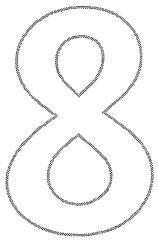

DECISION MAKING IN WILDLIFE MANAGEMENT

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Stop for a moment and think about any issue in wildlife management—about any other issue in your life for that matter. The issue might be as simple as selecting the type of boat you will need on a waterfowl refuge in the Midwest, or it may be as complex as multi-stakeholder deliberations about human–wild boar conflicts in suburban Berlin, Germany. What determines whether these situations are problems or opportunities? What can a wildlife manager do about them? If anything is going to happen, someone has to make decisions. Even choosing to do nothing—to make no management intervention—is a decision. Decision making is an essential task of management, including wildlife management; yet few students of wildlife management take a course in individual or group decision making.

This chapter aims to build your decision-making skills. It provides an overview of systematic methods for making decisions through the application of specific decision-aiding techniques. It also identifies common psychological traps that many people fall into when making decisions. Decision making in wildlife management ranges from small, easily described, and uncontroversial choices to those involving more consequential, complex situations about which reasonable people are likely to disagree, no matter which alternative is selected.

An understanding of decision making is particularly important in wildlife management because managers typically are required to address choices involving different dimensions of environmental, sociocultural, and economic impacts, and they are expected to make choices when uncertainty underlies almost every dimension. These choices are often controversial and affect issues and activities about which people are passionate. People involved in decision making frequently voice the opinion that science "makes" good decisions. Science is certainly a cornerstone of good decision making in wildlife management, but science can only inform decisions. Science cannot *make* decisions. People make decisions based on their values and their interpretations of available information.

Although most wildlife managers probably are not aware of this, the bulk of what they do every day involves making decisions. People are prone to do what worked well last time, last week, or last year. They simply react to the crisis of the moment. A lack of structure or rigor in decision making normally means choices are ill-defined in terms of how they are likely to affect the problem (the situation or context) or what the outcomes of various choices might be. Also left out too often are key concerns of stakeholders whose values might be affected by the decision outcomes. Researchers in psychology and judgment suggest there are only two ways to achieve a desirable outcome from a decision: follow a rigorous process or depend on being lucky.

8.1. FOUNDATIONS OF DECISION MAKING

Although it is not always obvious, a method is being applied whenever decisions are being made. In the last chapter, you were introduced to a way to map the management system that included several steps of decision making viewed within the larger context of management. Here, we examine the topic of decisions in more detail, review some common models, and suggest a simple yet effective approach for making better decisions.

Wildlife managers make, or are involved with others in making, more than one type of decision. They face a variety of different decision-making contexts, each of which carries its own challenges, demands, and opportunities. Sometimes managers are asked to recommend the best alternative from among a set of options. At other times, managers need to decide on a preferred sequence of actions, separating decisions into higher versus lower priority choices or decisions made sooner as opposed to later. Sometimes managers are asked to rank different alternatives or to decide whether an action is even within the category of things that they should be concerned about (as opposed to routing the decision to someone or somewhere else). A prevalent question is whether a choice is even theirs alone to make, or whether they need to confer with colleagues, partners, or stakeholders and resource users.

Another common judgment to be made is about information quality and whether there is enough information in hand to make a rational choice. Additional information may need to be acquired through consultation with other professionals or engagement with stakeholders. As pointed out in Chapter 2, to achieve good governance, managers increasingly are sharing decision making with stakeholders rather than only with wildlife experts.

Models of decision making vary with the context and the quality of information that is available on which to base decisions. A purely rational model assumes that managers and stakeholders know precisely what they want, that complete and accurate information about the consequences of management actions is known, and that all relevant management options have been identified. Yet this rational model neglects uncertainties associated with decisions as well as the limits of people's cognitive capabilities. Bounded rationality is the term proposed by Nobel Prize winner Herbert Simon to describe the limited applicability of a purely rational model of decision making. It assumes that not all information needed for a decision is known or can be known; therefore, rationality in a strict sense is bounded by the limits of what is knowable about a system, the cognitive capabilities of humans involved in the decision, and the time frame in which decisions must be made. As Simon (1990:7) wrote, "Human rational behavior is shaped by scissors whose two blades are the structure of task environments and the computational capabilities of the actor (decision maker)."

More recent research on how people make decisions emphasizes the role of heuristics, or mental shortcuts, as part of judgmental processes (Kahneman and Tversky 2000). Rather than being purely rational individuals, as traditionally portrayed in management and economics texts, humans exhibit systematic patterns in their thinking and judgment that work well in some cases, yet lead to misunderstanding or bias in other circumstances. One example is known as the availability bias. People think about an event most often in terms of the more readily available and salient information. This, in turn, misleads people to overemphasize recent or sensational information that they take in and to largely ignore normal conditions. As a result, the number of moose–vehicle accidents is overestimated after reading an account of a fatal crash, or the number of people hurt by accidents with moose is overestimated after seeing pictures of a collision on the news. Another example of bias is overconfidence. Humans tend to overestimate their confidence in our predictions about future events; yet most of us largely are unaware of the extent of this bias (Burgman 2005). The study of heuristics and biases in decision making is the subject of several best-selling books (e.g., *Predictably Irrational* [Ariely 2008]).

A practical model of decision making was proposed long ago by Lindblom (1959) in his paper titled "The science of muddling through." Lindblom proposed that although the literature on decision making promoted and formalized a purely rational approach, in practice (for many of the reasons already identified) it is virtually impossible for managers to achieve a rational approach in complex situations. Instead, Lindblom proposed a description of the process known as "incrementalism" for making decisions and formulating policy. Incrementalism assumes that the hallmark of rational decision making—seeking the single best or optimal solution for a decision problem—is not knowable, let alone achievable. Rather, incrementalism builds on clearly defined objectives to select and to implement alternatives such that changes in a system are achieved in small, incremental steps, thus leaving room for learning and revisions to management actions over time. Although incrementalism as a mode of decision making seldom keeps pace with the rates of change in a management system, it reflects the way bureaucracies function. Later in this chapter you will read about new models of decision making, such as adaptive management, that are evolving to stay abreast with changing management systems.

From a human dimensions perspective, a purely rational approach should be viewed with caution because the approach ignores management's inability to control the behavior of some people or entities whose actions will affect the outcome of decisions, regardless of what management or other stakeholders choose to do. In addition, the search for the perfect or optimal objective and management alternative before making a decision frequently is a factor in delaying action, and in some cases (particularly when wildlife populations are low or threatened, or stakeholders are incurring negative impacts from wildlife) a delay itself carries a cost. Scientists may not want to proceed before additional information is collected, but (as discussed later) managers may prefer to proceed on the basis of what already is known and to carefully incorporate new learning into ongoing actions.

A purely rational decision-making model may ignore how emotions affect decision making. Chapter 4 reviewed the role of emotions in social psychology, especially as an explanatory variable in the behaviors of stakeholders. Research in the decision sciences over the past 20 years reveals a powerful role for emotions in influencing decisions of all types made by all kinds of decision makers (Slovic et al. 2005). This research found that decisions generally are made using parallel but distinct ways of thinking. One is experiential and is based on intuition and beliefs; the experiential mode usually operates quickly and automatically. The other mode involves reasoning, operates more slowly, and is based on rational ways of making sense of information. A distinction between the two systems of thinking also has been explained in a number of best-selling trade books (e.g., Gladwell 2006). Reliance on dual modes of processing information is used by technically trained experts as well as members of the lay public. Although the distinction does not minimize the importance of careful analysis, the distinction does imply that models that do not consider the role of emotions are likely to provide an inaccurate view of decision making. The result can be a decreased ability of wildlife managers to anticipate how emotions affect stakeholder acceptance of decisions (Peters 2006).

8.2. STRUCTURED DECISION MODELS

A useful response to critiques of the rational decision-making model is to introduce a standard for good decision making: a set of steps that, if followed, provide a defensible basis for making good decisions. Effective decision-making processes for wildlife managers should account for two key aspects of choices in wildlife management: (1) values associated with wildlife and wildlife management are multi-dimensional and arise from different interests and concerns (e.g., values exist about environmental, economic, and social interests and concerns; see discussion of values and impacts in Chapters 1 and 4); and (2) usually a diverse set of participants or stakeholders may be affected by a wildlife management decision (Gregory et al. 2002).

One useful way to engage in value-based decisions is through structured decision-making (or SDM), a systematic way of decision making based on theoretical work in multi-attribute utility theory (Keeney and Raiffa 1993) and behavioral psychology (Hastie and Dawes 2001; Box 8.1). The highly readable book *Smart Choices* (Hammond et al. 1999) introduces a decision analytic approach as a sequence of five steps that form the acronym "PrOACT": define the Problem context, clarify Objectives or concerns, identify treatment Alternatives, distinguish Consequences in light of uncertainties, and evaluate key Trade-offs. Attending to these elements can guide you through a logical sequence of steps for an informed and defensible wildlife management decision-making process, serving as a useful aid to managers and policy makers engaged in selecting and communicating choices that lead to wildlife management actions.

8.2.1. Problem Definition

Wildlife managers try to ensure that actions they take achieve a desired, or at least a more desirable, end state in the management system—the condition of wildlife, habitat, or humans after a management intervention occurs. To determine what decision may lead to a better condition, it is imperative to know the current conditions, to have a desired condition identified, and to understand how and why any particular change might be helpful. This first step in decision making is often described as problem definition, problem bounding, context analysis, or what we called situational analysis in the last chapter (see description of the Manager's Model in Chapter 7). Prior to taking action, managers should have a clear idea of which components of the ecological and human systems might be altered, who might be affected by the decision, and to what extent these changes are likely to be perceived as beneficial or harmful. What you call it—situational analysis, problem definition, context analysis—is less important than making sure you do not follow the human tendency to skip this important first step of effective decision making.

The desired purpose of a situational analysis is to frame the decision-making situation by identifying potentially relevant impacts and describing the management environment in which these impacts occur. You read in Chapter 3 how different stakeholders are likely to frame a situation differently. A government wildlife agency might emphasize needs of achieving regulatory standards, such as those accompanying the Endangered Species Act. A local community might focus on jobs or restrictions in recreational opportunities. An industry might emphasize changes in profits or shifts in the production of certain goods. Conflicts in resource management frequently originate because of a lack of careful thought and explication at this initial problem definition and bounding stage.

A chief goal of most decision makers is to attain sustainable decisions. Sustainable decisions are ones that hold up through time and gain support of stakeholders. Sustainable decision making depends on abilities to summarize the most important elements of a problem, to assemble relevant facts, and to set priorities among the possible outcomes of their choices. The Manager's Model introduced in Chapter 7 is a process for generating a concept map of the management system. Development of a Manager's Model (Decker et al. 2011) or other device for articulating assumptions about the current situation and stating a desired future condition seeks to insure that managers are in agreement about what the problem or opportunity is and that everyone is working on the same core issues. If management processes (such as those described in Chapter 7) are followed, then stakeholders will play important roles at this early stage in identifying and obtaining data in a situational analysis as well as in defining objectives.

8.2.2. Objective Setting

Goals are general statements of intent about the purpose of management. In Chapter 2, we discussed governance as a framework within which wildlife management occurs as the act of orienting, steering, and adjusting organizations. Just as steering a ship in the absence of a chosen destination results in aimless wandering, governance and management cannot be effective (except by chance) without clear goals and objectives (the destination!). An example is the specific goal of bear management in New York, which is grounded in the five major goals of the overall state wildlife program (e.g., "assure that people are not caused to suffer from wildlife or users of wildlife"). Goals often are established through legislation and tend to be vague or abstract. That is, goals provide direction but are generally not quantifiable, nor is there always a realistic expectation that goals will be achieved. They provide guidance for defining a desired future condition, but leave wildlife managers the task of developing specific management objectives that are defined in sufficiently precise terms to direct and evaluate alternative actions in terms of achieving desired outcomes.

Objectives therefore describe what matters in a given situation, in terms of what might be affected with a realistic set of actions over a reasonable time frame. Decision-relevant objectives for any given decision situation are characterized by describing an object and a direction of preference (Hammond et al. 1999). Examples include "increasing the abundance of moose for viewing in a given area" or "increasing the amount of employment from wildlife tourism" or "minimizing the in-

Box 8.1 *STRUCTURED DECISION-MAKING*

Structured decision-making (SDM) is an approach to identifying and evaluating objectives and a set of alternatives to achieve those objectives based on trade-offs, assuming predicted consequences of alternatives. In environmental decision making, SDM combines the analytical methods of decision analysis (Keeney 1992) and applied ecology (Gunderson et al. 1995) with behavioral insights from psychology and the decision sciences (Kahneman and Tversky 2000). SDM is most commonly used to address environmental planning and resource allocation decisions characterized by multiple dimensions (that is, impacts that could occur over a variety of economic, environmental, social, health and safety, and cultural effects) and multiple participants (in many cases, involving different levels of government, industry, resource users, local citizens, and a variety of interest groups) in cases where there is uncertainty about the likely impacts of management actions. SDM approaches have been used to address a variety of wildlife and fisheries issues (Conroy and Carroll 2009, Gregory and Long 2009), implementation of adaptive management (Failing et al. 2004, Gregory et al. 2006), planning for climate change (Nichols et al. 2011), and consultation strategies involving diverse stakeholders as part of environmental planning (Gregory et al. 2012).

Structured decision-making has been used extensively in adaptive harvest management for mallards and other North American waterfowl (courtesy USFWS)

convenience of obtaining antlerless moose hunting permits." Usefulness of objectives is improved when they define (1) the direction (e.g., increase, decrease, stabilize), (2) an object (e.g., moose viewing opportunity), (3) a specific location (e.g., "Upper Peninsula of Michigan"), (4) the extent (e.g., 10%), and (5) a timeframe for achieving the objective (e.g., within 5 years). Thus, an objective stated as, "Increase moose-viewing recreation days in the Upper Peninsula of Michigan by ≥10% within five years" is more informative and measurable than a simple objective such as, "Increase the moose population." Developing a set of informative and measurable objectives is essential because they form the basis for evaluating possible management interventions. Objectives formulated with the participation of diverse parties are more likely to be broadly supported and easier to implement, which results in sustainable decisions (Gregory 2000). Our experience suggests the

process of formulating clear, acceptable objectives normally receives inadequate attention compared to its importance, although numerous techniques exist for determining objectives (Keeney 1992).

Two types of objectives support making smart choices. Fundamental objectives characterize the reason for management in terms of desired impacts. A fundamental objective answers the question, "Why is management necessary?" and is most effective when it reflects value-based thinking through defining impacts of concern. For example, a fundamental objective of black bear management could be to improve the psychological well-being of a community in which negative human–black bear interactions are frequent events. The second type of objective, an enabling objective, states how fundamental objectives will be achieved. A set of enabling objectives guides development and evaluation of management alternatives and interventions. An enabling objective in the black bear example could be to raise the level of awareness about ways to avoid conflicts related to black bears being attracted to food waste in garbage in that community.

Keeney (1992) provides a method for linking fundamental and enabling objectives through a listing of means–ends relationships. For each objective, participants in the decision-making process should ask, "Why is this important in the specific situation?" The answer either will be that the objective is an essential reason for management (fundamental objective), or the objective is important because it helps attain another objective (means). Each fundamental objective typically will have several means or enabling objectives linked to it. Enabling objectives similarly should support one or more fundamental objectives.

Consider the context of multiple objectives for a regional land-use planning process, involving several state and federal management agencies as well as local residents and resource users. The planning process seeks to improve economic and ecological objectives associated with local timber harvests as well as the quality of hunting experiences in local watersheds. One of the participants, who is an avid recreationist and operates a local lodge, believes it is important to fertilize meadows to encourage productivity (abundance) of moose. Clarifying means and ends is achieved by asking two deceptively simple questions: Why is productivity important? How could we achieve the objective of productivity? The "why question" motivates thinking about impacts to be achieved, while the "how question" motivates thinking about how to achieve those impacts. By asking these questions in tandem, the dialogue proceeds from the expression of means to the articulation of fundamental objectives:

- You want to fertilize meadows. Why?
- So we can increase nutrients. Why?
- So that primary productivity is increased. Why?
- So that moose population growth is increased. Why?
- So that hunting experiences can be improved. Why?
- So that greater economic return will be achieved for the local tourism industry.

At this point, the conversation stops. Economic return for the local tourism industry is identified as an important management objective. When you have arrived at an objective that appears to be important in its own right, regardless of how it is achieved, then you have created a fundamental objective. After a fundamental objective is defined there may be other ways to achieve it than the very first idea suggested. In the case above, fertilizing meadows was suggested first; a risk at that point is that participants in the decision "anchor" on that suggestion (that is, assign it more importance than is warranted). There may be other ideas (such as limiting human access) that might have the same desired outcome without as many side-effects. When setting objectives, remember to ask, "Why is that important?" in order to move from means to ends. Ask, "To achieve the fundamental objective what conditions or processes have to be in place?" in order to move from fundamental to enabling objectives.

8.2.3. Performance Measures

To make objectives clearly understood and operational, it is helpful to develop performance measures or attributes that clearly express the most important and desired characteristics of the outcomes from decisions. For example, stating that higher employment is a benefit of a proposed wildlife tourism initiative may be insufficient for selecting among alternatives because it fails to adequately describe the types of employment that will be provided. Will the jobs be full or part time? Will they be well-paid or minimum wage? Will they be temporary or permanent? Will they be open to local residents or likely to be filled by people from outside the region? Similarly, to make decisions accountable within a program designed to increase abundance of a sparse moose population, the manager needs to distinguish among improvements in adult survival, hunting opportunities for local versus non-residents, or income available to local hunting guides. Any set of performance measures needs to be understandable and easily communicated to stakeholders, who should be informed about the specific outputs and outcomes expected to occur (Keeney and Gregory 2005).

Performance measures used in SDM typically incorporate input from one of three types of measures: natural measures, proxy measures, and constructed measures. Natural measures are in general use and have a common interpretation by everyone. For example, a natural measure of an objective to "increase profits from wildlife tourism" could be in dollars gained per year. Similarly, the number of moose counted over a specified time period within a designated area might be a natural measure for the objective to "increase abundance of moose." Natural measures are best used whenever possible because they are easily understood and thus serve well to communicate a decision.

There are times when it is difficult, if not impossible, to either find or assess a natural measure. In these cases, proxy measures may be helpful. A common example is using the number of pellet groups per hectare as a proxy for abundance of a moose population. A proxy for the objective of increasing profits from wildlife tourism might be the number of vehicles

traveling from 4:00 p.m. to 10:00 p.m. on Friday on a road used by tourists to reach a wildlife viewing area. Proxy measures, however, generally are less accurate and less informative than natural measures because proxies indirectly measure progress toward an objective.

A third type of performance measure, constructed metrics, is used when no suitable natural measures exist, or when relevance or accuracy of a proxy measure is tenuous. One example is development of a scale to measure trust stakeholders have in a wildlife management agency to achieve objectives. In this case, a questionnaire could be developed that asks stakeholders to indicate on a scale of 0 to 10 how much trust they have in an agency, where 0 is no trust and 10 is 100% trust in the agency. Another example is a scale to measure community support for a proposed management practice. Because no natural scale exists to measure support, an index can be created (e.g., 1–5 or 1–10) with each rating representing a different level of support. These sorts of human dimensions inquiries are common in wildlife management (see Chapters 9 and 10 for how to design and implement such an inquiry). Many such constructed scales are in widespread use in other aspects of society. For instance, the Gross National Product is a constructed economic measure, as is the Dow Jones Industrial stock average in the United States or the Apgar score used to track the health of newborn babies. When thoughtfully designed, constructed indices facilitate choices by precisely defining ways the objective will be evaluated.

8.2.4. Alternatives

Alternatives represent the range of potential management actions to achieve enabling objectives, which, in turn, are the necessary building blocks to achieve fundamental objectives. When faced with a problem (especially a familiar one), it is common for humans to act on the basis of habits and to turn quickly to familiar alternatives rather than make an effort to clarify or reaffirm the alternatives that will best achieve objectives (i.e., values or benefits to be achieved from wildlife management). Keeney (1992) characterizes this decision error in terms of the distinction between value-focused and alternative-focused thinking. Every management decision can be an opportunity to create and to consider new alternatives. Options should not be limited to those believed to be easily available or previously developed. Linking choices of alternatives back to the enabling objectives, and then rigorously questioning constraints concerned with time, money, or personnel help to determine whether they really apply in a given situation, and can improve the chance of achieving objectives.

Stakeholders often have creative ideas for alternatives and can offer perspectives about expected impacts that may help managers to understand the effects of a proposed management action (Gregory et al. 2012). The experiences of other resource professionals also provide valuable information about traits useful in evaluating candidate alternatives. Access to the Internet makes it relatively easy to find out what others have done in similar circumstances or how other professionals might approach a given situation. Putting effort into identifying and evaluating alternatives is worthwhile because all the due diligence and skillful implementation in the world will not produce the best possible solution to a management problem if important alternatives are omitted from consideration. The key is continual analysis of any proposed intervention in terms of how well the actions will achieve the enabling objectives necessary to meet the fundamental objectives (kinds and levels of impacts) expressed by stakeholders. Whether the proposed alternatives will achieve the enabling objectives is evaluated by estimating their consequences.

A state wildlife manager and a human dimensions specialist (standing) answer questions as an environmental council in Woodstock, New York, discusses results from a quantitative simulation of the consequences of alternative actions to manage problematic human–bear interactions. Quantitative simulations are a structured decision-making tool that can help stakeholders and managers understand decision trade-offs. (courtesy Dion Ogust)

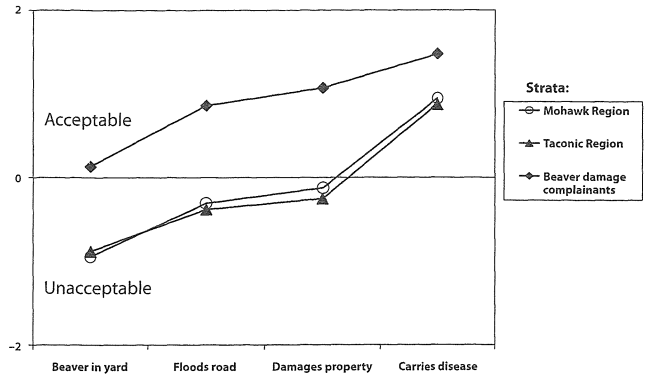


Figure 8.1. Stakeholder acceptance of lethal control of beaver (in 2002) in two regions of New York, and among residents throughout the state who previously had filed a complaint about beaver damage.

Researchers have found that public acceptance of lethal control of species (including beaver, coyote, and mountain lion) depends on how those species affect people (© Tomasz Kubis-Fotolia.com)

8.2.5. Consequences

All actions have consequences, both those intended to achieve enabling objectives and unintended consequences that should be identified and assessed before alternatives are chosen. Estimates of consequences resulting from each alternative—intended, collateral, or subsequent (see Chapter 7)—are informed by available data, new studies, and the judgments of technical specialists or stakeholders. An astute decision maker will remember that information about the consequences of actions may come from stakeholders such as residents of local communities or from knowledge holders within Native populations (indigenous or aboriginal communities). Managers may be particularly interested to learn about the acceptability of management actions from stakeholders; this learning often is achieved through human dimensions inquiry that asks stakeholders about how acceptable various actions are under different scenarios and management responses (Fig. 8.1).

In the case of New York beaver management, stakeholder acceptance of lethal control is greater among stakeholders who experience damage than those who do not (Siemer et al. 2004). These data, collected from a systematic survey in two regions of New York and of stakeholders throughout New York who previously had filed a complaint about beaver damage indicated that, regardless of the situation, a greater proportion of stakeholders who had filed complaints about beaver expressed greater acceptance of lethal control regardless of damage type or place of residence. During the study, 2,400 people in three sub-groups or strata were contacted. Stratum 1 was a random sample of 900 listed households in portions of Rensselaer and Washington counties labeled as the Taconic Region. The Taconic stratum is representative of rural upstate areas with a low beaver density. Stratum 2 was a random sample of 900 listed households in portions of Fulton, Herkimer, Montgomery, Oneida, Saratoga, Schenectady, Schoharie, and Washington counties. This area was defined as the Mohawk Region. Beaver occupancy was estimated to be greater in the Mohawk Region than the Taconic Region during 2002. It is important to note that these study sites were selected to facilitate hypothesis testing, not to provide a representation of the state as a whole.

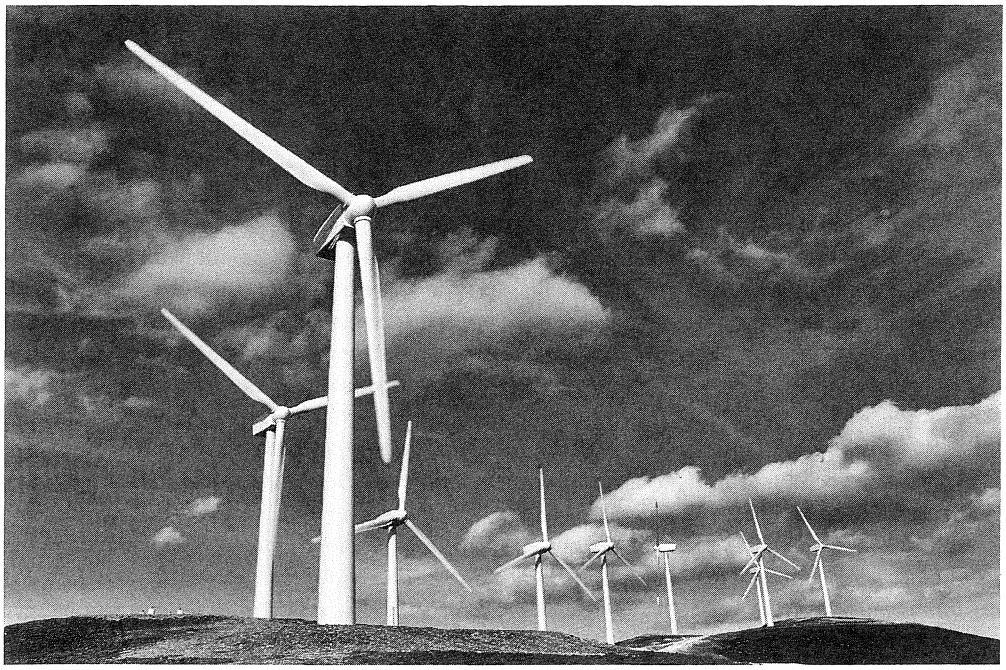
Stratum 3 was a statewide sample of 600 people who had contacted the New York Department of Environmental Conservation with a beaver damage complaint in 1999 or 2000. The complainant stratum is representative of residential complainants statewide. Members of this sub-group were selected from agency records of complaints filed in 1999 and 2000 (the most recent years for which these data were available from both states). Only private residents were included in the complainant sample (i.e., complaints on behalf of a highway department, municipality, railroad, or place of business were excluded). This is important to note because those sources account for a substantial proportion of the total nuisance complainants in New York. This is just one example of how human dimensions inquiry can help estimate the consequences of various decisions in wildlife management.

Findings about consequences can usefully be summarized in a consequence table, which shows the agreed-upon objectives or performance measures in rows and the agreed-upon alternatives in columns. This provides an easily communicated visual reference that helps to ensure that all participants have a common information base with which to evaluate the alternatives. For example, let us turn from beaver in New York to consider a wind farm proposed for a western state that is on the flyway used by several species of migrating birds. The number of turbines proposed for the site varies from a high of 200 to a low of 50. Impacts on songbirds and, therefore, community opposition are likely to be larger when turbine numbers are higher, even though more electricity can be generated and the per-kilowatt costs of a transmission line connection will be lower. After appropriate studies have been conducted, decision makers might be presented with the following consequence table (Table 8.1), which presents the key trade-offs facing decision makers.

Whenever consequences are uncertain, as shown in this example by the anticipated range of effects for bird fatalities, the quality of decisions can be improved by clearly represent-

Table 8.1. Consequences table displaying trade-offs of three alternatives for wind development

Objectives	Alt A: 200 wind turbines	Alt B: 100 wind turbines	Alt C: 50 wind turbines
Objective 1: minimize bird deaths/yr measured by no. of dead birds found (natural scale)	850 (400–2,000)	300 (150–800)	100 (50–250)
Objective 2: increase local employment measured by the number of different jobs in the community	25	15	10
Objective 3: reduce community opposition to wind development measured by questionnaire (constructed scale: 5 = high conflict to 0 = no conflict)	4	2	1



ing the nature and extent of the uncertainty in a manner that highlights key concerns. This can be done in a variety of ways. A starting point is to compare the consequences of different management alternatives in terms of whether some are more uncertain or less understood than others. In the table, clarification is shown for Objective 1 as a simple range of consequence values along with the best estimates of expected impacts. A more detailed explanation of uncertainty could include a visual presentation of the full probability distribution (showing the endpoints and associated levels of confidence) or, at minimum, additional information such as the mean or median of the distribution. At times, qualitative descriptions are also used to communicate the uncertainty of impact estimates, although this typically is not recommended (at least, not without quantitative uncertainty estimates as well) because the interpretation of terms such as "highly unlikely" or "probable" can vary among individuals, which leads to misunderstandings and confusion.

Different typologies of uncertainty have been developed by statisticians, philosophers, economists, and ecologists. From a practical perspective, two major sources of uncertainty are common to issues in wildlife management (Regan et al. 2002). One is epistemic uncertainty, arising as a result of a lack of knowledge about facts. Epistemic uncertainty arises from variation in the species, events of interest, environmental variation, measurement errors, imperfect control over human compliance with regulations, or uncertainty in the underlying models (i.e., we never have perfect models of environmental or human systems). The other prominent source is linguistic uncertainty, which arises because people fail to communicate precisely. Linguistic uncertainty emerges from ambiguity in how uncertainty is expressed (e.g., what does it mean that an event is "likely" to happen or that a consequence is "probably" not going to occur?), lack of clarity in terms that are used (e.g., what is "good habitat" or an "unhealthy wildlife population"?), or lack of context (e.g., does risk from wildlife disease characterized as "high" in one location have the same meaning in another?). The influence of uncertainty on the choice of management actions can be profound. To communicate with precision about uncertainty is also difficult, especially when communication involves stakeholders with varied backgrounds and who receive communication through varied channels (see Chapter 12 on communication).

Two other questions related to uncertainty in conse-

quences are important to consider when making decisions in wildlife management. First, ask how differences in the uncertainty of outcomes across alternatives might be addressed. For example, potential ways to gather more information (and thereby reduce uncertainty) or to mitigate the effects of uncertainty (for example, by undertaking incremental and sequenced decisions) should be explored. In some cases, the selection of a preferred management action may be made, at least in part, on the basis of whether it is sufficiently flexible to incorporate new information that is learned over time. Second, ask what the anticipated value of the information expected to be learned is, and whether it might change any aspect of managers' plans. If the answer is no, then the information might be useful from a scientific perspective, yet less relevant from the standpoint of the decision at hand.

8.2.6. Trade-offs

Selection of a preferred alternative is based on achieving a balance among multiple, often competing, values. This usually involves searching for win–win outcomes and facing up to difficult choices when a win–win outcome is not available. Evaluation tools, such as consequence tables (along with other supporting technical information), help to inform decisions with difficult trade-offs, but those devices do not "make" the decisions any more than science can make decisions—people make decisions! Decisions are made with reference to the underlying values and to how impacts are affected by each of the alternatives.

Wildlife managers often need to address trade-offs that require balancing considerations of outcomes and process. Although it is hoped that participants in any management decision agree about the likely consequences of actions (science plays an important role in providing reliable information), there is no reason to anticipate (or to seek to achieve) complete agreement with respect to their values. For example, some hunters might feel that a local forest should be selectively cut because they believe that thinning will improve the habitat for a selected species, and they are anxious for resource managers to get on with the job. Others living in the community may believe that the desires of hunters should be balanced against those of other individuals who collect mushrooms or firewood in the same area, and who might want thinning to be done in a different way or at a different time or not at all. As a result, issues of fairness or trust in the wildlife manager or management decision-making process arise. Other stakeholders may feel that no forest thinning should take place because the dense forest helps provide needed cover for Nordic ski trails in the area. The point is that no decision-making process exists whereby trade-offs either disappear or everyone ends up being happy. Instead, often all that wildlife managers can do is to develop a defensible and systematic decision-making process, follow it transparently, and then provide clear information about what was decided and why. Toward this end, managers may want to engage stakeholders (see Chapter 11 on stakeholder engagement) to develop an advisory committee that helps define and address conflicting preferences.

Table 8.2. Swing-weighting data used in decisions about wind-tower placement

Objective	Best	Worst	Importance ranking	Swing wt (normalized)
Minimize bird deaths	100	850	1	10 (0.55)
Increase local employment	25	10	3	3 (0.17)
Reduce community opposition	1	4	2	5 (0.28)

Several techniques have been developed to help clarify trade-offs, as discussed in Clemen and Reilly (2004) and other texts (von Winterfeldt and Edwards 1986). A common approach, known as swing-weighting, compares objectives in terms of the anticipated range in their values under all alternatives (from worst to best outcomes), proposes a hypothetical alternative with all attributes at their worst value, and then asks participants to identify which attribute they would most like to "swing" from worst to best (Table 8.2). Pertinent information from the earlier wind-farm example is summarized below. First, the different effects are ranked (in this case, from 1 to 3 in terms of importance) and then assigned "value" points, with 10 points awarded to the most highly valued effect and others valued on a ratio basis (i.e., the second most important effect, if valued half as much, would receive 5 points). This same bottom-up process is conducted for each of the attributes with the weights then normalized (so that all weights collectively sum to 1). A top-down approach, in contrast, would ask participants to rank the alternatives in order of preference and then to assign points reflecting how much better one alternative is relative to another. Each approach has advantages and disadvantages. The critical lesson is that methods exist for comparing importance of objectives without obvious commonalities, which can greatly assist in the development of broadly supported management actions.

Whatever weighting process is selected, participants—whether managers within the same agency or a broad-based group of stakeholders—are encouraged to acknowledge and openly discuss trade-offs using explicit criteria for selection among alternatives and review options for achieving an acceptable balance across all objectives. If a decision is significant and multiple stakeholders are affected, managers will need to engage stakeholders (see Chapter 11) to ensure that choices made reflect an understanding of broader community or institutional values. Where consensus on a preferred alternative is not reached, areas of agreement and disagreement (and the associated reasons) should be documented and this information passed on to decision makers. Agreement among participants is therefore not required, but, at minimum, managers should provide decision makers with a clear understanding of the reasons that individuals or groups might support or oppose a particular course of action.

8.2.7. Learning, Iteration, and Monitoring

The final consideration in an SDM process is to recognize that each decision is an opportunity to learn over time and

to make better decisions. This learning can be subsequently reflected in many ways: more accurately defining the nature of the problem; more precisely understanding stakeholders' objectives; developing new and more creative management alternatives; more accurate tracking of consequences; greater predictability of stakeholder acceptance of interventions; and evaluating and balancing associated trade-offs. Learning is often enhanced if a clear monitoring program is established to closely follow outcomes of greatest significance and to provide feedback to managers in a form that is readily incorporated into future planning and decision making. This is not easily done; it is often difficult to develop clear measures of outcomes that distinguish the effects of management actions from external developments (e.g., related to land-use changes or climate change), and it is not always easy to maintain flexibility or adaptability within an institutional setting. In the next section we examine some of the successes and failures of one approach to learning in wildlife management, that of adaptive management.

8.3. ADAPTIVE MANAGEMENT

The concept and term "adaptive management" (AM) is firmly fixed in the lexicon of wildlife management and is used with widespread and varied meaning (Organ et al. 2012). The concept, introduced by ecologists C. S. Holling (1978), Carl Walters (1986), and others provides a systematic approach focused on learning. AM seeks to accelerate learning through experimentation and monitoring. Rather than downplaying uncertainty and only using existing knowledge to implement a single "best" plan for ecological management, AM approaches explicitly recognize that uncertainty exists and propose a range of management alternatives to be tested and refined over time. In practice, AM encourages reducing uncertainty, thereby improving long-term performance of wildlife management interventions. AM is linked to effective decision making. The U.S. Department of Interior's *Technical Guide to Adaptive Management,* for example, states that "Adaptive management is framed within the context of structured decision-making, with an emphasis on uncertainty about resource responses to management actions" (Williams et al. 2007:vii).

AM is an attractive concept. Who would not want to learn and be adaptive? Implementation of a scientifically defensible AM approach, however, is intellectually and logistically challenging. Thus, it is not surprising that the case-list of successful applications remains modest. A key benefit of effective AM is a commitment to link learning derived from experimental trials to the wildlife management decisions being made. From a deliberative perspective, however, implementing an AM plan also requires those involved in the overall decision process to hold realistic beliefs about the ability of the proposed AM initiatives to deliver clear results within the desired timeframe (Riley et al. 2003).

Two variations of AM, passive and active, frequently are described in the literature (Walters and Holling 1990). Both passive and active AM recognize uncertainty, and they both design and monitor management interventions to learn while doing management. Choice of approach depends on the expertise and other resources available to the management program. Preferred approach depends on the emphasis placed on learning about the system as opposed to performance or response of the system (how wildlife responds to management interventions). An active approach places full emphasis on learning about the system, whereas a passive approach emphasizes effects of management on resources and stakeholders. With a passive approach, the most widely practiced approach, learning is a useful product of management but not the primary interest.

Passive AM typically involves using historical data and research literature to develop hypotheses and a model of system performance to implement a preferred management action (see Chapter 7 for an example of a conceptual model). An alternative is chosen by comparing potential responses of the system predicted by the model. System response to management is then closely monitored to learn and refine the underlying model through time. Monitoring under this process is similar to normal monitoring of effectiveness. By assessing system changes over time, the intention is to create an improved understanding of responses of wildlife, ecosystems, and stakeholders.

When practicing active AM, managers focus on reduction of uncertainty through the deliberate comparison of different alternatives. For example, consider a situation where there is substantial uncertainty about the relationship between flows within a managed river (e.g., downstream of a hydroelectric dam) and fish populations, which, in turn, affects the health of raptors and bears. A deliberate experimental comparison of the flows in the river might be set up to compare the effects on amphibian populations under flow regimes of 10 cubic meters per second (cms) for 3 years, 20 cms for another 3 years, and then (depending on how these results turn out) 5 cms for another period of time. In this sense, active AM is "management by experiment" as guided by competing models of the environmental system. Planned manipulations of the system through testing a range of alternative management actions or treatments (either simultaneously or sequentially) can achieve substantial learning, but only if accompanied by careful experimental design and monitoring.

It should be noted, however, that the cost of such treatments can be significant and the time required can be long, conceivably measured in decades rather than years (depending on the effect being addressed). As a result, it may be difficult to gain acceptance from participating stakeholders to conduct the experiment (after all, who wants to wait a decade or more to learn about an important issue?) and it also may be difficult to maintain sufficient institutional stability (decision makers have limited life in an agency) to have the experiment run its course and for results to be subject to careful analysis (Enck et al. 2006).

Active AM often is presumed to be more appealing from the standpoint of improving knowledge and contributing to the scientific (and, in turn, management) knowledge base.

This approach, however, imposes higher opportunity costs because other management actions cannot be conducted simultaneously (due to concerns about confounding study results) and typically requires a more sophisticated experimental design; if this is lacking, the experiments might deliver inconclusive information at a relatively high price (Gregory et al. 2006). Active AM also results in a different distribution of risks. Because a broader range of actions is tried, the usual result is that at least some of the manipulations will prove to be unsuccessful and as a result some resource users or other stakeholders may be upset. An active AM approach may be preferred by research-oriented scientists or managers, who tend to place a higher priority on long-term learning. Passive approaches, however, typically are favored by government decision makers and industry, which tend to place a higher priority on short-term results and reduction of risk (Lindblom 1959).

An adaptive approach, which promotes consideration of management actions as experiments, applies to the human dimensions of management (i.e., beliefs, attitudes, and behaviors), as well as to the biological and ecological dimensions. The adaptive part of AM refers not only to learning on the part of scientists and managers, but also to stakeholders learning as they engage in management (Enck et al. 2006). When learning is shared among scientists, managers, and stakeholders, greater support is gained for management actions, which results in more sustainable decisions in wildlife management. A variation on AM that uses stakeholder-defined impacts as the fundamental objective, rather than only the state of a wildlife population or habitat, is termed *adaptive impact management* (Riley et al. 2003). Adaptive impact management proposes that an essential component of any management program—adaptive or not—is determining fundamental objectives, in terms of stakeholder-identified impacts, prior to choosing enabling objectives that are the focus of management actions (see Chapter 7).

SUMMARY

Decision making is a skill critical to attaining success in wildlife management. Decisions range from small, everyday decisions to those that have potential to create enormous impacts (positive and negative) for stakeholders in wildlife management. The quality of these decisions can be improved by following a structured decision-making process.

- Some people argue that more science, logic, and rational thinking result in better choices; yet purely rational models of decisions are usually flawed because they assume managers and stakeholders know precisely what they want, have perfect information about the management system and the consequences of management interventions, and that all relevant management options have been identified.
- A bounded rational approach to decision making is introduced, which can be remembered by the acronym PrOACT: Problem identification, Objectives, Alternatives, Consequences, and Trade-offs. This structured decision-making (SDM) process encourages rigorous analysis of problems and opportunities; establishment of fundamental objectives in terms of stakeholder-defined impacts; creation of enabling objectives to accomplish fundamental objectives; description of alternatives to achieve enabling objectives; evaluation of consequences of each alternative; and weighing of trade-offs of each alternative relative to the objectives.
- A final component of any well-designed SDM process is learning through monitoring and evaluation. Although often overlooked, this is a vital step in the iterative process of management because evaluation of decisions in one cycle helps inform decisions in the next.
- Whenever uncertainty exists, as it almost always does in wildlife management, there is no guarantee that a decision will lead to desired consequences. Regardless of the process used, reduction of uncertainty associated with decisions remains a key issue in wildlife management.
- Adaptive management, practiced in its many forms, places a premium on reducing uncertainties through learning while doing management. Active adaptive management pursues management as an experiment with the overarching emphasis on learning (that is, reducing uncertainty) about wildlife resources and the effects of management action. Passive adaptive management follows a similar process, yet the chief motivation behind management is to understand the consequences of the decision on the ecosystem and the interests of stakeholders.
- Although decisions are often judged on the basis of outcomes (the quality of the consequences), decisions in wildlife management should be judged by the quality of the processes used to make the decisions. Thorough, inclusive, and transparent public-decision processes are elements of good governance.

Suggested Readings

Clemen, R. T., and T. Reilly. 2004. Making hard decisions with decision tools update. Duxbury, Belmont, California, USA.

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Organ, J. F., D. J. Decker, S. J. Riley, J. E. McDonald, Jr., and S. P. Mahoney. 2012. Adaptive management in wildlife conservation. Pages 43–54 *in* N. Silvy, editor. The wildlife techniques manual. Seventh edition. Johns Hopkins University Press, Baltimore, Maryland, USA.