CHAPTER TWO

Working in government: conservation research, policy and practice

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2.1 Introduction

In this chapter I will provide a view of conservation research, policy and practice from within government. This has been formed as a result of my experience as Chief Scientific Adviser at the UK Department for Environment, Food and Rural Affairs. I consider how government works in relation to conservation within two broad themes: the first deals with the general political and policy context, and the second considers how the results of conservation research can be integrated into policy and practice. Some of my account, which is directed towards government officials as well as researchers, affirms the robustness of current systems and structures, but other parts challenge aspects of current thinking.

2.2 Governmental processes and decision-making

Government is a highly diverse, multi-layered structure. In this chapter, I refer mainly to central government, defined by the departments of state, which have ultimate responsibility for setting strategy and delivering policy outcomes. However, governmental conservation research is often most closely associated with other arms of government, including semi-independent agencies of government and those that, in Britain, are called non-departmental public bodies with their own governance structures. These bodies exist specifically to separate some aspects of governance from central government because specialised capabilities are needed to manage particular assets or public services (Anon., 2018). Even if the objectives of these organisations can be set by the parent department in central government, their operational mode and relationship with central government can be quite different and 'arm's length'.

Decision-making by government, when viewed from the perspective of problem or decision theory, is a form of multi-dimensional optimisation in which a range of variables is considered in often opaque ways. This is

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unattractive to people who like to deal with problems that have unequivocal solutions: this includes many researchers. Governmental decisions about the environment, however, are taken in the murky, turbulent space where the dynamism and chaos of the natural world collide with human social systems in their various cultural and structural forms. Operating in this world can be very challenging and requires special skills and resilience. It is a world where problems are wicked, in that the very act of finding a solution can make the problem worse, and where ambiguity is the norm but can, perversely, serve a useful purpose. This is because ambiguity can be used as a mechanism to sustain dialogue between groups with strong common interests – which includes most parties involved in conservation debates – but where the discourse is dominated by a narrow difference of opinion.

When viewed through a narrow scientific lens, decisions and actions in government can sometimes seem obtuse or not based on evidence. If the lens is dilated, as happens when one gets closer to the action, then other perspectives can reveal the other factors in play, and this often brings interesting insights. Governments rarely act with intentional irrationality. Apparent irrationality happens mainly because an observer is unaware of all the dimensions of the problem being addressed. Sometimes apparent irrationality only emerges post hoc, when the benefit of experience suggests that an alternative action might have been the better course to take. Government is plagued by such post-hoc analyses, unaccompanied by counterfactuals. It is easy for critics of government to assert that alternatives would have produced better outcomes based on either the benefit of hindsight or when there is no possibility of testing whether those assertions are correct. This applies as much to conservation as to any other area of policy.

Government is not a machine. It is run by people, and even if civil servants are trained to minimise value-based biases, human frailty means that the operation of government will always be imperfect. Working successfully with, or in, government requires an understanding of the social, cultural, economic, resource, structural and political stresses operating at any time. Understanding how these are integrated can be daunting; there are no fixed formulas for how to recognise and then respond to such stresses. Shifts in these stresses can result in apparent inconsistency from government, illustrated best by what happens when new political leadership appears. In the worst cases, government lurches between extremes because of the severe complexity of the problems being tackled. Sometimes these lurches are politically driven; from the perspective of research, politics can be viewed as simply one driver of stochasticity (like the climate), rather than anything that researchers can control. Thus, a degree of detachment between the researcher and the politics is important.

2.3 The role and typology of conservation research

Given the complexity of government decision-making, how can conservation research add value to policy and practice? Research is the supplier of knowledge, the arbiter of uncertainty and the umpire of method in governmental formulation of policy and practice. More specifically, the role of conservation research is in revealing ambiguities, helping to define objectives and then designing adaptive management practice to shift policies in the direction of achieving those objectives. 'Policy' in this context is most closely aligned with the concept of strategic solutions, while 'practice' refers to tactical or operational interventions; these differ mainly in terms of the temporal and spatial scales of delivery. In addition, practice emerges from policy. For example, the UK National Ecosystem Assessment (2011) was underpinned by a major piece of strategic research delivered by the Department of Environment Food and Rural Affairs (Defra) and partners. It supported strategic thinking about the conservation paradigm, by highlighting the utility of different policy options using cost–benefit analysis and by making trade-offs explicit. Such research can provide the broad context within which many areas of operational research, such as species conservation and habitat restoration, occur. Some of this operational research, which has followed on from the UK National Ecosystem Assessment, will have general messages, but much of it is about providing specific solutions to particular problems in particular circumstances. Generalising from these studies is a post-hoc synthesis activity, the value of which will depend greatly on circumstances.

Therefore, strategic research is arguably a more important focus for central government than operational research. There is a stronger emphasis on operational research in some of the more independent organisations at arm's length from governments that often have responsibility for delivering policy outcomes. However, at both the strategic and operational scales, research provides a systematic method for building knowledge from experience.

Although the strategic/operational typology has utility, there is perhaps a perception of greater focus on operational circumstances in conservation research, which may stem from the traditional emphasis on conservation of species rather than ecological function (Mace, 2014). This has historically led to large numbers of highly specialised studies of particular species in particular circumstances, and it is not clear whether this is the most effective approach. Conservation researchers are increasingly considering how they can develop more functionally based hypotheses, with greater emphasis on strategic solutions. While a focus on species and habitat conservation is entirely justified in many cases, conservation research could do more to lead, and question, the fundamental basis for the current policy balance between protecting species and habitats versus protecting and restoring functional ecosystems. An important outcome of strategic research should be to

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challenge normative thinking, allowing novel and improved policies to evolve.

Finally, the boundaries of conservation research spread far into strategic decision-making across government. For example, the effects of economic growth are at the root of many conservation problems but, as the Nobel Prize-winning economist Simon Kuznets pointed out, it is only after sufficient economic growth has occurred that a country's impact on the environment tends to decline (Kuznets, 1955, but see critique in Stern, 2004). This presents the currently unresolved conundrum: conservation relies on the products of the very processes and societal changes that create the problems that conservation is attempting to solve. It is this kind of fundamental question that more conservation research needs to address.

2.4 Government as a direct and indirect sponsor of research

It is important to recognise that government can be both a direct and an indirect sponsor of research. In most other contexts these two functions would be closely entwined but, at least in Britain, much government funding for research is concerned with the strategic national interest, by supporting innovation and increased productivity to achieve economic and social benefits. Government is a customer of the outputs of this research, but only in the sense that it is concerned with ensuring its investments generate wealth, generally measured in terms of growth in GDP and tax receipts. Thus, the Government benefits indirectly.

There is much less emphasis on government as the direct recipient and user of research outputs, as in the case of its sponsorship of conservation research. Therefore, where the strategic national interest is concerned, conservation research is inevitably a lower priority compared with subjects such as materials, biomedical science, computing and advanced manufacturing.

Furthermore, when central government does provide leadership by setting the agenda for strategic research priorities, it often has trouble delivering on this role. At times of budget constraint, government expenditure on strategic research for its own benefit is often reduced faster than spending on fixed costs or critical services. This is understandable, but rebalancing is needed eventually, because investment in strategic research is comparable with capital investment in skills and infrastructure (OECD, 2015). Indeed, on this basis the UK now classifies strategic research and development expenditure as part of its capital investment. This is logical, because it reframes the rationale for research investment in terms of its incremental economic and social benefits, rather than as a service to support operational needs.

Elevating conservation research within government priorities will require a much stronger business case than has been constructed to date. This needs to be based on clear examples of how its outputs lead to economic and social

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advantage. For example, research in environmental economics, which is broadly linked to conservation research, has helped to support the idea that nature conservation has an important indirect role in supporting economic growth and health (see Chapter 12). Emphasis also needs to be placed on the interdisciplinary nature of conservation research, requiring strengths in fields such as behavioural ecology, community ecology, taxonomy and environmental biogeochemistry. Conservation research should also be closely linked to social science because most of the problems it tackles are generated by people and the solutions also depend on people.

Much of what is classed as conservation research, such as observing and monitoring or providing a support function for environmental management, might not qualify as research at all under a strict application of the Frascati definitions used to account for research spending by governments (OECD, 2015). These definitions emphasise the process of discovery, including the investigation of systems, process and functions. It can, therefore, be difficult for government to fund 'research' activities, which cannot appear in government accounts as research when passed through the filter of international definitions.

However, in Britain, government can also be a direct customer of research, a practice established following the publication of the Rothschild Report (HMSO, 1971), which recommended that government departments should hold research budgets to directly sponsor research to deliver to their needs. Due to budget cuts, this vision has subsequently been eroded, so that government departments are now minor sponsors of research, despite a continued need for research outputs. Arguably, the idea that central government departments could be effective sponsors of research was optimistic and risky because the processes for commissioning research are highly specialised and direct sponsorship of science by a politically led organisation carries the risk of biasing the research to satisfy short-term goals and comply with politically expedient outcomes.

2.5 Improving the policy impact of research

The contributions of scientists, of course, involve generating new information and synthesising knowledge, but promoting the use of the emerging evidence relies on penetrating government structures and processes and building trusted relationships with decision-makers. The ambition should be to make research a highly integrated part of the policy development and delivery process (Kenny et al., 2017; see also my discussion of coproduction later in this chapter).

Seeing policies as experiments in their own right creates huge opportunity for researchers. Policy implementation can involve the components familiar to researchers: the use of controls, replicates and accurate measurement

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accompanied by evaluation. It can happen at a range of spatial and temporal scales from the implementation of local measures, for example to reduce eutrophication in a water body, right up to national-scale measures to improve biodiversity. If the policy outcomes differ from the prior expectation, then policies can be adjusted and the experiment repeated, in an analogy of adaptive management, even if this takes decades to play out. For example, it could be argued that the UK has been involved in a massive, long-term experiment about how to optimise the relationship between farming and environmental stewardship, which began about 60 years ago and will continue to be refined for many decades to come. In the UK, the recent drive to make publicly funded research more policy-relevant may support a shift in attitudes among both researchers and policy-makers to make more of these experimental opportunities.

Viewed from this perspective, the policy cycle does not differ greatly from the scientific process, as both, when working at their best, test options iteratively and systemically to converge on solutions. Ideally, the outputs of conservation research combined with evaluation can drive the process of policy development and implementation. Research needs to become part of the core philosophy of conservation policy, rather than a bystander to be drawn in when others think it necessary. In my view, both policy officials and researchers can do more to achieve this shift.

Two activities which could improve the policy impact of research are the technical process of synthesis and the building of relationships. In most areas of science, it is very unlikely that individuals, or even groups of individuals, with expertise in a particular field can rely on the ad-hoc accumulation of knowledge to provide advice to build robust policy. Science is mostly just too complex and the evidence base too diverse for this kind of approach to be reliable. The rise of formal synthesis has been highlighted recently as a new and important discipline within science (Donnelly et al., 2018) and this applies equally to conservation science (Sutherland & Wordley, 2018; Chapter 7, this volume). The need for synthesis to be inclusive, rigorous, transparent and accessible emphasises that it has an important social function; through building consensus it helps to build acceptance of the experience reported within the scientific literature.

Synthesis is, therefore, also a route to building trusted relationships. In general, those responsible for creating and implementing policy will prioritise the use of evidence when it is trusted and delivered through trusted intermediaries – often those people from within the scientific community who are willing to put in the effort to synthesise scientific information or are specifically employed to do this. Synthesis that integrates evidence across many different lines of research is likely to be more trusted than narrowly based opinion. Communicating ideas that originated from within

the domain of science to those who operate within the domain of government needs to be worked on continuously by both parties. Patience and tolerance are needed.

Policy professionals often work to tight deadlines; however, these deadlines may appear especially difficult because of a deficit in long-term engagement and understanding between the policy professionals and conservation scientists. For example, the UK has recently published a 25-Year Plan for the environment and also plans for an independent body to hold government and others to account for the delivery of environmental outcomes, including objectives for nature conservation. This requires the consistent, cost-effective measurement of meaningful components of the environment that can work at all spatial and temporal scales and that are responsive to policy change. Early in the process of deciding these metrics, it became clear that insufficient long-term work had been applied to defining and validating these measurements for some components of the environment. While there were many reasons for this deficit in measurement capability, such a situation could arguably have been anticipated if there had been a more integrated relationship between science and policy.

2.6 The need for greater rigour

Conservation research is a central component of policy and practice in relevant areas of government, but the relationship between research and policy remains difficult to define. The adaptive management of policy and services calls for an intimate interaction between policy and research, recognising that the interface between ecological and social systems is complex, and that the response of both these systems is unpredictable.

As a result of this complexity, government and wider society are often guilty of applying loose definitions of what constitutes evidence. Belief-based processes, or processes that do not respect the disciplines of appropriate statistical sampling, may be used to generate evidence, which may then be used without awareness of the associated caveats. Government would be helped by the application of greater discipline in following the evidence hierarchy. This defines an ineluctable sequence, from measurement to data to information to knowledge and then finally to the generation of evidence; conservation researchers have an important role in interpreting the results they derive from scientific data so that they ultimately produce useful and relevant evidence.

While evidence is what decision-makers really seek, researchers need to take ownership and ensure that the process for generating evidence needs to be managed robustly. Data are the starting point for producing evidence, but data are not information unless one can detect structures and patterns in them, and information is not knowledge unless those patterns have been

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verified by statistical analysis and their implications understood. Knowledge becomes evidence when it is used to address specific questions in a given context (Donnelly et al., 2018).

The rigour of this hierarchy is under continuous challenge within government, driven by the stresses caused by the fast pace of decision-making and conflicting values. It is all too easy for researchers to acquiesce to the constraints. The considerable challenges of conservation research – lack of opportunity for replication, low statistical power and socially driven problems – mean it is especially vulnerable to loss of rigour, often because of optimism concerning the robustness of methodology at all stages of the hierarchy. For example, simply shifting the threshold of statistical significance applied in the transition from information to knowledge from 2-sigma (< 0.05) to 3-sigma (< 0.003) would render many of the conclusions from conservation research obsolete. And strong reasons exist for doing this, to help to take account of the prior probability of there being a real effect. In physics, a subject where the opportunity for controlling variables is generally much greater than in conservation research, 3-sigma is the norm. These kinds of issues are often glossed over in government, and the presentation of the significance of research results by the press and by researchers themselves often does little to promote rigour.

Research can become the servant of policy rather than its challenger. Literature reviews and evidence summaries (Donnelly et al., 2018; Sutherland & Wordley, 2018) can build pictures of what is known, but in many policy areas the outstanding knowledge gap is truly vast. Researchers are prone to dwell on the small parts of a knowledge landscape where there is information, rather than the huge areas where information is sparse. For example, there is an increasing and impressive flow of information from citizen science about the distribution of species across the country, but this remains a sparse data set; similarly, we focus on the conservation of species or habitats because they are well known and valued, such as birds, while we largely ignore others, such as keystone species in the soil microbiome. The result is that even apparently robust research can be biased and misleading in the hands of policy-makers who may not understand the difference between certainty and uncertainty (see Chapter 11).

None of this is helped by an imagined but ingrained notion that scientists can be 'independent' and therefore unbiased. The very concept of scientific independence is arguably a politically motivated doctrine promoted readily by the scientific community itself. Perhaps the most difficult task for any researcher working in a politically contentious field is to remain an honest broker and avoid becoming an advocate for one cause or another (Pielke, 2007). This is particularly important for those involved in conservation research, because of its frequently close association with applied problems and because nature conservation itself is a values-based concept. Those who

work at the interface between science and policy need an acute sense of their own position in the resulting social mix, because such sensitivity can mould better outcomes.

These challenges mean there is a danger that research is conducted to reinforce, rather than to challenge, normative views and this can lead to confirmation bias. The suspicions of bias devalue the outputs of research in the eyes of policy-makers and have led researchers to attempt to present the evidence on controversial subjects in policy-neutral terms (e.g. Godfray et al., 2014).

External pressure groups often operate in very subtle ways to promote confirmation bias when in their interests. The result can be that government may take a very sceptical view of evidence generated by independent organisations, even though government itself is equally susceptible to promoting confirmation bias when it supports a favoured political point of view. However, in general, the level of external scrutiny of government activities probably reduces this effect.

Separating science from politics in conservation research is fundamentally challenging because conservation is value based. This is true at all geo-political scales. Nature conservation is potentially impacted by the current politics of globalisation and nationalism because of the global connectedness of environmental issues and because national boundaries rarely match the appropriate scales for environmental governance. Transboundary concerns make conservation a natural ally of global solutions and multi-lateral treaties and accords, such as the Convention on Biological Diversity, making conservation an increasingly political subject (Owens, 2016). Arguably, this leaches power and influence in environmental decisions from the local and national levels to bigger but much more remote institutions. Whether this has led to greater equity is a debatable point, and in some circumstances conservation can present itself as a form of cultural imperialism, promoting one set of values over another, and there may be a strong correlation between these values and wealth and power (see Chapter 14 for further discussion of this subject). These are difficult issues for scientists to address, especially when the results of their research get caught up in such highly contentious issues.

Conservation research is challenged by the need to remain objective and balanced in these circumstances, and it often fails. For example, research underpins the idea that quantifiable cost–benefit trade-offs could be a rational basis for decision-making, formalised in the concepts of ecosystem services and natural capital. These are becoming increasingly important in environmental management and conservation (Costanza et al., 1997; Chapter 12, this volume), yet can be disempowering at a local level. While proposing and supporting these solutions, conservation researchers also need to consider alternatives that might avoid further centralisation of decision control.

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2.7 Skills and the role of specialists in government

These challenges of bias and rigour mean that the way in which government accesses scientific expertise has an important effect on how it uses knowledge in decision-making. The institutional, social and cultural source of expertise and knowledge will affect how it is interpreted and used as evidence.

Specialists can be broadly divided in to those employed by government and those external to government who mainly operate in a research market place. External expertise in the case of conservation research includes commercial companies, non-governmental organisations and academic institutions, but might also include some government employees who, in the UK, are increasingly encouraged to bid for work on a competitive basis. This covers a very broad range of research cultures, which is useful in sustaining a diversity of approaches to research-based problem-solving.

However, where there is a danger of market failure, government needs to support the existence of specialists required to deliver business-critical functions including research. For example, it is unlikely that the market could sustain all the skills in taxonomy needed to support species-based conservation or the statutory commitments of government to meet particular conservation objectives. For government, there will always be a trade-off between supporting a market solution to the supply of research and the risk of market failure in critical research capacity. To negotiate this balance, government needs expert commissioners and translators of research. These should be a cadre of generalists with skills in research specification and management, and a breadth of knowledge not normally associated with deep specialists, as well as a capacity for criticism and synthesis. These are skills that are not always taught or valued in higher education and, while this needs to change, government itself also has a role in promoting and supporting the development of these skills.

Transparency about how government uses the results of scientific research is important in building trust, and there is a role for scientific generalists embedded within government to make this happen. Promoting this trust can also be achieved by government sharing expertise with external organisations. Government needs to have a porous boundary across which the expertise needed to deliver functionality in government can flow. In effect, this means government should borrow some skills it needs from other organisations, through mechanisms such as secondments, student internships and fellowships.

2.8 Models of interactions between science and policy

In her book about the history of the Royal Commission on Environmental Pollution, Owens (2016) provided an analysis of the ways in which science interacts with policy in the government context. Based on her work, I describe three models, or modes, of behaviour (Table 2.1) which can operate within the

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Table 2.1 *A summary of the characteristics, strengths and weaknesses of different behavioural approaches to organising the interaction between scientific advice and government policy. The models, or modes, of behaviour are not mutually exclusive and operate effectively in different circumstances. Conflict can arise when different parties are operating to different models or where there is not a common understanding of the model which is most effective in particular circumstances. These are modified from the definitions given by Owens (2016)*

Model name	Characteristics	Strengths	Weaknesses
Technical rational	• Provides external challenge • Scientists operate largely independently • Mainly unidirectional flow of advice from science to policy • Scientists set the agenda	• Places science in the lead • Encourages a challenge-based way of working • Can highlight issues which are not visible to policy • Can build in horizon scanning and strategic thinking • Promotes 'independence' of scientific advice	• Can result in advice which is untargeted and poorly timed • Scientists sometimes start to formulate policy themselves • May be perceived by policy as scientists 'marking homework' • Vulnerable to politicisation by interest groups or by default, resulting in advice being ignored because of suspicion about the motives driving those providing it • Can promote the notion that no scientific advice is ever 'independent'
Political rational	• Policy is in the lead when deciding priorities • Science is advisory and responsive	• Ensures scientific advice is targeted and relevant	• Requires policy to formulate the right questions

Table 2.1 (*cont.*)

Model name	Characteristics	Strengths	Weaknesses
	• Science is explicitly seen as one component of multi-dimensional problem-solving	• Builds confidence among policy professionals that they are being supported • Encourages listening by policy to scientific advice	• Science becomes a service to policy • Scientific advice can be a tool to achieve political ends • Scientists end up trying to please their policy masters • Scientists can disengage if they think that they are being manipulated by policy professionals for political ends
Coproduction	• Cooperation is central to activities • Recognition that policy is neither incremental nor hierarchical and that science is about more than technical solutions • Exploits the additional diversity in decision-making brought by the cognitive differences between policy professionals and scientists • Ensures equal stake in the outcome	• Builds a common understanding of the problem being addressed • Promotes listening on the part of scientists and policy professionals • Creates constructive personal relationships between scientists and policy professionals • Builds scientific advice on trust	• Scientists may be less inclined to call out problems when they arise • Policy professionals may be disinclined to challenge the standard of scientific advice • Scientists become a component in the policy process and could misinterpret their position as one of *coproduction* when it is really *political rational* • Requires long-term building of relationships • Not all scientists will be comfortable with this way of working, where trade-offs are often needed between practicality and rigour

context of conservation research for policy and practice, although they apply equally in any area at the interface between science and policy.

In the first mode, the *technical rational* model, researchers follow their own agenda, and largely act independently of government's policy environment. In these cases, alignment with policy can be unpredictable. Researchers typically present a technical argument to government, which can then choose how to respond. It is a linear or unidirectional transfer of knowledge from those who generate knowledge to those who might use that knowledge. Typical examples include the production of evidence syntheses or technical reports, such as lists of 'ecological indicators', without close consultation with government about what would be most useful; this also includes most peer-reviewed scientific papers.

This mode is often associated with the idea of 'independent' scientific advice occasionally delivered intentionally to challenge current policy norms and to potentially displace the direction of policy. It can create a disruptive relationship between science and policy. At its most extreme, it can be seen as scientists marking the homework of policy professionals, which is just a small step from politicising science. If the motivations of those generating the research results are not transparent it can promote a 'them and us' relationship, causing distrust of researchers' motivation by policy professionals and politicians. When promoted by interest groups, such as environmental non-governmental organisations (NGOs), it can also put researchers in the invidious, and sometimes unwelcome, position of providing the rationale for challenging government on political grounds. It is particularly good at feeding press interest in reporting division rather than unity between policy and scientific advice and can result in the politicisation of research, researchers and their scientific advice.

The technical rational model can work well in certain circumstances, such as when it is the agreed way of working and the results of research are highly technical. At times it will also be good for government to be challenged by groups external to the policy process. However, in general, the technical rational mode fails to account for the complex and multi-dimensional nature of government decision-making. It can be the default position adopted by most scientists when interacting with government; it is much easier to deliver messages unidirectionally to government than to spend time understanding the complex dynamics of the problems being addressed, especially when those working within government appear to be unwilling or unable to listen. When operating in the technical rational mode, this apparent unwillingness is rarely seen as a part of the problem being addressed, which might require modification of how the scientists communicate. These kinds of problems are especially significant in conservation research when the issues being addressed can be steeped in moral and ethical dilemmas and the

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scientific advice is often very uncertain. In my view, the technical rational mode of operating is not well suited to solving problems in conservation policy.

In contrast, Owens' *political rational* model takes the multi-dimensionality of these kinds of policy problems in to account. This way of working sees researchers providing a service to policy. It hands the initiative about how much weight to place on the knowledge gained from research to those responsible for designing and delivering policy. However, the political rational model also runs the risk that research becomes an internalised mechanism to achieve a pre-determined political outcome. For example, a large, but almost universally unacknowledged, proportion of the rationale for government sponsoring some conservation research will have been to assuage particular pressure groups or to delay difficult decisions. The low probability of gaining clear results from many instances of conservation research means that while there may be a genuine intention to generate new knowledge, there is a low probability of this actually happening. Deflecting problems to expert advisory committees is also symptomatic of political rationality at play. Again, this can be functional and desirable in many circumstances, but there is often too little explicit acknowledgement of the context and motivations in play.

Following Owens (2016), I complement these two common, but occasionally pathological, ways of building relationships between policy and science with a *coproduction* model. I make a distinction between passive and active coproduction (Wyborn, 2015; Beier et al., 2017). The coproduction mode of working recognises policy as a messy and nonlinear process, which is neither incremental nor hierarchical. Instead, policy development is seen as a cognitive process where everybody is learning. Researchers and policy-makers create constructive relationships that help to share information within an environment in which common objectives have been agreed or have emerged. The iterative nature of problem-solving in this mode allows both researchers and policy professionals to converge towards an optimal solution, acknowledging imperfections. The open nature of the dialogue within this kind of relationship promotes common understanding and joint solutions.

Passive coproduction usually happens when the activities of researchers, often outside government, naturally align with national-level policy objectives. This may occur as a result of government's own approach to open policy-making applied over long time scales, leading to the creation of common goals between researchers and government. Much conservation research, such as the BTO breeding bird surveys and the National Biodiversity Network system of observation, has evolved in this way. Active coproduction involves the merging of different perspectives in designed deliberative situations. For example, researchers themselves may actively engage policy specialists or

expert advisory groups by adopting a mode of operation focused on positive action and problem-solving rather than challenge and criticism.

Coproduction is a more sophisticated, socially derived solution than the sequential *rational* methods. However, a downside of coproduction is that it is sometimes difficult to maintain the levels of cooperation needed, because of the high transactional overheads; it is therefore easy to slip into either of the *rational* modes. This is especially likely when researchers are working with small communities where the transactional overheads are especially challenging. In these circumstances, Sutherland et al. (2017) suggest a co-assessment approach can be adopted, which integrates local knowledge with scientific evidence.

When working in the coproduction mode there is also a danger that the discipline needed to sustain the knowledge hierarchy (see above) is allowed to slip, because the researchers have to negotiate trade-offs with their policy colleagues that will be a source of tension when there are relatively strict standards to maintain. For example, in fisheries management honest interpretation of scientifically derived information, such as providing realistic confidence intervals around results, can produce outcomes where those involved in negotiating trade-offs use scientific uncertainty to gain advantage. If those making decisions tend to always allocate catch towards the top end of the plausible range, over-exploitation becomes almost guaranteed. This can result in a loss of transparency in the scientific advice, as scientists try to correct for this cognitive deficit on the part of those making decisions, by constructing their advice in ways which builds their own values in to evidence. The coproduction mode may also select for particular researchers who are more amenable to trading off standards in order to preserve the coproduction relationship with policy colleagues. We need to be sensitive to these pitfalls.

These different modes of operating are very apparent to me as a scientist embedded within central government. I see examples of them on a daily basis and, as Chief Scientific Adviser, it is a central part of my job to recognise how interactions between researchers and policy professionals are constructed and, if necessary, to try and move them towards a different mode of working. All these modes have their place, but difficulties can arise when there is misunderstanding between parties about which modes they are operating in, or when the mode being used is inappropriate to the circumstances. In my view, the coproduction mode of working is the most desirable and usually reflects a mature and strategically based relationship between scientific research and policy. Both the other technical modes tend to be associated with short-term or less-mature relationships.

Conservation research is a challenging field because it has high scientific uncertainty and it often lacks a good theoretical foundation that helps draw general conclusions from research. Problems of sample size and replication

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can leave research practitioners and synthesisers struggling to adhere robustly to the principles of the evidence hierarchy. Moreover, the politics surrounding controversial subjects often demand research results irrespective of whether they are truly informative. Part of the skill in applying these kinds of results within policy and practice in government is to know how to weight them appropriately. There are no formulas about how to do this; it is a skill built through experience and it is greatly enhanced when decisions are coproduced between people with complementary capabilities. Interestingly, because conservation is such a values-driven subject, it may be less important that the results from conservation research are a true reflection of natural reality than a true reflection of social reality. Put simply, the results of some conservation research may say more about us than they do about nature.

I wish to end this chapter with a more personal comment. We expend immense effort attempting to solve the many practical problems in conservation and this effort includes research. While I am sure this effort is worthwhile (because we need to make incremental improvements wherever we can), from my own position looking at the breadth of the environmental problems facing people and the planet, I am drawn reluctantly to the conclusion that it is not research in nature conservation policy and practice that will solve the problems tackled by conservation. Rather, the solution lies in truly large-scale changes in governance which will lead to incentivising people to consume fewer resources. Like our burgeoning problems with waste or air pollution, nature conservation is a consequence of this fundamental problem and we will not make significant progress until that problem is addressed with a seriousness which has yet to be witnessed within any national government or international forum.

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