Illuminated or blinded by science?

A discussion paper on the role of science in environmental policy and decision-making

Office of the
PARLIAMENTARY COMMISSIONER FOR THE ENVIRONMENT
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Preface

New Zealand has a long tradition of using science-derived knowledge to help meet our society's needs and wants and manage our physical resources. Throughout most of the 20th century we developed scientific institutions, many of which were an integral part of government agencies with policy formulation roles in environmental management and other important areas.

Since the mid-1980s, state sector, local government and science organisational reforms have changed the relationships, capacities, and accountabilities within and between these sectors. This has led to concerns about the contribution that science (the knowledge) and scientific thinking (the approach) is making to environmental policy and decision-making. Is the contribution as extensive and appropriate as desired? Is New Zealand getting the best value from its investment in science and research? Do we have the capacity to manage the crucial science-society interface? These are only some of the questions that have prompted the development of this discussion paper.

The purpose of the paper is to explore ways in which environmental policy and decision-making can be effectively supported by science and research to achieve effective environmental management and good outcomes. It lays out the many elements of science, policy and decision-making processes and poses some questions. These are not meant, in any way, to confine discussion either on issues of concern or potential ways forward. They are simply a starting point.

My team and I look forward to your insights and will endeavour to distil them into a cohesive picture of opportunities for improvements with some recommendations for action. Thank you in advance for your input. If you wish to discuss any aspect before responding, please do not hesitate to telephone or email us.

Dr J Morgan Williams
Parliamentary Commissioner for the Environment

Outline of the discussion paper

Section 1 introduces the reasons for undertaking this project. It explains the purpose of first producing this discussion paper – to canvass a wide range of views on the topic – and the subsequent process and timeframe for analysing submissions and preparing a final report.

Section 2 provides the context for the discussion paper and some of the underlying assumptions about what policy-making, decision-making and science entails, particularly in relation to environmental management.

Section 3 discusses features of the interface between science and environmental policy and decision-making, exploring some of the issues that determine the need for, and contribution from, science in policy and decision-making.

Section 4 discusses features of the interface between non-scientific information and environmental policy and decision-making, exploring other sources of information that policy and decision makers need to consider in addition to scientific advice.

Section 5 deals with capacity and communication issues, and the pressures that environmental policy and decision makers face in fulfilling their roles, particularly with regard to dealing with uncertainty and knowledge gaps.

Section 6 is a brief summary of the key issues.

Questions of a general nature are included at the end of sections 2, 3, 4 and 5. Responses are invited to these questions. Comments are also welcome on any other aspects of science in environmental policy and decision-making whether or not they have been included in this discussion paper.

1 Purpose, origin, problem definition and scope

1.1 Purpose of this discussion paper

The overall purpose of this entire project is to explore ways in which environmental policy and decision-making can be effectively supported by science and research to encourage good environmental management and achieve environmentally sustainable outcomes. This discussion paper is the first step in the project. It aims to stimulate comments on a range of issues that present barriers and opportunities to improving the quality of policies and decisions. It highlights some of the challenges that environmental policy and decision makers face when dealing with issues that involve a mix of scientific and non-scientific arguments, perceptions and opinions.

1.2 Origin

Activities that have the potential to give rise to undesirable environmental effects, whether they are of global, national or local significance, often need scientific advice to identify, prioritise and guide decisions on managing such effects. Examples include impacts of climate change, ozone depletion, pollution, new technologies (for example, in transport, energy and biotechnology), biosecurity threats to biodiversity, and resource use and depletion.

Similarly, policies intended to encourage environmental sustainability[1] often need a sound scientific basis to justify their adoption and ensure their success. Examples include managing the marine environment, controlling possums and managing biosecurity risks to the environment. The role and adequacy of a wide range of science and research contributions to sustainable environmental policy and decision-making have been key themes emerging in a number of recent investigations[2] by the Parliamentary Commissioner for the Environment.

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[1] Four specific criteria that can define environmental sustainability are: *regeneration* – using renewable resources efficiently and not permitting their use to exceed their long-term rates of natural regeneration; *substitutability* – using non-renewable resources efficiently and limiting their use to levels that can be offset by substitution by renewable resources or other forms of capital; *assimilation* – not allowing releases of hazardous or polluting substances to the environment to exceed the environment's assimilative capacity; *irreversibility* – avoiding irreversible impacts of human activities on ecosystems (OECD Environmental Strategy for the First Decade of the 21st Century: adopted by OECD Environment Ministers 16 May 2001. Paris: OECD)

[2] Examples include: *Long-Term Management of the Environmental Effects of Tailings Dams* (1997); *The Rabbit Calicivirus Disease (RCD) Saga: a biosecurity/bio-control fiasco* (1998); *Setting Course for a Sustainable Future: the management of New Zealand's marine environment* (1999); *Caught in the Headlights: New Zealanders' reflections on possums, control options and genetic engineering* (2000); *New Zealand Under Siege: a review of the management of biosecurity risks to the environment* (2000); *Key Lessons from the History of Science and Technology:*

1.3 The problem being addressed

Environmental policy and decision-making often involves dealing with complex scientific issues as well as values, ethics and other forms of knowledge and concerns. Controversy over field trials or release of genetically engineered organisms is a good example of such a situation. Effective policies and decisions need reliable information, and for this reason decision makers depend on authoritative sources of advice.

The reality for policy and decision makers is that decisions have to be made even though the state of knowledge about effects may be incomplete or uncertain at the time when decisions have to be made. Added to this, policy and decision makers and their advisers will be operating under time constraints (for example, the time available to deliver policies and decisions). They will be operating on time scales that differ from those required to undertake scientific research. They will be faced with the demands and assertions of various interested parties, statutory requirements, and other pressures and constraints. Their decisions can have long-lasting effects and potentially irreversible consequences, so environmental policy and decision makers carry a heavy burden of responsibility for managing the environment in a sustainable manner.

These matters and their overall effects on environmental management are raised in this discussion paper to explore and seek feedback on how science contributes to environmental policy and decision-making and environmental outcomes, and how this can be maintained and, where necessary, improved. In doing so, it also examines other factors that influence policies and decisions.

In summary, this discussion paper raises issues associated with environmental policy and decision-making in situations complicated by:

- *uncertainty* (for example, uncertainty about cause and effect relationships, and outcomes)
- *dispute* (for example, conflicting opinions, beliefs, interests, values, and paradigms)
- *distrust* (for example, lack of trust in science, decision-making processes, and decision makers)
- *poor communication* (for example, leading to a lack of awareness of the issues).

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knowns and unknowns, breakthroughs and cautions (2001); *Creating Our Future: sustainable development for New Zealand* (2002).

1.4 The scope of this discussion paper

Undertaking this project is consistent with the functions of the Parliamentary Commissioner for the Environment under the Environment Act 1986, section 16(1)(a) and (b):

> *'With the objective of maintaining and improving the quality of the environment, to review from time to time the system of agencies and processes established by the Government to manage the allocation, use, and preservation of natural and physical resources, and to report the results of any such review to the House of Representatives and to such other bodies or persons as the Commissioner thinks appropriate.*
>
> *Where the Commissioner considers it necessary, to investigate the effectiveness of environmental planning and environmental management carried out by public authorities[3], and to advise them on any remedial action the Commissioner considers desirable.'*

When the Commissioner decided to embark on this project, he considered it essential to first canvass as wide a range of views as possible among interested parties. This is because of the number and type of decision makers involved and the wide range of interests that need to be considered (for example, local through to international interests). There is also the potential for some significant policy and decision-making process changes to be made depending on the findings of the project. Therefore, it was decided to first prepare a discussion paper to seek comment on issues about the relationship between science, environmental policy and decision-making, and sustainable environmental management.

This discussion paper is not a position statement by the Commissioner. It contains no recommendations, nor does it address the key role that economic analysis plays in policy and decision-making. It is, however, an opportunity to focus attention on the role that science and research plays in policy and decision-making at all levels of government. It enables interested parties to contribute their ideas on how science (and other sources of knowledge) should contribute to effective policies and decisions, and environmental management in general.

A number of questions are raised at the end of sections 2, 3, 4 and 5. Responses to these questions will help us focus on issues that need to be further investigated and addressed in the Commissioner's final report. But responses to this paper need not be restricted only to those specific issues and questions it raises. It is simply a starting point for further analysis of the topic.

[3] 'Public authority', as defined in section 2 of the Environment Act 1986, means a Minister of the Crown, a Government department, any instrument of the Executive Government of New Zealand, and any local authority.

The 'target audience' for this discussion paper is a wide range of organisations, groups and individuals that:

- have statutory responsibilities for environmental policy and/or decision-making (for example, elected representatives at both central and local government, the Environment Court, and appointed environmental decision-making boards such as the Environmental Risk Management Authority)
- manage environmental science and research funding
- undertake research that is relevant to environmental policy and decision-making
- provide scientific advice to environmental policy and decision makers and their advisers
- evaluate, translate and interpret scientific information, and communicate it to decision makers, their advisers, and members of the public
- provide policy advice to environmental policy and decision makers
- participate in environmental policy and decision-making processes
- as tangata whenua, are consulted prior to and during environmental policy and decision-making
- monitor, assess and report on the effectiveness of policies and decisions, and progress towards achieving environmental outcomes.

However, the Commissioner welcomes comments from anyone who has an interest in enhancing the interface between science and policy/decision-making.

Submissions are invited up to **Monday 15 September 2003**.
Please forward any comments by mail or fax to:

Parliamentary Commissioner for the Environment
(attention: Bruce Taylor)
P O Box 10241
Wellington

Fax: (04) 495 8350
Telephone: (04) 471 1669

Submissions can also be sent by email to: sip@pce.govt.nz.

Depending on demand and the range of issues raised in submissions, the Commissioner may hold workshops on the topic during October 2003. An analysis of all submissions, including matters raised in any workshops, will be completed by the end of December 2003.

The final report will include the findings and recommendations of the Commissioner, drawing on the analysis of responses he receives and on further analysis of the issues raised in this discussion paper. The final report will be completed during the first half of 2004.

All material, including this discussion paper, analysis of submissions, the final report and relevant background papers, will eventually be posted on the Commissioner's web site (www.pce.govt.nz).

2 Context and underlying assumptions

Science plays an important role in environmental policy and decision-making. This is whether it involves providing the evidence needed or, in the absence of sufficient evidence, a scientific opinion on the likely environmental impacts of a public policy or decision. Scientific advice can be the most significant factor when attempting to identify, quantify, understand and manage risks to people and the environment, and to evaluate potential environmental benefits and opportunities. Depending on the state of scientific knowledge, the application of science as a basis for policy and decision-making can influence decision makers' expectations about the certainty of environmental outcomes.

However, it is widely acknowledged that there are limits to scientific knowledge, especially of complex ecological systems. If too much reliance is placed on the 'scientific view' other important matters, such as social and cultural values, could be undermined. Equally, selective scientific arguments in adversarial situations can lead to poor decisions that fail to take account of other, sometimes contradictory evidence. So scientific evidence and opinion need to be considered alongside other points of view, particularly in situations where there is a great deal of uncertainty about the environmental outcomes.

The challenge for environmental policy and decision makers is to assess all the available and relevant information presented to them, while focusing on their responsibilities for environmental outcomes, when making their decisions. In many cases decisions will be made within a broader strategic context, such as sustainable development. This may include considering the environmental, social, cultural, ethical and economic implications. Decisions also have to comply with any statutory requirements and constraints, and take into account obligations under the Treaty of Waitangi, and international treaties and protocols.

For the purposes of providing background and clarification for the terms used, a distinction is made in sections 2.1 and 2.2 between environmental policy making and environmental decision-making. Although policy-making is essentially a form of decision-making, not all environmental management decision makers have a policy-making role. Two examples are the Environment Court[4] and the Environmental Risk Management Authority. The remainder of the discussion paper combines the two terms into one – environmental policy and decision-

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[4] From a constitutional perspective, courts do not make public policy. This is a function of government. However, in the absence of clear policy direction reflected in legislation, court decisions may become *de facto* policy or may influence the initiation and development of government policy.

making – on the assumption that the science needs of both policy and decision makers will essentially be the same.

Sections 2.3, 2.4, and 2.5 briefly outline:

- some of the key attributes and skills regarded as important for environmental policy and decision makers
- an explanation of the term 'science'
- a summary of how the Environment Court regards science and scientific evidence, which may have relevance to environmental policy and decision-making in general.

2.1 What is environmental policy making?

Public policy typically involves public authorities (for example, Ministers and local authorities) setting directions or making choices on behalf of society or a community on issues in which there is a strong element of public good.[5] Policy on climate change is a good example. It is also an example of an issue in which scientific uncertainty has been at the forefront of the public policy debate within international, national and local forums.[6]

The manner in which a public policy issue is framed strongly determines the population of interested stakeholders, the range of relevant inputs needed (for example, supportive evidence), future courses of action, and the prospects of achieving desired and desirable outcomes.[7] The problem may be a systemic one, requiring better integration of policies and interests, as in the case of the Government's commitment to an oceans policy.[8] Addressing policy issues may require a strategic approach, as in the case of biodiversity[9] and biosecurity[10], or a more specifically defined plan of action, as in the case of the Government's approach to sustainable development.[11] This highlights the need to tailor the policy response, and the associated policy advice (where necessary, supported by scientific research) to suit the nature of the problem.

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[5] Generally these are issues that are of interest to or affect society as a whole rather than each individual.

[6] For an outline of some of the issues see: Collins, E. and Roper, J. (University of Waikato). *From National Policy to Regional Implementation: local government's utilisation of climate science in New Zealand*. Unpublished paper presented at the Berlin conference on the human dimensions of global environmental change, Berlin, December 2002.

[7] Keystone Center and the Center for Science, Policy, and Outcomes, 2000. *New Roles for Science in Environmental Decision-making: discussion paper*. (http://www.cspo.org/products/reports/keystone.html)

[8] See: http://www.oceans.govt.nz/ for more details.

[9] See: http://www.biodiversity.govt.nz/ for more details.

[10] See: http://www.biostrategy.govt.nz/ for more details.

[11] Department of the Prime Minister and Cabinet (DPMC). 2003. *Sustainable Development for New Zealand: programme of action*. Wellington: DPMC.

Boston et al (1996)[12] distinguish between three main types of policy advice: *strategic*, *substantive* and *operational*. Strategic advice has a broad, inter-sectoral and longer-term focus, and is concerned with the outcomes a government wants to achieve. Substantive advice is described as being narrower and more sector-specific, dealing in more detail with discrete policy issues. Both strategic and substantive policy advice include an analysis of policy options and provide recommendations on the preferred course of action. On the other hand, operational advice focuses on the more technical or practical issues relating to the implementation of a policy or programme. The practical measures needed to fulfil obligations under the Kyoto Protocol are an example of operational advice.

In practice all three types of advice frequently overlap, so they may be regarded as a continuum. Where necessary, the level of scientific input to support each type of advice will vary according to scale, significance and the level of detail required – from the broad-based and general for strategic advice to the narrow and specific in the case of operational advice.

As mentioned above, environmental policy making at the macro level has recently led to the development and implementation of a number of government strategies. A common feature of these strategies is the extensive background scientific information needed to develop them. In addition, they also identify further needs for future research efforts. The frameworks established by these strategies play an important role in shaping future environmental policy issues. Taken collectively, these strategies are potentially an important component in New Zealand's progress towards sustainable development.[13]

Some of the characteristics that distinguish scientific inquiry from public policy development are as follows:

- Evidentiary standards typical of research science may not be a primary consideration during public debate on policy issues. For example, ethical or cultural issues may be the main concern.
- In science, peer review, standards of evidence and research practices all protect against false positives to avoid mistakenly adding to the stock of scientific knowledge and misguiding future research. In public policy, rigorous debate on a wide range of issues that cut across traditional disciplinary and advisory structures is important, both for the development of new and the review of existing policies.
- Democratic processes, including public participation, are fundamental to policy making. Scientific advice in the policy process relies to a large extent

[12] Boston, J., Martin, J., Pallot, J. and Walsh, P. 1996. *Public Management: the New Zealand model*. Oxford: Oxford University Press, p 122.

[13] Parliamentary Commissioner for the Environment (PCE). 2002. *Creating Our Future. sustainable development for New Zealand.* Wellington: PCE.

on the existence of *scientific consensus*.[14] Scientific consensus is not a democratic process and can have its limitations[15], but it represents the general agreement at a given time by most scientists specialised in a given field. It is valuable because it means that an argument is so clear and logical that it has swayed a majority of experts.

- Policies, whether or not they have a scientific contribution, will always contain some degree of uncertainty, simply because it is impossible to predict all possible outcomes. Science endeavours to reduce uncertainties, but there can be no absolute guarantees, particularly in environmental management where complex systems and interactions among ecosystems are not entirely understood.
- Scientific inquiry or research may be 'open-ended' in the sense that it is pursuing a scientific objective rather than a public policy purpose.

2.2 What is environmental decision making?

A decision may be regarded as a response to actual or potential problems or opportunities. In the context of environmental management, decisions generally relate to the allocation of resources within legal frameworks, and the avoidance or reduction of adverse environmental effects. The decision maker is one who has authority over the resources being allocated, and whose aim is to achieve some specified objective by allocating the resources.[16] Three main aspects of a decision-making situation are:

- the decision to be made and the information available to assist the decision maker
- the chance and unknown events that can affect the outcome
- the outcome itself.

Many of the core difficulties in environmental decision-making are not encountered in other types of decision-making. Some of these are listed below:

- The need for scientific input may be great, but the available scientific knowledge may be incomplete, complex and not well understood.
- A wide range of stakeholders with a variety of interests may be involved.
- The issues may straddle local, regional and even national boundaries.

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[14] Scientific consensus differs from policy consensus. The former is usually based on what is provable, reproducible or quantifiable. The latter is generally based on agreement on what is 'acceptable'.

[15] Lessons from the history of scientific consensus is mixed. For example, it was once a scientific consensus that the earth was flat. Furthermore, many great scientific theories started out as minority opinions, and often had to fight the consensus before they became widely accepted.

[16] Decision Analysis Society. 1997. *A Lexicon of Decision-making.* (http://faculty.fuqua.duke.edu/daweb/lexicon.htm).

- The distribution of risks, costs and benefits may be unfair, as when those who face the risks and costs receive none of the benefits (and vice versa).
- Monetary and non-monetary costs and benefits, and the valuation of environmental assets, may be inaccurate due, for example, to incorrect assumptions.
- The issues may involve a great deal of uncertainty and lead to irreversible consequences.
- The issues and the solutions may challenge traditional approaches to problem solving and ethics.
- The issues may involve a clash of cultural values and/or social and economic interests.

Whether a decision is regarded as 'good', 'fair' or 'reasonable' may be assessed on the basis of the process involved, the content of the decision, and the outcome resulting from the decision:

- The *process* is important to ensure that opportunities exist for all relevant information and views to be given due consideration prior to the decision.
- It is important that the *content* of the decision reflects a thorough analysis of the issues, that the decision is effective as a solution to the problem, and is able to be implemented, ethical and optimal.
- The *outcome* is the final determinant of the effectiveness of a decision, but may be influenced by other factors beyond the scope of the original decision.

Environmental decision-making often involves evaluating not only the scientific information available but also other knowledge and views expressed in public submissions. Both scientific and non-scientific considerations are important, but are assessed in different ways.

Scientific evidence can be challenged or defended on methodological grounds. On the other hand, non-scientific considerations may reflect strongly held ethical, cultural and moral values that are usually more subjective in nature and challenged or defended through debate rather than by using a standard assessment procedure or criteria. Where there are multiple but conflicting values, decisions become even more difficult to make and the outcomes more uncertain. This is because they may eventually involve trade-offs, compromises, or adherence to arbitrary rules.

A common feature of both scientific knowledge and expressions of community values is the fact that both aspects change over time. Advances in science provide us with new information on which to make decisions, and changes in societal values determine the acceptability of those decisions. It is important, therefore, that where issues involve mixed scientific and values arguments, all such arguments are given due consideration, and are properly assessed. It is also important that the grounds on which decisions are based are explicitly stated. Later reviews of environmental decisions, where the law provides for this, may reveal the need to revise decisions because of changing circumstances (for example, improved knowledge and/or changes in values).

2.2.1 Why environmental decision-making can sometimes fail

Not all decisions will produce the outcomes intended. Understanding the reasons for decision failures can help to identify how decision-making can be improved.

Some of the reasons why decisions by agencies acting on behalf of society or local communities can sometimes fail to address an issue or produce the outcomes expected have been described as:

- failing to correctly anticipate a problem before it actually arrives
- failing to recognise a problem that has actually arrived
- failing to try and resolve the problem after the problem is recognised
- trying to resolve the problem but failing to do so. [17]

Failing to resolve a problem may occur when there are flaws in the decision-making process, including poor judgement, failure to seek or understand advice, or because of political expediency. Decision makers may be focused on short-term local solutions for issues that are long-term, strategic and have widespread consequences. They may be presented with problems they have had no information on or no prior experience of, or their prior experience may have been forgotten or is outdated. When faced with unfamiliar situations, decision makers may resort to reasoning by false analogy.[18] Limited capacity within agencies and limited powers to act may give rise to efforts that are too little too late. Sometimes trade-offs to accommodate competing interests compromise the outcomes being sought.

Decision makers need to recognise these factors and others that may affect good environmental decision-making and sustainable outcomes.

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[17] Diamond, J. 2003. *Why Some Societies Make Disastrous Decisions?* Lewis Thomas Prize Lecture, Rockefeller Institute, New York City. (http://www.edge.org/documents/archive/edge114.html).

[18] This may arise when decision makers fall back on reasoning by analogy with old familiar situations. This is fine if the old an new situations are truly analogous, but may give rise to problems if the old and new situations are only superficially similar.

2.3 What makes an effective environmental policy and decision maker?

As discussed in section 3.1 there is a range of institutions that have statutory responsibilities for environmental policy and decision-making and associated outcomes. To a greater or lesser extent each of the public authorities involved needs the following attributes and skills to fulfil those responsibilities:

Attributes

Qualities that enable them to:

- demonstrate good judgement supported by sound advice, processes and systems
- maintain or have access to the skills and experience needed to function effectively
- maintain a high level of trust among all stakeholders and the public
- function in a transparent manner, particularly in cases of uncertainty
- encourage and engage stakeholders and the public in decision-making
- meet the information needs of the public
- take account of public values and concerns
- fulfil obligations under the Treaty of Waitangi
- substantiate and communicate rationale for decisions
- place high value on evidence-based policy and decision-making
- facilitate processes that foster the above attributes.

Skills

The ability to:

- identify and handle strategic, substantive and operational risks and opportunities
- critically assess the quality and reliability of the information provided for decision-making
- undertake horizon scanning (i.e. identify emerging issues)
- understand complex environmental interactions and linkages to social, cultural and economic needs and aspirations (i.e. a ‘sustainable systems’ perspective)
- respond to issues in an appropriate and timely manner
- manage environmental risks
- cope with crises and disputes

- identify gaps in knowledge or information, and seek advice from appropriate sources
- intervene to avoid, reduce or reverse adverse effects on the environment
- acknowledge and quickly address mistakes
- deal with the unexpected
- monitor environmental effects and outcomes
- reassess policies and decisions in the light of new information.

Capacity issues – the capacity of institutions to fulfil their responsibilities – are discussed in section 5.

2.4 What is science?

Put very simply, 'science' is a system of knowledge and a method of inquiry, organised in a particular way. Science seeks to understand things such as natural phenomena, their causes and effects. It does so through a process of putting forward a supposition (hypothesis) for how something works, then gathering evidence (via experiments) that seeks to falsify the hypothesis.

> *'I have steadily endeavoured to keep my mind free, so as to give up any hypothesis, however much beloved (and I cannot resist forming one on every subject), as soon as facts are shown to be opposed to it.'*
>
> *Charles Darwin (1809-1882)*

The usual sequence of scientific inquiry, or research is as follows:

- observations lead to an hypothesis
- predictions are formulated based on the hypothesis
- the predictions are tested through a series of experiments
- predictions that are not falsified through repeated testing increase the power of the hypothesis and, over time, may lead to the belief that the hypothesis is probably 'true'. Well known examples include Darwin's theory of natural selection and Einstein's theory of general relativity.

In short, science endeavours to be a rigorous process of 'trial and error' in pursuit of understanding. It tries to eliminate as much as possible the subjectivity and bias that scientists bring to their work from other experiences. It strives for objectivity relying on measurement, by the openness of the inquiry process, transparency of the methodology, and exposure of results to peer review, re-testing and scrutiny. Scientists use statistical theory for both sampling purposes and for the analysis of results to estimate the 'significance' of the findings. Nonetheless, science remains a distinctly human undertaking, subject to occasional controversy, dispute and hubris.

Scientific knowledge is the outcome of social processes that certify it as legitimate. The socially constructed nature of scientific reality, along with the way that facts and values intermingle in scientific disputes, in peer review, and in the behaviour and decisions of regulatory committees, are all becoming better understood.[19]

The questioning nature of science and scientists can be frustrating for decision makers. Scientists have a tendency to answer one question by posing several more hypotheses, and a preference for talking in levels of probability rather than certainty. This can be frustrating for decision makers who prefer certainty, unconditional explanations and precise estimates of risk.

Often science cannot, or should not, attempt to provide certainty when unknowns and uncertainties are dominant characteristics of the system under consideration. This is particularly the case with environmental sciences. In this context, systems are extremely complex, cause and effect can be difficult to determine, and outcomes can vary according to history and circumstances. This makes for exciting scientific challenges. However, environmental complexity and the associated difficulties of communicating and understanding such complexity can frustrate environmental policy and decision makers.

Another significant and related frustration for *all* parties engaged in science-policy dialogues can be the basic difficulties of communicating effectively between the parties. Policy jargon can obscure the basic objectives; scientific jargon can inhibit understanding. In the absence of what might be termed 'science and policy translators', the parties can fail to engage. These issues affect environmental policy and decision-making and are further discussed in section 5.3.

2.5 How does the Environment Court deal with scientific evidence?

The role of science in legal proceedings is a major topic on its own which goes beyond the scope of this discussion paper. However, it is useful to briefly highlight some of the key features of the expectations and admissibility of scientific evidence in proceedings of the Environment Court in particular. There are lessons to be learned from the evolution of the role of science and the expert witness in court proceedings that may be relevant to environmental decision-making generally. The following commentary draws mostly from a comprehensive article on the topic of scientific evidence and environmental litigation by Forret (1998).[20]

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[19] Jasanoff, S. 1990. *The Fifth Branch: science advisers as policymakers*. Cambridge, Massachusetts: Harvard University Press.

[20] Forret, J. 1998. Scientific Evidence and Environmental Litigation in New Zealand. *New Zealand Journal of Environmental Law*. Vol 2: 39-62.

Science and scientists are integral components of legal decision-making, particularly in the environmental arena. Evidence may be based on either accepted or unproven scientific theories. This can lead to situations where the courts are not only involved in making decisions on the merits of the case before them, but they also become a public forum for scientific debate.

2.5.1 The role of the expert witness, and rules of evidence

Features of the role of the expert witness include the following:

- expert witnesses are the only types of witness entitled to give opinions in evidence
- opinions of experts are likely to be relied on because they necessarily concern issues that are outside the ordinary knowledge of the court
- courts have to be careful to identify the role of expert witnesses and to distinguish that role from the decision-making function of the court.

The Environment Court is not bound by the rules of evidence. It has adopted a pragmatic approach that enables decisions to be made and those decisions to be founded on a firm base of judicial authority. Five common law rules of evidence have evolved in order to control the content and boundaries of expert testimony:

1. Witnesses must have a proven level of knowledge and experience to ensure that they are qualified to help the court in an expert capacity (the ‘expert rule’).
2. The area of expertise is one that has credible theoretical foundations and methodology (the ‘area of expertise rule’).
3. The substance of expert testimony should be outside the common knowledge of the court (the ‘common knowledge rule’).
4. Any expert opinion evidence that effectively supplants the courts’ decision-making function tends to be inadmissible (the ‘ultimate issue rule’).
5. Expert opinion evidence is restricted to those matters that are directly within the expert’s experience and observations (the ‘basis rule’).

Scientific evidence relies on a set of assumptions and choices that are influenced by a number of factors including:

- the individual standpoint of the researcher derived from his or her values and experiences of life and learning
- political and economic pressure from funding agencies and research institutions
- the politics that accompany decisions about selection of and inclusion of articles and research data in reputable journals
- the politics and economics that determine the reputable journals

- an individual researcher's desires for academic and economic advancement.

Four factors that are now commonly used as a guide to assist courts in assessing admissibility of scientific evidence are as follows:

- the degree of testing to which the theory or technique has undergone
- the extent of peer review and the publication of the theory or technique
- the known or potential margin of error for a particular technique together with its methodological reliability
- the level of general acceptance within the relevant scientific community.[21]

The overall effect of these factors is to focus issues about admissibility of scientific evidence on basic principles of relevance and probative value.

Although not bound by the rules of evidence, the Environment Court nevertheless uses the criteria for admissibility of scientific evidence as a type of evidentiary sieve. The Court also generally applies the 'expert rule' to determine whether a particular witness qualifies as an expert. The Court expects expert scientific testimony to be both helpful and relevant to the decisions that it has to make. Decisions of the Environment Court have emphasised its judicial role, which requires it to make findings on the evidence of the balance of probabilities rather than as scientists seeking to find absolute truth or imposing a standard of proof beyond reasonable doubt.[22]

1. What important attributes and skills (see section 2.3) are needed for effective policy-making and decision-making? Are the right processes in place to maximise the use and effectiveness of such attributes and skills? How can these be encouraged among public authorities with environmental management responsibilities?
2. What aspects of the role of scientific advice in proceedings of the Environment Court could usefully be applied to environmental policy and decision-making? How appropriate would it be to apply the principles behind the 'rules of evidence' (see section 2.5.1) in the context of environmental policy development?

[21] These are based on the decision in *Daubert v Merrell Dow Pharmaceuticals Inc*, supra note 52, at 483.
[22] For example, see *Canterbury Regional Council v Canterbury Frozen Meat Company* (1994) 3 NZPTD 368.

3 The interface between science and environmental policy and decision-making

Environmental policy and decision makers come from a wide range of backgrounds and from within diverse occupational groups. They can range from non-specialist, democratically elected representatives (for example, Cabinet and individual Ministers at the national level, and Councillors within regional councils and territorial authorities at a regional or local level), to appointed Judges and Commissioners (Environment Court), to members of a statutory authority such as the Environmental Risk Management Authority (ERMA). Among these bodies there will be a range of expertise and experience related to the decisions they have to make. All share a responsibility and duty for making decisions that will influence environmental outcomes. All rely on access to sources of information and advice, including science and research, which will enable them to make appropriate decisions.

The 'products' of environmental policy and decision-making include:

- environmental legislation
- national policies and strategies for environmental management and sustainability
- national guidelines and standards
- regional policies, plans and rules, and district plans and rules dealing with the management of natural and physical resources
- resource consent decisions
- environmental and health risk management decisions.

3.1 Environmental policy and decision makers

The development of public policy generally, and environmental policy in particular, is a significant function of central and local government, usually, but not exclusively, on the advice that Ministers and Councillors receive from their respective internal science and/or policy advisers. Often government departments and councils will seek external scientific or other specialist advice to assist them in analysing both the problems being tackled and the potential solutions. Environmental policy advice assists central and local government policy makers to determine how they can achieve the results (i.e. environmental outcomes) they expect. It also involves examining the actual or potential environmental implications of policies in other areas such as trade.

Environmental decision makers, including regional councils and territorial authorities, generally react to problems or consider applications, such as consents under the Resource Management Act 1991 (RMA), to carry out activities associated with a statutory requirement. Under certain circumstances these environmental decisions can be reviewed or appealed. A consent authority may review resource consent conditions (section 128, RMA), and decisions of consent authorities may be appealed to the Environment Court (sections 120, 121 and 290, RMA). Monitoring and reviewing decisions is an important, but underrated function among environmental decision makers. Consent authorities need to monitor both for compliance with consent conditions and for effects of consented activities on the environment.[23]

Regional councils and territorial authorities may also be proactive in bringing about changes that will improve environmental management and avoid foreseeable problems. They may achieve this through resource management policies, plans and other tools, such as environmental education and awareness-raising. For example, each regional council is required to prepare a regional policy statement to achieve the sustainable management of natural and physical resources by providing an overview of the resource management issues of their region (section 59, RMA).

Through regional plans a regional council may have rules that prohibit, regulate or allow activities (section 68, RMA). Regional councils also undertake a significant amount of scientific research and monitoring of the natural resources within their regions, and regularly publish reports on the state of the resources they manage.

Environmental decisions makers who do not have a formal policy role, but whose role is to make decisions on a case-by-case basis include:

- the Environmental Risk Management Authority in relation to applications to introduce new hazardous substances and new organisms into New Zealand
- the Environment Court which, among other things, determines appeals on cases involving disputes over the management of resources.

3.2 'Narrow' and 'broad' approaches to environmental sciences

Much of science is characterised as 'reductionist' in its approach. A reductionist approach involves the analysis of complex systems or problems by identifying and exploring the parts, or examining the effect of one variable at a time. It is frequently used in testing hypotheses. This is the more traditional approach to science and has proved to be extremely successful, such as in the classic

[23] Parliamentary Commissioner for the Environment (PCE). 1996. *Administration of Compliance with Resource Consents*. Wellington: PCE.

disciplines of physics and chemistry and more recently in molecular biology and genetic engineering.

In contrast, ecological science is increasingly representing a very different scientific way of seeing the world. Holling (1998) describes this stream of science as integrative, broad and explorative, characterised by evolutionary biology.[24] It is based on the premise that: '…knowledge of the system we deal with is always incomplete. Surprise is inevitable.' Holling states that the bridge between these two streams comes with the realisation that neither is complete in itself: 'Both the science of parts and the science of the integration of parts are essential for understanding and action.' Each has the responsibility to understand the other: 'Otherwise the science of parts can fall into the trap of providing precise answers to the wrong question and the science of the integration of parts into providing useless answers to the right question.' This raises the issue of adapting questions and answers, which have been developed for a science framework, into an appropriate environmental policy framework.

The issue of how science sees the world, and how it frames and investigates problems has particular relevance to environmental sciences and, in other policy contexts, to social sciences as well. As an example, consider biosecurity. A reductionist approach considers isolated elements of the problem, such as improving border-focused screening technologies or pest control through genetic modification systems. While these are valuable 'parts' of the problem, an integrative broader approach might give priority to questions of human motivation and response, implications of changing trade patterns and flows on potential threats, influence of climate change on biosecurity risks, and the characteristics of internal pathways and the development of effective systems to monitor them.

These questions of how science approaches environmental problems and uncertainties is particularly relevant given the complexities and far-reaching nature of many of the issues now facing environmental managers.

[24] Holling, C.S. 1998. Two cultures of ecology. *Conservation Ecology* 2(2):4. {online} Available from: www.consecol.org/vol12/iss2/art4.

The challenge of doing interdisciplinary science

Addressing today's critical environmental challenges has led to calls for more effort to work across traditional scientific disciplines if policy makers are to get the information and tools they need. This was the message in a report presented in January 2003 to the USA National Science Foundation. Titled *Complex Environmental Systems: synthesis for Earth, life and society in the 21st century*, it called for long-term funding plans to incorporate interdisciplinary approaches. The report identified three specific interrelated areas – coupled human and natural systems, coupled biological and physical systems, and people and technology.

Under 'coupled human and natural systems' the report lists four major research challenges that also have a familiar ring in a New Zealand context: land, resources and the built environment; human health and the environment; freshwater resources, estuaries and coastal environments; environmental services and valuation.[25]

Such calls are not new. Often so-called *interdisciplinary* research is simply *multidisciplinary*. In the latter, outcomes reflect the perspectives of separate disciplines; in the former, disciplinary boundaries can be transcended and true synthesis and new insights may emerge.

3.3 The role of science in environmental policy and decision-making

Scientific information and research contributes in numerous ways to environmental policy and decision-making. It can assist at different spatial scales (local to international) and temporal scales (short-term to geologic periods). For example, Government's climate change policy benefits from the work of the Intergovernmental Panel on Climate Change (IPCC), while research by the National Institute of Water and Atmosphere Research (NIWA) into El Nino patterns helps to predict risks of drought for vulnerable farming regions. But does the role of science and the scientist stop at the point of publishing such predictions? It is important to consider in this situation whether the application of the scientific predictions leads to the adoption of effective drought-proofing measures in the agricultural sector.

[25] For details see: http://www.nsf.gov/geo/ere/ereweb/index.cfm

3.3.1 The IPCC Model – integrative science for big environmental problems

The IPCC was established in 1988 with three main tasks. These were to:

- assess available information on the science, impacts and economics of climate change
- assess options for mitigating and adapting to climate change
- provide scientific, technical and socio-economic advice to the Conference of the Parties to the United Nations (UN) Framework Convention on Climate Change (FCCC).

The IPCC is charged with providing advice that is *relevant* to policy, but the advice should not be *policy-prescriptive*. It has been instrumental in summarising the evidence of climate change for policy makers and the need for them to take action, despite the many uncertainties over the rate and magnitude of climate change and also over the adaptation strategies and mitigation targets that are needed.[26] While the scientific advice has become increasingly clear on climate change, impediments to implementing that advice remain in the political area, as shown by the various arguments for and against the Kyoto Protocol.

3.3.2 The UN Millennium Ecosystem Assessment

On a similarly broad scale, the UN's Millennium Ecosystem Assessment is a current four-year, $21 million effort (launched in June 2001) involving some 1,500 scientists to provide decision makers with authoritative information on the impacts of changes to the world's ecosystems on human livelihoods and the environment.[27] It aims to meet the assessment needs for those states that have reporting obligations under three environmental conventions:

- the UN Convention on Biological Diversity
- the Ramsar Convention on Wetlands
- the UN Convention to Combat Desertification.

The scientific challenge will be to present the findings in ways that can be clearly understood by policy makers who will then have the task of formulating and pushing for solutions to problems.

[26] Pittock, A.B., 2002. What next for IPCC. *Environment* 44 (10): 20-36.
[27] Details and updates can be viewed at: www.millenniumassessment.org

3.3.3 State of the environment reporting

The 1997 report *The State of New Zealand's Environment*[28] illustrates our dependence on quality scientific investigation and monitoring of environmental systems. The report concluded that:

> *'New Zealand's environmental information needs considerable upgrading if the state of the nation's environment is to be accurately described and trends detected'.*

However, it was also able to point to major problems. These included loss of biological diversity, the importance of pest control, factors affecting soil quantity and quality, the priorities for addressing issues of water and air quality, and the threats of exploitation to marine ecosystems.

The Ministry for the Environment continues to develop a comprehensive set of environmental performance indicators for New Zealand. When these are completed and implemented both management and policy agencies should have national measures against which to judge not only performance in environmental management, but also the appropriateness of environmental policies and decisions. In similar exercises, the Institute of Environmental Science and Research (ESR) is developing a set of environmental health indicators, and Statistics New Zealand is undertaking work on co-ordinating environment statistics. Such developments raise questions about the present and future needs of an audit capacity to monitor government's progress in implementing environmental strategies and policies, as well as sustainable development goals.[29]

3.3.4 Trade issues

Another area where science plays a significant role that may affect environmental policy and decision-making is biosecurity in the context of international trade. The Sanitary and Phytosanitary Agreement of the World Trade Organisation (WTO) provides a framework for managing biosecurity risks in imported agricultural products, under which the application of risk management measures must be justified by a scientific assessment of risks.[30] On the other hand, multilateral environmental agreements (MEAs), such as the Convention on Biological Diversity, are premised on the 'precautionary principle' (see section 5.4.3). Critics of trade globalisation fear that the environment could be the loser if WTO rules (including those relating to the

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[28] Ministry for the Environment, 1997. *The State of New Zealand's Environment*. Wellington: Ministry for the Environment.

[29] Department of the Prime Minister and Cabinet (DPMC). 2003. *Sustainable Development for New Zealand: programme of action.* Wellington: DPMC.

[30] Pharo, H.J. 2002. *Acceptable Biosecurity Risk in New Zealand.* Unpublished research paper in partial fulfilment of the degree of Master of Public Policy, Victoria University of Wellington.

need for scientific justification for trade restrictions) clash with the more cautionary approach and terms of MEAs.[31]

3.4 Issues associated with the use of science in environmental policy and decision-making

The use of science is common in the area of environmental management. Scientific advice may be part of the overall policy advice, although the relevant scientific research involved may be operating entirely independent of it. Activities contributing to such advice may include the following:

- new or ongoing research
- operational research
- modelling and forecasting
- statistical reports and surveys
- information from routine monitoring (for example, state of the environment reporting).

Other advice that plays a major role in environmental policy making includes:

- cost benefit analysis
- regulatory analysis (for example, compliance costs and the practicalities of implementing legislation)
- economic, environmental, social and health impact assessment
- implications for Treaty of Waitangi obligations.

Some view science as a source of definitive, authoritative, 'black or white' answers that can provide a predictive foundation for action, but this may be true only to a limited extent. Implicit burdens of proof in science have been designed or have evolved to serve the aims of scientific understanding and research, not necessarily to serve public policy purposes.

Although science can help guide policy makers manage the complex inter-dependent systems characteristic of environmental management, this often requires a systems-level scientific understanding rather than a rigid disciplinary approach. Equally, good environmental policy making requires an understanding of the value and limitations of science, as well as a broad understanding of the larger context in which environmental policies are made, such as strategies for sustainable development.

[31] Parliamentary Commissioner for the Environment (PCE). 2000. *New Zealand Under Siege: a review of the management of biosecurity risks to the environment*. Wellington: PCE.

A critical analysis of policy debates will be important to ascertain and understand the bases of the arguments and evidence being presented. This would address questions such as who is saying what, why are they saying it, what is at stake, and how credible are their arguments. Also of interest will be the sources of scientific expertise being used, whether they are appropriate to the issue, and the influence that the source of funding may have on the nature and content of the scientific advice offered.

The value of scientific advice in policy making depends on factors such as:

- the necessity of having scientific input to guide the development of the policy (Is scientific advice crucial to the issue? What do we need to know?)
- whether the issue is or has been the subject of scientific research (What do we know scientifically?)
- if science has addressed the issue, the extent of scientific understanding (What are the complexities and uncertainties? What do we *not* know?)
- the reliability of scientific advice in the context of the decisions to be made (What assumptions have been made in the absence of reliable data?)
- the contentious nature of the scientific advice (Are there conflicting scientific views on the issue?)
- the significance of the scientific advice relative to other considerations (for example, costs, benefits, society's values, beliefs, and so on).

In the absence of scientific evidence, or where such evidence is insufficient, unclear or inconclusive, policy choices and decisions become more difficult to make, and long-term environmental consequences harder to predict and manage.

3.4.1 Public confidence in science and its application to environmental policy and decision-making

Science can become embroiled in political debate that can undermine its legitimacy, value and public confidence in its application to policy.

An example of a science/policy fiasco that created significant public mistrust in government decision-making was the handling of the BSE[32] crisis in Britain. The findings of the inquiry into the handling of this crisis revealed a number of significant weaknesses in the science/policy/communication interfaces for handling hazards to both animals and humans. Among its findings, the inquiry concluded that:

- Government measures to address both hazards (i.e. to animals and humans) were not always timely nor adequately implemented and enforced.

[32] Bovine spongiform encephalopathy. For more details about the inquiry into BSE see: http://www.bse.org.uk/

- The rigour with which policy measures were implemented for the protection of human health was affected by the belief of many prior to early 1996 that BSE was not a potential threat to human life (i.e. not considered linked to variant Creutzfeldt-Jakob disease (vCJD)).
- The Government sought and followed the advice of independent scientific experts – sometimes when decisions could have been reached more swiftly and satisfactorily within Government.
- At times officials showed a lack of rigour in considering how policy should be turned into practice, to the detriment of the efficacy of the measures taken.
- At times bureaucratic processes resulted in unacceptable delay in giving effect to policy.
- The possibility of a risk to humans was not communicated to the public or to those whose job it was to implement and enforce the precautionary measures.
- While the Government did not lie to the public about BSE, it was preoccupied with preventing an alarmist over-reaction to BSE because it believed that the risk was remote.
- The public felt that they had been betrayed, and confidence in subsequent government pronouncements about risk was a further casualty of the BSE incident.

The inquiry's report documents numerous errors of science, policy formulation and political misperception of the 'public interest'. The BSE crisis dramatically demonstrates how a combination of poor science, false reassurances to the public, unnecessary delays in undertaking critical research and preventive measures, plus a lack of scientific and political openness, led to a major erosion of public confidence. This lack of confidence was not only in politicians, but also in the integrity and trustworthiness of scientists. That erosion of trust spilled over into the debate on genetically modified (GM) food in Britain.[33]

In many countries there is now considerable public concern over whether their governments have the ability to make good decisions based on sound scientific advice and openness. In New Zealand, MAF's aerial spraying programme to eradicate the painted apple moth from suburbs of Auckland did not receive unanimous support among the residents. Some residents continue to have concerns about the eradication method and uncertainty about the health effects of exposure to such blanket spraying. Their concerns were exacerbated by the commercial secrecy surrounding the pesticide's ingredients.

Science can bring public attention to environmental problems. However, once an issue becomes highly contentious beyond scientific issues, as in the case of

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[33] Parliamentary Commissioner for the Environment (PCE). 2001. *Key Lessons From the History of Science: knowns and unknowns, breakthroughs and cautions.* Wellington: PCE.

the debate on genetic modification, it may be beneficial to minimise the role of science in the political process until a clear problem definition emerges. Science can continue to assist the process of identifying options, but in a more supportive rather than leading role.

One such approach with growing appeal is that of 'adaptive management' (see section 5.4.2). Adaptive management does not require scientific certainty prior to taking action – in fact, it assumes that such certainty cannot be achieved, and instead identifies the role of science as that of monitoring progress toward pre-defined goals. In this way, science steps in *after* the problem is well defined and after desired goals are identified through political means.

3.4.2 Science in its place

The importance placed on the role of science in policy making is not without controversy. The *perceptions* of key sectors and stakeholders about science, its validity and conclusiveness are key factors that influence trust. Over-emphasis on science as a basis for making decisions may undermine other important considerations such as issues of equity, culture and traditions, and community values. Equally, under-emphasising the role of science may result in ineffective policies and uncertain outcomes because of the lack of supporting evidence and methods to measure and assess effectiveness.

While scientists have the technical expertise to advise, unless they have been elected or appointed to do so, they do not have the mandate to make moral and political judgements on behalf of society. A phrase commonly used is that scientists should be 'on tap' rather than 'on top' when it comes to environmental policy and decision-making. This suggestion could equally apply to other specialist advice in policy development.

3.5 Examples of processes for incorporating science in environmental policy and decision-making

The use of information in environmental policy and decision-making is a critical factor affecting outcomes. The use of science in policy formulation was the subject of a report prepared for the Ministry of Research, Science and Technology.[34] Among other things, the report identified constraints on scientific input to Cabinet Committee papers. These include time, limitations on paper length, Ministers' preferences, and human and financial resources. The report highlighted the difficulties of incorporating the findings from physical science

[34] Ministry of Research, Science and Technology (MoRST), 1998. *Science into Policy: an evaluation of the use of science in policy formulation*. A report prepared by Dr W. Smith, University of Auckland. Wellington: MoRST.

research into Cabinet papers when such papers are meant to be concise, clear and no longer than 10 pages. The State Services Commission (SSC) reinforces this point by stating that: 'there is no mechanism to assure Ministers that the assertions in advice are more than informed guesswork'.[35]

Science in policy making is further complicated when dealing with issues in which there is no definitive scientific consensus and when the evidence must be interpreted within the context of a complex biophysical system. Other countries have addressed this by developing new ways for exploring complex issues that are a mix of science and non-science perspectives (see sections 3.6.2 and 3.6.4).

3.5.1 Methodologies

While New Zealand lacks such structures as outlined in sections 3.6.2, 3.6.3 and 3.6.4, it has made an effort to be clear about how science and non-science views will be resolved, and decisions made, with respect to one particular area of environmental decision-making.

The Hazardous Substances and New Organisms (HSNO) Act 1996 is unique in that it establishes a methodology for making decisions – the Hazardous Substances and New Organisms (Methodology) Order 1998. This methodology has to be consistently applied by the Environmental Risk Management Authority (ERMA) when considering applications to introduce hazardous substances and new organisms into New Zealand.

The methodology requires, among other things that, when evaluating risks, the Authority:

> *'must use recognised risk identification, assessment, evaluation, and management techniques' (clause 24);*
>
> *'must begin with a consideration of the scientific evidence relating to the application and take into account the degree of uncertainty attaching to that evidence' (clause 25 (1)).*

Where evidence refers to other values:

> *'including the relationship of Maori culture and traditions with their ancestral lands and taonga, the Authority must also consider the values and other matters in that evidence' (clause 25(2)).*

Clauses 29 to 32 set out the procedure that ERMA must follow where it encounters:

> *'scientific and technical uncertainty relating to the potential adverse effects of a substance or organism, or where there is disputed scientific or technical information'.*

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[35] State Services Commission (SSC). 1999. *Essential Ingredients: improving the quality of policy advice*. Occasional Paper No. 9. SSC: Wellington, (p.10).

This includes determining the materiality and significance to the application of the uncertainty or dispute, and endeavouring to clarify the uncertainty or dispute through facilitated discussion between the parties. Where the matter cannot be resolved, ERMA must take into account the need for caution in managing the adverse effects. The Authority may request the applicant to provide further information if the uncertainty arises from an absence of information, inconclusive or contradictory information, or information from an unreliable source.

Another example, not of a methodology but of guidance, is the Fourth Schedule of the Resource Management Act 1991 which sets out instructions on preparing an 'assessment of effects on the environment' (AEE) primarily aimed at resource consent applicants. If properly done, an AEE will assist in the decision-making process.

3.6 Examples of science structures

Only the Ministry of Research, Science and Technology (MoRST) is recognised as providing formal science policy advice to government (see Appendix 1). MoRST sees its primary role as promoting the development of policy that is based on sound science. It encourages other departments to take responsibility for research that is needed to underpin their statutory or operational functions. The Ministry's limited capacity to meet all of the Government's science needs has meant that its attention has been focused on those areas that:

- impact on New Zealand's innovation capability
- cut across the interests of a number of portfolios where a large number of agencies have responsibilities for different components, as is the case in the development of an oceans policy
- are of widespread public concern, such as genetic modification
- involve global issues and obligations, such as biodiversity which links to the Convention on Biological Diversity
- provide an opportunity to catalyse the development of scientific and technical capability within other government departments, such as climate change
- are new and significant issues that might affect New Zealand science, economic wellbeing or the environment, such as biosecurity.[36]

The following section (3.6.1) outlines the position of Crown Research Institutes (CRIs) in New Zealand with respect to scientific advice for policy development. While other institutions, such as universities and private researchers, may be contracted from time to time to carry out specific policy-relevant or operational research, attention is focused on CRIs because of their unique statutory functions

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[36] Lesley Middleton, Ministry of Research, Science and Technology, pers. comm., 10 June 2003.

and responsibilities, and history of involvement in scientific research for public policy purposes. Sections 3.6.2, 3.6.3 and 3.6.4 describe other structures that have been used overseas to link science to the policy process.

3.6.1 Crown Research Institutes

When CRIs were established in 1992 they were expected to be commercially viable companies and compete for public and private sector research contracts. However, unlike most commercial companies, CRIs are specifically directed by the Crown Research Institutes Act 1992 to exhibit a sense of social responsibility and to undertake research for the benefit of New Zealand, amongst other operating principles.

The CRIs, on average, receive about 50% of their revenue from Vote: Research Science and Technology research contracts. The balance comes from government departments' operational research contracts and other non-government national and international contracts. This provides a significant tension between their dual roles as providers of research for the benefit of New Zealand and for commercially focused enterprises.[37] The appraisal (footnoted below) that noted this tension also identified that:

> *'In their public good capacity CRIs may have a key role in informing Government policy'.*

One aspect of this tension relates to questions about what happens when the results of commercially sensitive and privately funded research conflicts with the results of research carried out on behalf of the public sector, and how this might influence the nature of any subsequent policy advice. A further tension is provided by the experience of some CRIs indicating that government departments can be reluctant to purchase advice at the user-pay, full cost funding rates that apply to all other clients.

Prior to the science sector restructuring in 1992, the Department of Scientific and Industrial Research (DSIR) had funding to support public policy and decision-making. Many DSIR scientists were members of advisory committees and officials groups directly advising government on policy matters. This made the provision of consolidated scientific advice more straightforward. The funding now provided by Cabinet for MoRST to carry out some of these activities:

> *'…only identified the cost of those direct DSIR head office activities attributed to supporting science for policy advice. No account was taken of the actual costs attributed to the scientists in carrying out their research to*

[37] Ministry of Research, Science and Technology (MoRST). 2002. *An Appraisal of Crown Research Institutes 1992 - 2002*. A report prepared by MoRST with assistance from the Crown Company Monitoring Advisory Unit. Wellington: MoRST.

support policy advice or of the costs associated with broader underpinning areas of science that supported departmental initiatives.'[38]

Consequently there is now a substantial financial gap between these direct and indirect costs compared to the situation before 1992.

In Australia, by comparison, the Chief Executive of the Commonwealth Science and Industrial Research Organisation (CSIRO) is a member of the Prime Minister's Science, Engineering and Innovation Council and the Coordination Committee on Science and Technology. CSIRO provides members for five Commonwealth-State Standing Committees with an environmental focus and many CSIRO officers participate in government committees and working groups. CSIRO contributes scientific advice to government policy and made 50 submissions to Government inquiries in the past three years.

Linked to the question of costs and the need for CRIs to be commercially viable is the issue of intellectual property. CRIs see a tension between their public good role, the need to show a sense of social responsibility, and their commercial focus. In some circumstances, such as the inquiry of the Royal Commission on Genetic Modification, this commercial focus led to public mistrust of some CRIs as independent providers of scientific advice.[39] Intellectual property can lead to commercial gain through patenting and licensing, the establishment of joint ventures and spinning-out[40] companies.

On the other hand, CRIs have difficulties with the way some government departments deal with ownership and use of intellectual property developed as part of contracts. They consider that some departments insist on their ownership of the intellectual property although they 'are not in a position to capture any value from this intellectual property. This significantly impedes the ability to market the products and services derived'.[41] The extent to which this creates difficulties in the context of environmental policy and decision-making, to our knowledge, has not been explored.

3.6.2 Technology assessment bodies

Other countries have similar ministries that provide advice on science policy to government as MoRST does in New Zealand. A growing number of countries are recognising, however, the value and need for additional streams of scientific advice for politicians, policy and decision makers, and the public.

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[38] Smith, W. and Halliwell, J. 1999. *Principles and Practices for using Scientific Advice in Government Decision-making: international best practices*. Report to the S&T Strategy Directorate, Industry Canada.

[39] MoRST. 2002. *ibid*.

[40] This refers to the ability of CRIs to create new firms or joint venturing activities that are not seen as 'core business' or which have clearly moved into the commercial sector.

[41] MoRST. 2002. *ibid*.

One successful model has been specifically developed for the provision of scientific advice concerning technologies. Within the last 20 years, over a dozen European countries have created technology assessment bodies that are either attached to parliaments, as in Britain[42], or else operate as independent institutes. Small in size (with an average of about six professional staff), they provide MPs, and policy and decision makers with timely, impartial information and analyses about emerging or old technologies.

For example, the British technology assessment agency provides MPs with numerous 'briefing notes' (about four pages long) on topical issues and more detailed assessments (30-80 pages) that take three to nine months to prepare. A review of six such agencies concluded that they were of increasing value for policy analysis, putting technological issues into a broader social and environmental context, and becoming 'an indispensable tool of democracy'.[43]

Some go well beyond providing advice and information just within parliamentary and government systems. In Denmark and the Netherlands technology assessment is a more general and 'open' process that involves the public in policy dialogues and building societal consensus on issues of technological change. This process plays a significant role in the growing demand for more public participation in assessing the opportunities and costs of new technologies that may profoundly affect the future of their societies.

New Zealand has an agency for assessing new health technologies whose major client is the Ministry of Health, but not one for environmental technologies.[44] The idea of technology assessment has been proposed in the context of providing a 'future-watch' capacity for biotechnology developments. The New Zealand Biotechnology Strategy includes a proposal to 'strengthen New Zealand's biotechnology future-watch capability'. This arose from a recommendation by the Royal Commission on Genetic Modification to develop mechanisms for supporting community awareness and engagement on biotechnology issues to ensure that biotechnology developments continue to balance innovation and assurance.

MoRST has also been considering mechanisms for the different interests represented by 'science and society' to work together more effectively.[45]

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[42] For example, see: http://www.parliament.uk/post/home.htm.

[43] Vig, N.J. and Paschen, H. (Eds.). 2000. *Parliaments and Technology: the development of technology assessment in Europe*. New York: State University of New York Press.

[44] The agency is New Zealand Health Technology Assessment: (http://nzhta.chmeds.ac.nz).

[45] See: http://www.morst.govt.nz/?CHANNEL=SCIENCE+IN+SOCIETY&PAGE=Science+in+Society.

3.6.3 Chief Scientist role

Australia has an Office of the Chief Scientist. The appointee provides advice on science, technology and innovation issues to the Prime Minister, as well as being a link between government and science, engineering, innovation and industry groups. The Chief Scientist sits on a number of federal science committees and councils and may represent the government nationally and internationally. To help maintain independence from government, these duties are undertaken on about two days a week, the rest of the time is spent on work associated with the person's primary employment. The 'Chief Scientist' concept is more widely used in Europe. For example, the United Kingdom has Chief Scientist positions as part of the Department of Health and the Department for Environment, Food and Rural Affairs.

3.6.4 Independent Environmental Institutes

The Dutch have invested considerable effort in developing workable models for bringing together government, business and citizens to work out long-term deals that focus on sustainable development. They are regarded as having one of the best structures of independent institutes covering environmental, social and economic planning. Lessons were learned and applied from the development of successive Dutch National Environmental Policy Plans (NEPPs). Science played an important role in these initiatives. One key element in developing NEPPs was the provision of clear information backed by science. Also, success depended, in part, on building a solid foundation of respected scientific data. This was achieved through government funding of a scientifically autonomous institute with the function of producing annual reports on the state of the Netherlands' environment and commenting on the success and failures of environmental policy.

3.7 Science funding and access to information

The Government provides funding for public good science and technology (PGS&T) research. The funding framework consists of six output classes, of which Environmental Research is one.[46] The portfolios of research involve partnerships with private companies, central and local government, Maori organisations, and other communities of interest within New Zealand. These partnerships provide the opportunity for research teams to develop and sustain research programmes that will generate significant benefits to New Zealand.[47] The Research for Industry output class, for example, places particular emphasis on wealth creation as an outcome of the research.

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[46] The other five output classes are: Non-Specific Output Funding, Research for Industry, Maori Knowledge and Development Research, Health Research, and Social Research.

[47] http://www.frst.govt.nz/research/pgst.cfm

Examples of sources of funding for research for environmental policy and decision-making purposes are outlined in Appendix 2. Funding for operational research within central government departments and regional councils is included in the overall operating costs of these agencies. In addition to publicly funded research, the private sector also funds its own research, some of which may be undertaken by CRIs or privately funded research organisations. The amount of private sector funding for research in New Zealand is generally low compared to other countries in the Organisation for Economic Co-operation and Development (OECD). Although private sector research funding is increasing, it needs to at least triple to achieve the OECD average of 1.2% of GDP (Gross Domestic Product).

Privately funded environmental research may be for the purpose of assessing effects on the environment as part of a resource consent application or application for the approval of a new organism or hazardous substance. In this case the information can become publicly available for scrutiny. It is possible that in other situations, where the research is privately funded but the results are not made public, information that is important for environmental policy and decision-making is not presently accessible**.** When 'public good' science is privately funded or has commercial value to the provider organisation it can remain commercially confidential and therefore inaccessible. This practice could result in information that is useful for environmental policy and decision-making being withheld. It would be useful to explore the extent to which this happens.

3.8 The science-policy-decision pathway

A critical point in environmental policy and decision-making processes is when information is transferred from scientific advisers to decision makers. This frequently involves an intermediate step – policy analysis. Critical factors that determine the success of connecting science with final decisions include:

- the integrity of the scientific process
- the skill of scientists to take sometimes complex and highly technical data and convert it into information that contributes to environmental policy and decision-making
- the skill of policy analysts to critique, accurately interpret and use scientific information for policy purposes, while being explicit about any limitations and uncertainties associated with that information
- the capacity of policy and decision makers to understand the scientific and other information they receive, and the consequences of the choices they face
- the ability of policy and decision makers to make sound judgements, and to gain the public's confidence in the decisions they make

- the willingness of policy and decision makers to monitor and review the effectiveness of their policies and decisions, and to engage the scientific community in this process.

Environmental policy and decision-making does not always keep pace with developments in scientific research and technology. For example, advances in genetic engineering have exceeded the ability of policy makers to establish rules that govern its applications and establish controls in the interests of public safety and environmental protection. In other situations, scientific research may not be at a stage where information about concerns such as long-term environmental effects is reliable enough to satisfy doubts among decision makers. These issues create difficulties for those who must provide the necessary information and those who rely on it for policy analysis and subsequent environmental policy and decision-making.

Improving environmental policy and decision-making involves providing information that is not only relevant and accessible, but is also easily understood by decision makers who may come from a wide range of backgrounds and educational levels. A key consideration when providing science input to environmental policy and decision-making is the need for complex scientific information to be concisely but accurately explained to those who have to make the decisions.

In other circumstances, decision makers may be faced with very strong scientific evidence of minimal or no adverse effects, but equally strong objections to a proposal on the basis, for example, of ethical or cultural concerns. Decision makers are then faced with having to make a judgement where valid, objective scientific evidence is ‘competing’ with equally valid but subjective views and values of affected parties.

3.9 Quality assurance in the provision of scientific advice

Not all scientific or other information provided for environmental policy and decision-making is unerringly accurate or reliable, unless later shown to be so based on follow up monitoring and assessment. At times decisions makers have to arrive at decisions that involve uncertainties, complex interactions or conflicting views. The significance of such factors may not always be appreciated, from an environmental management perspective. It is also important, from a quality assurance point of view, that any discredited scientific claims are identified and exposed.

To ensure an appropriate and quality assured contribution from science into environmental policy and decision-making, decision makers may seek further independent[48] scientific advice. But access to such advice may prove difficult in any of the following situations:

- there are only limited available sources of the expertise needed, and this expertise may already be involved in advancing a particular argument
- the independent advice presents an additional, new perspective, which may or may not be helpful in the circumstances (especially in adversarial situations)
- the science is novel and not well understood
- the proponents or opponents have not provided sufficient information
- information is withheld because it is regarded as commercially or culturally sensitive, but it is also in the public interest to ascertain the significance of such information
- questions remain over who pays for any additional independent assessment.

Some countries have established systems, such as independent panels of experts to consider scientific matters associated with public policy development, and for evaluating any competing scientific claims being put forward. The aim is to ensure that, where necessary, environmental policy and decision-making processes use the best possible scientific advice, and avoid unnecessary delays caused by detailed debate on the merits of scientific arguments at the policy making stage or in adversarial proceedings.

A review of expert scientific panels (including the Tussock Moth Science Panel and the BSE Expert Science Panel) for the development of public policy[49] identified *independence* and *objectivity* of a panel's advice as the two most important criteria in its success. Three imperatives were also identified:

- the advisory panel should incorporate quality control mechanisms
- the composition of panel members should reflect the nature of the issue and the breadth of judgement required
- clear authority and accountability should be vested in panels.

This report advocated a more open approach to independent expert advice for public policy for the following reasons:

- the range of issues on which governments expect and need science to provide insight is expanding
- there is a need to maintain and restore public and political confidence in science advice

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[48] 'Independent' in the context of this discussion paper means a source of scientific advice that has no direct interest in (i.e. does not stand to gain or lose by) the outcome of the decision under consideration.

[49] Ministry of Research, Science and Technology (MoRST). 1997. *Review of Expert Panels for Provision of Scientific and Technological Advice for Development of Public Policy*. A report prepared by Dr W. Smith, University of Auckland. Wellington: MoRST.

- risk assessment is emerging as an important issue in the development of public policy.

The report also recognised that in a democratic society people themselves must also be able to influence policy decisions.

A later report[50] developed a set of New Zealand guidelines on independent science panels, pointing out:

> *'Science panels – whether independent or not – should always be expert panels. That is, their members should be individuals able to contribute expert scientific advice to the issue in hand. That a panel is also 'independent' reflects not on its expert status, but rather on its relationship to government. Members of an independent science panel will typically be employed outside the Public Service (central government departments or ministries), or at least be in a position to provide advice that can be assured to be independent of any professional interest or commitments to government.'*

> *'The 'independent' nature of a science panel has an overriding purpose: to ensure that scientific advice contributed to policy/decisions is as objective as possible. In being explicitly 'independent' such panels can help maintain or restore public confidence in policy processes and government operations.'*

Other relatively recent developments include the establishment by MoRST of National Science Strategy Committees (NSSCs) to improve co-ordination of national research efforts. NSSCs have been established in the past to deal with issues such as climate change[51], possum and bovine Tb control, and sustainable land management.

3.10 Quality assurance in policy development

The State Services Commission (SSC) has described the role of information in the policy process:

> *'Information is the raw ingredient which, after being put through an analytical process, becomes the foundation for policy advice. The quality of policy advice depends on high quality information, which in turn depends on the substance and integrity of the sources from which it is drawn. Information used throughout the policy process – problem definition,*

[50] Ministry of Research, Science and Technology (MoRST). 1998. *Independent Science Panels: a handbook of guidelines for their establishment and operations.* Wellington: MoRST. p 1.

[51] New Zealand's climate change programme is now being managed by the Climate Change Office (see: http://www.climatechange.govt.nz).

analysis, options, decision-making, implementation, and evaluation – is derived using a range of methods:

- *trawling secondary material, e.g. through literature searches and the Internet*
- *tapping expert knowledge, both local and international*
- *extrapolating from existing domestic and international research*
- *utilising existing data sets and statistics*
- *public consultation, and consultation with stakeholders and client networks*
- *purpose built evaluation or meta-evaluations*
- *primary (quantitative and qualitative) research.'*[52]

As outlined in section 5.1, the same report drew attention to difficulties government agencies experience in recruiting specialists, such as staff with the capacity to bridge the science/policy divide.

The quality of advice for environmental policy and decision-making relies heavily on the skills and capabilities of those whose function is to provide that advice, whether in-house or externally sourced. Peer review of advice, whether by independent external sources or by interested or affected parties, helps to enhance the quality and robustness of policy advice.

There will always be room for improvement in the quality of policy advice generally, and for environmental policy and decision-making in particular. More information, more time, more resources and more expertise are always needed. But it must be recognised that policy agencies will always be operating under one set of limitations or another. Those responsible for environmental policy and decision-making will often have to make a judgement based on the best available information. This reinforces the need for quality assurance systems to incorporate processes that enable policies and decisions to be monitored and reviewed to ensure that they are achieving what they set out to do.

3.11 Timing and timeliness

In environmental policy and decision-making processes there is often limited time available to amass the facts and data needed to convey cogent, timely, pertinent and robust advice. This assumes that the facts and data exist in the first

[52] State Services Commission (SSC), 1999. *Essential Ingredients: improving the quality of policy advice*. Occasional Paper No. 9. Wellington: SSC. pp 17-18.

place. Problems are further compounded when the facts are uncertain, the decision is urgent, and the implications are severe.[53]

Decisions may be made under various pressures including time constraints that interfere with a careful consideration of the options and consequences. The SSC[54] has noted that Cabinet papers are prepared increasingly under conditions of urgency, potentially limiting the capacity of policy advisers to consult with researchers to obtain and use their knowledge and insights. Time limitations may also constrain the use of research where existing information is not immediately available. In short, policy research may be hindered by the demand for fast solutions. The challenge is to 'keep ahead of the game' by anticipating future needs of policy makers.

3	Questions and answers developed for a science framework may not necessarily be useful for environmental policy and decision-making purposes (see sections 3.2 and 3.4). How should this be addressed to ensure that, where appropriate, science and research is relevant to the policies and decisions that have to be made?
4	How adequate is the current environmental science and research system, and its level of funding, for meeting the information needs of environmental policy and decision makers? What real difference has investment in science made to the quality and success of environmental policy and decision-making processes and outcomes? (See sections 3.3 and 3.7)
5	What should be the role of science in environmental policy and decision-making? (See sections 3.3 and 3.4.2) What criteria should govern such a role?
6	Where science is needed for policy and decision-making, how should the interface be managed to ensure that scientific advice is accurately interpreted for, and understood by, policy and decision makers? What role should science play in the post-decision phase? (See sections 3.4 and 3.8)

[53] Ministry of Research, Science and Technology (MoRST), 1998. *Science into Policy: An Evaluation of the Use of Science in Policy Formulation.* A report prepared by Dr W Smith, University of Auckland. MoRST, Wellington.
[54] SSC.1999. *ibid*. pp 18-19.

7	Given the importance of gaining public confidence in the integrity of scientific advice and its role in decision-making, how can the public's trust in the system be effectively achieved and maintained? (See sections 3.4.1 and 3.4.2)
8	Given the current emphasis by central government on 'whole-of-government' policy formulation, does New Zealand have the right mix of models for providing the appropriate scientific advice for policy and decision-making? (See section 3.6) If not, what changes are needed?
9	How can the quality of both scientific and policy advice be assured? (See sections 3.9, 3.10 and 3.11)

4 The interface between non-scientific information and environmental policy and decision-making

A diverse range of information, existing outside the formal frameworks of science and scientific research, is equally important in the processes of environmental policy and decision-making. This information includes:

- various sources of knowledge, data, assessments, and practical skills and experience in environmental management
- the fundamental conceptual frameworks, paradigms, values, beliefs and worldviews that shape and influence people's approaches to environmental management, policy and decision-making
- these same fundamentals that underpin people's expectations of science and knowledge itself
- statements or expressions of the goals, aspirations and priorities of communities or stakeholder sectors for their particular activities or relationships with the environment
- communities' or stakeholder sectors' specific knowledge and participation in environmental policy and decision-making processes.

Policy and decision makers have responsibilities to ensure that they receive – as well as sound scientific information and advice – relevant information from such 'non-science' sources. In doing so a number of issues arise. Many of these issues are only peripherally about science itself, but derive from other contexts. These include social, economic, cultural, spiritual, statutory and political contexts, within which environmental policy and decision-making occurs.

4.1 Nga Taonga Tuku Iho

For tangata whenua, a primary source of information and guidance is matauranga Maori, the knowledge and associated tikanga, principles and protocols for appropriate human interaction with te ao marama, the natural world. This knowledge has accumulated over many generations of close engagement with places, ecosystems and natural resources, and has been passed down from the ancestors as a taonga in itself.[55]

[55] Roberts, M., Norman, W., Minhinnick, N., Wihongi, D. and Kirkwood, C. 1995. Kaitiakitanga: Maori perspectives on conservation. *Pacific Conservation Biology.* Vol 2; Kawharu, M. (ed). 2002. *Whenua: managing our resources.* Auckland: Reed; Barlow, C. 1991. *Tikanga Whakaaro: key concepts in Maori culture.* Auckland: Oxford University Press.

Matauranga and tikanga are determined, as inherent in the exercise of rangatiratanga, by each iwi and hapu, or in some cases, whanau. Thus there may be variations between groups and regions – although there are also broad similarities and consistencies. Relationships, and an ethic of respect and reciprocity between people and the environment, are central. Traditionally all plants, birds, fish, insects and other creatures of Aotearoa/New Zealand, including humanity, are descended in whakapapa from the original atua, Ranginui and Papatuanuku. Inter-relationships also connect people with the ancestral mountains, rivers, natural resources and landscapes of each iwi and hapu.

With matauranga Maori, as with the knowledge frameworks of indigenous peoples elsewhere in the world, it is often difficult to separate environmental information from its spiritual, cultural and social contexts. Access to information, and its application, will be controlled according to the tikanga of the iwi or hapu concerned.[56] Much sensitive information is governed by tapu and thus kept confidential or appropriately protected. This may include historical and spiritual dimensions, or the location and significance of wahi tapu or burial sites.

A claim before the Waitangi Tribunal, the ‘indigenous flora and fauna claim’, commonly known as WAI 262, seeks amongst other matters to ensure appropriate recognition for Maori environmental knowledge. WAI 262 is a wide-ranging claim from six iwi in regard to the management, use, commercialisation, export and patenting of native plants and animals, of the genetic resources inherent within these taonga, and the whakapapa, intellectual property and traditional knowledge associated with them.[57]

Traditionally-based knowledge and information may take many forms. Some knowledge, particularly esoteric matters relating to the interconnections between the physical and the metaphysical, are the subject of study in wananga or other formal traditional learning processes. Information about natural species and places is also embedded in whakapapa, history, waiata, whakatauki, and whaikorero.

4.1.1 Kaitiakitanga

The practical business of kaitiakitanga is where knowledge is applied to present day realities. Respect for the interlinkages between the human, spiritual and natural worlds is at the core of the responsibilities of kaitiakitanga. Many iwi and hapu have developed environmental management plans for the places and resources in their rohe or takiwa. Many have gathered extensive information on their relationships with natural resources, the environment and ancestral

[56] See the 1993 Mataatua Declaration on Cultural and Intellectual Property Rights of Indigenous Peoples

[57] See: www.waitangi-tribunal.govt.nz.

landscapes as evidence for claims to the Waitangi Tribunal or other legal proceedings.

Iwi or hapu statements or policies in response to new developments, from subdivisions to genetically modified organisms, will also be based in traditional knowledge and tikanga. Some iwi and hapu have undertaken or commissioned their own research into contemporary aspects of environmental science and resource management. This may be done in partnership with Crown Research Institutes or academic institutions.[58] Agencies such as the Foundation for Research, Science and Technology, Technology NZ, and the Department of Conservation provide support for Maori research and matauranga-based initiatives.[59]

4.2 Local and community knowledge

Many individuals and groups hold a lot of valuable information about natural resources, ecosystems and ecosystem processes, and environmental management. Among these are local residents, communities, farmers and other land managers, and stakeholder groups including NGOs or lobby groups. Regular users of natural places or resources, such as recreational fishers, trampers or scuba divers also hold valuable information.

While such information may not be articulated and determined within a formal cultural framework as is matauranga Maori, it is often based in similar kinds of close observation of natural processes, inter-relationships between species, and trends over many years. It can include:

- statistical data and records
- information about species dynamics, requirements and habitats
- practical ‘hands-on’ management skills and techniques.

Local environmental knowledge and information may be gathered together in regional development studies, or emerge in response to particular sustainability problems.[60] It may be expressed in various statements of community goals,

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[58] For example, the partnership between Ngai Tahu Rakiura runanga and the University of Otago to study titi sustainability: see: www.otago.ac.nz/Zoology/hui_wananga.html.

[59] See www.frst.govt.nz/maori/ for information about the Maori Development and Advancement research strategy and projects; ‘Traditional Maori know-how key to exciting future’. *NZ Herald*. 10 September 2002. A8; see: www.biodiversity.govt.nz/land/nzbs/information/matauranga/index.html for details of the Matauranga Kura Taiao fund.

[60] For example, South Island high country farmers’ involvement with rabbit control programmes: refer Parliamentary Commissioner for the Environment (PCE). 1998. *The Rabbit Calicivirus Disease (RCD) Saga: a biosecurity / bio-control fiasco.* Wellington: PCE; or the efforts of coastal residents in the Cheltenham, Piha and Raglan communities to monitor and reverse declines in shellfish and marine biodiversity: refer Parliamentary Commissioner for the Environment (PCE). 1999. *Setting Course for a Sustainable Future: the management of New Zealand’s marine environment.* Wellington: PCE. pp 40-41.

aspirations and values, such as the Regional Policy Statements and plans required under the Resource Management Act, the regional Conservation Management Strategies established under the Conservation Act, or the community plans required under recent amendments to the Local Government Act.

4.3 Ethics

The frameworks of ethics, morality and religion are important in environmental policy and decision-making,[61] especially in relation to controversial scientific and technological developments such as genetic modification:

> *'Many, perhaps most, significant disputes about the use of science and technology in society centre on issues of ethics, equity, and justice, and how to choose the most prudent collective course of action… not necessarily on the science itself.'*[62]

These dimensions of human experience, motivation and values may be understood within the systems of religious belief:

> *'Our religious tradition teaches us that we are much more than mere chemicals.'*[63]

Or they may be understood within more secular frameworks of thought, principle and commitment. These include such modes of meaning as ecological thinking, ecofeminism,[64] recognition of the intrinsic rights of natural species, and recognition of the rights of future generations.

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[61] Nicholas, B. 1999. Making Decisions, Making the World. In: *Innovation, ethics and animal welfare: Public confidence in science and agriculture*. Proceedings of the joint AWAC/ANZCCART Conference, Wellington, November 1999; Fox, W. 1990. *Toward a Transpersonal Ecology: developing new foundations for environmentalism*. London: Shambhala; Howell, J. (ed) 1986. *Environment and Ethics – a New Zealand contribution*. Lincoln: NZ Environmental Council / Centre for Resource Management; Nash, R. 1990. *The Rights of Nature: A History of Environmental Ethics*. Leichhardt: Primavera Press / Wilderness Society.

[62] Hornig Priest, S. 2001. *A Grain of Truth: the media, the public, and biotechnology*. Lanham MD: Rowman and Littlefield. pp 126-7.

[63] Richard Davis, submission for a committee of Methodist, Presbyterian, Churches of Christ, and Quaker churches, quoted in: Royal Commission on Genetic Modification, 2001. *Report and recommendations*. Wellington: RCGM. p32.

[64] Mies, M. and Shiva, V. 1993. *Ecofeminism.* Melbourne :Spinifex Press.

4.4 Incorporating other knowledges and science in environmental policy and decision-making

Some studies[65] have drawn attention to the limitations of conventional scientific modes of understanding, particularly in some of science's more reductionist forms and applications, and the problems that can arise when environmental policy and decision-making relies too narrowly on scientific and technological approaches to complex, multi-faceted issues:

> *'[the expectation] that science would resolve problems through technological solutions... perpetuates several convenient myths: that science can provide definitive answers about risk, that 'facts' speak for themselves rather than being open to interpretation, and that decisions about socially acceptable risk are scientific rather than political judgements.'*[66]

Basing environmental policy and decision-making in a more comprehensive understanding, drawn from a sufficient breadth of relevant forms of knowledge and experience, is important in several ways. It will strengthen the ability of environmental policy and decision makers to:

- maximise the practical usefulness of that information
- ensure adequate consideration of the interests, priorities and values of affected communities, stakeholders and the wider society
- gain acceptance, support and compliance of communities and stakeholder groups with the policies or decisions, so that they feel their views and voices have been heard and heeded
- develop trust and confidence in environmental policy and decision-making institutions
- ensure viability – financial, economic, social, and for the development of human and natural capital – of the policies or decisions over the medium and longer term

[65] Roberts et al, 1995. *ibid*; Knudtson, P. and Suzuki, D. 1992. *Wisdom of the Elders*. Toronto: Allen & Unwin; Berkes, F. 1999. *Sacred Ecology: traditional ecological knowledge and resource management*. London :Taylor & Francis; Irwin and Wynne, 1996; Sullivan, R. and Hunt, A R. 1999. Risk Assessment: the myth of scientific objectivity. *Environment and Planning Law Journal*, 6:522-530; Wolpert, L and Goldsmith, E. 2000. Is Science Neutral? *The Ecologist* 30:3; Nader, L. (ed) 1996. *Naked Science: anthropological inquiry into boundaries, power and knowledge*. Routledge Publishing; Crosby, A W. 1997. *The Measure of Reality: quantification and western society*. Cambridge University Press; Barnes, B., Bloor, D. and Henry, J. 1996. *Scientific Knowledge: a sociological analysis*. University of Chicago Press; Jardine, N. 2000 (revised edition). *The Scenes of Inquiry: on the reality of questions in the sciences*. Oxford University Press; Hacking, I. 1999. *The Social Construction of What?* Harvard University Press.

[66] Nelkin, D. 1995. (revised edition). *Selling Science: how the press covers science and technology*. New York: W H Freeman. pp 51-2.

- fulfil statutory and legal obligations.[67]

However, such 'non-science' information, and the ways it is developed, expressed and employed, may often take very different forms from the standard conventions of scientific knowledge (see Table 1).

Table 1: Characteristics of systems of knowledge[68]

Traditional & indigenous knowledge	**Empiricist scientific knowledge**
Embedded in the local cultural milieu	Decontextualised, abstracted
Bounded in space and time	Assumed to be universal
Importance of community, and collective knowledge bases	Individualism, personal careers and reputations
Lack of separation between nature and culture, and between subject and object	Dichotomies / boundaries between nature and culture, subject and object
Lack of separation between physical and spiritual / metaphysical dimensions	Exclusion of intangibles or anything that cannot be quantified
Commitment or attachment to the local environment as unique and irreplaceable	Detachment, mobility, exchangeability
A non-instrumental approach to nature	An instrumental attitude toward nature as a commodity

These differences highlight some of the challenges for environmental policy and decision makers in dealing with divergent approaches and conceptual paradigms relating to the resources, ecosystems or landscapes under consideration. Many aspects of matauranga and other knowledges will be unfamiliar and difficult to pin down. Evaluations, judgements or concepts of relevance may be governed by different kinds of criteria and measurement from the empirical systems of science. Dimensions that are not easy to quantify may include:

- assessments of regional, local and community well-being
- regional, local and community identity and character
- aesthetics and amenity
- environmental ideals such as the range of values attributed to unmodified nature that underpins much conservation management and the establishment of wilderness areas

[67] These include obligations under the Resource Management Act 1991, the Hazardous Substances and New Organisms Act 1996, the Conservation Act 1987, and the Local Government Act 2002. It also includes requirements of agencies in relation to the principles of the Treaty of Waitangi and public consultation, and compliance with the requirements of other Government policies and strategies.

[68] Table developed from: Berkes, F. 1999. *ibid.* p 10.

- ethics and morality
- the rights of future generations.

In the efforts of policy and decision makers to deal with information and values from diverse sources, a number of issues can arise including:

- assumptions that different approaches have similar or equivalent objectives[69]
- risks of romanticising indigenous or community knowledge and values
- difficulties with verification of information, especially when it may not be recorded in written form
- difficulties with competing claims to authoritative status or mandate.

10	How can environmental policy and decision makers most effectively and usefully engage with the diverse range of other information, values, worldviews and ethics alongside science? (See sections 4 to 4.4)

[69] Roberts et al. 1995. *ibid*. p 16; Berkes, F. 1999. *ibid*. pp 151-6.

5 Capacity issues

One of the most important considerations in environmental policy and decision-making is the capacity[70] of the institutions involved to fulfil their responsibilities.

As outlined above, the decisions faced by environmental policy and decision-making institutions generally involve making choices that sometimes involve consideration of complex interactions (for example, within or between ecosystems) and values, such as cultural or spiritual values, intrinsic value of ecosystems, economic and social values. Often knowledge of complex interactions may be limited, or the decision maker's confidence in being able to understand such complexities may be misplaced. Decision makers confronted with these and other contentious issues are still required to make decisions, usually within statutory timeframes. They may be able to delay decisions pending further information (for example, section 92 RMA), but they cannot opt out of their responsibilities simply because the decisions are too tough or likely to be unpopular.

Environmental policy and decision makers have a responsibility to their constituencies (and to future generations) to ensure that their capacities to undertake their functions match the demands placed on them, such as the nature and extent of environmental issues on which they are required to make decisions.

5.1 Gaps and weaknesses identified in previous reports on science in policy

Generally, officials' advice to central and local government policy and decision makers addresses issues that require decisions, such as the setting of priorities and the allocation of funding and other resources. This advice is usually based on information gathered on such things as risks, costs, benefits and equity issues. However, evidence suggests that the role that science plays in such advice is sometimes weak. For example, an analysis of science input to Cabinet papers[71] (i.e. focusing on central government policy development) concluded that:

- the lack of an adequate audit trail through to Cabinet paper level leaves departments (and their advice) open to criticism
- the procedures for science input to policy advice are neither clearly established nor commonly accepted

[70] Includes agencies' mandate, resources, skills and commitment to undertake their functions.

[71] Ministry of Research, Science and Technology (MoRST). 1998. *Science into Policy: an evaluation of the use of science in policy formulation*. A report prepared by Dr W. Smith, University of Auckland. Wellington: MoRST.

- there is probably no single approach to improving the quality and quantity of research, science and technology into government decision-making
- there is a willingness among departments to increase the use of science in decision-making, but they are often thwarted by time constraints or other peculiar circumstances
- there is a need for more officials to be conscious of the potential of research and science to support their work, and of scientists to better comprehend the policy process
- there is a need to ensure that policy issues and related research take into account wider strategic goals
- scientific advice from individuals in CRIs, universities and other research organisations is often obtained through informal links without payment
- the lack of a specific 'science/research' sign-off to Cabinet papers needs to be addressed
- the effective incorporation of research, science and technology into policy advice is conditional on who defines the policy problem and how the problem is defined.

A report on improving the quality of policy advice[72] identified a number of factors impacting on the information-gathering process and the resulting quality of advice:

- very short time frames inhibit in-depth research
- focus on short-term outputs is at the expense of longer-term capability
- there is a shortage of policy advisers and managers highly skilled in information management and use, particularly those who can bridge the science/policy divide and can understand and use scientific data (physical and social)
- information is typically generated in departmental silos as there are few incentives to share information and resources
- New Zealand lacks the external think tanks that, in other jurisdictions, germinate ideas and examine policy issues to inform government policy deliberations and become actual policy proposals. Research organisations (for example, CRIs, private researchers and universities) are sources of research but usually only when contracted to do so by government agencies. This leaves a gap in research that is forward-looking, environmental scanning and non-intervention specific.

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[72] State Services Commission (SSC). 1999. *Essential Ingredients: improving the quality of policy advice*. Occasional Paper No. 9. Wellington: SSC.

5.2 In-house and external sources of scientific advice

During the public sector restructuring of the 1980s and 1990s, only the Department of Conservation (DoC), of all the environmental agencies, retained its full in-house scientific functions. Other departments had their scientific workforce considerably diminished (for example, the Ministry of Agriculture and Forestry (MAF)) or lost completely to the Crown research institute structure (for example, the Forest Service). DoC successfully argued that the nature of its management responsibilities justified retention of a strong, in-house research capacity that would be focused on helping to undertake its management functions. Nonetheless, DoC still buys a considerable amount of research, particularly from Landcare Research, given its limited capacity in certain key areas, such as mammalian and plant ecology. Agencies such as the current MAF rely extensively on contract operational research for scientific advice in support of policy initiatives. The Ministry for the Environment (MfE) has no in-house research capacity.

Arguments in support of in-house science capacity include:

- opportunities for researchers to assist managers in identifying research topics to meet management needs
- retention of scientific institutional memory and in-house capacity building
- easier access to scientific advice in support of environmental policy and decision-making
- an up-to-date research knowledge base
- development of a science-backed culture of environmental management.

Arguments in support of using external sources of scientific advice include:

- cost efficiency when it avoids duplication of skills between agencies
- greater flexibility – the ability to purchase expertise relevant to issues under consideration
- wider options for obtaining contestable advice.

However, out-sourcing scientific advice could lead to situations with a potential conflict of interest when the scientific pool is relatively small. For example, this might arise when two agencies rely on the same CRI for advice to advance different agendas or when parties to a dispute before the Environment Court seek supporting evidence from the same science provider.

5.3 Communicating and understanding scientific and other sources of knowledge

A number of issues arise in environmental policy and decision-making efforts to integrate scientific information and other kinds of knowledge. There are significant differences between various sectors or disciplines within science itself.[73] Generally, however, science and the other kinds of knowledges, worldviews and values (discussed in section 4) are often shaped, ordered and expressed in very different ways. Such differences can include:

- what kinds of things are considered to be 'information'
- how those things can be grasped and defined
- what is authoritative and to be taken seriously
- the different ways in which things might be relevant to environmental policy and decision-making
- how things are most appropriately expressed and communicated.

Thus communication and integration in processes such as environmental policy and decision-making can be difficult, incomplete or unreliable:

> *'dimensions of incompatibility and mutual credibility [between scientists and farmers] existed at a structural level which was deeper than that of evidence and information… Each side only recognised, even as possible evidence, claims expressed within its cultural style… the farmers' expertise was not recognised because it was not formally organised in documentary, standardised and control-oriented ways recognisable to scientific culture.'*[74]

Yet effective communication – with the goal of building understanding and acceptance of the range of scientific and other knowledges, worldviews and values – is a critically important starting point to improving capacities within environmental policy and decision-making.

5.3.1 Knowledge about science

Levels of understanding and familiarity with science, its methodologies, and specific scientific matters vary widely amongst different groups, sectors and individuals, including environmental policy and decision makers. There often seems to be an assumption that inadequacies in 'science literacy' are the cause or determining factor in public concerns or opposition to science proposals,

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[73] Collins, H. and Pinch, T. 1998 (2nd edition). *The Golem: what you should know about science*. Cambridge: Cambridge University Press.

[74] Wynne, B. 1996. Misunderstood Misunderstandings: social identities and public uptake of science. In Irwin, A. and Wynne, B. (eds). 1996. *Misunderstanding Science? The public reconstruction of science and technology*. Cambridge: Cambridge University Press. p 37.

controversial technologies and science-based policies and decisions.[75] This 'deficit model' leads to an emphasis on education and promotion of science, based on the expectation that improved public knowledge will lead to greater acceptance of and support for science and technological developments.

However it has been shown that 'greater knowledge about science sometimes lead(s) to greater scepticism of it',[76] and that public support for science and technology is influenced by a range of non-technical factors including moral acceptability.[77] A recent British report on school science developed a more rounded ideal of citizen participation in science processes, suggesting that:

> *'a healthy democracy needs a public with a broad understanding of major scientific issues, one that can engage critically with issues and arguments, which involve both scientific knowledge and the limitations of science.'*[78]

The successful integration of science with community values and views will also depend upon the capacities and practical requirements of dialogue and consultation processes. These include the resourcing, timeframes, information, facilitation, protocols, and appropriate forums for scientists and the public to meet and debate the issues. Many local and Maori communities are already heavily consulted by official agencies on a wide range of topics, and hence overload or under-participation are common problems.[79]

Another essential component for any meaningful exchange of information in the environmental policy and decision-making context is trust (see also sections 3.4.1 and 3.4.2). Factors that influence trust include:

- the reputation, motivation and credibility of information providers and decision makers
- the confidence of decision makers in the integrity of the information they receive
- forums for discussion and exploration of the issues where all participants have the safety to express their ideas and concerns openly and appropriately, and to acknowledge and respect others' information, perspectives and values.

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[75] MacDonald, S. 1996. Authorising Science: public understanding of science in museums. In: Irwin and Wynne (eds) 1996, *ibid*. pp 152-169.

[76] MacDonald, S. 1996. *ibid*. p 154. See also: Europe ambivalent on biotechnology. Report on the European Union Eurobarometer on Biotechnology survey. *Nature* 387, 26 June 1997, p 845.

[77] Gamble, J (HortResearch NZ), 1999. Consumer attitudes to transgenic plants and plant-based products. *Food for Thought.* National Agricultural and Horticultural Science Convention, Auckland. p 12.

[78] House of Lords Select Committee on Science and Technology. 2001. *Science in Schools.* London: The Stationery Office.

[79] Parliamentary Commissioner for the Environment (PCE). 1998. *Kaitiakitanga and Local Government: tangata whenua participation in environmental management.* Wellington: PCE.

5.4 Dealing with uncertainties and knowledge gaps

> *'Science is not a matter of certainties but of hypotheses and experiments. It advances by examining alternative explanations for phenomena, and by abandoning superseded views. It has provided very powerful tools for gaining understanding of complex environmental processes and systems…In a scientific assessment of an environmental issue there are bound to be limitations and uncertainties associated with the data at each stage…decision-making procedures should recognise that.'*[80]

Perfect information – all the needed facts – is available in very few decision-making situations. Many environmental decisions are based on information that is limited in some way, such as limitations in the quantity or quality of data, or uncertainty about long-term effects. Difficulties also arise when the decision alternatives are complex, or when decisions are made under social, political or time pressures and constraints that interfere with careful consideration of all the options and consequences.

Uncertainty fundamentally affects how decisions are made. Key issues include:

- Standard decision-making tools rely on quantifiable and objective facts and often fail where there is uncertainty: environmental problems and their solutions are often complex, value laden and subjective and will not conform to set assessment criteria.
- Environmental and political crises may emerge only slowly but at high costs to society, not the least being the erosion of public confidence and legitimacy. Examples are the BSE crisis in UK, and the management of biosecurity risks in New Zealand.
- Risk assessment and cost benefit analysis can inform decision-making, but should be supplemented by more qualitative techniques that include a wider range of attitudes and values.
- Areas of high uncertainty need to be acknowledged by researchers and policy makers.
- Gaining public trust is not only a matter of providing more information, establishing new institutions or undertaking further research, but also openness about risks. Legitimate, transparent decision-making is crucial.[81]

Among the approaches that can be applied by decision makers to help them deal with uncertainties and knowledge gaps include:

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[80] UK Royal Commission on Environmental Pollution, 21st report. 1998. London: The Stationery Office.

[81] Economic & Social Research Council Global Environmental Change Programme. 2000. *Risky Choices, Soft Disasters: environmental decision-making under uncertainty*. University of Sussex: Brighton, UK (available at: http://www.gecko.ac.uk/risky.pdf)

- acknowledging the extent and contribution of usable knowledge and usable ignorance to encourage more dialogue and more iterations in the decision process
- an adaptive management approach recognising that successful policies develop as part of a social learning process, and acknowledging the need for experimentation in order to learn what works and what does not[82]
- a precautionary approach in situations where there is scientific and technical uncertainty about adverse effects[83]
- value-focused thinking to encourage the use of 'values' rather than 'alternatives' as the driving force for decision-making
- risk management as a method to identify hazards, characterise risks, predict outcomes, establish priorities, and ascertain 'acceptable' levels of risk
- monitoring, evaluation and review systems to identify and deal with unforeseen environmental effects.

The remainder of section 5 describes these approaches in more detail.

5.4.1 Usable knowledge and usable ignorance in policy

Environmental policy and decision-making often raises problems in environmental sciences that are complex, poorly understood, and cross-disciplinary by nature (see section 2.4). Coupled with the pressure for action that environmental policy and decision makers are often under, what is an appropriate framework for action?

Jerome Ravetz suggests that when faced with decision-making in situations of 'severe ignorance' we need better procedures for self-criticism and quality control in science, as well as a more articulated policy process.[84] When ignorance is really severe then sophisticated calculations are not enough for decisions. Other considerations of prudence, costs and benefits are needed. How these considerations are weighted depends on values, and those values must be made explicit.

> *'In terms of a dialogue between opposed interests, this effectively takes the form of a burden of proof: in the absence of strong evidence on either side do we deem a system safe or do we deem it dangerous?'*[85]

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[82] Keystone Center and the Center for Science, Policy, and Outcomes, 2000. *New Roles for Science in Environmental Decision-making: discussion paper*. (http://www.cspo.org/products/reports/keystone.html)

[83] For example, the precautionary approach is provided for in section 7 of the HSNO Act 1996.

[84] Ravetz, J.R. 1986.Usable Knowledge, Usable Ignorance: incomplete science with policy implications. In Clarke, W.C. and Munn, R.E. (eds). 1986. *Sustainable Development of the Biosphere*. Cambridge: Cambridge University Press.

[85] Ravetz, J.R. 1986. *ibid*.

This was the issue for the Royal Commission on Genetic Modification, which will also demand the attention of the Bioethics Council.

By self-criticism and quality control Ravetz is proposing more post-decision monitoring to pick up early warning signals, more iterations in the decision process, more dialogue at several levels, along with explicit attention to methodologies, organisational structure and variety in scientific expertise. To counter the concern that this all means higher transaction costs, Ravetz argues that better ways of coping with ignorance is preferable to heroic fantasies that invite debacle sooner or later.

If usable ignorance is to be incorporated into science for policy, however, two conditions will need to be met. First, establishing the goodwill of individuals and secondly, an openness to work across boundaries agreed to by both scientific disciplines and political institutions. The latter condition is more complex and more difficult to meet, especially for the recognition of problems that can threaten not only institutional or discipline values, but also may undermine the institutions themselves.

It is in circumstances of relative ignorance that an adaptive management approach can be helpful as a way forward.

5.4.2 Adaptive management

This approach explicitly recognises that dealing with environmental complexities and social systems requires managers to juggle political, community, bureaucratic and adaptive, science-based processes at the same time.[86] Adaptive management is a systematic process that, in the absence of scientific certainty, seeks to continually improve management policies and practices by learning from the outcomes of operational programmes. It also uses scientific information to help formulate management strategies in order to learn what does or does not work so that subsequent improvements can be made.

Adaptive management has been described as embodying 'a simple imperative: policies are experiments; learn from them'.[87] The technique of adaptive management was developed in the 1970s as a means of bringing scientists, policy makers and managers together to try and collectively devise smarter ways of dealing with complex issues of environmental management that were not responding to traditional approaches.[88] The Department of Conservation

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[86] See several papers in: *Panarchy. understanding transformations in human and natural systems.* L.H. Gunderson and C.S. Holling (Eds). 2002. Washington D.C.: Island Press.

[87] Lee, K.L. 1993. *Compass and gyroscope: integrating science and politics for the environment*. Washington D.C.: Island Press.

[88] Holling, C.S. 1978. *Adaptive Environmental Assessment and Management*. New York: John Wiley.

increasingly applies this approach to the management of ‘mainland islands’ for species recovery and ecological restoration.[89]

5.4.3 The precautionary approach

Also referred to as the ‘precautionary principle’, the main element of this approach, as it was originally developed, was a general rule of public policy action to be used in situations of potentially serious or irreversible threats to health or the environment. In these situations, there is a need to act to reduce potential hazards *before* there is strong proof of harm, taking into account the likely costs and benefits of action and inaction.[90]

Since the 1970s, the precautionary principle has been incorporated into many international agreements, including the UN Rio Declaration on Environment and Development in 1992. Principle 15 of that declaration states that:

> *‘In order to protect the environment the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.’*

Tensions remain at all political levels over the relevance and application of precaution in a number of important areas, including trade issues (see section 3.3.4), the allocation and management of resources such as water, and dealing with applications to introduce new or modify existing organisms.

5.4.4 Value-focused and alternative-focused thinking

As mentioned in 2.2, values, like science, change over time so decisions based on either or both are particularly relevant to the time when decisions are made.

Keeney (1992) suggests that values, which are what we care about, should be the driving force for decision-making in general.[91] In practice, decision-making usually focuses on the choice among alternatives and characterises a decision problem by the alternatives available. However, Keeney suggests that values are more fundamental to a decision problem than are the alternatives, which may limit the choices available. By focusing early and deeply on values when facing difficult problems, better decisions and more desirable outcomes are likely to ensue.

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[89] Saunders, A. 2000. *A Review of Department of Conservation Mainland Restoration Projects and Recommendations for Further Action.* Wellington: Department of Conservation.

[90] European Environment Agency. 2001. *Late Lessons from Early Warnings: the precautionary principle 1896-2000*. Copenhagen: European Environment Agency.

[91] Keeney, R.L. 1992. *Value-focused Thinking: a path to creative decisionmaking.* Cambridge, Massachusetts: Harvard University Press.

5.4.5 Risk management

Risk management is an integral part of good management practice. It is an iterative process consisting of sequential steps that enable continual improvement in decision-making. It is a logical and systematic method of identifying, analysing, assessing, treating, monitoring and communicating risks associated with any activity, function or process in a way that enables decision makers to minimise losses and maximise opportunities. Risk management is as much about identifying opportunities as avoiding or mitigating losses.[92]

Risk management is the basis for the decision-making function of the Environmental Risk Management Authority. It is one of the principles on which a number of statutes are based, including the Hazardous Substances and New Organisms Act 1996, the Biosecurity Act 1993, the Building Act 1991 and proposals for new public health legislation. It is also a fundamental decision-making criterion in the requirements of international trade agreements (see section 3.3.4).

A risk management approach is a useful way of addressing uncertainties, setting priorities and targeting resources. Its application to environmental management is becoming more evident in decisions by resource managers and the Environment Court under the Resource Management Act 1991. Among other things, the Act (s.3 RMA) defines 'effect' in terms of probability and impact, thus introducing the concept of risk.

5.4.6 Monitoring, evaluation and review systems

These systems are part of the approaches mentioned above. In particular, adaptive mangement, the precautionary approach and the management of risk all need systems in place to enable the effectiveness of policies and decisions to be assessed, and unforeseen effects to be identified. Establishing systems to monitor, evaluate and review decisions recognises that uncertainty is compatible with action, and that error is an acceptable consequence of action. However, errors and surprises can be minimised by tracking progress.

Scientific input to policy and decision-making advice, and subsequent decisions, needs to be regarded not as a linear process but as part of a decision review loop. This is to assess whether the policies or decisions have been effective and, if not, how science can address any deficiencies.

The choice of approach or approaches will depend, among other things, on the complexity of the issues, the information available and the outcomes being sought. Where uncertainties cannot be avoided or reduced, a focus on environmental sustainability is a useful 'touchstone' or basis on which to make

[92] Australian/New Zealand Standard on Risk Management (AS/NZS 4360).

environmental policies and decisions. Measuring progress towards environmental sustainability against a set of goals and objectives, for example, will then help to determine what works and what does not, and draw attention to any changes in direction that may be needed.

11	What gaps and weaknesses exist in the environmental management capacities of central and local government? (See section 5.1) How should the effectiveness of their environmental management be monitored and assessed?
12	What are effective arrangements for integrating scientific advice into policy and decision-making, and how should the interface between science, policy and decision-making be structured to provide that integration? (See section 5.2)
13	How can communication be improved between scientists, policy advisers, policy and decision makers, and members of the public? (See section 5.3)
14	What are the most relevant approaches for dealing with uncertainties and knowledge gaps in environmental policy and decision-making, and are they being applied most effectively and usefully? (See section 5.4)

6 Summary

This discussion paper has outlined a number of features of science, environmental policy and decision-making, and the interface between them.

Environmental policy-making, in particular, is fundamentally a political process in which elected representatives in public authorities must consider a wide range of views and values, including technical and non-technical, economic, social, cultural, ethical, local, national and international issues, to highlight just a few. So the role of science (and the various branches of science) in this area must be recognised as one of many components that potentially influence the choices that are made.

By convention, scientific research has to meet high standards of integrity, and the results are subject to close scrutiny, as outlined in section 2.4. However, the very nature of scientific inquiry associated with environmental matters means that there will be some element of uncertainty that places a qualifier on any scientific conclusions or advice offered. Sometimes this uncertainty may not be made clear in the advice to policy and decision makers, or if the uncertainties are explicit some may regard them as a weakness and a reason to distrust or dispute scientific findings or predictions.

Environmental policy and decision makers need to be aware of the strengths and limitations of science and other views that need to be considered. Differences between scientific and non-scientific views highlight some of the difficulties faced by environmental policy and decision makers when dealing with divergent approaches and views. Some of these will involve a mix of facts and values about the same issue, and little or no common ground on which to debate the merits of the arguments or negotiate an acceptable solution.

The questions posed in this discussion paper are an attempt to open up the debate and encourage the exploration of ideas on how science can contribute to the development of policies and decisions that ultimately lead to improved environmental management and environmental sustainability.

Appendix 1: Science in environmental policy and decision-making – institutions and functions

Institutions	Research funds manager	Operational research purchaser	Science provider	Environmental policy	Environmental decisions	Science policy	Resource manager	Sources of additional advice
MfE		x		x				
DoC		x	x	x	x		x	
MAF		x		x				
Mfish		x		x			x	
MoH		x		x				
MoRST		x				x		
Regional councils		x	x	x	x		x	
Territorial authorities		x		x	x		x	
ERMA					x			
Environment Court					x			
FRST	x							
RSNZ	x							x
HRC	x							
CRIs			x					x
Private researchers			x					x
Universities			x					x
Iwi	x			x			x	x
NGOs								x
Industry								x
Regional public health services								x
Professional groups								x
Public submissions								x

Appendix 2: Examples of sources of funding for research and other activities relevant to environmental policy and decision-making

Source	Managed by	Comments
Public Good Science and Technology (PGS&T) – Environmental Research	FRST[93]	Environmental research investment for 2003/04 is $88.6 million. The Environmental Research output class supports public good research, science and technology that enhance the understanding and management of the environment. Objectives include: • increasing knowledge and awareness of the state of New Zealand's ecosystems and improving their health, biodiversity and resilience • increasing understanding of the global biophysical environment • improving the quality of human environments and enhancing the capacity to use and manage ecosystems efficiently and sustainably • sustainable management of the productive sector. • Environmental Research funding is open to all science and technology providers.[94]
Cross Departmental Research Pool (CDRP)	Jointly managed by MoRST & FRST	CDRP supports policy-related research in government departments, specifically research of critical cross portfolio interest. Funds are transferred from Vote: Research, Science and Technology to departmental votes. Objectives include: • funding high quality cross-departmental research, which will support Government's policies • catalysing new relationships and capabilities within and between departments so that over time departments take responsibility for investment in long-term, high quality research • developing a portfolio of research activity divided between smaller, short-term projects to catalyse new relationships and capabilities, and multi-year large scale projects to provide key building blocks for Government's decision-making.[95]
The Marsden Fund	RSNZ[96]	The Marsden Fund supports investigator-initiated research at the frontier of new knowledge, the results of which could be of international significance. The fund has $32.8 million available in 2003/04. The fund's objectives are: • enhancing the underpinning research knowledge base in New Zealand, and contributing to the global advancement of knowledge • broadening and deepening the research skill base in New Zealand • undertaking research that is investigator driven.[97]

[93] Foundation for Research, Science and Technology
[94] http://www.morst.govt.nz/environment/environmentalsummary.html
[95] http://www.morst.govt.nz/funding/overview.html

Health Research	HRC[98]	The HRC's mission is to improve human health by promoting and funding health research. One of its research portfolio strategies, 'Determinants of Health'[99] recognises that environmental determinants of health can be both global (e.g. climate change) and local (e.g. water and air quality). The term 'environment' is seen as including the interface between the social and physical environment.
Sustainable Management Fund (SMF)	MfE	The SMF supports communities, industries, iwi, and local government in practical environmental management initiatives. It is intended to help achieve the Government's environmental objectives and priorities by funding projects that provide outcomes with national benefit. Objectives of the SMF are: • building partnerships and encouraging community involvement • promoting the innovative use of existing information to encourage positive behavioural changes and improved environmental management • providing models and examples that can be adapted and used by other people • stimulating environmental action that would not otherwise occur.[100]
Non-specific Output Funding	FRST	This funds Crown Research Institutes (CRIs) for public good science and technology that is independent of government priorities, in order to maintain their viability and capacity. The total funding available in 2003/04 is $28.5 million. Funding to each CRI is calculated at 10% of the value of contracts awarded to CRIs in the previous year. Outputs purchased are to contribute to: • increased knowledge or understanding of the physical, biological or social environment • the development, maintenance or increase in scientific or technological expertise that is of particular importance to New Zealand • research of benefit to New Zealand but unlikely to be funded or adequately funded from non-government sources.[101]

[96] The Royal Society of New Zealand

[97] http://www.rsnz.org/funding/marsden_fund/

[98] Health Research Council

[99] http://www.hrc.govt.nz/download/pdf/DoH%20strategy%202002.pdf

[100] http://www.smf.govt.nz/about/index.htm

[101] Budget 2003, Vote: Research, Science and Technology.

Glossary

atua	god(s)
hapu	family or district groups, communities
iwi	tribal groups
kaitiakitanga	the responsibilities and kaupapa, passed down from the ancestors, for tangata whenua to take care of the places, natural resources and other taonga in their rohe, and the mauri of those places, resources and taonga
kaupapa	plan, strategy, tactics, methods, fundamental principles
matauranga	Maori traditional knowledge of Maori people
mauri	essential life force, the spiritual power and distinctiveness that enables each thing to exist as itself
nga taonga tuku iho	valued resources, assets, prized possessions both material and non-material (passed down from the ancestors and the gods)
rangatiratanga	rights of autonomous self-regulation, the authority of the iwi or hapu to make decisions and control resources
rohe	geographical territory of an iwi or hapu
takiwa	geographical territory of an iwi or hapu
tangata whenua	people of the land, Maori people
taonga	valued resources, assets, prized possessions, both material and non-material
tikanga	customary, correct ways of doing things, traditional protocols
wahi tapu	special and sacred places
waiata	song
wananga	place of education and research, university
whaikorero	formal speeches
whakapapa	genealogy, ancestry, identity with place, hapu and iwi
whakatauki	proverb, pithy saying
whanau	family groups

Abbreviations

CRI	Crown Research Institute
DoC	Department of Conservation
DPMC	Department of the Prime Minister and Cabinet
ERMA	Environmental Risk Management Authority
FRST	Foundation for Research Science and Technology
HRC	Health Research Council
HSNO	Hazardous Substance and New Organisms (Act)
MAF	Ministry of Agriculture and Forestry
MfE	Ministry for the Environment
MFish	Ministry of Fisheries
MoH	Ministry of Health
MoRST	Ministry of Research, Science and Technology
NGOs	non-government organisations
PCE	Parliamentary Commissioner for the Environment
RMA	Resource Management Act 1991
RSNZ	Royal Society of New Zealand
SSC	State Services Commission