppressed if they are exposed prematurely to others' ideas and judgments. Once you buy into another person's line of thinking, especially someone you consider to be an expert in the matter at hand, you may easily become anchored by what they say and your own thoughts may become less accessible.

One practical implication of this concern involves the elicitation of ideas from a group. It is often helpful for a leader or analyst to introduce a topic but then, before it is discussed, to ask each individual to take three to five minutes and write down what they think about it – depending on the task, to write down their objectives, or to write down their ideas about who might be the leading technical experts on the topic. These ideas can then be introduced into the discussion by going around the room and asking each participant to identify one (and only one) item from their list at a time. In this way, the diversity of ideas is preserved and the resulting discussion can serve to stimulate innovative new thoughts and connections rather than, as is often the case, to override and erode existing ideas.

Learn From Experience

Resource managers typically fail to learn from their own experience for a variety of reasons: the time frame within which decisions need to be made may be very short, there is a lack of accurate feedback from previous similar choices, or there may be institutional reasons for looking on each new decision as unique and one of a kind (which, in our experience, is rarely true). As a result, most managers fail to learn sufficiently from their own (and others') history. In many cases, particularly with access to the internet and world wide communication, it is relatively easy to find out what others have done in similar circumstances (although you don't want to fall into the "business as

usual" trap we noted earlier). In other cases, a one time decision problem can be reframed as a sequential decision in which learning is explicitly considered as an objective; the "adaptive management" framework used to address several large scale water management problems is a well known example (Gunderson *et al.*, 1995). Often, simply reserving funds for monitoring recommended actions – and providing an explicit decision pathway for reexamining management actions based on the results of the monitoring studies – can provide easy access to learning and improved decision making over time.

ASSESSING TRADEOFFS

Tradeoffs are at the heart of most controversial resource management decisions. Tradeoffs arise because we want more of all the good things simultaneously, and unfortunately getting more of some things that we want – such as increasing spawning habitat, decreasing costs, providing work opportunities, increasing sales, or not overexploiting a resource – also means getting less of some others. Dealing with these tough tradeoffs is therefore a technical task, requiring knowledge of the impacts of a selected alternative over the relevant period of time; an evaluation task, requiring valuing and balancing the different impacts across objectives; and a managerial task, requiring the ability to frame a tough problem and face its multiple dimensions clearly and comprehensively.

The coastal estuary project in Tillamook Bay, Oregon, again provides a good example. Community residents were wanting to restore local fish populations, which had been damaged by waterborne pollution from animal wastes, but also worried about the health of the local dairy industry and didn't want to impose an unnecessary cost burden on any one group. The problem was difficult for residents to think about because every benefit seemed to be offset by a cost. Typically, these involved different parties: what helped coastal anglers would hurt regional dairy farmers, and what helped the tourist industry would result in higher costs to forest operators. The solution was not to wait until the conflicts disappeared, because they wouldn't. Instead, a structured decision process allowed residents to work through the tradeoffs in a way that attempted to balance the competing objectives and interests and facilitated an informed choice among alternatives (Gregory and Wellman, 2001). As in many such cases, making the costs and benefits of a decision explicit allowed for adjustments through input to the initially proposed plan, reducing its negative aspects while maintaining nearly all of

the reasons why the choice was desired in the first place.

Tradeoffs in resource management decisions are most often thought about in terms of achieving a balance across objectives that describe positive and negative outcomes: economic vs. health impacts, or cultural vs. environmental effects. Understanding the technical information (e.g., impact studies, computer models, historical data bases) that will clarify the magnitude and probability of these impacts is obviously essential. Yet the technical information needs to address and inform tradeoffs that arise with respect to the values and objectives that are at issue.

Remembering a few common sense techniques of smart decision making can help resource managers make tough tradeoffs. Four steps in addressing tradeoffs have proven particularly helpful to our own work.

Search for Dominated Alternatives

One thing that simplifies the choice among alternatives is to eliminate some options because they are clearly inferior. The fewer the alternatives, the fewer the tradeoffs that will need to be made and the easier the decision will be. If one alternative A is better than another alternative B in terms of some objectives and no worse than B on all other objectives, then B can be eliminated from further consideration because it is dominated by A.

Pay Attention Only to the Objectives That Distinguish Among Alternatives

Stakeholders involved in resource management decisions often place great emphasis upon one or two objectives that typically matter most to them; for example, an environmental group will emphasize preservation of a natural area whereas a union group will emphasize employment opportunities. Yet consider the decision between two alternatives, one that would employ 100 workers and a second that would employ 101 workers. Even though the employment objective is important to union members, it is likely that, in this particular instance, the difference between 100 and 101 jobs is not useful as a means to distinguish among choices because the anticipated range of impacts is so small (in this case, the "range" or impact difference is only one job). From a decision making perspective, the objectives that matter in a specific context are those distinguished most clearly among the relevant alternatives.

Make "Even Swaps" Across Objectives as a Way to Simplify the Decision Under Consideration

If two or more alternatives are rated equally for a given objective (e.g., they all cost the same), then that objective can be ignored in choosing among these alternatives. This observation constitutes the heart of the "even swap" method for making tradeoffs, in which the value of one alternative is simultaneously increased in terms of one objective and decreased by an equivalent amount in terms of another objective (Hammond *et al.*, 1999). It is essentially a form of bartering across objectives, in which the value of one objective is expressed in terms of some other objective. For example, if stream restoration alternatives differ in terms of the amount of equipment and labor that are required, it might be possible to express equipment costs in terms of labor (i.e., you could "swap" two hours of a backhoe for 12 hours of manual labor) and thereby eliminate the equipment objective. By making this even swap, you make the decision easier by eliminating an objective. Such swaps may also allow you to find new dominated alternatives, using the remaining objectives.

Address Tradeoffs Across Process as Well as Outcome Objectives

As noted earlier, some of the most important objectives, and toughest tradeoffs, are encountered in process decisions, which concern how to do things, as compared to outcome decisions, which concern what should be done. For example, tough tradeoffs concerning the best use of time and resources can arise in the context of how to design a defensible resource impacts study, who to involve as part of an advisory committee, or how to decide which experts should be asked to contribute background information. Such process or procedural questions often lie at the heart of environmental management disputes and can have an important influence on the trust placed by participants in a decision or the willingness of stakeholders to support a proposed resource management plan.

CONCLUSION

The practical advice outlined here to structure objectives, create alternatives, and address tradeoffs has been used on many types of resource management problems. The range of applications to water resources problems includes drafting an integrated

resource management plan, designing a stakeholder consultation process for relicensing hydroelectric facilities, creating an ecosystem reserve, protecting municipal water supplies, creating a fair compensation or damage award as a result of rerouting a river, building new urban wastewater facilities, choosing the best stream restoration initiative, and reducing shoreline losses due to seismic risks. In each of these situations, the use of structured decision making techniques has helped resource managers to make smarter and more defensible choices. Reframing these management problems as decision problems – by addressing objectives, alternatives, and tradeoffs explicitly and openly – also helped to increase the scope for soliciting direct, meaningful input to the choice or policy development and, as a result, improved the acceptability of the resulting decisions (Slovic and Gregory, 1999).

Making good decisions is not the domain of a small number of specialists; it is a fundamental skill that can be learned and improved through practice. Yet few resource managers have had the opportunity, or have been encouraged, to develop their decision-making skills in the manner that we learn other skills such as using the internet, playing tennis, driving a car, or learning a musical instrument. For these other skills, we typically break our subject of interest (e.g., tennis) into elements (serve, backhand, forehand, net play, etc.). We next learn how to execute each element and we practice frequently in simple situations. Then we try to integrate these elements in interesting situations (a tennis game) to help us learn over time to play better and better. And we practice: even world class race car drivers, musicians, or tennis players have workout sessions and coaches and continue to train, to practice each element, and to improve.

For most people, and certainly for most water-resource managers, good decision making is more important for one's career and life than is racecar driving or tennis. In our opinion, it is worth treating decision making as a skill and working to improve it.

The elements of decision making we focus on in this paper would allow resource managers to sharpen their objectives, face tough tradeoffs, and create better alternatives. The ideas and techniques we present are easy to use and require no special training, but they do require some hard thinking and careful practice. They are designed to facilitate the meaningful involvement of, and contribution by, individual resource experts, management team members, and stakeholders in complex decision making processes. This not only contributes to a more complete expression of objectives and a more inspired set of alternatives, but it enhances the defensibility and acceptance of both the resource management process and its conclusions by a broad range of participants.

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