DECISION POINT

Connecting conservation policy makers, researchers and practitioners

Issue #74 / October 2013

Making decisions for real

Using models, structured decision making & adaptive management

Decisions on managing the impacts of camping

Decisions on resource allocation in the Otways

Decisions on visitor impact in marine protected areas

Decision Point

Decision Point is the monthly magazine of the Environmental Decisions Group (EDG). It presents news and views on environmental decision making, biodiversity, conservation planning and monitoring. See the back cover for more info on the EDG. ***Decision Point*** is available free from http://www.decision-point.com.au/

Plus

DECISION POINT

Issue #74 / October 2013

Contents



Monitoring the condition of the intertidal zone in marine parks in Victoria. Parks Victoria want a measure that will trigger management action if that condition falls below a certain level. See the story on page 8. Photo by Museum Victoria.

On the point

SDM out of the box

This issue is about models and frameworks for making robust decisions. Sounds a bit dry? Well, not the way we tell it. The stories gathered here make a compelling case for the appropriate use of models and frameworks like structured decision making (SDM), and it's not hard to see the passion that lies between our arguments.

Prue Addison sets the scene by discussing why people don't use models (page 4). She then suggests five ways modellers can improve the effectiveness and relevance of their work in conservation decision making; and a big part of that is by including stakeholders in the decision making process. But it's more than just about models. "Simply using a model alone to solve a conservation management decision is not enough," says Prue. "A framework is needed to guide good modelling practice, and we believe structured decision making and adaptive management frameworks are well suited to do this."

What is structured decision making? Kelly Hunt de Bie and Libby Rumpff explain it's a decision framework driven by decision makers (page 6). They set out how it's done and then demonstrate how it works in three case studies of collaborations between EDG researchers and Parks Victoria (page 6-11). Tony Varcoe from Parks Victoria then reflects on the value of this framework to decision making in his organisation (page 11).

The closely related framework of adaptive management (AM) is discussed by Martin Westgate (page12). Martin reviewed the literature on AM and discovered that while everyone is talking about it, not many are actually doing it. Which just goes to show that AM (and SDM) can be challenging to implement.

Hugh Possingham then wades into the debate and takes on the nay sayers. He does this by exploring the most common objections to the use of decision science (and explains why they are wrong). "I'd describe them [the objections] as myths that the nation can no longer afford," he says (See page 14).

So, if you think decision frameworks are a bit dry. Read on and discover why this topic elicits such passion within the EDG. Without them we simply fall short of what we could be achieving. As Hugh says on page 14: "Since 1990, the Australian Federal Government has announced seven major natural resource programs collectively worth $6.51 billion. In almost every case the allocation decisions continue to be ad hoc and opaque."

David Salt, Editor, Decision Point, David.Salt@anu.edu.au

DECISION POINT

Decision Point is the monthly magazine of the Environmental Decision Group (EDG). The EDG is a network of conservation researchers working on the science of effective decision making to better conserve biodiversity. Our members are largely based at the University of Queensland, the Australian National University, the University of Melbourne, the University of Western Australia, RMIT and CSIRO.

Decision Point is available free from: http://www.decision-point.com.au/

Short accounts of papers from EDG researchers. If you would like copies of any of these papers see: http://decision-point.com.au/research-briefs.html

SDM for wildlife disease outbreaks

Structured decision making (SDM) is the theme of this issue of Decision Point and in the following pages we show how it can be applied to a variety of resourcing issues from camping in the Grampians to trampling in the intertidal (see pages 6-11). In this research brief, SDM is applied to managing wildlife disease in Montana (with one of the researchers here being EDG's Terry Walshe).

Infectious diseases in wildlife are on the increase, and they pose significant threats to the health of wildlife, humans and biodiversity more generally. Wildlife managers are generally poorly prepared to manage disease outbreaks proactively, relying instead on reactive 'crisis management'. This study reports on a structured-decision-making framework developed for Montana Fish, Wildlife, and Parks (USA) for understanding the trade-offs of managing disease outbreaks proactively or reactively.

The first part of the framework is a model to estimate the probability of disease outbreak given field observations available to managers. The second part of the framework is decision analysis that evaluates likely outcomes of management alternatives based on the estimated probability of disease outbreak, and applies managers' values for different objectives to indicate a preferred management strategy.

The researchers used pneumonia in bighorn sheep as a case study for their approach, applying it to two populations in Montana that differed in their likelihood of a pneumonia outbreak. The framework provided credible predictions of both probability of disease outbreaks, as well as biological and monetary consequences of management actions.

The structured decision-making approach to this problem was valuable for defining the challenges of disease management in a decentralized agency where decisions are generally made at the local level in cooperation with stakeholders. Their approach provides local managers with the ability to tailor management planning for disease outbreaks to local conditions.

More info: Terry Walshe twalshe@unimelb.edu.au

Reference

Mitchell MS, JA Gude, NJ Anderson, JM Ramsey, MJ Thompson, MB Sullivan, VL Edwards, CN Gower, JF Cochrane, ER Irwin & T Walshe (2013). Using structured decision making to manage disease risk for Montana wildlife. *Wildlife Society Bulletin* 37: 107-114.

Why INFFER?

The quality of decision making by environmental managers may be enhanced by the use of formal decision frameworks to assist with the development and evaluation of prospective projects. Various decision tools and frameworks have been used in biodiversity conservation (Examples include Assets, Threats and Solvability (ATS); Conservation Action Planning (CAP); multicriteria andscape assessment and optimisation (MULBO); and benefit : cost analysis (BCA)). However, following extensive experience working with environmental organisations to help them assess their priorities, David Pannell and colleagues judged that none of the existing tools provided an ideal combination of usability, rigour and comprehensiveness. None assist environmental organisations to undertake the full range of tasks that are essential for investment planning. These tasks include initial project identification, development of well costed and logically consistent environmental projects for public funding and prioritisation of the available projects. None of the available tools includes the capacity to analyse the choice of delivery mechanisms to be used in the project, which was identified as an important weakness in many existing programs.

To meet these gaps, David Pannell's team developed the Investment Framework for Environmental Resources (INFFER). It is intended to help investors improve the delivery of benefits from programs that aim to protect or enhance particular environmental assets. It is a tool that allows users to prioritise among competing projects on the basis of the benefits and costs of each project. It also assists with the development and design of projects, and with the selection of delivery mechanisms. INFFER is designed to maximise the learning from experience that should occur in these programs.

In the development of INFFER, close attention was paid to its usability, acceptability and usefulness to users, and its theoretical rigour. The purpose of this paper in *Wildlife Research* is to describe how and why INFFER was designed the way it was, covering both practical and theoretical aspects.

Reference

Pannell D, AM Roberts, G Park & J Alexander (2013). Designing a practical and rigorous framework for comprehensive evaluation and prioritisation of environmental projects. *Wildlife Research* 40: 126-133. http://dx.doi.org/10.1071/WR12072

Editor's note: For a very readable and engaging discussion of the perils and pitfalls of ranking environmental projects, see David Pannell's blog 'Pannell Discussions'. David has just completed a 20 part series on this topic (a summary of which we include in the next issue of Decision Point). This article in Wildlife Research is one of the underpinning papers to this series. The whole series is available as a download at http://purl.umn.edu/156482

Translocation in a time of climate change

The translocation of species for conservation involves both the restoration of historic populations (moving organisms to where they once occurred) to managing the relocation of imperiled species to new locations (moving organisms from a place where they are increasingly unable to survive to a place where they might be able to thrive, say in the face of climate change). It's a challenging management strategy that usually comes with high risk and high cost, yet it is increasingly being considered.

In this paper, Mark Schwartz and EDG's Tara Martin review the literature in three areas—translocation, managed relocation, and conservation decision making—to inform conservation translocation under changing climates.

They found that climate change increases the potential for conflict over both the efficacy and the acceptability of conservation translocation. The emerging literature on managed relocation highlights this discourse.

They also found that conservation translocation works in concert with other strategies. The emerging literature in structured decision making provides a framework for prioritizing conservation actions—considering many possible alternatives that are evaluated based on expected benefit, risk, and social–political feasibility.

Finally, the translocation literature has historically been primarily concerned with risks associated with the target species. In contrast, the managed relocation literature raises concerns about the ecological risk to the recipient ecosystem. Engaging in a structured decision process that explicitly focuses on stakeholder engagement, problem definition and specification of goals from the outset will allow creative solutions to be developed and evaluated based on their expected effectiveness.

Reference

Schwartz MW & TG Martin (2013). Translocation of imperiled species under changing climates. *Annals of the New York Academy of Sciences* 1286: 15-28.

A model solution for good conservation

Making models indispensable in conservation decision-making

By Prue Addison (University of Melbourne)

Conservation managers often have to make decisions in uncertain and complex situations. This uncertainty can be paralysing: "Do I choose option A or option B? Both have so much uncertainty around them that I just can't decide!"

One way of dealing with this uncertainty is by modelling the different choices on offer to see what type of results they might yield. The correct use of the appropriate model not only helps in making robust, transparent and defensible conservation decisions, it often generates insights on the nature of the system being managed. Examples where models have helped in making conservation management decisions include: the re-introduction of populations of hihi in New Zealand (Armstrong et al., 2007); the re-introduction of gray wolves in Yellowstone National Park, USA (Varley & Boyce, 2006); and protecting Kemp's Ridley sea turtle in the Gulf of Mexico from habitat degradation (Crowder & Heppell, 2011).

So there's no question that, when used well, models can deliver good outcomes. However, despite their demonstrated benefits, models are often mis-used or not used at all to support conservation decisions. Instead, decisions are frequently based on intuition, personal experience or unaided expert opinion; and this can lead to biased decisions that rest on hidden assumptions and individual agendas. This in turn can lead to poor outcomes with little capacity to learn.

I recently led an investigation on why models are still not used in many conservation decisions (Addison et al., 2013). We searched the scientific and grey literature for evidence of views and attitudes towards the use of models by those who commonly participate in environmental decision-making. We then divide these objections up into three separate categories that related to the role of models in making a decision, modelling practice and model outputs. Common objections to the use of models in environmental decision-making are summarised in Table 1. (See also the story on page 14.)

Here are some quotes that represent these common objections:

- *"In most countries conservation is grossly under-funded, and for many organizations the cost of hardware, an expert operator, and the experimentation required may inhibit the use of reserve selection algorithms (even if the software itself is free)" (Prendergast et al., 1999)*

Table 1. Common objections to the use of models in decision-making

The role of models in decision-making
We don't need models for decision-making, we have experts
Developing and using models in decision-making is too resource intensive
Modelling practice
Models do not represent my conceptual understanding of the decision context
Models focus on environmental considerations of the decision context, but fail to capture the social, economic and political factors which influence conservation management options
Models are either too complicated or too simple
There are insufficient data to do quantitative modelling
Inadequate data quantity/quality leads to inaccurate model predictions
Model outputs
I don't understand the way scientists communicate
Model outputs are too uncertain for decision-making

> "Despite their demonstrated benefits, models are often mis-used or not used at all to support conservation decisions. Instead, decisions are frequently based on intuition, personal experience or unaided expert opinion."

- *Models "remain so complex that they are seen as black boxes instead of transparent analytical tools" (De Smedt, 2010)*
- *"Neither are they [water managers and researchers] sharing the same language for expressing results or the requirements of models" (Borowski & Hare, 2007)*

How do you deal with common objections such as these? We gave this some thought and would like to suggest five practical solutions to help modellers improve the effectiveness and relevance of their work in conservation decision-making:

Solution 1: Dispel common misconceptions

Modellers need to appreciate that there are common objections to the use of models. Some of these can be misconceptions and should be addressed. Modellers can begin to anticipate common objections to models and prepare responses by using the list of objections in Table 1. A simple response to the objection that models diminish the autonomy of decision-makers could be: Models are tools for helping us think, they provide decision support and they do not replace decision-makers.

Solution 2: Guide good modelling practice: Structured Decision Making

Simply using a model alone to solve a conservation management decision is not enough. A framework is needed to guide good modelling practice, and we believe structured decision making (SDM) and adaptive management (AM) frameworks are well suited to do this. These frameworks also enable the participation of decision-makers, stakeholders and experts in the decision-making process. (See the stories on pages 6-11.)

There are a variety of decision-analysis tools to aid rigorous, transparent and logical decision-making. In Figure 1 we list some techniques that are particularly useful in engaging participants and assisting with the decision-making process. These include:

- **Qualitative techniques** such as values-focused thinking. These can help participants develop a shared understanding of the problem, clarify the decision context and develop management alternatives.
- **Cause-and-effect models:** These help explore the consequences of management alternatives. As models can be confusing to participants without modelling experience, models that retain a visual conceptual form, such as Bayesian Networks, can be useful. These can help avoid participants' perceptions that models are black boxes.

- **Simple visual management tools** such as control charts. These can be used to interpret monitoring data. Such tools assist with the learning and review feedback loops of adaptive management.

Solution 3: Improve the social process

A SDM/AM framework on its own does not facilitate the social process of decision-making. There are a number of ways to improve the interactions and dynamics between participants. Many of these relate to genuinely including participants in the decision-making process and ensuring there is a balanced representation of participants. When genuinely engaged in the decision-making process, participants often feel a greater sense of ownership of decisions. However, participatory model building can become challenging when participants hold divergent views. There may be little that modellers can do to remedy such challenges through the model building process, although improving communication and building trust will help.

Solution 4: Improve communication

We have all been told that good communication is an essential skill to have, but very few modellers have had comprehensive training in this area. Two-way face-to-face communication, active listening, and demonstrating respect towards participants can create a more productive modelling process. However, we recognise that some modellers may lack the communication skills to competently engage participants. If communication is not a strength, we suggest modellers should seek specialist training in communication or employ a skilled workshop facilitator. Independent facilitators are particularly useful in high-stakes cases involving conflict, as it is easier for them to remain objective and not become emotionally involved in workshop discussions.

Solution 5: Build trust

Trust is an essential element of effective decision-making. To build trust, a modeller should demonstrate both their professional credibility and that of their modelling technique. Investing time in frequent personal contact, such as face-to-face meetings, telephone calls and emails, will help modellers foster interpersonal ties. An important aspect of building trust is that a modeller should not allow their values to influence the essential objectivity of their work. This can be very challenging as modellers who work closely with decision-makers are bound to form value judgments about the decisions in which they are involved.

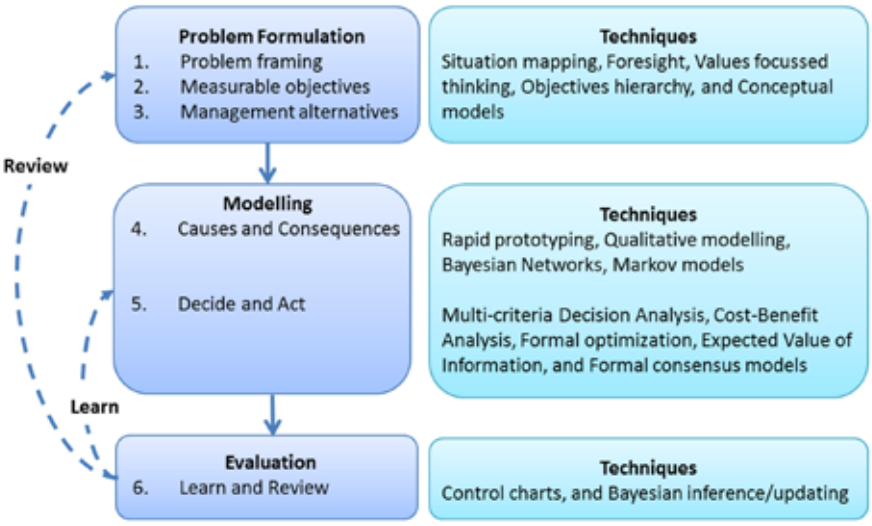

Figure 1: A Structured Decision Making/Adaptive Management framework with modelling techniques that can assist the decision-making process.

Good decision making involves the appropriate use of the right model. Figuring out what's appropriate is all about sharing, collaboration and communication. Pictured here are Parks Australia staff working with decision scientists with the aim of providing decision support for resource allocation on Christmas Island (see Decision Point #61).

Making models indispensable

If all five of the solutions outlined here were a regular part of a modellers' practice, we believe most of the obstacles to models being used would be overcome. And the result of this would be more effective decision making and better conservation outcomes.

Of course, implementing some of the solutions will challenge many modellers as they require skills outside of their core training and experience. However, if the aim is to achieve better conservation outcomes, then it's definitely worth considering.

We hope that our recommendations help broaden the use of models, forging deeper and more appropriate linkages between science and management. If we can make models indispensable in conservation decision-making, everyone is a winner.

More info: Prue Addison p.addison@student.unimelb.edu.au

References

Addison PFE, L Rumpff, SS Bau, JM Carey, YE Chee, FC Jarrad, MF McBride & MA Burgman (2013). Practical solutions for making models indispensable in conservation decision-making. *Diversity and Distributions* 19: 490–502.

Armstrong DP, I Castro & R Griffiths (2007). Using adaptive management to determine requirements of re-introduced populations: the case of the New Zealand hihi. *Journal of Applied Ecology* 44: 953–962.

Borowski I & M Hare (2007). Exploring the gap between water managers and researchers: difficulties of model-based tools to support practical water management. *Water Resources Management* 21: 1049–1074.

Crowder L & S Heppell (2011). The Decline and Rise of a Sea Turtle: How Kemp's Ridleys Are Recovering in the Gulf of Mexico. *Solutions* 2: 67-73.

De Smedt P (2010). The use of impact assessment tools to support sustainable policy objectives in Europe. *Ecology and Society* 15: 30.

Prendergast JR, RM Quinn & JH Lawton (1999). The gaps between theory and practice in selecting nature reserves. *Conservation Biology* 13: 484–492.

Varley N & MS Boyce (2006). Adaptive management for reintroductions: updating a wolf recovery model for Yellowstone National Park. *Ecological Modelling* 193: 315–339.

A decision framework driven by the decision makers

Structured Decision Making in environmental management

By Kelly Hunt de Bie and Libby Rumpff (University of Melbourne)

Managers of the environment are routinely faced with making complex decisions with little information and high levels of uncertainty. It's a tough ask, but that's their job. When decisions have to be made regardless of these constraints, structured decision making (often simply referred to as SDM) is a useful tool for guiding managers through the decision process.

It doesn't guarantee that the 'right' choice will be made every time (some people might define 'right' as a solution that resolves the problem quickly and cheaply), but structured decision making does ensure that the decisions made will be transparent, logical and defensible (Gregory et al 2012). And decisions that are transparent, logical and defensible are 'good' decisions. The SDM framework is also flexible in how it can be applied. It's applicable to a range of problem types, from decisions relating to specific issues in a local region through to complex decisions involving multiple stakeholders.

SDM refers to a decision framework driven by the objectives, or values, of those involved in the decision-making process. Essentially, the process involves an organized analysis of problems in order to reach decisions that are focused explicitly on achieving fundamental objectives. This is accomplished through 6 steps, used to structure and guide thinking (Runge 2011).

There are many tools and techniques available that can be utilized throughout the framework. Some steps may require external expertise. Others can be effectively implemented by the decision maker(s) without the need for specialist training and expertise (Addison et al 2013, and see Prue's story on page 4). In any case, each step of the SDM approach is undertaken formally and cooperatively in order to support defensible decision making.

The six steps involved in structured decision making are outlined over the following pages. How it works in practice is illustrated in four case studies also presented in this story.

> "An emphasis on the development of possible alternatives is a key component that sets SDM apart from other decision assessment methods."

Case Study 1: A camping we will go

SDM to inform management of recreational impacts on a national park

By Kelly Hunt de Bie (University of Melbourne)

National parks in Victoria are established with the twin aims of conserving environmental assets while also providing quality, sustainable recreational experiences. But what if the recreational experiences result in the trashing of the environmental assets? Activities of visitors can have significant negative impacts on the natural values of parks, both at the site and landscape scale.

The marked increase in nature tourism over the last 20 years has meant that managers are increasingly challenged in finding the right balance between enabling recreation and ensuring conservation. Structured decision making (SDM) provides a useful framework for guiding decisions about the management of visitors and their associated environmental impacts. It provides a formalised approach to identifying objectives regarding the provision of recreation and prioritising management strategies based on informed trade-offs.

In this case study, we applied an SDM framework to explore possible management approaches in response to the proliferation of bush camping in the Grampians (Gariwerd) National Park. The Grampians is one of Victoria's premier nature-based tourism destinations. It's receiving just over 1,000,000 visits per year. The park offers a range of camping opportunities, with large serviced campgrounds, commercial camping operations and dispersed, unserviced bush camps.

Historically, bush campsites were developed by campers. They involved minimal planning, and received little consideration in their placement in terms of their impact on environmental or cultural values. Around 273 individual campsites have now been identified throughout the park, and concerns have been raised about their decreasing condition and proliferation.

The growing number of unplanned bush campsites in the park was identified by park managers as potentially resulting in negative ecological impacts – such as soil erosion and vegetation loss – as well as creating logistical issues relating to on-ground management and visitor safety.

The growing number of unplanned campsites in the Grampians National Park in Victoria is becoming a problem. Management want to retain the possibility of campers being able to use these sites but they want to curb the environmental damage they are causing.

"SDM involves an organized analysis of problems in order to reach decisions that are focused explicitly on achieving fundamental objectives."

Several EDG researchers from the University of Melbourne have been collaborating with Parks Victoria to apply SDM to a range of protected area management issues. The first three case studies are based on this work. The problems tackled ranged from a large, resource allocation issue to the management of recreation impacts in a single park (see 'a camping we will go').

The fourth case study is a short editorial by a Parks Victoria manager, Tony Varcoe, on the value he sees in SDM for the agency's planning and decision making. He says up front that: "Parks Victoria needs to make tough decisions about how it will allocate its limited resources." He acknowledges the benefits of SDM but also points out that SDM is a resource intensive process itself. Do the benefits outweigh the costs?

There are many descriptions available on what constitutes SDM. At its core, however, lie six basic steps.

Step 1. Articulate the decision context

The first step involves clearly articulating the scope of the problem and the decision to be made. Clarifying the context of the decision involves defining what decision is being made and why, establishing roles and responsibilities (including stakeholders and experts) and identifying time scales, spatial scales and constraints.

Step 2. Define objectives & performance measures

The core of SDM is a well defined set of objectives and associated performance measures. First, the decision needs to be focused around the fundamental objectives. These state the primary reason for the decision, and are the focus of analysis (Runge 2011).

Fundamental objectives are often difficult to define and they may require multiple performance measures. Consequently, other sub-objectives are sometimes necessary to represent the various ways of achieving the fundamental objective (means, strategic or process objectives).

Performance measures in SDM are defined as specific metrics for consistently reporting and estimating the consequences of any decision on the objectives. Good performance measures are clear and concise, unambiguous, understandable, direct and operational (Gregory et al., 2012). This is critical because they define how an objective is to be interpreted and evaluated in the decision context.

Continued on page 8

"SDM is a useful tool for facilitating the development of visitor management and monitoring problems in protected areas."

We used an SDM framework in a workshop setting involving both decision makers and on ground parks staff from Parks Victoria. During the problem framing (step 1), it was established that Parks Victoria want to continue to provide a bush camping experience at the Grampians National Park. However, this activity needs to be practiced in an ecologically and logistically sustainable manner.

Objectives (step 2) were then developed that covered minimising ecological impacts, maximising visitor safety and satisfaction, and reducing total cost (both staff time and dollars).

The alternative management strategies (step 3) involved combinations of camp site maintenance, closure, and relocation as well as maintaining the status quo.

Estimates of the consequences of management alternatives on the management objectives were elicited (step 4) and a multi-method approach was used to quantify the trade-offs (step 5). This resulted in decision scores that could be used to compare the performance of the various management strategies.

For this case study, the SDM process could be further used to include views of relevant stakeholders, such as user groups and tour operators.

We propose that SDM is a useful tool for facilitating the development of visitor management and monitoring problems in protected areas. This approach has some advantages over traditional decision frameworks commonly used in visitor management, through formulation of objective hierarchies and the ability to incorporate uncertainty. It's also handy for developing objectives for temporally and spatially explicit issues that arise but are not covered by strategic park level objectives (as outlined in management plans).

Alternative management strategies involved combinations of camp site maintenance, closure, and relocation as well as maintaining the status quo.

More info: Kelly Hunt de Bie khun@unimelb.edu.au

SDM in environmental management

Continued from page 7

Once established, objectives and performance measures form the framework for developing and evaluating alternative courses of action for management.

Step 3. Develop alternatives

This step involves the clear articulation of the various management actions or alternatives relevant to the problem. An emphasis on the development and analysis of possible alternatives in relation to the objectives is a key component that sets SDM apart from other decision assessment methods (Gregory et al 2012).

Alternatives allow decision-makers to compare a range of solutions to the given problem. Within the SDM process, an alternative can be a single management action, or a management scenario that encompasses a range of management actions. Alternatives are explicitly designed to address fundamental objectives, and should be technically sound and clearly defined.

Step 4. Estimate consequences

This step involves a quantitative analysis of the consequences of the management alternatives in relation to the objectives, utilising available knowledge and /or predictive tools. Estimates of consequences can be based on existing data, expert opinion, and conceptual or predictive models.

A consequence table (Gregory et al. 2012) is a useful tool in this step. These tables clearly illustrate the estimates (and uncertainty) of predicted consequences of various alternatives in relation to each measurable objective. It may become evident that a particular alternative is favoured, or should be rejected from further analysis (of trade-offs, Step 5).

Step 5. Multiple objective trade offs

Making a decision about which alternative has the greatest merit requires a decision maker to consider both the consequences of management alternatives, and the values they attribute to the various objectives. These trade-offs are inevitable when decision making involves multiple (and often competing) objectives.

A range of approaches can be utilised within the SDM framework to make trade offs explicit, and based on a thorough understanding of consequences and their significance.

Step 6. Decide and take action

Based on the previous steps, the most favoured alternative can be determined, and resources allocated accordingly. Alternatively, it may be apparent that objectives or actions were missing from the analysis, and the process needs repeating and refining!

Continued on page 10

Case study 2: Trampling through the intertidal

Exploring management thresholds for Victoria's Marine National Parks

By Prue Addison, Kelly Hunt de Bie and Libby Rumpff (University of Melbourne)*

In order to adaptively manage protected areas, conservation managers need to know when to implement management actions to prevent ecosystems trending towards an unfavourable condition. Whilst ecological research and monitoring can help define unfavourable ecosystem conditions; the question of when to implement a management action requires value judgements by decision-makers. Such judgements require decision-makers to subjectively trade-off competing objectives. For example, if visitors to a reserve are having an impact, there is a trade-off between environmental (eg, biodiversity benefits), social (eg, visitor satisfaction) and economic (eg, the cost of management actions) objectives.

We worked with Parks Victoria to trial a SDM process to explore where to set management thresholds for the intertidal brown alga, *Hormosira banksii*, at Port Phillip Heads Marine National Park*. *Hormosira* (commonly referred to as Neptune's necklace) is an indicator of the condition of invertebrate and algal communities on Victoria's rocky intertidal reefs. Parks Victoria has identified that a key threat to intertidal reef communities is trampling by humans.

"At what point should a more intensive management strategy be implemented to minimise the impact of trampling?"

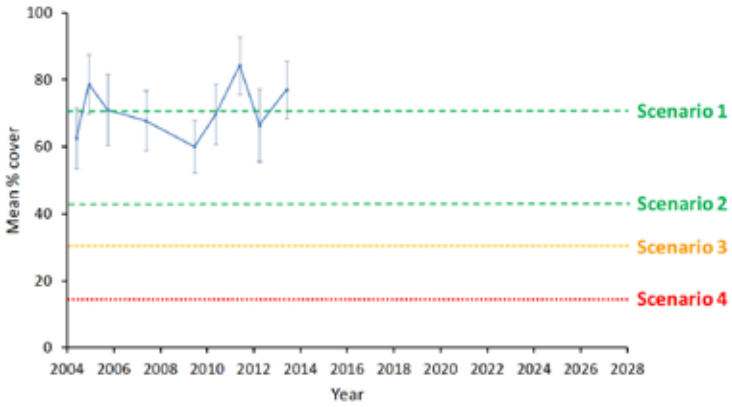

Figure 1: The current condition of Hormosira (blue line: mean % cover ± standard error) at Point Lonsdale intertidal reef (Port Phillip Heads Marine National Park) from 2004 – 2013. Through the SDM process, participants were asked to consider the current condition of Hormosira (Scenario 1) and three future scenarios of reduced condition of Hormosira (Scenario 2-4), when estimating the consequences of management alternatives on management objectives.

While the condition of *Hormosira* has remained relatively stable since 2004 (Fig 1), Parks Victoria are concerned that human trampling may increase in the future and is likely to result in declining condition of intertidal reef communities.

The challenge for Parks Victoria is this: If the condition of *Hormosira* starts to decline in the future, at what point should

Continued on page 9

Tramping through the intertidal

Continued from page 8

a more intensive management strategy be implemented to minimise the impact of trampling?

We involved Parks Victoria staff (decision-makers and on-the-ground rangers) and marine scientists with expertise in intertidal ecology in the SDM process. All participants had valuable experience and knowledge of the management of marine national parks and the effectiveness of biodiversity protection which they could contribute.

By building on work already done by Parks Victoria, participants developed a series of management objectives and alternative management actions relevant to the decision context. The management objectives (step 2) represented environmental factors (eg, to improve the condition of Hormosira), social factors (eg, to improve visitor satisfaction) and economic factors (eg, to minimise resources spent), all of which were considered fundamentally important to the decision context by participants.

The management alternatives (step 3) represented increasing levels of investment to address the impact of trampling (eg, from ranger patrols to ensure visitor awareness, through to restricting visitor access to reducing the impacts of trampling).

Participants were asked to consider the current condition of *Hormosira* (Scenario 1; Fig 1) and three future scenarios of reduced condition of Hormosira (Scenario 2-4; Fig 1). Under each of these scenarios, we elicited participants' estimates of the consequences of management alternatives on the management objectives (step 4). The SDM process is particularly useful at this stage, as we can incorporate participants' uncertainty in scientific knowledge, particularly when it comes to predicting the effectiveness of management alternatives under future scenarios.

We also guided the decision-makers through an exploration of their value judgements relating to the trade-offs involved under different scenarios of decline in the condition of *Hormosira* (step 5).

By combining the consequences and trade-offs elicited in our workshop, we were able to present decision scores for each

Figure 2. Example decision scores presented to Parks Victoria decision-makers. Decision scores are based on the consequences and trade-offs elicited through the SDM process.

management alternative under each scenario of reduced condition of Hormosira (eg, Fig 2). These decision scores represent the management alternatives that best perform under the different scenarios of decline of *Hormosira*.

The SDM outputs can be used to help Parks Victoria decision-makers decide where to set management thresholds for Hormosira at Port Phillip Heads Marine National Park (step 6).

More info: Prue Addison p.addison@student.unimelb.edu.au

**This project is part of Prue Addison's research. It is being supported by Parks Victoria's Research Partners Panel program. The results of this case study are being considered by Parks Victoria in relation to how well the SDM process can assist them in developing management thresholds for the MNP Adaptive Management program.*

Hormosira banksii (aobove) is one of the most distinct seaweeds in Australia. The common name for this species (Neptune's necklace) is derived from its pearl necklace shape. Parks Victoria use Hormosira as an indicator of the condition of invertebrate and algal communities on Victoria's rocky intertidal reefs.

Pictured on the left is a survey of the intertidal zone. (Photo by Museum Victoria)

SDM in environmental management

Continued from page 9

Complex decisions are often complex for a good reason, and it may be that several iterations of the process are necessary to ensure a 'complete' analysis of the problem.

Another possibility is that a clear decision is difficult given the uncertainty highlighted throughout this process. It may be that an adaptive management approach is warranted. Adaptive management is a form of structured decision making, where monitoring is used to learn about the most effective course of action (Runge 2011).

More info: Kelly Hunt De Bie khun@unimelb.edu.au

References

Addison PFE, L Rumpff, SS Bau, JM Carey, YE Chee, FC Jarrad, MF McBride & MA Burgman (2013). Practical solutions for making models indispensable in conservation decision-making. *Diversity and Distributions* 19: 490–502.

Gregory R, L Failing, M Harstone, G Long & T McDaniels (2012). *Structured decision making: a practical guide to environmental management choices*. West Sussex: Wiley Blackwell.

Keeney RL (1996). *Value-Focused Thinking: A Path to Creative Decision making*. Cambridge: Harvard University Press.

Runge MC (2011). An Introduction to Adaptive Management for Threatened and Endangered Species. *Journal of Fish and Wildlife Management* 2: 220–233.

Parks Victoria staff work with researchers from the University of Melbourne to explore a range of management strategies using a structured decision making approach. Together they quantified the consequences of alternative management strategies using expert elicitation and statistical modelling, and incorporating value judgement trade-offs among objectives.

Case Study 3: Shaking the status quo

Decision support for a large, multi-faceted resource allocation problem

By Frith Jarrad and Terry Walshe (University of Melbourne)

The available resources of a conservation management agency are typically spread over many ecological values and multiple threats. Management plans guide the manner in which the allocation takes place and these plans are periodically reviewed in order to consider better ways that the available resources might be spread around. But the complexity of the problems being dealt with often mean the reviews don't achieve much in the way of change. In many instances, the opportunity amounts to a tired regurgitation of previously documented values and assumed threats and the retention of the status quo.

Parks Victoria recently committed to a more in-depth and candid assessment of its allocation of resources through use of structured decision-making. Our case study* is concerned with resources committed under Parks Victoria's Environmental Land & Water Area of Work in the West Coast District (in other words, resources available for managing the natural values in the Otway's and surrounds).

The application of SDM in this project provided a framework for thinking critically about a large, multi-faceted resource allocation problem. It relates to navigating and coherently integrating:

(a) *cause-and-effect judgments* concerning the capacity of alternative strategies to protect natural assets; and

(b) *value judgments* concerning trade-offs between asset protection, costs, and other relevant considerations.

Experts and stakeholders vary in their judgments of both elements. Variation in cause-and-effect judgments arises from uncertainty in scientific knowledge. Variation in value judgments reflects the priorities and preferences of individuals and organisations. This project integrated both elements in a structured decision-making framework.

The purpose of the project was to develop an efficient structured decision-making process that will enable the development and ongoing implementation (including ongoing refinement through the practice of adaptive management) of the West Coast Implementation Plan (WCIP) for the Environment, Land & Water Area of Work. The aims of this plan are to:

- Identify and describe priority assets, threats and management responses;
- Identify objectives for resource allocation across ecosystems;
- Prioritise alternative management strategies/actions using a structured decision-making process drawing on available scientific and local knowledge and informed tradeoffs.

Importantly, SDM allowed us to tackle this large, multi-faceted problem by breaking it up into units small enough for people to handle cognitively, allowing them to make sensible judgements. The decision problem included over 100 competing objectives, across seven ecosystems (including marine and terrestrial), dozens of threats, and dozens of possible candidate management actions.

Using both a fixed budget that was broadly consistent with the current allocation, and increased budgets (to around double), we explored a range of management strategies (step 4), by quantifying consequences of those alternative management strategies using

"The decision problem included over 100 competing objectives, across seven ecosystems (including marine and terrestrial), dozens of threats, and dozens of possible candidate management actions."

Case study 4: The manager's perspective

Parks Victoria and SDM

By Tony Varcoe (Parks Victoria)*

It should come as no surprise that in seeking to effectively manage around four million hectares of parks (including national, state, wilderness, marine, historic and urban parks and waterways), Parks Victoria needs to make tough decisions about how it will allocate its limited resources.

Complementary to the question of how to allocate resources for best outcomes is the fact that, over many years, park managers have made many assumptions around 'if I do x then y conservation outcomes will be achieved'. More and more we are realising that we are managing complex ecological and social processes led by complex drivers in which our assumptions need to be constantly tested and reviewed.

In recent years Parks Victoria has been moving from a 'who-shouts-loudest' decision making and resource-allocation model to a more systematic, transparent and evidence-based model. This includes much clearer definitions of the conservation assets and values that are important to the community.

"More and more we are realising that we are managing complex ecological and social processes led by complex drivers in which our assumptions need to be constantly tested and reviewed."

Decisions about setting priorities for park management need to be made at a range of different scales: from the entire parks network to the scale of the landscape and down to the level of individual sites. Likewise, we need to be more targeted in our monitoring and evaluation efforts. Monitoring is expensive so we need to make sure it is actually answering questions related to the effectiveness of our interventions and the extent to which we are meeting our desired conservation or social outcomes.

As part of Parks Victoria's Research Partners Program, we have been working with partners such as the University of Melbourne to test and evaluate Structured Decision Making as a tool to assist park managers in being more objective about how they make decisions and allocate scarce resources.

Some of the benefits of SDM are self evident. By its very nature the SDM process requires a systematic, step-by-step process of options analysis and decision making which is transparent to senior decision makers, auditors and the community. It might be systematic and transparent but does it actually help park managers? Our experience is that it does.

Some of the other benefits of SDM are less tangible but equally valuable. First, the SDM process 'forces' collaborative decisions to be made about what is more or less important even in the face of uncertainty. Second, SDM facilitates active engagement and sharing of knowledge between experts and local park managers. Local park staff have felt more confident in implementing agreed interventions and, importantly, more confident in explaining why interventions are not being implemented in the face of stakeholder expectations. Finally, staff are more clearly able to see the 'results chains' between the local actions they are carrying out on the ground and the conservation outcomes they are seeking.

Parks Victoria's experience in the application of SDM is evolving. While the process has been applied at the local scale (eg, minimising camping impacts in the Grampians NP, see case study 1) and at the landscape/program scale (eg, resource allocation in West Coast District see case study 3), we will be continuing to work with our partners to explore the application of SDM tools that have broader application. We are also exploring the opportunity to incorporate SDM into other conservation planning processes.

And we'll be exploring ways of making the SDM process itself more streamlined and cost efficient for Parks Victoria. Bringing people together to discuss, frame and model management issues is always a nice thing to do but, at the same time, it's resource intensive so we need to make sure we're doing it in the most cost-effective way.

SDM has proved a valuable framework for Parks Victoria. It's helped us take stock, introduced greater rigour into our decision making process and given us greater confidence in dealing with the uncertainty and complexity that confronts us daily.

More info: Tony Varcoe tony.varcoe@parks.vic.gov.au

**Tony Varcoe is the Manager of Parks Victoria's Science and Management Effectiveness Branch.*

expert elicitation and statistical modelling, and incorporating value judgement trade-offs among objectives (step 5).

In this project, we specifically address whether current resource allocation represents the greatest opportunity for achieving desired conservation outcomes within best current knowledge. The SDM outputs show the candidate strategies that perform best overall, in addressing ecological objectives within resource constraints (step 6).

For some ecosystems, the current management strategy did perform the best; for others it did not. The results indicate there is scope for improvement and better performing alternatives should be considered. The SDM framework allowed us to explore whether more expensive alternatives ranked higher than less expensive alternatives, as well as their comparative cost-effectiveness.

The SDM process has engaged stakeholders, technical experts and decision makers in a deliberative decision process over several days of workshopping (which included multiple one-on-one meetings). Because the knowledge was gained through sharing, there is confidence in the outcomes of the process.

Findings of our project are being used to inform Parks Victoria's future resource allocations within the West Coast District. We hope to see the SDM framework used more widely in natural resource management, where decision problems are usually of comparable magnitude and complexity to the one described here.

More info: Frith Jarrad frith.jarrad@unimelb.edu.au

**The work discussed here is part of a collaborative project between Parks Victoria and the University of Melbourne, 'Decision support for effective allocation of natural values management resources'.*

The evidence on adaptive management

Everyone is talking about it but how many are actually doing it?

By Martin Westgate (Australian National University)

Adaptive management is everywhere. Google it and you'll get over five million hits, while academic search engines can return over 20,000 articles. These articles discuss a huge range of topics – from ecology and conservation biology through to epidemiology, medicine and even construction. And more are being written all the time.

Adaptive management receives so much attention because it is intuitive, broadly applicable and conceptually appealing. Its basic premise is that as management proceeds, information is collected that improves knowledge of the system being managed. This knowledge is then used to improve future management practice, in an iterative process sometimes described as 'learning by doing' (Walters & Holling, 1990). Consequently, adaptive management should be a good way to manage systems that are poorly understood.

Unfortunately, this simple overview masks a large amount of controversy in the academic literature (eg, see Keith et al, 2011). For example, some proponents have advocated that adaptive management be applied to nearly all environmental problems. Conversely, detractors have argued that adaptive management is merely a corporate buzzword, sometimes used to justify the continuation of flawed policies. Despite this diversity of opinion, quantitative evidence describing the pros and cons of adaptive management is difficult to find.

The evidence on AM

Working with David Lindenmayer and Gene Likens, I recently assessed the current 'state of the science' of adaptive management in ecology, with the aim of quantifying the usefulness of the concept (Westgate et al., 2013). We did this by finding articles whose authors stated that they were part of an adaptive management project, then looked for similarities and differences between these projects. We found several unusual results.

First, we quantified just how rare the actual application of adaptive management was in the academic literature. In a series of stages, we narrowed down our original 1,336 articles to 61 that explicitly claimed to enact adaptive management. Put differently, more than 95% of articles that discuss adaptive management don't test it.

"More than 95% of articles that discuss adaptive management don't test it."

"Few projects were able to sustain the effort to complete the adaptive management cycle."

Second, there is a notable lack of empiricism in the adaptive-management literature. The articles that we identified related to 54 separate projects, but most were only discussed in a qualitative manner, usually as a part of a broad review. Only 13 projects were supported by published monitoring data.

Finally, few projects were able to sustain the effort to complete the adaptive management cycle. Most papers that claimed to be starting adaptive-management projects were recent (mean age = 4.8 years, n= 58 articles). Only four of the 13 adaptive management projects that we identified lasted longer than 10 years.

Correspondingly, the number of projects that met adaptive management criteria decreased as we included criteria describing successively later stages of the adaptive management cycle (see the box on 'What is adaptive management?'). More specifically, all 13 projects described their management goals (stage 1), ten of which tested more than one management intervention (stage 4), but only five projects altered management in response to new information (stage 6).

AM and relevance

On the basis of our results, it is fair to say that the term 'adaptive management' is rife in the peer-reviewed literature. However, only a small but increasing number of projects have been able to effectively apply adaptive management to complex problems. We feel confident that this number can be increased through better collaboration between scientists and representatives from resource-extracting industries; better communication of the risks of not doing adaptive management; and by ensuring adaptive-management projects 'pass the test of management relevance'.

Although not a specific focus of our study, an important consideration for potential practitioners should be the likelihood that adaptive management will provide useful, timely, and cost-effective information in their particular case. For example, if collecting further information will not improve management effectiveness, then adaptive management should not be considered (see Mcdonald-Madden et al., 2010).

I think we did a good job summarizing the adaptive-management literature, but I also think the adaptive-management concept could be improved by addressing a couple of core concepts.

First, despite some very useful guides (eg, Williams et al., 2009), the term 'adaptive management' still means different things to different people. This is a problem because it means there is very little prospect that a practitioner could understand adaptive management from the academic literature, still less aim to use adaptive management to solve on-ground problems. Further, confusion over terminology hinders the development of these important ideas in the academic literature. Some of us at CEED will be working on this issue in the near future.

Second, our review focussed on published literature, but it is likely that most management is carried out by people who have very little time or incentive to publish their findings, so we probably missed a lot of very exciting adaptive-management projects. If we could somehow harvest some of this experience it's likely our capacity to effectively implement adaptive management would be improved.

The bottom line is that despite the enormous literature on adaptive management, articles describing adaptive management projects are extremely rare. That means many of the outcomes of past interventions have not been appropriately evaluated. Application and monitoring of management interventions has been inadequate, limiting our understanding of important ecological processes necessary for effectively managing biological systems.

Our review showed that a large number of practitioners are already doing a great job of testing management effectiveness in ecology and biodiversity conservation. As a result, strong progress has been made in identifying the mechanisms through which management interventions influence biological systems. What is needed in future is new ways to capitalize on this knowledge by iteratively improving management and research questions though time, and communicating those results to a global audience.

What is adaptive management?

The clearest and most succinct definition that we are aware of is given by Williams et al. (2009): 'Adaptive management is a systematic approach for improving resource management by learning from management outcomes.'

This general goal can be implemented using a range of methods, as appropriate to each study system. Although different authors provide different advice for how to implement adaptive management, there is general agreement that the process typically involves several steps:

1. Identification of management goals in collaboration with stakeholders.

2. Specification of multiple management options, one of which can be 'do nothing'.

3. Creation of a rigorous statistical process for **interpreting how the system responds to management interventions.** This stage typically involves creation of quantitative conceptual models and/or a rigorous experimental design.

4. Implementation of management action(s).

5. Monitoring of system response to management interventions (preferably on a regular basis).

6. Adjust management practice in response to results from monitoring.

More info: Martin Westgate martin.westgate@anu.edu.au

References

Keith DA, TG Martin, E McDonald-Madden & C Walters (2011). Uncertainty and adaptive management for biodiversity conservation. *Biological Conservation* 144: 1175-1178.

McDonald-Madden E, PWT Baxter, RA Fuller, TG Martin, ET Game, J Montambault & HP Possingham (2010). Monitoring does not always count. *Trends in Ecology & Evolution* 25: 547-550.

Walters CJ & CS Holling (1990). Large-scale management experiments and learning by doing. *Ecology* 71: 2060-2068.

Westgate MJ, GE Likens & DB Lindenmayer (2013). Adaptive management of biological systems: a review. *Biological Conservation* 158: 128-139.

Williams BK, RC Szaro & CD Shapiro (2009). *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Adaptive Management Working Group, US Department of the Interior, Washington DC.

"Despite the enormous literature on adaptive management, articles describing adaptive management projects are extremely rare. That means many of the outcomes of past interventions have not been appropriately evaluated."

Five objections to using decision science in conservation

And why they are wrong

By Hugh Possingham (University of Queensland)

Author's note: *In this issue of Decision Point we have discussed the application of decision science and making more of models (pages 4,5), structured decision making (pages 6-11) and adaptive management (pages 12,13). This is the core territory of our two centres. While the advantages of this approach to conservation are spelt out in multiple ways throughout this and every issue of Decision Point, it's important to note that many people still have objections to the use of decision science for a variety of reasons. Back in 2009 I wrote an editorial on this very topic for one of the early issues of Decision Point and it seems timely to reproduce it here. The text is largely unaltered from then, and the Stefan Hajkowicz (2008) reference on NRM expenditure is still relevant: we're still spending billions of dollars on the environment in a largely ad hoc, unaccountable and opaque fashion. While systematic spatial conservation planning tools are now the norm, simpler non-spatial tools for prioritisation, like cost-effectiveness, are only just starting to be used. Further, the recent Senate Inquiry into the Effectiveness of threatened species and ecological communities' protection in Australia uncovered people expressing discomfort (or disquiet) with using rational repeatable processes for allocating government funds. So it's a good time to face the doubters again. Hugh Possingham, Director, Environmental Decision Group*

Since 1994 I have given over 300 seminars to every manner of audience on how decision science can inform environmental management. In that time I've received a wide range of arguments about why decision theory tools should not be applied to conservation problems. Sometimes people reject the general message that anything could be wrong with current decision making. Sometimes they take exception to the details in specific case studies. Sometimes they just get a little angry.

I'd like to take a moment and review the most common objections and suggest that they are wrong. But I'm going to go further and say that natural resource management in Australia must embrace the tools of decision science, like every other rational profession, from medicine to engineering (and it needs to happen sooner than later).

It's important to dispel the myths surrounding these objections. To ignore the value of environmental decision science is to repeat the many mistakes that we have made in the last two decades. As a nation we're failing hopelessly to secure our most precious and unique natural asset – Australia's biodiversity. Since 1990, the Australian federal government has announced seven major natural resource programs collectively worth $6.51 billion (Hajkowicz, 2009). In almost every case the allocation decisions continue to be ad hoc and opaque (despite a lot of excellent advice, see 'Why INFFER' on page 3).

So, here are the five most common objections with their strengths and weaknesses.

Objection 1: It's based on models

"This is all ecological modelling and ecological models are all wrong."

Well, of course, this is correct; all models of everything are wrong. The only perfect model for something is the thing itself, and then it ceases to be a model. However models are our only way of predicting the future and if you are a manager you must be predicting the future as a consequence of actions – otherwise you could never take an action. Hence, by definition, every manager, indeed every human being, is a modeller – it is just that most don't use maths.

Furthermore there is confusion between what is a model, what is a problem and what is an algorithm. Much of decision theory is about mathematically defining a problem with objectives and constraints. This is the translation of human hopes, dreams and fears into maths, another language. It is not classical ecological modelling. Often there are some more typical ecological models (that either predict in space and time) that lie inside the problem definition, and they should be scrutinised with care. Finally we use algorithms, not models, to find good solutions to the problem (not the model). If one uses mathematically credible algorithms (not scoring systems or overlays of GIS maps) then the solutions are likely to be close to correct.

(See Decision Point #22 for a more detailed discussion on this point.)

Objection 2: It's all economics

"The principles of decision theory are founded in economics and it is economics that has made a mess of the world. Decision science is the tool of the Devil."

You can kill someone with a hammer but it doesn't mean that hammers are bad tools. The tools we use are largely from a branch of mathematics called operations research, designed to solve mathematically well-defined problems. These tools are used by engineers, mathematicians and economists (mathematicians who know some big complex words).

The tools of decision science drive most small scale (micro-economic) decisions from how to supply troops in a battle, to oil refineries ordering crude supplies, to airline companies devising their plane schedules.

One aspect of decision science that really irks some people (and is very much an economic way of thinking) is that we generally need to give every value a numerical quantity. Typically economists deal mainly with money, but environmental values often deal with things that at first glance seem harder to quantify – threatened species, ecosystem services and social values.

However, with thought, most can be quantified, albeit with some uncertainty (see point 5) and they do not have to be turned into dollars and cents for them to be used in decision science. One algorithm that provides good solutions to many conservation problems involves ranking actions in terms of their cost-effectiveness – that is their biodiversity benefit divided by their cost (in dollars). This simply requires an integrated and numerical measure of the biodiversity benefits of an action.

Objection 3: It's too cumbersome

"Using decision theory takes too long. While the general idea is good, we haven't got the time or money to use these approaches."

In cases where decisions are small and once-off, you are correct, spending money on using or developing a decision theory tool is like cracking a nut with a steam roller. However tools are becoming easier and easier to use, and many environmental management problems involve millions of dollars. In most cases the use of an approach or tool will save money and biodiversity. Or, more uncharitably, if you are not using the most appropriate decision theory tools you may well be consigning some biodiversity to extinction!

Developing decision theory tools might slow some projects down. In many cases, however, the focus provided by formulating and solving

> "I'd describe them all as myths that the nation can no longer afford to accept."

an explicit problem speeds things up. For example consider the project prioritisation protocol (PPP) that the New Zealand environment department has developed and used in partnership with the Environmental Decision Group (Joseph et al, 2009). In less than three years they have not only developed action plans for over 600 species, they have costed and prioritised them – all because the decision-making framework made recovery planning more focussed. Australian agencies have been developing recovery plans for two decades at huge expense: many remain unfinished or incomplete.

See *Decision Point #29* for a description of how PPP works.

Objection 4: It's a black box

"Nobody wants to have a computer tell them what to do. 'Black-box' solutions to problems will never fly with politicians and stake-holders."

You are correct, which is why we always say that these approaches and tools inform decisions rather than make decisions. There are invariably considerations that cannot be accommodated in the formulation of a complex socio-ecological problem – so we need some wiggle room.

As far as black-boxes are concerned – so what? What percentage of the public know how planes fly, or hand calculators calculate, or microwaves cook? Although, if you want to look a bit more closely at the mechanism inside a decision-tool black box, you might be surprised at how simple they are. Many decision-making tools are much simpler than people think if they are explained well and people take some time to work with them. (Consider for example our 'Marxan out of the box' discussion in *Decision Point #62*)

Objection 5: There's too much uncertainty

"There is too much uncertainty and risk to use a decision theory approach. Furthermore, optimisation is not robust."

Uncertainty and risk are rife in ecological systems – and we face it far more than, say, an engineer (but no more than economists or doctors). Fortunately the mathematicians have many ways of rigorously accounting for uncertainty in decision-making – indeed if a system has a lot of randomness then it is even more important to take a formal quantitative decision-making approach. Furthermore, the ideas of 'active adaptive management' (see *Decision Point #17*) and 'value of information theory' (see *Decision Point #67*) enables us to include the benefits of learning in prioritising our actions.

Some people think that decision theory tools can only deliver perfect but fragile solutions – however there are many algorithms for obtaining robust solutions, solutions that deliver reasonable results under a lot of randomness and uncertainty.

So there are 'my' five objections to decision science (they are really classes or streams of objections rather than specific snipes), and I'd describe them all as myths that the nation can no longer afford to accept. After peddling the decision-theory message for 20 years, I think the message is unanimous and unambiguous – it is now the responsibility of managers and policy-makers to make use of the best available science and tools.

References

Hajkowicz SA. (2009) The Evolution of Australia's Natural Resource Management Programs: Towards improved targeting and evaluation of investments. *Land Use Policy* 26: 471-478. doi:10.1016/j.landusepol.2008.06.004

Joseph LN, Maloney RF & Possingham HP (2009) Optimal Allocation of Resources among Threatened Species: a Project Prioritization Protocol. *Conservation Biology* 23:328-338.

Dbytes

Dbytes is EDG's internal eNewsletter. It gets sent to members and associates of EDG each week, and consists of small snippets of information relating to environmental decision making. They might be government documents, research articles, blogs or reports from other research groups. Here are five bytes from recent issues. If you would like to receive the *Dbytes* eNewsletter, email David.Salt@anu.edu.au

1. An area's capacity for conservation.

These reports, produced by NERP Landscapes and Policy Hub, bring together census data on the social characteristics of the areas Australian Alps and the Tasmanian Midlands. They include an interpretation of what the census data tells us about the study areas' capacity to engage in various biodiversity conservation options.

http://www.nerplandscapes.edu.au/publication/australian-alps-socio-economic-report

http://www.nerplandscapes.edu.au/publication/tasmanian-midlands-socio-economic-profile

2. Land Accounts for Queensland

As part of its work in developing an integrated set of environmental accounts, the Australian Bureau of Statistics has released *Experimental Land Account Estimates for Queensland* and its associated fifteen Natural Resource Management areas. The Account provides data on land use, land cover and land value. The information in this release would be valuable to a range of users, especially those in agencies involved in agriculture, mining, environment and land management, emergency management and development planning.

http://www.abs.gov.au/ausstats/abs@.nsf/mf/4609.0.55.003?OpenDocument

3. Revised standard for forests

A revised Australian standard for forest management (AS4708–2013) is now in force. The revised standard strengthens forest managers' responsibilities in relation to social, cultural and public participation requirements. Among other things, the Standard clarifies the role of monitoring and review of biodiversity values.

http://www.forestrystandard.org.au/announcements/a-new-standard-for-managing-australias-forests

4. Science for Policy

Science for Policy: Mapping Australian Government Investments and Institutions seeks to contribute to the ongoing improvement of the links between science and policy. It does this by mapping – for the first time – existing Australian Government investments and institutions that support the creation and delivery of science for policy. It is the product of a collaborative project commissioned by the HC Coombs Policy Forum at the ANU.

https://crawford.anu.edu.au/public_policy_community/content/doc/APS200-Science-for-Policy-mapping-report.pdf?0

5. A science strategy for DAFF

The DAFF (Dept of Ag, Fisheries & Forestry) Science Strategy provides a high-level framework for the development of its science capability over the next five years to 2018.

http://www.daff.gov.au/about/publications/daff-science-strategy-2013

Science & policy development (and NERP)

The Australian Government has recently released a report on 'the place of science policy development in the Public Service'. The study holds up NERP as an example of how science can effectively influence policy.

The Place of Science in Policy Development in the Public Service systematically reviewed the ways in which scientific input is used to inform policy development in the Australian Public Service (APS). It provides departments and agencies with practical and useful strategies to maximise the use of science in policy development. Ultimately, the project has sought to arrive at an end-state where policy making within the APS draws on the best available scientific evidence on a routine and systematic basis.

And it suggests this is already happening with NERP (p14): "The NERP example demonstrates that through thoughtful program design, it is possible to fund activities that achieve the twin objectives of enhancing Australia's world-class environmental research capabilities while also delivering useful knowledge, tools and information to policy makers and the broader community."

The ingredients to NERP's success, the report suggests, is through: involving policy makers in the framing of research questions, focusing on knowledge brokering and translation, facilitating access to research, enhancing mutual understanding and encouraging innovation in evaluation.

See http://www.innovation.gov.au/science/Pages/Library%20Card/APS200ScienceinPolicyReport.aspx for the whole report.

What's the point?

Give me a home among the gum trees!

Editor's note: Have you ever come across a picture and thought: "That's the perfect image for my story/article/blog post!" And then cursed because you published that story two months ago and now it's too late. It happens to me all the time. But this time I've decided better late than never.

Pictured below is an eastern yellow robin building its nest in a gum tree using thin strips of red stringybark. The nest also contains flakes of box gum, yellow box and long-leaf box delicately woven into the rim, or stitched to form a hanging skirt around the side of the nest. A beautiful bird building a work of art high in the bough of Australia's iconic tree species.

Climate change promises to have profound impacts on the distribution of gum trees right across Australia. And, of course (and as this image graphically demonstrates), those impacts will have consequences for the broud suite of organisms that depend on these trees. See the story on the climate change impacts on gum trees in Decision Point #72.

The picture was taken by Geoff Park and is featured on his blog, Natural Newstead. Geoff's blog is highly recommended for anyone interested in birds, photography or the natural rhythms of central Victoria. If only he published this pic a couple of months ago!

ENVIRONMENTAL DECISIONS GROUP

The Environmental Decision Group (EDG) is a network of conservation researchers working on the science of effective decision making to better conserve biodiversity. Our members are largely based at the University of Queensland, the Australian National University, the University of Melbourne, the University of Western Australia, RMIT and CSIRO.

The EDG is jointly funded by the Australian Government's National Environmental Research Program and the Australian Research Council's Centre of Excellence program.

Decision Point is the monthly magazine of the EDG.
The funding of the research presented in this issue of Decision Point, like most research, comes from multiple sources and is identified in the original papers on which the stories are based (references are provided in each story). In terms of CEED and NERP ED, the work on making models indispensable (p4,5) and adaptive management (p12,13) were both supported by CEED. The work with Parks Victoria on structured decision making was supported by NERP ED.

To contact the EDG please visit our websites at:
http://ceed.edu.au/ or http://www.nerpdecisions.edu.au/

National Environmental Research Program

ARC ceed Centre of Excellence for Environmental Decisions

Australian Government
Department of the Environment
Australian Research Council

The University Of Queensland AUSTRALIA

Australian National University

The University of Melbourne

RMIT UNIVERSITY

The University of Western Australia