8 Making Decisions for Policy and Practice

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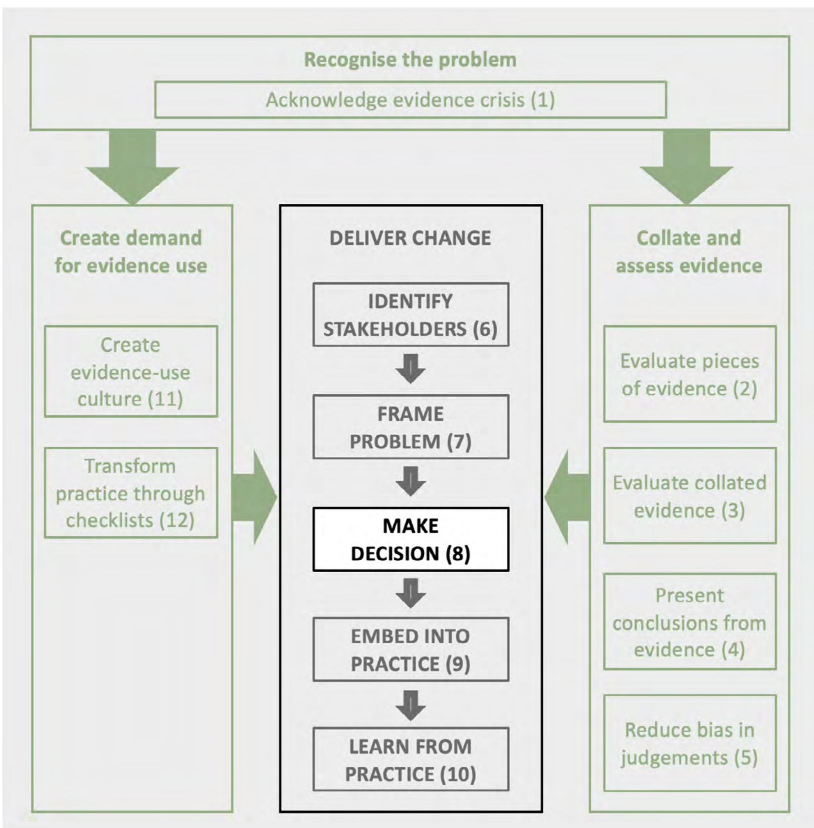
Having collaborated with the community to decide upon the objectives, identified the major threats to be addressed, considered the possible options and assessed the evidence, the next stage is to decide what to do. Many decisions can be decided easily, as either obvious or trivial, thus requiring no additional assessment of different stages of the process. The harder decisions then require assessing the likely consequences of options and determining the preferred trade off. There is a range of approaches for making each of these stages more rigorous, reducing the likelihood of making inefficient decisions. These approaches are described with an account of the situations under which is most appropriate to address the conservation problem.



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8.1 What is a Structured Approach to Decision-Making?

The previous chapters have described the processes involved in preparing to make a decision: understanding the context for the decision (Chapters 6 and 7), clearly identifying the targets (Chapter 7), and compiling all the information required to make an informed choice (Chapters 2, 3, 4 and 5). Almost any conservation decision will need to use elements from these chapters.

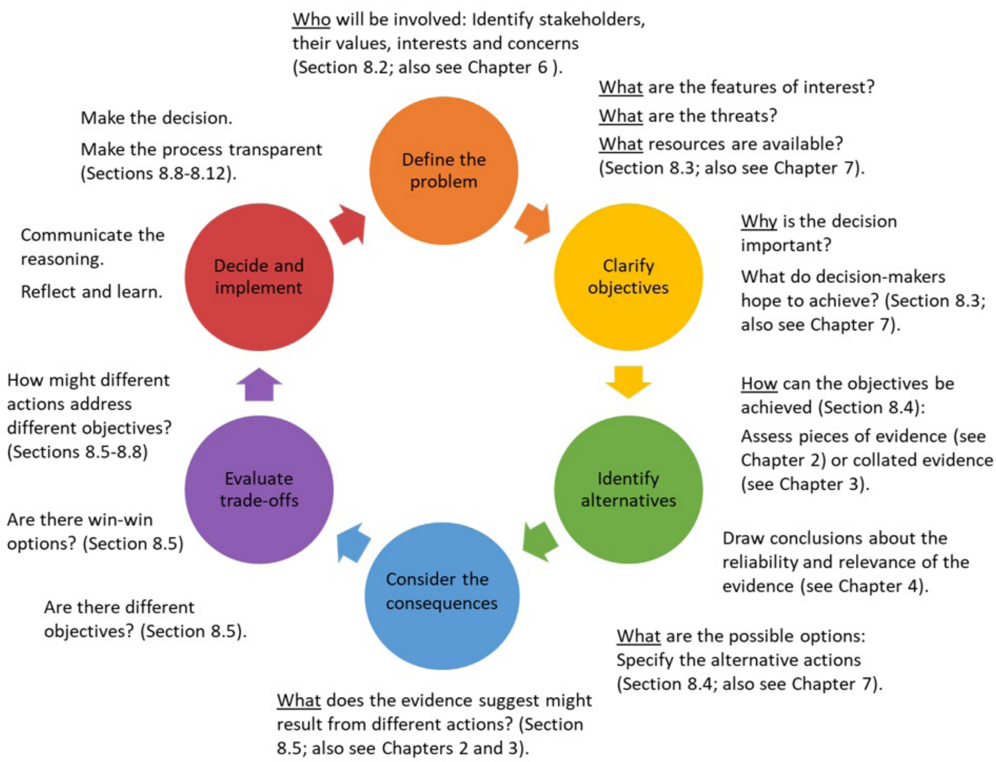

Figure 8.1 The stages in a structured decision process are represented by coloured circles, alongside text suggesting questions to consider during the process. While many of these considerations can be made unconsciously, a structured process helps decision makers to explicitly consider *who, what, why* and *how,* even if done quickly and simply (Box 8.1). (*Source*: authors, adapted from Gregory et al., 2012)

This chapter describes the various stages in the decision process (Figure 8.1; Box 8.1) and provides tools to support the decision maker to integrate relevant information when considering potential alternatives, assessing trade-offs and deciding how to act. The same process can be adopted whether an individual is thinking through a decision alone or as part of a group. Using a structured process to consider the essential elements of the decision offers decision makers the opportunity to document the process involved in reaching their decision, which has three important advantages. First, decision makers can communicate the rationale behind the choice to stakeholders who can then decide whether any concerns they raised were considered (Moon et al., 2019). Second, it can ensure the decision-making process is transparent and repeatable, thus helping to identify where knowledge about the system needs to be improved (Hemming et al., 2022). Third, it provides an opportunity to scrutinise the process and potentially improve future decisions (Gregory et al., 2012; Schwartz et al., 2018). Capturing the rationale and evidence supporting a decision can be a form of knowledge transfer, making sure that future decision makers understand why past decisions were made (Christie et al., 2022). Implementing the decision then offers an opportunity to learn, update our understanding of the system, and work through the process again to refine our management (Gregory et al., 2012).

8.1.1 The process of decision making

We make decisions all the time, consciously or not. Some are simple matters that do not require much thought; deciding not to do anything is also a decision. Others are complex and multi-faceted with potentially irreversible consequences for which a structured process and careful consideration could guard against disaster. Regardless of how simple or complex the decision is, most are improved by, at least briefly, considering the different elements of the problem using the information currently available (Figure 8.1).

Box 8.1 outlines the general decision-making process with an example.

8.1.2 Summary of tools to help structure decisions

In this chapter we discuss tools that can support decision makers to work through the decision-making process. These can be used selectively, depending on the type of decision, the needs of the decision maker, and the time and resources available. The tools and the processes they promote can help decision makers be transparent about, and communicate the rationale behind, their decisions (Hemming et al., 2022). This helps engage stakeholders and promotes learning and improvement. Table 8.1 summarises the various tools, and provides examples of how each can be used and when it might be appropriate.

Box 8.1. The decision-making process

(see Keeney, 2004; Gregory et al., 2012)

Regardless of the time or resources available to make a decision there is an underlying logic to the process (Figure 8.1). Decisions can be made quickly, and it is worthwhile moving through these steps rapidly to identify whether there is a preferred solution, or whether iteration is needed (Garrard et al., 2017). When multiple stakeholders are involved, the following steps are worked through together, to get a shared understanding of the problem, and preferred solution(s).

- Identify who will be consulted or involved in the decision making process.
- Frame the decision — collectively agree on the problem to solve and the subsequent decision to be made, and brainstorm what you are fundamentally trying to achieve, or avoid, with your decision (these form your objectives).

- Consider the range of options available to achieve the objectives (Chapter 7). Start with a long list of possible options that focus on meeting all objectives. Narrow the list by excluding actions that are impossible to implement (e.g. too expensive, too technical, not socially acceptable), do not work in the relevant context (e.g. good for low-lying areas but not for uplands) or are irrelevant (e.g. focused on mammals, not birds). This generally leaves a much shorter list of relevant options.
- Consider which options are likely to give the best outcomes for all objectives, using the available evidence (Chapters 2 and 3). This step often involves trade-offs between competing objectives (see Section 8.5); these could relate to cost (e.g. an option may be preferred because it is cheaper and can be used over a larger area) or social constraints (e.g. it may be more important to keep the community on-side by selecting a less cost-effective action). We often make trade-offs unconsciously but discussion of preferred alternatives is critical, and if required, decision tools can support choices.
- Make a choice, or refine the preferred options. This choice may be based solely on the evidence for the most effective action. Usually, it will be a compromise, incorporating value judgements, and economic, social or political constraints. Multiple stakeholders often will have different preferred options that a decision maker must weigh up.
- Present draft conclusions to stakeholders for consultation, or iterate (e.g. including new options) where needed.

For example, I need to decide how to reduce the impact of roads on an arboreal mammal.

1. Managers and other stakeholders want possums to be able to cross the road safely, to connect populations that have become separated.
2. I consult local ecologists and others with local ecological knowledge, look at the Conservation Evidence database for actions to increase connectivity across roads, and reports produced by road safety agencies in other parts of the country. Based on this research, I create a list of options (in consultation with stakeholders) — building an overpass, creating tunnels, installing rope bridges, installing glider poles or doing nothing. I can quickly reduce these options because those with local knowledge tell me that possums rarely come to the ground and won't use tunnels. I do not have the money to build an overpass. So I must consider glider poles or rope bridges if I want to improve connectivity.
3. The local ecologist shows me a draft paper revealing that rope bridges are twice as effective as poles in increasing connectivity for this species. I consider the cost of the two options. Rope bridges cost four times more than glider poles

so our budget will only enable three rope bridges to be installed along a 20 km stretch of road, whereas we can install 12 glider poles along the same area. Glider poles will, therefore, increase connectivity more efficiently.

4. Given the trade-off between cost and effectiveness, I decide to install glider poles.
5. When discussing this choice with stakeholders, they point out that, on bends in the road, headlights illuminate the forest thereby discouraging the possums. They suggest selecting straight stretches of road to install the glider poles.

These tools can be carried out with different levels of complexity. They can be adapted for a decision (such as which vehicle to hire next season) in a process that takes a few minutes involving a few colleagues. On the other extreme, for a difficult and contentious issue, a series of workshops may bring together a broad community, allowing the creation of models to support decision making.

Table 8.1 Summary of tools described in this chapter.

Tool	Section	Description	Uses
Just doing	8.2	Act (but occasionally reflect)	Suitable for self evident or low stakes problems
Decision sketching (or rapid prototyping)	8.3.1	Outline the components of the decision	Allows relatively quick decisions
Benefit-cost/Cost-effectiveness analyses	8.3.2	Assess the change that is expected to occur when considering the cost of each action; suitable when objectives can be distilled into a single measure	Fundamental for any decision with a limited budget and a single measure of utility.
Clarifying objectives	8.3.3	Identifying fundamental objectives of the stakeholders and decision makers	Identifying objectives underpins the decision and understanding differences in objectives illuminates disputes
Means-ends networks	8.3.4	Sketch ways of achieving end given means, much like theory of change	Clarifies the problem: separate what you want to achieve from how to achieve it.
Multi-criteria decision making/structured decision making	8.5	Assess the outcome of different options against the key criteria/objectives, negotiate trade-offs	Complex decisions where win-win outcomes are unlikely, and trade-offs are involved

Tool	Section	Description	Uses
Consequence tables	8.5.1-8	Compare the performance of different alternatives against multiple objectives	Simplifies a decision context by ruling out redundant objectives, identifying dominant or dominated alternatives, identifying unavoidable trade-offs or win-win alternatives.
Revealing hidden values	8.5.3	Identifying values that have not been stated but influence decision choices	Helps understand decisions and reasons for variation in decisions.
Strategy Table	8.6	Organises alternative actions into packages 'strategies' or series of actions	When need to consider which combination of measures to adopt
Classifying decisions	8.7	Linking set of decisions	When there is a hierarchy of decisions and sub-decisions
Decision trees	8.8	Presenting a range of different options and consequences	When decisions involve a series of smaller, related decisions
Models	8.9	Identify potential actions and make predictions about potential outcomes	Essential for quantifying many changes, to populate
Achieving consensus and dealing with conflict	8.10	Bringing individuals together to find mutually acceptable solution	When stakeholders hold different objectives

8.2 Filter Easy Decisions: Deciding Whether to Invest in Decision Making

It is a common misconception that a structured approach to decision making is a time consuming and complicated process reserved for the most challenging decisions. This does not need to be the case. Figure 8.2 illustrates appropriate levels of analysis for an imaginary 10,000 decisions. The main point is that most decisions can be dealt with almost instantaneously because the best course of action is self-evident, or the alternative actions have such small consequences that make little difference. Many others can be dealt with by simple processes. Detailed consideration necessary for only a small proportion of complex decisions in which there are competing objectives, and the actions may result in substantial differences.

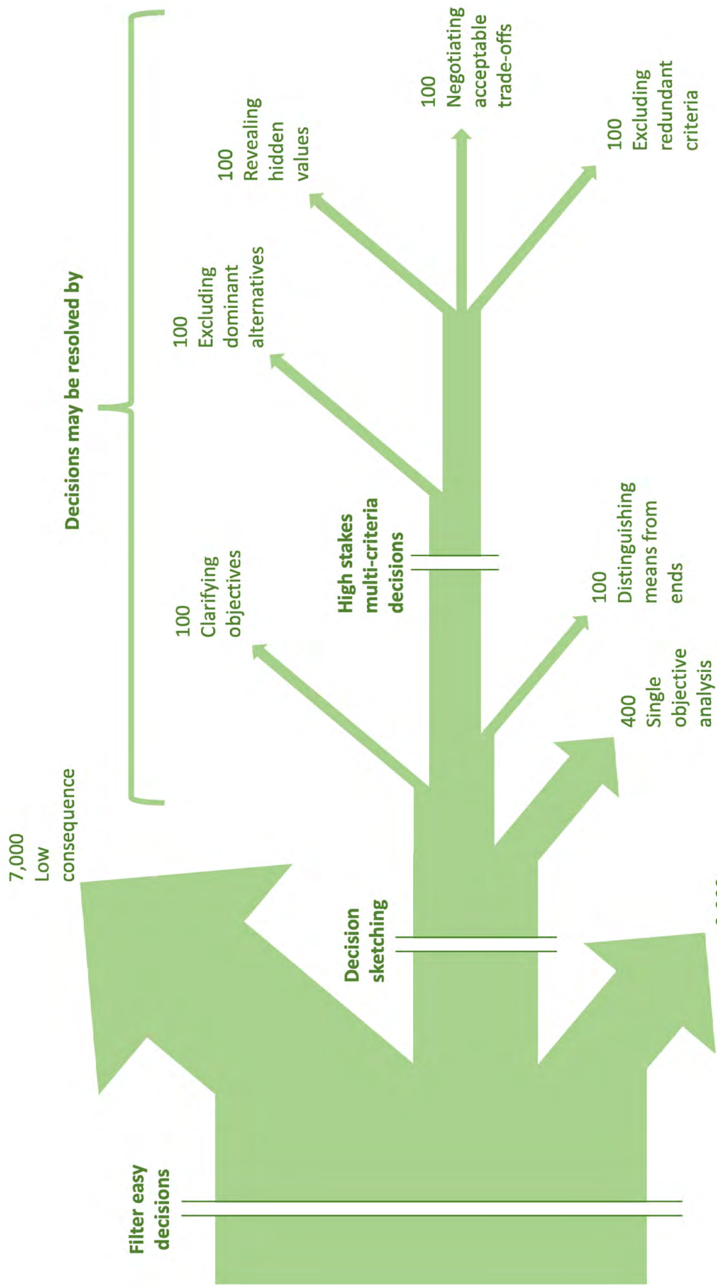

Figure 8.2 An illustration of how 10,000 decisions may be resolved (*Source*: authors, based on a figure from Keeney 2004). BCA and ROI refer to benefit-cost analysis and return-on-investment analysis, respectively.

8.2.1 Self-evident (high certainty) decisions

Many decisions are self-evident, drawing on existing, well-established knowledge. For example, a self-evident decision may include seeing a tourist on a boat pumping out their latrine into a lake and immediately asking them to stop, or discovering a harmful, invasive plant in a campsite, pulling it up and then reporting it.

Many decisions are implicit, simple continuations of the status quo. Decisions embedded in a set of procedures for the management of a protected area may include that a visitor centre opens at 9 am, a guided walk is available at 2 pm, and dogs are not allowed. Analysing every routine decision on every occasion would mean nothing else was ever done. However, it is worth occasionally reviewing the rationale and effectiveness of routine decisions, to avoid complacency (Hockings, 2003; Pullin and Knight, 2009). The process of kaizen (Section 7.4.2) may result in considerable benefits from sometimes looking at ways of improving routine practice (Sutherland, 2019).

8.2.2 Low-stakes decisions

Low-stakes decisions are those in which the outcomes matter so little that they do not justify further thought. This can be because the overall action is trivial (i.e. someone wants to sample the water from a critical bird breeding site, but after the breeding season so any disturbance will be minimal) or because the impact does not substantially extend to the project scope (i.e. a national hydrological project will affect an adjacent watershed but is expected to have minimal local impact, so local actions do not need to change).

8.2.3 High-stakes, low certainty decisions

Issues may be high-stakes for ecological, social, reputational or financial reasons (McShane et al., 2011). Some conservation decisions are high-stakes with irreversible consequences (Lindenmayer et al., 2013). An extreme example of this is species extinction. An estimated 617 vertebrate species alone have gone extinct since 1500 CE (Ceballos et al., 2015), many because of decisions that were made by humans (e.g. a bounty placed on the skins of the Tasmanian tiger, *Thylacinus cynocephalus;* Guiler and Godard, 1998), decisions that were not made (e.g. failure to ban hunting of Steller's sea cow, *Hydrodamalis gigas;* Domning, 1978) or that were delayed (e.g. monitoring the decline but not implementing management action to protect the Christmas Island pipistrelle bat, *Pipistrellus murrayi*; Martin et al. 2012).

There are also considerable risks to decision makers associated with some conservation decisions. The US Fish and Wildlife Service has been sued hundreds of times by stakeholders seeking to challenge their decisions about whether or not to list species under the US Endangered Species Act 1973 (Schwartz, 2008). In these cases, decision makers must be able to defend their rationale in court for why a species does or does not meet the required standard.

Importantly, decision makers must be cognisant that decisions can have direct implications for stakeholders (Bennett et al., 2019). Changes to policies regarding the exploitation of natural resources can lead to the loss of livelihoods, for example where marine protected areas displace local fishers or protecting native forests displace forestry activities. Even when the consequences for local communities are not financial, conflicting values can lead to contentious decisions with significant political and social implications for decision makers and the broader community. In these cases, stakeholders may have very different objectives and values, and their differing perspectives may mean that the facts of the problem are contested (Redpath et al., 2013).

8.3 Preparing to Make the Decision

Many day-to-day decisions in conservation may be considered simple or low stakes, but as noted above, most decisions are improved by briefly considering the different elements of the problem using the information currently available. Quickly working through the structure of the decision can be a cost-effective way of assessing what is already known about the context of the decision (Gregory et al., 2012; Garrard et al., 2017). This may reveal that we already know enough to make the decision or identify issues that need to be investigated further or clarified.

8.3.1 Decision sketching

Decision sketching, also known as rapid prototyping, can be used to outline the components of the decision, providing a simple way for the decision maker to structure their knowledge about the problem and possible solutions (Garrard et al., 2017). It entails asking a series of questions relating to the *who*, *what*, *why*, *how* and *when* of the decision (Figure 8.1, Table 8.2; Schwartz et al., 2018; Hemming et al., 2022). It is often sufficient to enable the decision to be made.

Table 8.2 A list of fundamental questions that can be used to quickly sketch a decision.

Type	Question	Chapter
Who	Who has a stake in the decision?	6
	Who should be involved in making the decision?	6
	Who will be impacted by the decision?	6
What	What is the problem the decision maker is trying to solve? E.g. seabird nests being predated by invasive rodents; or uncontrolled wildfires impacting wildlife, tourism, and water supply.	7
	What is known about the cause of the problem? E.g. non-native rats targeting seabird eggs or illegal burning of heathland.	7
	What options are available to address the problem? E.g. baited traps; or reduce area of reserve scheduled for burning	7
	What are the trade-offs among goals?	7

Type	Question	Chapter
	What resources are available to address the problem?	7
	What are the potential consequences associated with the different choices that could be made?	7
	What prompted the decisions?	7
Why	Why is this an important problem for the decision maker?	7
	Why is this an important problem for stakeholders?	6
How	How confident are they that those options will partially or fully address the problem?	4
	How much will the different options cost?	4
When	When does the decision need to be made?	7

By brainstorming the answers to these questions, decision makers can quickly identify whether they know enough to act confidently. Another advantage of decision sketching is that setting out the important elements of the decision may quickly eliminate potential choices because they are not practical given the resource constraints, or because none of the stakeholders prefer them. Likewise, considering the timeframe or urgency with which the decision needs to be made can prompt decision makers not to wait until they have perfect information (Lindenmayer et al., 2013). Where sketching the decision reveals knowledge gaps that impede a decision, the decision maker must ask how important it is to resolve that uncertainty before they act. In some cases, it may be worth investing time in reducing uncertainty before making a decision (Section 10.6); in other cases 'learning by doing' may be more appropriate (i.e. adaptive management). Because it is a rapid process, sketching the decision can be an iterative process, where issues are identified, knowledge is refined and the decision sketched again with any new information (Garrard et al., 2017).

Failing to consider a wide range of alternatives can risk decision makers defaulting to business as usual, even when that action has not been successful in the past (Gregory et al., 2012). It is likewise important that decision makers consider the consequences of delaying a decision or choosing not to act (Martin et al., 2017). Ideally, they have a strong evidence base from which to identify the range of different options and their likely consequences (Chapter 4). There are many tools that can help decision makers to organise their understanding of the system to identify leverage points that suggest potential actions (e.g. conceptual and mental models; Moon et al. 2019).

8.3.2 Benefit-cost/cost-effectiveness analyses

There are several decision-making tools to help calculate and compare cost-effectiveness of different actions, also known as return on investment (Section 2.4.4). These include economic analysis tools, such as cost-effectiveness analysis and benefit-cost analysis, which require detailed assessments of the costs and effects of actions (Cook et al., 2017). Cost-effectiveness analysis is particularly common when spending public funds but often is useful to identify how to deliver conservation effectively. It is appropriate when outcomes can be distilled into a single measure of utility, or there is a single, relevant criterion. Maximising the conservation outcomes under a given budget requires information on costs to be combined with information on the effectiveness of different actions, and for actions to be prioritised based on the evidence of their cost-effectiveness (Joseph et al., 2009). A conservation project may make claims that proposed actions are cost-effective, which can be supported or refuted by evidence.

There are many possible ways to combine information on effects and costs. For example, cost-effectiveness can be expressed as dollars per unit of conservation outcome. Cost-benefit analysis takes that process one step further, attempting to compare costs with the dollar value of the outcomes or benefits (Burgman, 2005). In this case, outcomes would be compared as the amount of conservation outcome per dollar, or in purely financial terms as the financial gain per dollar spent.

Economic analyses are widely used in healthcare, and whilst less frequently used in conservation, their use is increasing (Pienkowski et al., 2021). Other tools such as the Evidence to Decision tool (Section 9.10.3) encourages consideration of costs alongside other information in decision making (Christie et al., 2022). It is important to consider the direct (e.g. materials) and indirect costs (e.g. staff time) (Section 2.4.4; Iacona et al., 2018).

8.3.3 Clarifying objectives

If the objective is uncertain, or if individuals differ in what they see as the priorities, then there can be disagreement on the way forward. Resolving the purpose may reduce disagreement. Box 8.2 shows how conflicting ideas may be resolved by identifying core objectives.

Box 8.2 Clarifying objectives

Description: Managers of adjacent protected areas discuss their budget priorities for park management. Manager 1 rates weed control and eradication as 'low' in the list of priorities, and Manager 2 rates it as 'high'. The Managers have responsibilities for areas that are equivalent in terms of ecological conditions and the potential for harm from invasive species. The actions taken to control weeds depend on the biology of the weed species. The area manager needs to decide what proportion of their budget should be spent on weed management.

Potential actions: 1. eradicate all invasive species, 2. eradicate all harmful invasive species, 3. eradicate all large invasive species close to visitor areas and walking tracks, 4. monitor and eliminate all newly established invasive species.

Who: Stakeholders include park managers, park visitors, adjacent farmers, local community groups, NGOs focused on invasive species.

What: Values at stake include species of conservation importance, ecosystems, ecological processes that may be affected by invasive species, visitor experience, and revenue from visitors.

When: eradication and control programs over the next 12 months.

Clarify objectives: The objectives may be to 1. minimise the number of new weed species, 2. minimise the extent of all weeds, 3. minimise the ecological impact of all weeds, 4., minimize the potential for the escape of harmful agricultural species, or 5. minimise the visual impact of weeds for park visitors.

Decision: The managers agree to identify the subset of weed species that may harm the park environment, and develop a management plan to minimise the impact of potentially harmful weeds using cost effectiveness analysis. They agree to disregard weed species that have negligible environmental impacts.

Why: Manager 1 knows most weeds in her reserve have limited environmental impacts and have minor effects on visitor experience, even though some have extensive distributions and would be very expensive to eradicate. Manager 2 knows a small handful of invasive species are potentially very harmful in some habitats, but none are of concern for agriculture. The managers agree that the primary objective is to minimise the ecological impact of weeds.

8.3.4 Sketching means-ends networks

Means-ends networks can be used to separate fundamental objectives (the 'ends', the outcomes we want to achieve) from the means objectives (what we do to influence or generate those outcomes) (Gregory et al., 2012). A useful way to start is to collate statements of what is to be achieved, or avoided, in a particular decision context. Examining each statement, fundamental objectives are revealed by asking "why is that important?", and means objectives are revealed by asking "how can that be achieved?" Fundamental objectives help define the reasons for a decision and are the focus of future deliberation and analysis. Means objectives can be used to help generate management options. Means-ends diagrams can be constructed by the decision maker alone, or as part of a participatory process with stakeholders (Section 8.3.2). They can be quickly and easily sketched with the available information and can be a useful communication tool to explain the fundamental objective and point to actions that could lead to that objective being achieved (Moon et al., 2019; Burgman et al., 2021).

8.4 Making Decisions

In reality, most conservation decisions have more than one objective, even if that is to keep within existing budgets and satisfy stakeholders (Possingham et al., 2001). Sometimes these issues are easy to navigate — the action is affordable and stakeholders agree. In other cases, financial, social and political considerations may be at odds (Williams and Kendall, 2017). In these cases, unstructured brainstorming may not reveal acceptable trade-offs among objectives for different alternatives. It can be helpful to use simple tools to lay out the decision based on how the different actions might perform relative to the different considerations (Gregory et al., 2012). This can identify where alternatives perform poorly across all objectives (lose-lose consequences), are costly, ineffective and unpopular. It can hopefully find a win-win solution. At the very least, it will reveal trade-offs that allow decision makers to make explicit choices. For example, the cheapest, most effective management action to deal with invasive plants may be to treat with herbicides but this may be unacceptable to some stakeholders who are concerned about poisons in the environment. The decision maker must then decide whether to take an unpopular action to remove plants manually. Being clear about the consequences allows a trade-off to be identified and whatever the decision is, it can then be communicated (Converse, 2020).

8.4.1 All decisions have consequences

It is important to consider the full range of possible decisions. While all decisions require choices, they do not always need to result in action; choosing *not* to do something can be equally, and sometimes more consequential than choosing to *do* something (e.g. Martin et al. 2012). This is an important distinction and why considering different alternatives is a crucial part of the decision-making process (Gregory and Keeney, 2002). Chapter 7 describes how a decision maker can derive alternatives and Chapters 2, 3 and 4 describe how to interpret the evidence. Sometimes there is good information about the alternative actions available, and the probability they will be effective under different circumstances. More often, there is considerable uncertainty about the consequences of different alternatives and the conditions under which one alternative may perform better than another (Burgman, 2005; Regan et al., 2005). Weighing up the pros and cons of each action can ensure transparency and create opportunities to learn and inform future decisions (Gregory et al., 2012). Where there is a clear understanding of the consequences of doing nothing, and the only alternative has a good chance of a better outcome, then the decision may be simple. Failing to consider the range of alternatives can mean failing to identify an innovative new approach (Christie et al., 2022). Likewise failing to consider the decision context may lead to conflict over the most appropriate management alternative (e.g. the best approach to reducing the impact of feral cats in communities with pet cats). So, while some decisions are no-brainers, in many cases at least briefly considering the essential elements of the decision and justification for the choice made, can ensure decisions are transparent and create opportunities to learn and inform future decisions.

8.5 Multi-Criteria Analysis

Most decisions comprise making a choice based on a range of different criteria such as the cost, likelihood of success, or acceptability to neighbours.

8.5.1 Consequences tables

When the aims have been established, the options that might help address the problem have been shortlisted, and the evidence accessed, the next stage is to present the details of these alternative actions to stakeholders so they can be compared. Presenting this as a consequence table offers a straightforward method to compare the different options and their consequences even if only rough estimates (Gregory et al., 2012). Different actions are likely to have different consequences for the things we care about (the fundamental objectives). The nature of conservation decisions means there is almost always at least one ecological, economic and social aim (Possingham et al., 2001).

The basic structure of a consequence table is a list of objectives, each with an associated performance measure, and a list of alternative actions (Table 8.1; see Keeney and Gregory, 2005). Alternatives should always include doing nothing or continuing doing what is already being done (status quo), as a point of comparison (i.e. are the proposed alternatives better than what is being done?). Each objective needs a specific and practical performance measure to enable comparisons between different actions (Gregory et al., 2012). If possible, performance measures should be appropriate metrics for the subject of interest rather than being proxies or indirect measures (Hemming et al., 2021). Ideally, the consequence table will include evidence-based, quantitative estimates such as the financial cost of implementing the different alternatives or the expected increase in the population of a threatened species (Failing and Gregory, 2003). Social values may be expressed best by constructed scales, such as Likert scales. Where it is not possible to estimate values precisely, it is still valuable to estimate the degree to which the performance measure is likely to increase or decrease under the proposed action, to assess the relative performance of alternatives. A range of different modelling tools (Section 9.11) can generate estimates of how performance measures might respond to different actions. Each cell of the consequence table should be accompanied by a measure of the precision of the estimate, such as a confidence interval, or a subjective credible interval (Hemming et al., 2018).

In addition to helping structure the decision, consequence tables are useful to reveal when alternatives are not genuinely different from one another. It can also become clear if an alternative performs poorly across all objectives or at least performs poorly relative to the other alternatives and so it is not worth further consideration (e.g. Walshe and Hemming, 2019). Considering the consequences of different alternatives across all of the objectives can also reveal where there are unavoidable trade-offs and we will have to choose which objectives to prioritise (Converse, 2020; Moon et al., 2019).

It can be difficult to define and classify fundamental objectives unambiguously. This is best done by creating a values hierarchy (Figure 8.3) that classifies the means, objectives and measures. The specification of measures helps to clarify what is meant by them. When making tradeoffs, it is important that nothing has been omitted, leading to hidden agendas in negotiations (for example, omitting political considerations may distort discussions about other objectives). It is also important to ensure nothing is double counted (for example, the fundamental objective of conserving threatened species should be kept separate from the objective of maintaining ecosystem services). Objectives hierarchies provide a means for ordering thinking about fundamental objectives, serving to distinguish means from ends, ensuring that all relevant values at stake are considered, and that nothing is double counted.

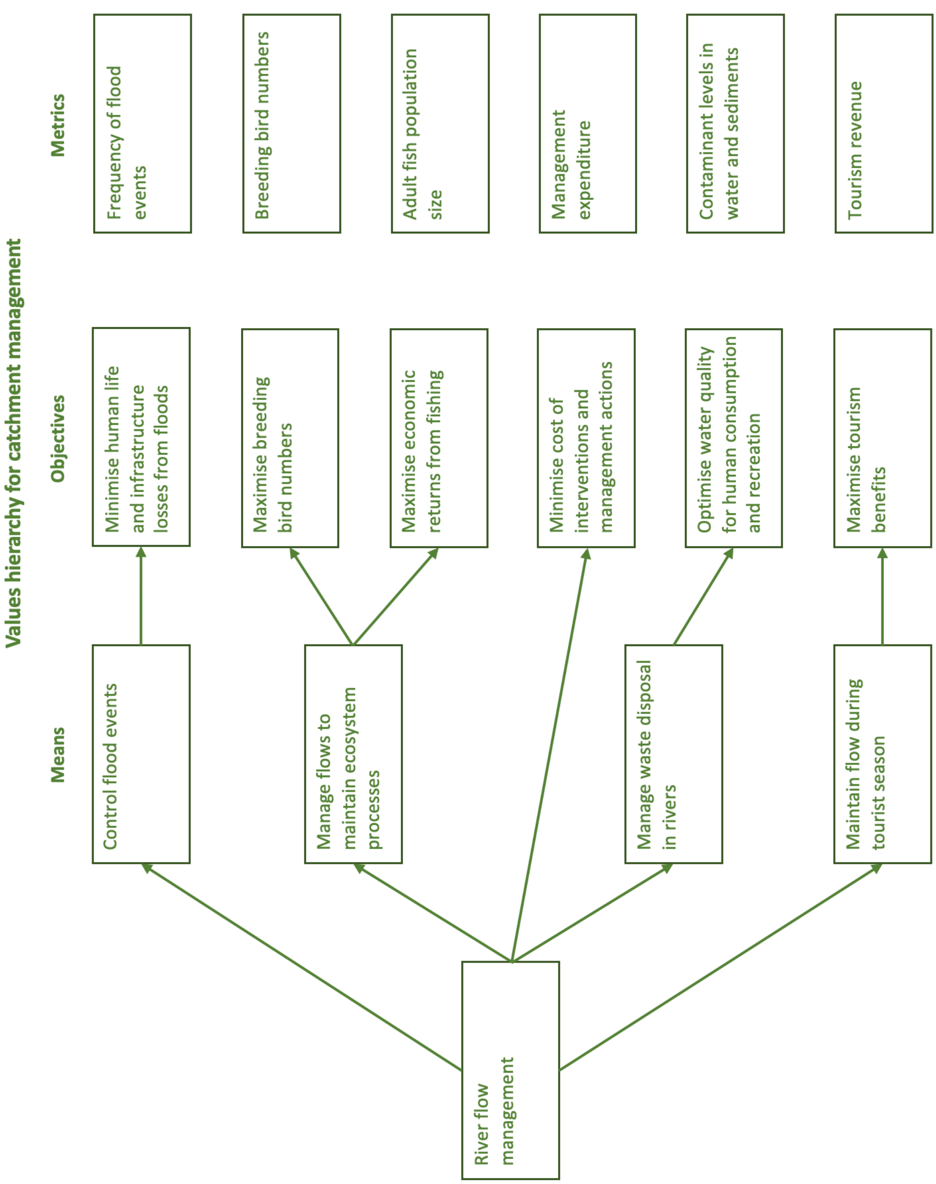

Figure 8.3 A values hierarchy for a catchment management example. (*Source:* authors)

Consequence tables are not just a valuable tool to compare alternatives and assess trade-offs among objectives, they contain the essential elements of a decision. Constructing the consequence table can be a valuable process in itself. These need to be based on evidence for outcomes (Chapter 4).

An example of a consequences table is provided in Table 8.3. How is it then possible to make a decision?

8.5.2 Checking for a dominant alternative

A dominant alternative is one that is better than all the other options being considered across all criteria. For example, option C in Table 8.3 might have been the superior option had it not been so expensive. If a dominant alternative option emerges then the decision could be considered resolved. There is no dominant alternative option in this scenario, so we need to reduce the number of alternatives based on the project aims and agreed trade-offs.

8.5.3 Revealing hidden values

All stakeholders and decision makers have unique perspectives on a decision and what is to be gained or lost from the outcomes of actions. For example, Vucetich et al. (2021) identified a wide range of motivations for conservation actions including care for future generations, present-day fairness, and utilitarian goals (Vucetich 2021). Values are amplified by cultural norms and world views (e.g., Riepe et al. 2021). Thus, for example, in managing a park, some stakeholders may oppose additional visitors because of their impacts, while others welcome visitors who pay to use facilities, some may welcome the return of stock grazing because it encourages a specific, valued bird species, while others oppose stock because fencing hinders dog walking and stock disturb wetland soils.

Typically, such values are captured and represented in values hierarchies and consequence tables. However, stakeholders may fail to disclose values for several reasons including because they were not asked about them, they did not anticipate them being affected by potential actions, or they did not know how to express them. Hidden values can derail discussions because stakeholders will negotiate for actions by weighting other factors correlated with their unstated objectives and preferred outcomes. They may be responsible when support for an action is equivocal, even though the consequence table suggests that there is a dominant alternative. Hidden values may be revealed by exploring options and objections through facilitated discussion of the consequence table, or in private discussion with a facilitator.

8.5.4 Excluding unacceptable options

Although all of the options in Table 8.3 were considered acceptable during the initial stages of the process it is apparent that some are now unacceptable for various reasons. Based on the project scope, budget and aims, it is clear from the analysis shown in Table 8.3 that, although beneficial, option C is unacceptably expensive — the cost exceeds the allocated funds. Furthermore, option F would result in an unacceptable increase in flood risk to communities downstream so is also excluded. This leaves five options.

Table 8.3 A consequences table for seven different river management options (including no change with the river continuing to deteriorate) assessed under six criteria. Evidence is shown in relation to the current status.

	Performance measure	A Do nothing	B Original DWA proposal	C Full scheme	D District suggestion	E Wildlife group proposal	F Grazers proposal	G Fisheries group proposal
Proposal		Status quo	Creating flood reservoir	Restore original water features	Connecting river with surrounding meadows	Creation of pools	Enhance river banks, plant hedges	Restore shingle, fish passes, nesting island
Ecological	Breeding bird numbers	No change	Moderate evidence of minor benefits	Moderate evidence of considerable benefits	Moderate evidence of considerable benefits	Moderate evidence of moderate benefits	Strong evidence of moderate benefits	Moderate evidence of considerable benefit
Economic	Fish numbers	No change	Weak evidence of moderate benefits	Strong evidence of considerable benefits	Moderate evidence of moderate benefits	Moderate evidence of moderate benefits	Overwhelming evidence of minor harms	Moderate evidence of considerable benefits
Water management	Frequency of downstream flood events	+5%	-60%	-80%	-60%	-10%	+200%	-20%
Water quality	Sediment in column	-10%	+10%	+40%	+10%	+10%	+5%	-10%
Cost		0	$$	$$$$$	$$	$$	$$$	$$
Tourism interest	Number non local visitors	Low	Very low	Low	No access	Low	Low	Very low

8.5.5 Excluding redundant criteria

In the example scenario in Table 8.3, the number of tourists is low and better catered for by other projects elsewhere in the valley. Tourism is not a priority for this project, so it is decided it will be excluded. The process of excluding redundant criteria can be used repeatedly as the table is simplified.

8.5.6 Removing dominated alternatives

The consequence Table 8.4 is simpler following the removal of two columns and one row. The next task is to try and simplify it further.

Dominated alternatives are options that are not superior to another in any criterion (Hemming et al., 2022). Option B is an inferior option that is equally as effective in reducing flood risk, for the same costs, as D but it has poorer ecological benefits (Table 8.4). Option E is also excluded as it has the same ecological benefits as option G but lower flood and water quality benefits. Options B and E are thus dominated alternatives and excluded. At each stage, we can exclude redundant criteria (see Section 8.5.4): water quality does not vary between the remaining options so is excluded.

As the table gets reduced more detail may be researched and added, for example, in Table 8.5 there is now a more detailed estimate of costs and the ecological consequences.

The retained options all have a unique feature (and are thus not dominated). Option A is retained as it is cheaper than all others; D is retained as it has the highest flood protection; while G is retained as it has the highest ecological benefits. It is now necessary to consider the relative importance of these benefits.

Practical dominance

Imagine in the table that there is an option with a slightly better water quality measure but is much worse in all other comparisons. The decision might be made that this small difference does not outweigh the other disadvantages. For practical reasons it is dominated — hence practical dominance — and the option is eliminated.

8.5.7 Addressing trade-offs

Trade-offs arise when there is no dominant option, and the consequences vary in important ways across the options under consideration. Decision makers need to balance two issues: how much the fundamental aims vary over the alternatives; and how much stakeholders care about what they stand to gain or lose from each option. In doing so, they aim to maximise the expected net benefit or to minimise the chances of unacceptable outcomes.

There are four main ways of addressing trade-offs:

Table 8.4 As for Table 8.3 but with options C (expensive), F (flooding) and the tourism criterion (not important) all removed

	Performance measure	**A No change**	**B Original DWA proposal**	**D District suggestion**	**E Modified DWA proposal**	**G Fisheries group proposal**
Ecological	Breeding birds	No change	Moderate evidence of minor benefits	Moderate evidence of considerable benefit	Moderate evidence of moderate benefits	Moderate evidence of considerable benefit
Economic	Annual fish survey	No change	Weak evidence of moderate benefits	Moderate evidence of moderate benefits	Moderate evidence of moderate benefits	Moderate evidence of considerable benefit
Water management	Flood events	+5%	-60%	-60%	-10%	-20%
Water quality	Sediment in column.	-10%	+10%	-10%	+10%	-10%
Cost		0	$$	$$	$$	$$

Table 8.5 As for Table 8.4 but with dominated options B and E removed along with water quality (as no longer differs). Details on costs, birds and fish researched and added.

	Performance measure	**A No change**	**D District suggestion**	**G Fisheries group proposal**
Ecological	Breeding birds	No change	An estimated 3–15 further pairs of lapwing and a very likely (90–95%) chance that cranes will start nesting	An estimated 3–15 further pairs of lapwing and a very likely (90–95%) chance that cranes will start nesting
Economic	Annual fish survey	No change	Likely to be a 5–20% increase in the main fish populations	Likely to be a 50–100% increase in the main fish population and eels about as likely as not (40–60% chance) to return
Water management	Flood events	+5%	-60%	-20%
Cost		0	$120k	$130

Apply weights to criteria

If each element of the table is given a score then one approach is to decide how important each criterion is and give each a weight reflecting their (agreed) value or utility (Gregory et al., 2012). Each score for an option is then multiplied by the relevant weight and the scores are summed to give a total score (or utility).

There are some tools for assigning weights. Analytic Hierarchic Processing is a process that entails asking a series of pairs of questions (what is the relative importance of sediment in the water against breeding birds), which then generates weights. If the uncertainties associated with the outcomes of each potential course of action are well understood then sensitivity analyses may be used to identify the options that are most likely to avoid unacceptable outcomes. This could be done by exploring 'what if' scenarios (e.g. Borsuk et al., 2003) or using models (Burgman, 2005). Weights can also be elicited from stakeholders (Walshe and Slade, 2020). In practice assigning weights is difficult (when buying lunch what is the relative importance of price, quantity, and taste?) but quickly resolves with specific examples (do you prefer this smaller tasty option or this equal price, bland but more substantial alternative?).

Common currencies

If each criterion can be converted into a common currency (usually money but can be biodiversity, time or risk) then the total net benefit of each can be calculated (e.g. cost-benefit analysis; Section 8.7). Thus the example could assess the cost of a flooding event and multiply it by the probability. The value of the water quality could be assessed just by the amount the water company might have to pay to clean the water or the value to the community of not having water with high sediment loads. Similarly, the total value of a change in fish or bird population can be assessed. With this approach, the total worth of each column can simply be added. In some cases, this is difficult (what is the value of a lapwing?) and some consider it unethical to equate environmental or social outcomes with money.

Negotiate a consensus

The consensus can be agreed upon by those involved through a process called deliberative decision making. In doing so, each stakeholder contemplates what they stand to gain or lose from each of the actions, and how much they are willing to forgo for one criterion to achieve gains on another. They also consider what others stand to gain or lose.

Even swaps

Even swaps entails considering what reduction in benefit of X would be needed to cancel out the gain in Y. For example, by asking whether people would sacrifice access along the river if there is a high probability (say 65%) of herons reoccupying the colony.

In the example, it could be asked how much people would swap an increase in flood protection for an increase in the fish population. It might be decided that flooding is really unpleasant to the community but that they would agree to a minor increase in risk for an improved fishery — perhaps 2% for moderate benefits and 5% for considerable benefits (Table 8.6).

Table 8.6 As for Table 8.5 but with D's moderate gain in fish swapped for a 2% reduction in flood risk and G's considerable benefits in fish swapped for a 5% reduction in flood risk.

	Performance measure	A No change	D District suggestion	G Fisheries group proposal
Ecological	Breeding birds	No change	An estimated 3–15 further pairs of lapwing and a very likely (90–95%) chance that cranes will start nesting	An estimated 3–15 further pairs of lapwing and a very likely (90–95%) chance that cranes will start nesting
Water management	Flood events	+5%	-58%	-15%
Cost		0	$120k	$130

The next question might be the worth of the extra flood reduction. This can be in simple financial terms such as damage caused. It can also be in terms of reputation. Suppose it is decided that each percentage reduction in flood risk is worth $5k (Table 8.7).

Table 8.7 As for Table 8.6 but with A's increase in flood risk considered equivalent $5k cost, D's reduction in flood risk considered equivalent to $290k savings and G's equivalent to $75k savings.

	Performance measure	A No change	D District suggestion	G Fisheries group proposal
Ecological	Breeding birds	No change	An estimated 3–15 further pairs of lapwing and a very likely (90–95%) chance that cranes will start nesting	An estimated 3–15 further pairs of lapwing and a very likely (90–95%) chance that cranes will start nesting
Cost		+$5k	-$170k	+$55

Option D is then a dominant alternative and selected. This approach of even swaps can be carried out for any sized table. It is better to start with the easy choices and hope that a solution appears before needing to make the more difficult choices.

8.5.8 Adding new options

Ideally, considering a wide range of alternative actions enables a decision maker to identify an option that will achieve the best outcomes for the subjects of interest. Often, there is no single option that achieves this (Gregory et al., 2012; Walshe and Hemming, 2019). The process of considering the various options, with their strengths and weaknesses, and confronting what the other stakeholders may gain or lose from each alternative option may lead to suggesting new alternative options.

It can be valuable to ask stakeholders to discuss the options and to suggest new courses of action that may satisfy all parties (Moon et al., 2019). In our scenario above, option D was preferred although it was not ideal for fish. A new alternative (H) was then suggested that provided greater benefit to fish but was slightly more expensive (Table 8.8). This was agreed as the preferred option.

Table 8.8 The consequence table with the preferred option D but with a new option (H) added, which is now considered the overall preferred option.

	Performance measure	D District suggestion	H District suggestion with meanders
Ecological	Breeding birds	3–15 further pairs of lapwing and a very likely (90–95%) chance that cranes will start nesting	6 further pairs of lapwing and a very likely (90–95%) chance that cranes will start nesting
Economic	Annual fish survey	A 5–20% increase in the main fish populations	A8 60–120% increase in the main fish population, eels likely (70–90% chance) to return and possible but unlikely (<30%) chance that salmon will return
Water manage ment	Flood events	-60%	-60%
Cost		$120k	$125k

The District suggestion (D) recommends a strategy that results in 3–15 pairs of lapwings. The best guess is that 10 pairs will establish. Suggestion H suggests that 6 additional pairs of lapwings will establish. Because appropriate ecological conditions are more certain, the prediction under suggestion H is more certain. Stakeholders or decision makers may prefer the expectation of 6 pairs over an expectation of 10 pairs, if the latter includes a more uncertain outcome that could be as low as 3 pairs. Thus, participants may trade an expectation of higher utility for an expectation of lower utility that nevertheless has a more reliable outcome. Attitude to risk is an inherent part of decision-making (Burgman, 2005; Cinner and Barnes, 2019), only possible if uncertainty is made explicit in consequence tables. In general, analyses that focus on detrimental or unacceptable outcomes are the domain of formal risk analysis.

8.5.9 Converting the table to ranks

Where possible, performance measures in a consequence table should be given realistic values. It is also possible to indicate broadly expected changes, such as a general increase in one objective and a general decrease in another. The consequence table can be confusing with a lot of information and a high number can indicate a beneficial (water clarity) or negative (costs, flood risk) outcome. It can be helpful to rank the options in each row (with 1 being the most favourable). The objectives that are most critical could also be placed at the top of the table. It is often clear as to which columns and rows can then be removed. Alternatively, it is possible to indicate the broadly expected changes, such as an increase in one objective and a general decrease in another and see if that leads to an answer without the need for more complex analysis.

8.6 Strategy Table

When there is a range of possible alternatives it can be useful to create a strategy table that organises alternatives into logical packages (see Table 8.9). This can be a useful way to see which alternatives are fundamentally different, rather than just different versions of the same thing.

Table 8.9 Strategy table for an imaginary series of programmes. The different options are placed under broad categories, such as habitat management. These options are then brought together in a set of strategies.

Strategies		**Elements**		
	Habitat management	**New habitat**	**Reintroductions**	**Monitoring**
Maintain existing status	Retain existing practice	Status quo	None	Monitor status in existing sites
Reverse decline	Reintroduce native herbivores	Status quo	None	Monitor status in existing sites
Return to former status	Reintroduce native herbivores Recreate habitats Restore open areas	Identify suitable sites Create agreements with landowners	Establish propagation Programme Transplant individuals	Monitor status in existing sites Test success of management of new sites Monitor success of reintroductions

8.7 Classifying Decisions

8.7.1 Decisions within decisions

Problems or decisions are often spoken about as if they are a single choice, but conservation decisions are generally more like a series of linked choices. First, there is a choice about whether we need to act, often followed by a string of choices about what to do, and when and where to do it, that branch from the initial decision (Gregory et al., 2012). Mapping out the decision can help reveal the decisions within decisions and the important branch points that might lead to different considerations or trade-offs.

For example, if we decide to control an environmental weed because it is impacting something we care about, this leads to a choice about which method to use to remove the weed. Applying herbicide and physical removal can both control the weed, but physical removal is more expensive. If we choose physical removal then we can only treat half the area we could treat if we used herbicide. This leads to a decision about where to prioritise action. Herbicide needs to be applied annually, while physical removal is only needed every two or three years. We now need to decide when to act, to invest more resources now or in the future. This decision will influence whether we treat a smaller area with physical removal or treat a larger area with herbicide but reserve some of our budget to re-treat the same area. If we are not able to treat the same area of weed infestation then we may have to choose priority areas to target. Physical removal can be conducted all year round but herbicide application can only occur at certain times of the year. So the decision about how to act also creates a decision about when to act.

Decision sketching can help identify the different decisions and sub-decisions (Garrard et al., 2017). Given the nested or linked nature of many of these sub-decisions, tools like decision trees (see Figure 8.4) can be useful to identify the branch points and the different pathways and end points for the broader decision. Tools like Bayes Nets (Section 4.7.7) can also be useful to consider these linked decisions, by assigning probabilities to the different branch points.

8.8 Decision Trees

Decision trees are a means of identifying which action to adopt depending upon the circumstances by providing a series of choices. They have the merit of simplifying what separates the different options and creating a sequence of decisions that will identify the appropriate action. They are created by bringing together the range of possible actions, then removing those that are ineffective or inferior under all conditions to another. Ideally the higher choices are those that divide up the group more equally so producing a shorter tree. Figure 8.4 shows a decision tree created from the evidence for the effectiveness of different actions from Conservation Evidence for treating the invasive aquatic plant *Crassula helmsii*.

Multiple decision trees can be used to identify trade-offs between completing actions (Oliver et al., 2012). These could be taken to the stakeholders to help achieve consensus (Section 8.12).

8.9 Creating Models

Models are useful ways of representing the world. They can clarify thinking by representing the elements of a problem and revealing assumptions about how the different components of a system are connected and interact to produce outcomes. They can be used to explore possible outcomes and give indications of future outcomes. Sometimes by challenging our assumptions, models give surprising results, and provide unexpected insights as to how a system functions.

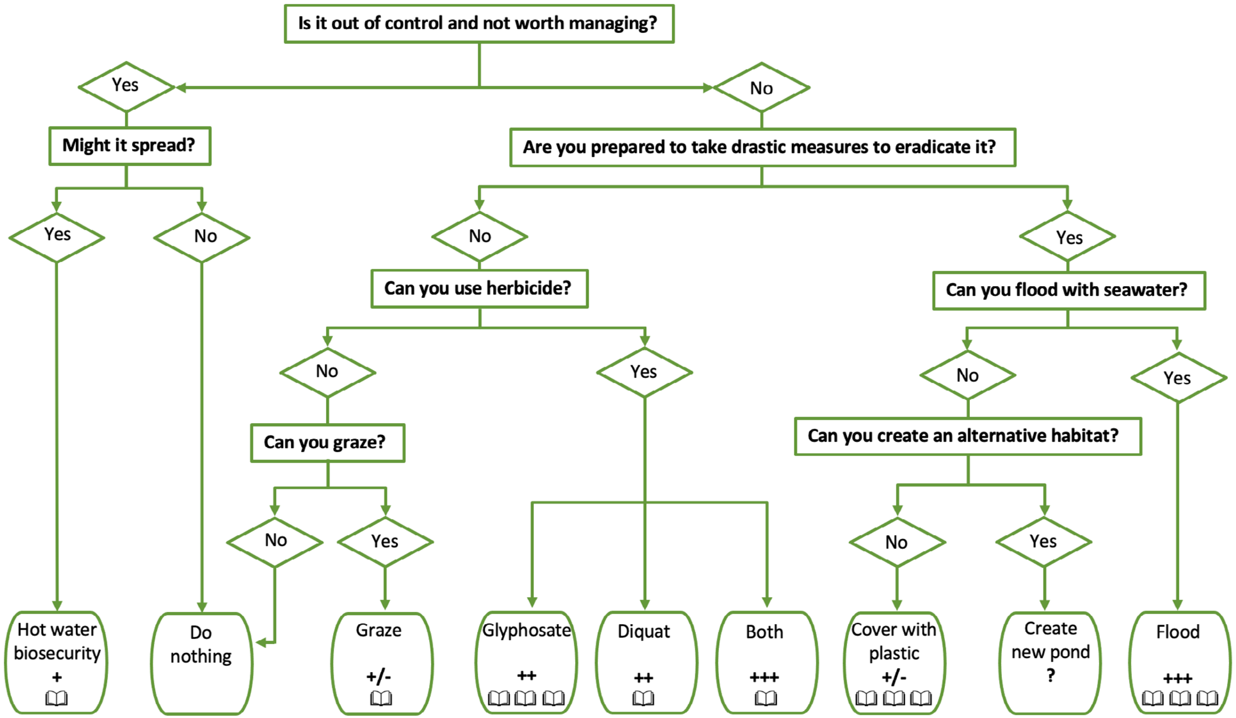

Figure 8.4 A generalised decision tree to consider options for controlling the invasive plant *Crassula helmsii*. ? = no evidence; - - - = considerable harm; - - = moderate harm; - = minor harm; 0 = no effect; +/- = mixed effect; + = little benefit; ++ = moderate benefit; +++ = considerable benefit, 📖📖📖📖📖 = overwhelming evidence; 📖📖📖📖 = strong evidence; 📖📖📖 = moderate evidence; 📖📖 = weak evidence; 📖 = negligible evidence. (*Source*: authors)

However, models are only as good as the information on which they are constructed. It is therefore important that the assumptions and information on which models are built are not just accepted. This can be a particular problem for quantitative models, where numbers can be derived from a computer model and accepted without question.

Models can be simple representations of a system, that allow the complexity of a system to be reduced to an appropriate level of simplicity by focusing on the most relevant aspects and making explicit assumptions about how actions lead to outcomes. Previous sections have already presented three ways in which concepts can be linked together. Mind maps (Section 4.7.4) are an informal means of representing the links between a wide range of ideas. Means-ends networks (Section 8.3.2) provide a relatively informal means of sketching the proposed actions (means) to the desired outcomes (ends). The Theory of change (Section 7.5.2) can be a well structured means of planning a proposal by showing the links between elements. Miradi (Section 9.10.2) is a well accepted means of presenting theories of change. In making decisions, conceptual and/or explicit qualitative or quantitative models provide the links between casual observations, data, and the all-important consequences of decisions. Ideally, the underlying choices of the models are explicit and can be subject to confirmation with data, and cross-examination with theory.

Decision makers and stakeholders generally have implicit models of how a system works. Helping individuals to make those 'mental models' explicit (e.g. by creating a diagram) can have a wide range of benefits (Moon et al., 2019). Firstly, eliciting mental models can help individuals to recognise the assumptions they are making about a system (Moon et al., 2017). When done as part of a group process, eliciting mental models provide an opportunity to create a conceptual model of how a system works based on the collective knowledge of a group (e.g. Colvin et al., 2016). This group process can also help to create a shared vision for how to achieve a particular outcome. But it can also help groups with different perspectives to understand the assumptions and preferences and knowledge of other stakeholders, even if they do not share those views. By sharing mental models, it is possible to share knowledge, but also to correct misconceptions, permit solutions to be negotiated and help in conflict resolution by providing people with an opportunity to share their point of view based on their own knowledge and experiences (Moon et al., 2019).

Figure 8.5 shows the conventional process of building models to support decision making. It also shows the type of decision making adopted by the processes described in this book in which evidence use and expert elicitation play major roles. Evidence from all available sources provides the platform for developing ideas of cause and effect, transforming those ideas into equations and parameters, and validating the assumptions made in developing the model and estimating its parameters. Model building may conclude with a conceptual model that guides the creation of a consequence table. Alternatively, it may lead to a suite of different mathematical and statistical models for some or all of the elements in a consequence table. These ideas were introduced in Section 2.7.

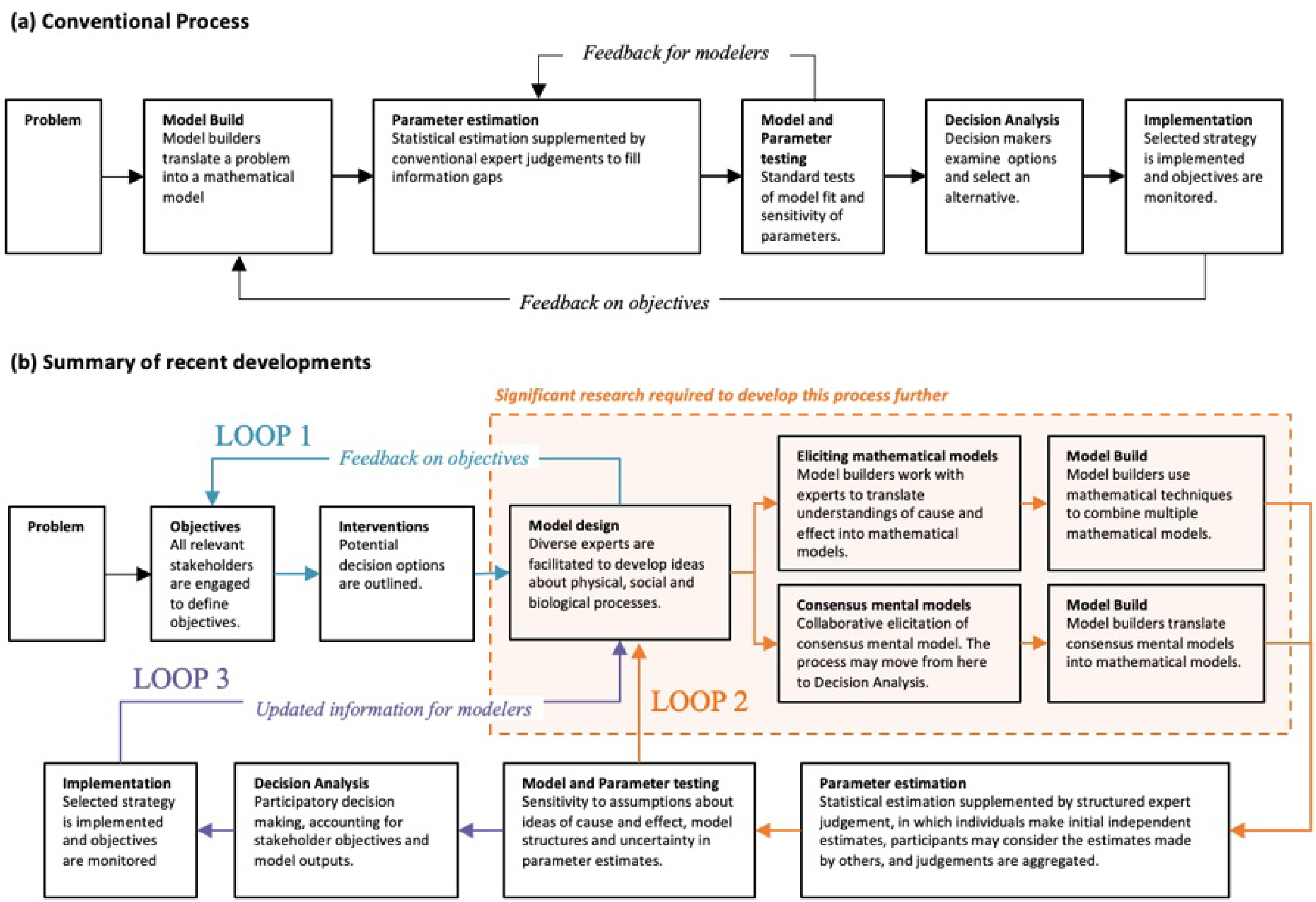

Figure 8.5 Steps in model development for decision making, summarising (A) processes typically deployed in most model developments, and (B) emerging approaches. (*Source:* modified from Burgman et al. 2021, which provides references for each step, CC-BY-4.0)

8.10 Achieving Consensus

Using the processes for stakeholder engagement presented in Chapter 6, the decision maker needs to present the different options and allow all stakeholders to evaluate the trade-offs to reach a consensus. It is most challenging when high-stakes decisions involve stakeholders with conflicting objectives. Behavioural consensus is effective when participants agree to negotiate to resolve conflict (Valverde, 2001).

The stages described previously can be approached at a range of scales from just two individuals to a range of teams. Workshops are especially useful when issues are complex and require the extraction of a wide set of evidence and views, if community involvement is key, or if there are substantially differing views, perhaps including conflict. The consequence tables described above are a key element in negotiations. They summarise what is to be expected from each management option, providing a clear picture of what each participant stands to gain or lose from each action. The fundamental objectives encapsulate what participants care about. Once dominant and dominated alternatives and redundant objectives have been removed, the remaining table focuses participants on the core issues. The measures provide unambiguous representations of these key objectives.

The facilitator's role is to look for areas in which participants may be willing to concede gains in the interests of finding a mutually acceptable, consensus solution. This requires participants to decide what they can tolerate, rather than seek an optimal outcome from their perspective. Valverde (2001) suggested a framework to achieve consensus that has its foundations in an approach developed by Kaplan (1992; see Burgman, 2005). It involves decomposing arguments (as in argument maps) into basic elements: claims, evidence, models that link claims to data and assumptions, and objections. Disagreements may be about facts, theories, data, or reasoning. Sources of disagreement may be semantic interpretations, different preferences and values, opinions about the validity of evidence, or adherence to different theories of cause and effect. Closure or resolution may be achieved through sound argument, agreeing that a particular position is 'best', or reaching a resolution that is acceptable to the participants and that is 'fair' rather than correct or optimal. Sometimes a conflict dissipates and is resolved because it turns out that the differences between actions are trivial. Participants may also trade the surety of an outcome for a particular objective for the expectation of the magnitude of the outcome. Thus, a participant may agree to a smaller expected adult fish population each year, if the variation in expected fish population size is also smaller or if the proposal includes marketing resulting in higher prices.

8.10.1 Dealing with conflict

Conflict arises when there is a difference in opinion between individuals or organisations about which options should be analysed, which objectives should be included, how options should be assessed, whether change is necessary or which trade-offs should be made (Redpath et al., 2013). The underlying principle is to discover the compromises that are most acceptable to the key stakeholders. This may include agreeing that some objectives are not essential or accepting that an option, whilst being ideal for one group, is unacceptable to others but that an alternative option is acceptable to both. In some cases the conclusion might be to acknowledge the conflict and accept that a compromise will not be found by the participants.

Conservation conflicts will likely increase (Redpath et al., 2013) and, where they do arise, it is likely due to a lack of communication and/or lack of understanding about the impacts of a particular action (Minderman et al., 2019). At a minimum, using transparent processes for decision-making can help clarify the information and rationale behind a decision.

Open and transparent processes, such as identifying the problem, gathering the evidence, and early engagement with stakeholders, can increase trust and help avoid misunderstanding. Sharing mental models can be useful to identify differences in the assumptions made by different groups. Making these assumptions clear at the start provides the opportunity to identify preferences and correct misconceptions (Moon et al., 2019).

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