AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Precaution: principles and practice in Australian environmental and natural resource management

Deborah C Peterson
Productivity Commission

Presidential Address

50th Annual Australian Agricultural and Resource Economics Society Conference, Manly, New South Wales
8 – 10 February 2006

Since the late 1980s, the concept of precaution has been incorporated into numerous international agreements and laws, as well as in domestic statutes and policies in many countries. This paper examines the international emergence of the concept and its application in Australia. Despite rapid growth in adoption of the so-called 'precautionary principle', the concept remains highly controversial, and its success in terms of improving environmental and natural resource management has been questioned. This paper argues that implementation guidelines are essential to ensure that precautionary decision making is consistent with good decision making principles, and to avoid unnecessary costs and the potential for perverse outcomes. Economists have an important role in contributing to these guidelines and in developing techniques for incorporating uncertainty into decision making.

Note: The views expressed in this paper do not necessarily reflect those of the Australian Government or the Productivity Commission.

Acknowledgments

This report was prepared with research assistance from Annette Weier, and benefited from helpful comments from a number of people. In alphabetical order, I would like to thank Neil Byron, Geoff Edwards, Steve Hatfield-Dodds, Warwick Gullett, Lindsay Hogan, Phil Hughes, John Quiggin, Roger Rose, Ian Wills and Mike Young.

1. Introduction

The precautionary principle is a mandate to address uncertainty and to ensure that potential, though not well-defined or understood, hazards are taken into account in decision making. There is no universally accepted definition of the principle, or even agreement as to whether or not it is a principle. Since the late 1980s, the principle – in one of its many guises – has been incorporated into numerous international agreements and laws, as well as in domestic statutes and policies in many countries, including Australia. Despite rapid growth in its adoption, the principle remains highly controversial, and its success in terms of improving environmental and natural resource management, and of promoting sustainable development, has been questioned, by both proponents and opponents of the principle.

Uncertainty describes situations where the nature of future possible events is known but probabilities cannot be assigned to their outcomes, or where there is ignorance about both what events are possible as well as their probabilities.[1] Uncertainty is pervasive in regulatory and policy decision making, particularly in the field of environmental and natural resource management. Uncertainty arises from many sources, including incomplete understanding of natural processes and phenomena and of complex socioeconomic systems. In addition, there is uncertainty regarding the preferences of future generations, and of future resource endowments, products and technologies.

Increasing awareness of serious environmental degradation and damage to human health – in some cases, many years after potential hazards were first identified and no action to address them was taken – prompted pressures for anticipatory action to deal with potential, uncertain hazards (EEA 2001; OECD 2002).

> … not only *known* risks, but also *potential* risks to the environment and human health may need to be addressed; when there is a rational basis for concern, when their nature or magnitude is uncertain, and when a causal link with a certain action or process is not fully established. … This notion of precaution is based upon the assumption that in certain cases, scientific certainty, to the extent that it is obtainable with regard to environmental issues, may be achieved too late to provide effective responses to environmental threats. (OECD 2002, p. 6)

The precautionary principle was conceived as a means to ensure that decision makers would take into account uncertain but potentially serious and/or irreversible threats of harm. Decisions may be considered to have been ‘right’ or ‘wrong’ in hindsight, but at the time of decision making, policy makers may face major information gaps and a range of conflicting scientific opinions. Doing nothing is a decision in itself.

---

[1] Risk describes situations where there is uncertainty about which outcome will eventuate, but the range of all possible events is known and objective probabilities can be assigned to each and every possible event. Under situations of uncertainty, the range of all possible events/outcomes is known but there is insufficient information to permit objective probabilities to be assigned (Knight 1921). Ignorance (or radical uncertainty) is where objective (or sometimes even subjective) probabilities cannot be assigned to outcomes and the full range of possible events cannot be identified. Other terms used to describe types of uncertainty include ‘indeterminacy’ and ‘ambiguity’. See Harding and Fisher 1999; O’Riordan, Cameron and Jordan 2001, pp. 24–25; Peel 2005, pp. 43–44; Wills 1997, 2006.

In practice, the precautionary principle has proven difficult to apply, due largely to the absence of a clear formulation of the principle, and a lack of clear guidelines on when and how to apply it. This has created difficulties for public decision makers, uncertainty for business, opportunities for legal challenges to environmental policies and regulatory decisions, and the potential for misuse as a protectionist barrier.

The paper begins with a brief examination of the origins and development of the precautionary principle. Key formulations of the principle are presented and a classification system is described and applied. The significance of differences between various formulations is highlighted. Criticisms are then discussed, with many found to relate to extreme definitions of the principle or poor implementation.

Definitions of the principle adopted in Australian environmental and natural resource management and key legal decisions on its application are considered next. Application of the principle in Australian environmental and natural resource management decision making raises the question of whether there is sufficient advice available to achieve clarity and consistency. Many of the implementation problems experienced in Australia follow from the absence of official guidelines to assist decision makers. An assessment of a number of guidelines, developed overseas to clarify how precaution should be applied in decision making, concludes the paper. These may provide a useful starting point for the development of Australian guidelines for managing uncertainty. The application of such guidelines would be enhanced by further development of techniques for managing uncertainty in decision making. The paper notes a number of promising techniques for consideration.

2. Origins and development of the precautionary principle

The precautionary principle originated in Europe in the early 1970s, with the development of the German concept *Vorsorgeprinzip* which advocated 'long term planning to avoid damage to the environment, early detection of dangers to health and the environment through comprehensive research, and acting in advance of conclusive scientific evidence of harm' (LaFranchi 2005, p. 681). The first explicit reference to the precautionary principle was in 1987 in the Second International Conference on the Protection of the North Sea, which stated that marine ecosystems should be safeguarded with the best available technology, 'even where there is no scientific evidence to prove a causal link between emissions and effects' (Ministerial Declaration Calling for Reduction of Pollution). Despite a growing body of scientific evidence indicating substantial damage to the North Sea marine environment, pollution control regulations had, until then, been rejected due to the absence of definitive scientific proof of environmental damage. The Ministerial Declaration aimed to remove uncertainty as a barrier to action (Hanson 2003).

It was not until the 1992 United Nations Conference on Environment and Development that the precautionary principle achieved broad international recognition. The principle was included in the 1992 Rio Declaration on Environment and Development where it was positioned as an underlying element of the broader framework for sustainable development. It was further promulgated in the 1992 UN Framework Convention on Climate Change and the 1992 UN Convention on Biological Diversity. The precautionary principle has, since then, spread rapidly in multilateral agreements, international laws, and domestic laws and policies, dealing with climate change, biodiversity, endangered

species, fisheries management, wildlife trade, food safety, pollution controls, chemicals regulation, exposure to toxins, and other environmental and public health issues.

In Europe, the precautionary principle became one of the foundations of European Union (EU) environmental policy, with its inclusion in the 1992 Maastricht Treaty on the European Union (Andorno 2004). Although this Treaty is not binding on policy makers unless implemented through directives or domestic legislation, the precautionary principle has been subsequently applied in a broad range of environmental and public health and safety legislation and policies in the European Union. (See Annex III of OECD 2002 for examples of uses of precaution in the legislation of Member countries.)

Although US legislation and policies avoid the use of the term 'precautionary principle', the adoption of a precautionary approach is widespread in US legislation and regulations (Christoforou 2004; EEA 2001; Goklany 2001; Goldstein and Carruth 2003; LaFranchi 2005; OECD 2002). Examples include those relating to food additives, air and water-borne pollutants, environmental safety (such as the ban on CFCs), fisheries management, endangered species, public health (such as the ban on the use of DES as a growth promoter in beef), and toxic chemicals (CEC 2003; OECD 2002).

In Australia, the precautionary principle is one of the guiding principles of ecologically sustainable development (ESD) included in the National Strategy for Ecologically Sustainable Development (ESD Steering Committee 1992) and in the Inter-Governmental Agreement on the Environment (IGAE) (Australian Government 1992, para. 3.5.1). The IGAE provides an overarching framework for environmental and natural resource management in Australia. The precautionary principle is also a key component of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), a significant piece of legislation with broad applicability to environmental, natural resource management, and conservation activities. References to the principle have been incorporated into many laws and policies including fisheries legislation, management of the Great Barrier Reef, rules governing the grant of development approvals, and other natural resource management policies.

3. The meaning of precaution

There are numerous definitions of the precautionary principle. A classification system proposed by Cooney (2005) is discussed in section 3.1. The wide range of potential precautionary actions, from 'wait and see' to prohibition of action, are outlined in section 3.2. Finally, some comments are made in section 3.3 about whether the concept of precaution constitutes a principle or an approach.

3.1 Definitions of the precautionary principle

The most widely quoted statement of the precautionary principle is the one formulated at the 1992 UN Conference on Environment and Development:

> 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. (Principle 15, Rio Declaration on Environment and Development, 1992)

Much criticism of the precautionary principle has focused on the lack of a clear definition (Majone 2002; Marchant and Mossman 2004; Sandin 2004; Treich 2001; Turner and Hartzell 2004). The Rio definition is not universally accepted and there are many alternative definitions. Quiggin (2005, p. 20) rejects criticisms of the lack of definitional precision:

> Advocates of the precautionary principle have been criticized for failing to provide a precise operational definition of the principle. … [T]his criticism is misplaced. Any precise definition implies the existence of a well-defined formal analytical model within which the principle may be applied. But the incompleteness hypothesis states that any such model will exclude relevant factors. Hence, the precautionary principle must necessarily be considered as a heuristic check on decision making procedures rather than as a rule to be applied within a given formal framework.

While most definitions share common features, the differences between the numerous statements of the principle complicate the task of interpreting what the principle means and how it should be applied to environmental and natural resource management issues. The main areas of difference among the various statements of the principle are:

1. What level of threat or potential for harm is sufficient to trigger application of the principle (the threshold of harm)?
2. Are the potential threats balanced against other considerations, such as costs or non-economic factors, in deciding what precautionary measures to implement?
3. Does the principle impose a positive obligation to act or simply permit action?
4. Where does the burden of proof rest to show the existence or absence of risk of harm?
5. Is liability for environmental harm assigned and, if so, who bears liability?

Based on these differences, Cooney (2005) suggests categorising the different versions of the principle as 'weak', 'moderate' or 'strong' (adapted from Wiener 2002). This approach has been applied to the key international definitions of the principle in Box 1.

3.1.1 Weak formulations

The most widely-cited and influential international definitions of the principle, namely those contained in the Rio Declaration and other UN agreements, fall into the weak category. One of the key characteristics of the weak formulation is that 'lack of scientific certainty should not be used as a reason for postponing action'. As Wiener (2002, p. 1520) notes, weak formulations act as a 'rebuttal to the mistaken claim that uncertainty warrants inaction.' However, this form does not require action to prevent environmental damage once the threshold has been satisfied.

Under the weak, or least restrictive, form, the precautionary principle comes into play when threats of harm are 'serious', 'irreversible' or 'significant'. To satisfy the threshold of threat, there must be some evidence relating to both likelihood of occurrence and severity of consequences. Scientific uncertainty alone or the possibility of environmental damage below the threshold level will not satisfy the threshold test for precautionary measures.

Many, but not all, weak formulations are qualified by an explicit requirement to consider the costs of precautionary measures. The Rio Declaration and the UN Framework Convention on Climate Change, for example, both require that precautionary measures should be 'cost-effective'. Cost-effectiveness means achieving the stated objective using the minimum level of inputs. Cost-effectiveness analysis is often used as an alternative to cost-benefit analysis where benefits can be identified but where they are difficult to value.

Box 1 **Key international formulations of the precautionary principle**

Weak formulations

Rio Declaration on Environment and Development, 1992 (Principle 15): 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.

UN Framework Convention on Climate Change, 1992: The Parties should take precautionary measures to anticipate, prevent or minimise the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost.

Bergen Ministerial Declaration on Sustainable Development in the Economic Commission for Europe Region, 1990: In order to achieve sustainable development, policies must be based on the precautionary principle. … Environmental measures must anticipate, prevent and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

UN Convention on Biological Diversity, 1992: Noting also that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimise such a threat.

Moderate formulations

Third International Conference on the Protection of the North Sea, Ministerial Declaration, 1990: The participants … will continue to apply the precautionary principle, that is to take action to avoid potentially damaging impacts of substances that are persistent, toxic, and liable to bioaccumulate even where there is no scientific evidence to prove a causal link between emissions and effects.

UK Biodiversity Action Plan, Department of the Environment, 1994 (para. 6.8): In line with the precautionary principle, where interactions are complex and where the available evidence suggests that there is a significant chance of damage to our biodiversity heritage occurring, conservation measures are appropriate, even in the absence of conclusive scientific evidence that the damage will occur.

Strong formulations

Wingspread Statement on the Precautionary Principle, 1998: When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof.

Earth Charter, 2000 (article 6): Prevent harm as the best method of environmental protection and, when knowledge is limited, apply a precautionary approach. Take action to avoid the possibility of serious or irreversible environmental harm even when scientific knowledge is incomplete or inconclusive. Place the burden of proof on those who argue that a proposed activity will not cause significant harm, and make the responsible parties liable for environmental harm.

A cost-effectiveness study cannot by itself demonstrate a conclusive case for or against the appropriateness of a proposal, because it is concerned only with possible alternative unit costs, and not whether the total costs are likely to be exceeded by the total potential benefits. In other words, the effect, although achieved as cheaply as possible, may not be worth the cost. However, weak versions do not preclude a weighing up of benefits against costs. Factors other than scientific uncertainty, including economic considerations, may provide legitimate grounds for postponing action.

Under weak formulations, the requirement to justify the need for action (the burden of proof) generally falls on those advocating precautionary action. No mention is made of assignment of liability for environmental harm.

3.1.2 Moderate formulations

In moderate versions of the precautionary principle, the threat of environmental damage *justifies* or requires action to address the threat. Such formulations may not be as different from weak versions as they may first appear, because precautionary measures (action) may include 'wait and see' approaches (see section 3.2). However, the language is certainly stronger and may be suggestive of stronger forms of action.

Usually, there are no explicit qualifications requiring proposed precautionary measures to be assessed against factors such as economic or social costs. In addition, the trigger for action may be defined less rigorously, for example, as 'potential damage', rather than 'serious or irreversible' damage as in the weak version. Liability is not mentioned, and the burden of proof remains unchanged.

3.1.3 Strong formulations

Strong versions of the principle differ significantly from the weak and moderate versions in reversing the burden of proof. Like moderate formulations, strong versions justify or require precautionary measures. The threshold for action varies, sometimes expressed simply as 'harm'. Some strong versions, for example, that of Earth Charter, establish liability for environmental harm (a strong form of 'polluter pays').

Under the reversal of proof, proponents of an activity with potential for harm – whether serious or minor – are required to prove that the product, process or technology is sufficiently 'safe' before approval is granted. Virtually no human actions are risk-free, including actions designed to address environmental degradation. Inherent scientific uncertainty, which the precautionary principle is designed to address, thwarts attempts to definitively prove safety, even for products and processes for which no plausible hazards have been identified. Requiring proof of no environmental harm before any action can proceed implies the public is not prepared to accept any environmental risk, no matter what benefits might arise (such as economic or social benefits). At the extreme, such a requirement could 'involve bans and prohibitions on entire classes of potentially threatening activities or substances, without the option for proponents or others to demonstrate that they are harmless' (Cooney 2005, np). However, the standard of proof, such as 'reasonable certainty' of safety or safety 'on the balance of probabilities', can moderate the potential negative economic and social impacts from reversing the burden of proof.

Official statements of the precautionary principle do not generally fall within the strong category. Most strong versions are framed by private organisations and, as such, have no international or domestic legal status. Earth Charter, for example, is a community-based

environmental organisation, while the Wingspread Statement emerged from a conference of scientists, academics and environmental activists. Both the Earth Charter version and Wingspread Statement are frequently cited by critics, yet they have no official or legal standing.

The particular formulation of the precautionary principle applied by decision makers will be a major factor determining the economic consequences of precautionary measures. The economic effects of different formulations of the principle are considered further in section 4.

3.2 Options for precautionary action

Much opposition to the application of precautionary approaches to natural resource and environmental management derives from a belief that the precautionary principle requires the prohibition of activities associated with uncertain, but potentially serious, environmental damage. Yet none of the three formulations of the principle specify the nature of any precautionary measure that must be taken, and there are many, often quite varied, ways to approach and implement precaution (CEC 2003).

Some options for precautionary measures are listed in Box 2. Options range from a 'wait and see approach' where the issue is reviewed when better information becomes available, through the adoption of flexible policies that can be adapted in response to new information, to prohibition (either temporary or permanent). Options may be combined, for example, an action might be temporarily prohibited while research examines alternative options. The appropriate course of action will depend on the circumstances of each case, which include:

- the extent and significance of the information gaps and uncertainties, and the prospects and potential costs and benefits of obtaining better information in the future;
- the seriousness of possible hazards, including the possibility of catastrophic events, and society's degree of risk aversion;
- the incidence of damage, for example, whether those likely to be most seriously affected are children (where larger safety factors are often applied), whether adverse effects are concentrated on future generations, or whether environmental impacts will have large flow-on effects through ecological systems;
- the capacity, and ease or difficulty, of altering policies in the future, which may depend on whether policy measures would require, or generate incentives for, long-lived investments; and
- the potential costs and benefits to society of each alternative course of action.

3.3 'Principle' or 'approach'?

There has been considerable debate over whether any of the various expressions of the concept of precaution are appropriately described as a 'principle' or as an 'approach'. A common (layperson's) definition of a principle is 'a fundamental truth or law as the basis for reasoning or action' (Moore 2004). Opponents to the label 'principle' consider that the concept falls well short of this standard. Some suggest that the use of the term precautionary 'principle' dictates a 'hard line' approach involving mandatory risk averse action, sometimes involving complete prohibition of certain activities, whenever there are potential threats to the environment or to human health, and regardless of any balancing of costs and benefits (Cooney 2005; Graham 2004).

Box 2 **Some options for implementing precaution**

- Deferral of a decision until more information is available ('wait and see' approach).
- Research into alternative, less damaging options, and/or provision of funding for the development of such alternatives.
- Mandatory environmental impact assessments, which increase the amount of information available to decision makers and may identify uncertainties and potential hazards associated with the proposed activity.
- Inclusion of 'safety margins' or 'uncertainty factors' in risk assessments. Safety margins are commonly applied in assessing risks from exposure to toxic substances and non-carcinogenic food additives.
- Adaptive management involving the identification of knowledge gaps, ongoing monitoring and research to improve the knowledge base, and incorporation of flexibility and reversibility into decisions so that measures can be modified in line with advances in information.
- Actions to increase the resilience of social or ecological systems, that is, their capacity to recover from or adapt to changed conditions.
- Use of the best available technology.
- Imposition of conditions on the use of new products, processes or technologies, and monitoring of environmental or public health and safety impacts.
- Requirements for pre-approval or product registration prior to placing products on the market, or for obtaining permits to undertake specific activities. Examples include: approvals required to permit the sale or use of food additives, drugs, medical devices, or pesticides; licensing of hazardous waste facilities, nuclear power plants, aquaculture operations, and commercial fishing; and permits for development proposals and water diversions.
- Banning of an activity until there is 'reasonable certainty' of safety.
- Banning of the activity until there is strong evidence of safety.

Sources: Compiled from Cameron 1999; CEC 2003; Deville and Harding 1997; Gullett 1997; Wills 2006; Young 1993.

A precautionary 'approach' is argued to allow for flexible context specific measures, a balancing of various objectives, and a weighing of expected costs and benefits (Cooney 2005; OIRA 2003). Peel (2005, p. 2) observes that an 'underlying theme of the debate between precautionary principle 'proponents' and 'critics' seems to be the mutual suspicion of the other's social and political agenda'. To the extent that this is true, changing the label seems unlikely to reduce controversy.

There is also debate over the status of the term 'precautionary principle' in the legal profession. Despite broad application of the precautionary principle in international law and policies, and its prominent role in several trade disputes, the OECD notes that none of the international tribunals (the International Court of Justice, the WTO Appellate Body, and the European Court of Justice) that have dealt with cases involving the principle have 'clarified the legal status of precaution, nor confirmed the existence of a precautionary principle as a principle of international law' (OECD 2002, p. 13). Considerable conflict remains between the EU view of the principle as a 'general customary rule of international law' and the US view that the principle is no more than 'an "approach" – the content of which may vary from context to context' (WTO Appellate Body Report, quoted in Sindico 2005, pp. 27–28). Debate over the terminology used to describe the application of precaution in decision making is no doubt significant from a legal

perspective. Greater legal clarity would provide a firmer legal foundation for decision makers, and greater certainty for businesses and others affected by precautionary decisions.

Despite questions over the legal standing of the precautionary principle, and debate on the appropriateness of the use of the term 'principle', it is clear that precaution is widely applied in decision making concerning environmental and natural resource management. Widespread application of the precautionary principle indicates that, regardless of whether it is described as a principle or as an approach, it is recognised by many decision makers as a legitimate means of taking into account uncertainty in a range of decisions.

The most important factor influencing outcomes is how precaution is actually implemented in decision making. Clear implementation and interpretation guidelines may potentially resolve many of the underlying difficulties perceived to arise from the use of the term 'principle' in the context of precautionary decision making. For the purposes of this paper, the two terms will be used interchangeably.

4. Criticisms of the precautionary principle

Critics have identified potential problems with application of the precautionary principle, including harm to the environment and the imposition of significant costs on society. The likelihood of these problems arising depends on the specific formulation of the principle and the way in which it is implemented. Careful definition and good design of guidelines for implementation may help to avoid many of the problems associated with the principle. The most frequent criticisms of the principle are addressed below.

4.1 Excessive discretion

Some commentators note that the major social choice and definitional problems involved in implementing the principle may confer a high degree of discretion on decision makers (PC 2004; Wills 1997). Excessive discretion may lead to unpredictable and inconsistent environmental management decisions, which create uncertainty and higher costs for businesses, and inhibit corporate planning (Harding and Fisher 1999; Wills 1997).

A lack of clarity in how decisions have been made opens up opportunities for legal challenge, and the potential for courts to adopt an interpretation of the precautionary principle at odds with that intended by the policy maker. As Segal (1999, p. 77) observes, 'To leave the entire application of the principle to judicial discretion does not provide industry with sufficient guidance or certainty'. Some urgency attaches, therefore, to the development of guidelines that place the precautionary principle within a framework of good regulatory practice, including transparency, accountability and effective consultation (see Box 4 in section 6).

4.2 Reversal of the burden of proof

Some critics oppose the precautionary principle on the grounds that a reversal in the burden of proof imposes excessive costs on developers and producers. Most regulatory regimes, such as development approvals and licensing systems, require developers and producers to provide, at their own expense, evidence about the proposed activity and its consequences. It is not clear, except perhaps under some strong versions of the principle, that a reversal in the burden of proof under the precautionary principle would be

significantly more onerous than existing obligations. A more important factor influencing the costs of proposals may be the standard of proof.

Assignment of the burden of proof does not necessarily dictate who will pay the costs. Some of the guidelines developed for applying the precautionary principle address the question of reversal of proof and indicate how the costs of scientific assessment of safety should be distributed. These guidelines are discussed in section 6.2.

4.3 Distortion of regulatory priorities

Concerns have been expressed that application of the precautionary principle may distort regulatory priorities (Majone 2002), by causing a loss of focus on the most dangerous hazards (Goldstein and Carruth 2003), and redirecting regulatory attention from 'known or plausible hazards to speculative and ill-founded ones' (Graham 2004, p. 1). Such an outcome may impose significant costs on society and may even increase the overall amount of environmental damage. Distortions to regulatory priorities are less likely under weak formulations of the principle, which require that potential hazards are 'serious or irreversible', often qualified by a requirement for an assessment of costs.

4.4 Stifling of development and technological innovation

A frequent criticism is that application of the principle will stifle technological innovation and paralyse development (Hahn and Sunstein 2005; Goldstein and Carruth 2003; Graham 2004). Weak versions of the principle are unlikely to have this effect as they do not require precautionary measures and there is no reversal of the burden of proof. The effect of stronger versions will depend on how they are implemented, for example, the standard of proof of safety that is required.

Supporters of the principle suggest that its application may promote the development and implementation of safer, technologically feasible and commercially viable alternatives that are discounted when potential hazards to the environment or human health are ignored (EEA 2001; LaFranchi 2005). A UK Government working group found that:

> *Properly applied* it is a positive, proportionate policy tool to encourage technological innovation and sustainable development by helping to engender stakeholder confidence that appropriate risk control measures are in place. (ILGRA 2002, p. 4, emphasis added)

4.5 Costs of precautionary measures

Some critics highlight the costs of measures taken to avoid potential, but uncertain, risks (Cross 1996). Such criticism frequently overlooks or discounts the potential benefits from precautionary measures in terms of avoiding or minimising damage to human health and the environment. The European Energy Agency (EEA) suggests an explanation for such discounting of potential benefits:

> The costs of preventative actions are usually tangible, clearly allocated and often short term, whereas the costs of failing to act are less tangible, less clearly distributed and usually longer term (EEA 2001, p. 3).

The case studies presented by the EEA (2001) indicate that the benefits from avoiding some hazards may be substantial (for example, the experience with asbestos). Of course, due to the existence of uncertainty, some anticipated hazards may prove to be either overestimated or unfounded (see, for example, the case studies in Lieberman and Kwon 2004).

Another reason for the discounting of potential benefits may be that scientific uncertainty about the probability of harm, or even about the specific nature of potential hazards, leads to a downgrading of the benefits of avoiding such hazards. If such hazards do not eventuate, expenditures on measures to avoid the potential hazard are seen as wasted. However, even if later information shows that the expected hazard does not eventuate, a decision to take regulatory measures to avoid the hazard will be optimal ex ante provided: (i) the expected benefits of precautionary measures outweighed the expected costs; (ii) the most cost-effective and efficient alternative was chosen; and (iii) all relevant information available at the time was taken into account. Decisions applying precaution within the context of a consideration of costs and benefits are most likely to satisfy these criteria.

4.6 Perverse consequences

A common criticism of the precautionary principle is that it may have perverse consequences, where the costs of precautionary measures exceed the costs of waiting until the anticipated risks are proven. Wills (1997, p. 58) argues that, where precautionary measures are costly but ultimately revealed to be ineffective, due to uncertainty about hazards and how to address them, 'a risk-averse society could make things worse'. Goklany (2001), Cross (1996) and Lieberman and Kwon (2004) set out a large number of examples where regulations had perverse impacts. In most of these cases the perverse outcomes occurred because the negative consequences of the regulations were not assessed and weighed against the expected benefits prior to implementation.

The risk of perverse outcomes from precautionary measures results from a failure to recognise that regulatory measures have costs, as well as benefits, and may themselves give rise to risks (eg Hahn and Sunstein 2005; OIRA 2003). According to Bodansky (1991, p. 43), the 'precautionary principle seems to suggest that the choice is between risk and caution, but often the choice is between one risk and another'. A high potential for perverse outcomes may be associated with applications of the principle that are not based on an assessment of the consequences of precautionary measures.

Because of uncertainty, no assessment of the risks of various alternatives can be definitive. However, the potential for perverse outcomes may be reduced by thorough assessment of the costs, risks and consequences of the policy options as well as of the potential environmental hazard, using the best information available at the time. Decision makers may have to determine appropriate risk trade-offs where all of the alternatives have associated risks.

Full assessment of the costs, benefits and risks of potential hazards and of policy options for addressing these hazards, while seen as desirable, has been criticised as unrealistic (Goklany 2001; Wills 1997). Such assessments demand a considerable amount of 'scientific and economic information, in particular information about the degrees of uncertainty associated with different policies, the costs of precautionary measures, and their effectiveness in reducing future environmental damage and adjustment costs' (Wills 1997, p. 61). While some decisions may require additional research to obtain necessary information, decision makers have to accept that full information may never be available at reasonable cost. The precautionary principle was specifically formulated to assist decision makers in circumstances of limited information and scientific uncertainty. Implementation guidelines are important to ensure that decision makers undertake an assessment of the costs, benefits and risks associated with alternative courses of action.

The guidelines should ideally give decision makers guidance on how to deal with information gaps and conflicting scientific opinions.

4.7 Misuse as a protectionist barrier

A final criticism frequently raised is that the precautionary principle is open to misuse and opportunistic manipulation by rent-seeking commercial interests (Gollier and Treich 2003; Graham 2004; Majone 2002; Treich 2001). For example, commercial interests may oppose a new product or process that would compete effectively with existing products or processes on the grounds that it may have unproven adverse environmental or health impacts. In particular, it has been argued that the precautionary principle may be used as a disguised form of protectionism.

The principle has been implicated in a number of trade disputes. For example, the European Union has referred to the precautionary principle, and a high desired level of protection, to justify import barriers to hormone-treated beef and genetically modified food products. The United States (and other countries) challenged the import bans on the grounds that there was no scientific evidence of potential harm to human health from either the hormones used in beef or from genetically modified foods.

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) applies to trade restrictions implemented for environmental and human health protection. While the Agreement does not specifically refer to the precautionary principle, it states:

> … in cases where relevant scientific evidence is insufficient, a Member may provisionally adopt sanitary or phytosanitary measures on the basis of available pertinent information … Members shall seek to obtain the additional information necessary for a more objective assessment of risk and review the sanitary or phytosanitary measure accordingly within a reasonable period of time. (Article 5.7)

The SPS Agreement has been seen as sanctioning the use of precautionary measures to address scientific uncertainty (Sindico 2005; WTO 1998). It is important to note, however, that the Agreement requires that such measures are taken in the context of risk assessment and identification of potential hazards. Although the WTO upheld the European Union's right to determine an appropriate level of protection for its citizens, it decided in 1998 that the ban on hormone-treated beef was in breach of the SPS Agreement because no risk assessment had identified plausible health risks from the hormones used to produce the beef (WTO 1998). This decision accords with the OECD view that:

> Invoking precaution in situations where … there is no risk, or the risk is very negligible, or where there is a perceived risk for which there is no scientific basis, may be seen as a misuse, or abuse, of the concept. Such abuse could lead to undesired consequences, such as imposing disproportionate costs on society and business, stifling technological innovation, or creating unjustified trade barriers. (OECD 2002, p. 8)

4.8 Avoiding the shortcomings of the precautionary principle

In summary, some of the alleged shortcomings of the precautionary principle appear to be due to a lack of care in interpretation. Many may be avoided or minimised by good implementation processes. Under strong versions, there may be no attempt to assess the costs, benefits and risks of various hazards and options to prevent them. Implementation of precautionary measures that are not justified by some weighing of potential costs and

benefits may expose society to substantial costs with, in some cases, no real benefits for the environment or for human health.

Weak formulations of the principle generally avoid many of the problems associated with stronger versions. They draw attention of decision makers to the issue of uncertainty, and do not allow the mere existence of uncertainty to be a reason to postpone action. However, they do not require action or prescribe the nature of measures to prevent potential harm. Weak versions incorporate thresholds of harm to avoid taking inappropriate actions to address trivial risks. Some weak statements of the principle require analysis of cost-effectiveness. Guidelines developed to support application of the principle may require some form of modified cost-benefit analysis to ensure that expected benefits outweigh expected costs.

While guidelines will assist decision makers in applying the principle, the existence of a legal statement requiring the incorporation of precaution into decision making, and the form of words used in the definition of the principle, are important: the formulation of the principle can be pivotal in legal disputes, and without a legal foundation for the application of precaution, decision makers may lack authority to take precautionary measures. Guidelines with legal backing provide incentives to pay regard to them.

5. Application of the precautionary principle in Australia

The precautionary principle has been firmly established in Australian environmental and natural resource management legislation. As well as being incorporated into a number of international treaties and agreements[2] that Australia is party to, the principle has been incorporated into a multitude of domestic policies and statutes. But, despite broad application of the principle, no official implementation guidelines to support decision making have been adopted. Australian provisions, definitions and recent legal decisions on the application of the principle are considered next.

5.1 Australian provisions for the precautionary principle

Provision for the application of the precautionary principle is included in Australian legislation and policies in a variety of ways. It may be included directly, either as a legislative objective or as a more substantive legal provision. Or it may be implicitly incorporated through reference to the principles of ecologically sustainable development (ESD). Even when there is no explicit or implicit reference to the principle in legislation, it may still be legally relevant ‘because its widespread acceptance in the environmental policy context has imbued it with general relevance for environmental decision making’ (Gullett 2006, pp. 4–5).

ESD is defined as ‘development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends’ in the National Strategy for Ecologically Sustainable Development (NSESD) (ESD Steering Committee 1992). The Strategy was endorsed by the Council of Australian Governments

2 Including, for example, the Convention on International Trade in Endangered Species (CITES), the UN Convention on Biodiversity, and the WTO Agreement on the Application of Sanitary and Phytosanitary Measures.

in December 1992. Seven guiding principles are enunciated in the NSESD, including the precautionary principle, which states that:

> where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

The precautionary principle is also one of four guiding principles of ESD included in the IGAE (Australian Government 1992, para. 3.5.1). The IGAE provides an overarching framework for environmental and natural resource management. The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which applies to a broad range of environmental, natural resource management, and conservation activities, requires the Minister to consider the precautionary principle in decision making (s. 391(2)). Various statements of the principle are included in more than 120 Australian and state statutes and hundreds of non-binding policies (Dovers 2002). (See Peel 2005, Appendix A for a list of some of the main Australian legislation providing for application of the precautionary principle or precautionary approaches.)

5.2 Australian definitions of the precautionary principle

Australian definitions of the precautionary principle in Australian and state legislation and policies are generally very similar, in many cases being modelled on, or referring directly to, the definition included in the IGAE (see Box 3 and Peel 2005, Appendix A). Most of the examples in Box 3 refer to a risk of serious or irreversible harm. The majority state that a lack of full scientific certainty is not a reason to postpone measures to protect the environment, so that they do not require, action (one of the key characteristics of weak versions of the principle). A minority of legislation, such as South Australia's *Environment Protection Act 1993* and Tasmania's *Environment Management and Pollution Control Act 1994*, differ from other formulations by omitting reference to a lack of scientific certainty as not being a reason to postpone precautionary measures. However, these formulations require only that 'all aspects of environmental quality … are considered' in decision making, rather than requiring or justifying action (as in moderate or strong formulations).

As shown in Box 3, some, but not all, definitions include reference to measures being 'cost-effective' or to an 'assessment of risk-weighted consequences'. The EPBC Act, for example, makes no mention of costs or risk assessment. However, decision makers applying definitions that do not make reference to costs or consequences may nevertheless be influenced by the NSESD and IGAE provisions, either because they refer to these directly or because of their overarching nature.

In addition to the precautionary principle, the guiding principles in the NSESD provide for the integration of short and long term economic, environmental, social and equity considerations into decision making; promotion of international competitiveness and a strong and growing economy; the adoption of cost-effective and flexible policy instruments; and broad community involvement in decision making. Decision makers are required to give equal weight to each of the objectives, which may prove difficult in practice.

Box 3 Selected Australian formulations of the precautionary principle

Commonwealth

Inter-Governmental Agreement on the Environment 1992, para. 3.5.1: Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by: (i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and (ii) an assessment of the risk-weighted consequences of various options.

Environment Protection and Biodiversity Conservation Act 1999, s. 391: The Minister must take account of the precautionary principle in making a decision … to the extent he or she can do so consistently with the other provisions of this Act. The precautionary principle is that lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment where there are threats of serious or irreversible environmental damage.

Gene Technology Act 2000: Where there are threats of serious or irreversible environmental damage, a lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

New South Wales

Protection of the Environment Administration Act 1991*:* … if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

Victoria

Environment Protection Act 1970*:* (1) If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. (2) Decision making should be guided by: (a) a careful evaluation to avoid serious or irreversible damage to the environment wherever practicable; and (b) an assessment of the risk-weighted consequences of various options.

South Australia

Environment Protection Act 1993*:* … to apply a precautionary approach to the assessment of risk of environmental harm and ensure that all aspects of environmental quality affected by pollution and waste (including ecosystem sustainability and valued environmental attributes) are considered in decisions relating to the environment.

Tasmania

Environment Management and Pollution Control Act 1994: … to adopt a precautionary approach when assessing environmental risk to ensure that all aspects of environmental quality, including ecosystem sustainability and integrity and beneficial uses of the environment, are considered in assessing, and making decisions in relation to, the environment.

Sources: Commonwealth and state legislation.

In the IGAE, the three other principles of ESD relate to intergenerational equity, conservation of biological diversity and ecological integrity, and improved valuation, pricing and incentive mechanisms. The last principle requires that ‘environmental goals, having been established, should be pursued in the most cost-effective way’ (Australian Government 1992, para. 3.5.4). The three other ESD principles moderate the application of the precautionary principle, above and beyond the qualifications included in the definition of the principle itself (Harding and Fisher 1999).

In much legislation, the precautionary principle is one of a number of factors to be taken into account in any particular decision, such as in the formulation of management plans under the *Great Barrier Reef Marine Park Act 1975*, and in the determination of total allowable catch limits under the NSW *Fisheries Management Act 1994* (s. 30). The *Fisheries Management Act 1991* (Cth) (ss. 3–4) requires decision makers to pursue fisheries exploitation objectives in a manner consistent with the precautionary principle simultaneously with more traditional fisheries management objectives of optimal resource utilisation and economic efficiency, and compliance with international fisheries laws and agreements.

5.3 Absence of Australian implementation guidelines

Despite the broad application of the precautionary principle to environmental and natural resource management issues, there has been little attempt within Australia to develop official implementation guidelines.[3] Gullett concludes that:

> Existing legislative and policy formulations are too vague or ambiguous to enable it [the precautionary principle] to be implemented systematically. Its practical use is currently limited because decision-makers are not bound to apply it and are in doubt as to how to apply it. (Gullett 1997, p. 64)

The absence of implementation guidelines confers a significant degree of discretion on decision makers, and creates opportunities for legal challenge by those adversely affected by regulatory and policy decisions, generating costs for government agencies. Businesses may also incur costs as a result of uncertainty about the application of precaution or inconsistency in administrative decision making. Some businesses, for example, may initiate unsuccessful and costly litigation challenging administrative decisions, while others may incur expense in applying for approvals for which they have little chance of success. The next section considers recent Australian legal decisions applying the precautionary principle.

5.4 Merits review of Australian applications of the precautionary principle

There are a growing number of legal decisions involving the precautionary principle. Virtually all Australian cases have involved merits review of administrative decisions by tribunals or specialist courts, which have authority to substitute a new decision for the one under review. These tribunals and courts reach their own conclusions about the merits or reasonableness of the decision under review, which may involve examination of how the precautionary principle has been applied in the decision making process.

To date, there has been no judicial review of the legality of the precautionary principle itself. Such review could potentially clarify the legal standing and interpretation of the principle in Australia, increasing certainty for those operating under the legislation and reducing litigation and the associated costs. Where court interpretations differ from those intended by policy makers, clarification of the courts' approach would facilitate legislative review to ensure that policy makers' intentions are accurately embodied in legislation.

---

[3] The Office of the Gene Technology Regulator has produced a risk analysis framework that includes guidelines for dealing with uncertainty in genetically modified organism licence applications (OGTR 2005). These guidelines may form a useful starting point for the development of broader Australian guidelines or specific guidelines for other policy areas.

5.4.1 The precautionary principle as 'common sense'

The most widely-quoted legal case on the application of the precautionary principle in Australia is that of *Leatch v National Parks and Wildlife Service* (1993) 81 LGERA 270. In that case, Justice Stein accepted, in the NSW Land and Environment Court, the relevance of the precautionary principle in the context of a lack of scientific certainty about the impact of a proposed road on an endangered frog species. Justice Stein considered the precautionary principle to be a 'statement of common-sense', requiring decision makers to adopt a 'common-sense duty to be cautious' where scientific uncertainty exists. Justice Stein's ruling discussed methods of balancing different factors in decision making. He emphasised that taking a precautionary approach did not require a 'no risk' policy but did require consideration of alternatives that protect the environment.

The ruling in the case overturned the decision to proceed with construction of the proposed road on the grounds that there had been insufficient consideration of less environmentally damaging alternative routes. Justice Stein made clear his view that the precautionary principle was not simply a means of accounting for uncertainty in isolation but required the adoption of decision making procedures that balanced economic cost-benefit analyses, scientific uncertainty and social concerns (Fisher and Harding 2001). In finding that an alternative road route had been rejected on the basis of a cost-benefit analysis that did not include environmental factors, Justice Stein stated:

> There are a number of environmental economic models which factor environmental values into cost/benefit analysis. Surely an approach which attempts to integrate economic and environmental factors is preferable. (*Leatch v National Parks and Wildlife Service* (1993) 81 LGERA 270, pp. 285–6)

While the *Leatch* case has been widely referred to in subsequent legal cases, most emphasis has been placed on the finding that the precautionary principle is a 'common-sense duty to be cautious', with much less attention given to Justice Stein's comments about the need to balance economic, environmental, social and other factors (Fisher and Harding 2001). Legal interpretations of the precautionary principle as a matter of 'common sense' provide little guidance to decision makers on the procedures that should be followed to implement the principle, how it should be weighed against conflicting factors, or what action is required. Consequently, uncertainty remains about what decision processes to implement in order to satisfy the courts, in the event of legal challenge, that due regard has been given to the principle (Gullett 2006).

In addition, there is some doubt about whether the precautionary principle is a legally binding principle when no statutory directions to apply or take account of the precautionary principle are included in the legislation in question (Bates 2002). For example, in *Nicholls v Director-General of National Parks and Wildlife* (1994) 84 LGERA 397, the IGAE and other policies enunciating the precautionary principle were judged to 'create no binding obligation upon the Director-General or this Court' (the NSW Land and Environment Court). Legislative provision for the precautionary principle, such as s. 30(2)(c) of the NSW *Fisheries Management Act 1994*, would clarify for decision makers and those affected by their decisions when the principle is 'a legally relevant, and, therefore, an obligatory consideration, in decision making' (Bates 2002, p. 132).

5.4.2 Balancing of competing factors

In *Greenpeace Australia Ltd v Redbank Power Co Pty Ltd* (1994) NSWLEC 178, development consent for a power station in the Hunter Valley was opposed on the grounds that its emissions would contribute to the greenhouse effect. In rejecting the application, the NSW Land and Environment Court stated that 'application of the precautionary principle dictates that a cautious approach should be adopted in evaluating the various relevant factors in determining whether or not to grant consent; it does not require that the greenhouse issue should outweigh all other issues'. Evaluation of the various factors was seen as 'a matter of government policy'.

Balancing of the various factors involved in precautionary decision making has therefore been left to decision makers. These types of value judgements, requiring a balancing of economic, environmental, social and other factors, and taking into account society's risk preferences, are appropriately a matter for governments, rather than courts. Public decision makers would benefit from guidance on the weights to apply in decision making. Modified cost-benefit analysis would assist in clarifying the choices and trade-offs to be made in each decision process (see section 6.3).

5.4.3 Decision maker discretion

Some commentators have been concerned that, without clear guidelines, decision makers may pay only 'lip service' to the principle (Bates 2002, p. 132). Others consider that almost any decision can be seen as applying a precautionary approach (Fisher and Harding 2001). This view appears consistent with that expressed by Justice Talbot in the *Alumino* case that:

> the precautionary principle adds nothing to the consideration that the Court undertakes by applying common sense. It is obvious that where development involves the handling and processing of materials which have the potential to cause significant harm to the health of human beings and vegetation, extreme caution must be used in determining whether development consent will be forthcoming. (Alumino (Aust) Pty Ltd v Minister Administering the Environmental Planning and Assessment Act 1979, unreported, Land and Environment Court, Talbot J, 29 March 1996, emphasis added).

Similarly, in *Friends of Hinchinbrook Society Inc v Minister for the Environment* (1997) 142 ALR 632 in the Federal Court, the Minister was considered to have taken a cautious approach by addressing the risks to World Heritage values identified in scientific and other reports available to him even though the precautionary principle was not explicitly mentioned in his decision. In many court judgements, application of the precautionary principle has apparently added little to conventional decision making 'given that caution and commonsense are generally assumed to form the basis of environmental decision making and review' (Peel 2005, p. 204). However, as Gullett (2006, p. 6) points out, in 'the absence of a unified detailed conceptualization of the principle … courts have had little ability to identify its legal content and have generally deferred to a department's interpretation or application of legislation'.

Implementation guidelines, and legislative provisions clarifying when the principle is to be applied, would promote consistency and greater certainty in the application of the principle. Guidelines would also provide decision makers with techniques for dealing effectively with uncertainty and information gaps, which may not form part of conventional decision making (Peel 2005). It is important to note, however, that some scope for administrative discretion will remain, just as it does in decision areas not affected by significant uncertainties. Attempts to eliminate discretion would result in

excessive prescription and removal of the flexibility needed to take into account the circumstances of each case.

5.4.4 The threshold test

Despite the formulation of the threshold of threat in the IGAE and in most Australian legislation as 'serious or irreversible damage to the environment', Gullett (2006) identifies two divergent trends in rulings on the threshold for application of the principle in Australian case law. In several merit reviews of fisheries management decisions,[4] the Administrative Appeals Tribunal accepted the existence of uncertainty about the impacts of commercial fishing as sufficient to trigger the threshold for applying precaution in decision making, even though there was *no evidence* of a threat of serious or irreversible damage (Gullett 2006; Peel 2005). In contrast, in merit reviews of development decisions,[5] courts have required *credible evidence* of 'serious or irreversible damage' in order to satisfy the threshold of threat (Gullett 2006).

In determining what evidence of harm will satisfy the threshold, it appears that the courts have required more rigorous evidence in small-scale planning matters where the issues and uncertainties are seen as fairly straight-forward. In natural resource management decisions, involving more complex issues, large information gaps, high levels of scientific uncertainty, and the potential for serious and long-lasting damage in large ecosystems, the courts have accepted less objective evidence of threat as sufficient to satisfy the threshold test. In fisheries cases, for example, support for a finding of potential serious environmental damage – despite the absence of *any* scientific evidence of damage for a particular fishery – appears to have been inferred from past experience, such as the 1942 collapse of the Californian sardine fishery and the 1992 collapse of the Canadian Northern cod fisheries (Peel 2005). Inferences may also have been drawn from evidence that many of Australia's fish stocks have become over-fished (Caton and McLoughlin 2004), despite the existence of management controls in those fisheries (Peel 2005). Gullett (2006 np) concludes:

> … no clear rule can be discerned from the cases and we are still yet to see a full judicial review challenge in Australia …[It is]…clear from the cases … that the various tribunals and merits review courts have differed with regard to what level of evidence satisfies the threshold test. Their variance is most likely attributable to the context of the decision at hand – whether it is a decision on natural resource management or on a small-scale planning matter. This reasoning is likely to inform any future judicial review cases.

Unpredictability creates uncertainty and costs for businesses and others subject to precautionary decisions. As Gullett (2006) notes, although the precautionary principle is not a 'rigid rule', a threshold has been expressed in Australian legislation and 'some legal meaning must be ascribed to it so that the principle cannot be a complete shield for public decision-makers and a blanket excuse for arbitrary action in the infinite number of environmental issues where uncertainty exists' (Gullett 2006, np). Decision makers and

---

4 *Justice v Australian Fisheries Management Authority (AFMA)* (2001) AATA 49, *Ajka Pty Ltd v AFMA* (2001) AATA 258, and *Ajka Pty Ltd v AFMA* (2003) FCA 248.

5 For example, *Conservation Council of South Australia v DAC and Tuna Boat Owners Association* (1999) SAERDC 86, *Histpark Pty Ltd v Maroochy Shire Council* (2001) QPEC 059, *Commercial Crash Repairs Pty Ltd v Corporation of the city of Adelaide* (2000) SAERDC 83, and *Aldekerk Pty Ltd v City of Port Adelaide Enfield and Environment Protection Authority* (2000) SAERDC 47.

those affected by the decisions would benefit from access to guidelines that specify the nature and amount of evidence required to satisfy the threshold in different contexts. For example, evidentiary requirements may vary according to the level of uncertainty (such as where scientific information is so scarce that credible evidence demonstrating a potential hazard is unavailable, as in many fisheries) or the potential for large negative consequences (such as the catastrophic outcomes predicted by some scientists to result from climate change).

6. Implementation guidelines

It is argued in this paper that many of the shortcomings of the precautionary principle result from a failure to place the application of the principle within a framework of good regulatory practice. Scientific uncertainties and the potential for serious, irreversible or even catastrophic harm do not exempt precautionary decision making from normal standards of good regulatory practice. Without a full assessment of the costs, benefits and risks of alternatives, arbitrary invocation of the precautionary principle risks substituting one type of damage to the environment and human health with other unforeseen environmental and public health damage (see section 4.6 and the examples given in Goklany 2001; Cross 1996; Lieberman and Kwon 2004; PPP 2005). At the same time, substantial economic and social costs may be incurred, potentially leaving society worse off.

High levels of uncertainty complicate the analysis of options, and necessitate guidelines to assist decision makers to deal with information deficiencies in a consistent and rational manner. As noted earlier in the paper, scientific uncertainty is endemic to environmental and natural resource policy making and regulation.

6.1 Questions for implementation

Existing formulations of the precautionary principle give little guidance to decision makers on how to implement the principle. Stronger versions generally leave open how decision makers should determine the threshold for action and the method for evaluating alternative courses of action. In contrast, most weak definitions set the threshold for threat of harm, being ‘serious’, ‘irreversible’ or ‘significant’. Some weak definitions direct decision makers to consider ‘cost-effectiveness’ or ‘the risk-weighted consequences of various options’. However, significant questions remain – how to define ‘serious’ and ‘irreversible’, for example, when some actions may be reversible in theory but only over a very long time period and at substantial cost.

More broadly, questions that remain problematic under most formulations of the principle include (Cooney 2005; Harding and Fisher 1999; Marchant and Mossman 2004; Wills 1997, 2006):

- how to treat conflicting or incomplete scientific information and opinion;
- how to evaluate uncertainties and incorporate such evaluations into decision making;
- how to choose ‘between different courses of action or conservation strategies which may each pose risks, of different sorts and over different timescales’ (Cooney 2005, np); and
- how to balance competing interests and address distributional consequences.

6.2 International guidelines for implementing precaution

Increasing attention has been devoted in recent years to developing guidelines to apply the precautionary principle or, as it is termed in the United States, a precautionary approach. However, Fisher and Harding (2006, p. 171) note that 'very little critical attention [has been] given to these frameworks. This is a considerable deficiency in the literature when one considers that these frameworks are one of the most important means of operationalising it'. Others (eg Gullett 1997; PPP 2005) have also called for the development of implementation guidelines. The guidelines considered in this paper are those developed by:

- the European Commission (EC) in its 2000 *Communication from the Commission on the Precautionary Principle* (EC 2000);
- the UK Government's Inter-Departmental Liaison Group on Risk Assessment (ILGRA 2002);
- the US Office of Information and Regulatory Affairs within the Office of Management and Budget (OIRA 2003); and
- the Precautionary Principle Project, an environmental non-government organisation comprising Fauna and Flora International, IUCN–The World Conservation Union, ResourceAfrica and TRAFFIC (PPP 2005).

These sets of guidelines for applying precaution in regulatory decision making will be assessed against the criteria for good regulatory practice set out in Box 4. The focus will be on identifying whether the guidelines ensure that decisions (including decisions to take no action or to defer action until more information is available) will be efficient, cost-effective and appropriate.

6.2.1 EC and UK guidelines

The European Commission's 2000 Communication places the precautionary principle within the existing framework of risk analysis (EC 2000; Loefstedt 2004). The stated aim of the Communication is to establish guidelines for applying the principle and to 'avoid unwarranted recourse to the precautionary principle, as a disguised form of protectionism' (EC 2000, p. 3). Decisions must be based on scientific risk assessments and satisfy the following criteria:

- Scientific evidence of risk – 'Before the precautionary principle is invoked, the scientific data relevant to the risks must first be evaluated. … it is not possible in all cases to complete a comprehensive assessment of risk, but all effort should be made to evaluate the available scientific information.' (EC 2000, p. 14)
- Proportionality – 'Measures based on the precautionary principle must not be disproportionate to the desired level of protection and must not aim at zero risk, something which rarely exists.' (EC 2000, p. 18) Decision makers must consider less restrictive alternatives that make it possible to achieve an equivalent level of protection.
- Non-discrimination and consistency – 'Comparable situations should not be treated differently and different situations should not be treated in the same way.' (EC 2000, p. 4)
- Examination of costs and benefits – The overall costs, including non-economic considerations, to the European Union of action and lack of action must be compared. In weighing various costs and benefits, the protection of health takes precedence over economic considerations (EC 2000, p. 5). An economic cost-benefit analysis should be undertaken where possible (EC 2000, p. 19).

- Examination of scientific developments – Precautionary measures should be maintained as long as the scientific data are inadequate, imprecise, and inconclusive, and as long as the risk is considered too high to be imposed on society (EC 2000, p. 5).
- Assignment of responsibility for producing scientific evidence – While there will often be a reversal of proof, where the proponent of an activity must provide reasonable evidence of safety, 'such an obligation cannot be systematically entertained as a general principle' (EC 2000, p. 21). In some cases, there will be benefit in research funded by the public.

The UK guidelines for implementing the precautionary principle have much in common with the European Commission's guidelines. The UK guidelines require that: 'Action in response to the precautionary principle should accord with the principles of good regulation, ie. be proportionate, consistent, targeted, transparent and accountable' (ILGRA 2002, p. 2). There must be a comparison of the costs and benefits of action and inaction, including social and environmental costs (ILGRA 2002, p. 10). Decision making must be based on 'standard procedures of risk assessment and management' (ILGRA 2002, p. 2), using 'the best available scientific advice, taking into account the uncertainties' (ILGRA 2002, p. 9). Accounting for uncertainties may require 'making assumptions about consequences and likelihoods to establish credible scenarios' (ILGRA 2002, p. 2). Decisions must be reviewed when more information becomes available.

As a general rule, the UK approach shifts the burden of proof to the proponent of the activity to provide the information needed for decision making, but 'flexibility is needed and the extent to which the burden of proof shifts towards the hazard creator is determined case-by-case' (ILGRA 2002, p. 11). Public funding for research may be appropriate when there is significant social value from getting the information and little prospect of it being generated within the private sector (ILGRA 2002).

The guidelines developed by the European Commission and the UK Government demonstrate many of the features of good regulatory practice listed in Box 4. Both sets of guidelines require a comparison of the costs and benefits of precautionary measures and their alternatives (including no action). Economic cost-benefit analyses should be undertaken where sufficient information is available, as well as regulatory impact studies that incorporate social and environmental concerns. Regulatory action should be targeted at the objective of a desired level of protection. For the European Commission, the desired level of protection is high, but not zero-risk, which is recognised as unrealistic.

Precautionary measures must be proportionate to the problem or hazard to be addressed. Wiener (2003, p. 251) describes the European proportionality principle as 'a weighing of benefits and costs, conceptually equivalent to cost-benefit analysis (though perhaps less frequently quantitative in practice)'.

In requiring formal assessments of costs and benefits, risk calculations, and a clear statement of the assumptions used in decision making, the EC and UK guidelines should improve the transparency, accountability and consistency of decision making. In addition, application of these guidelines – by placing constraints on the way the precautionary principle is to be incorporated into decision making – modifies the practical effect of moderate and strong versions of the principle. The guidelines may effectively 'weaken' the more stringent statements of the principle and thereby avoid some of the associated problems (real or perceived).

Box 4 Checklist for assessing regulatory quality

Regulations that conform to best practice design standards are characterised by the following seven criteria:

- Minimum necessary to achieve objectives
  - Overall benefits to the community justify costs
  - Kept simple to avoid unnecessary restrictions
  - Targeted at the problem to achieve objectives
  - Not imposing an unnecessary burden on those affected
  - Does not restrict competition, unless demonstrated net benefit
- Not unduly prescriptive
  - Performance and outcomes focused
  - General rather than overly specific
- Accessible, transparent and accountable
  - Readily available to the public
  - Easy to understand
  - Fairly and consistently enforced
  - Flexible enough to deal with special circumstances
  - Open to appeal and review
- Integrated and consistent with other laws
  - Addresses a problem not addressed by other regulations
  - Recognises existing regulations and international obligations
- Communicated effectively
  - Written in 'plain language'
  - Clear and concise
- Mindful of the compliance burden imposed
  - Proportionate to the problem
  - Set at a level that avoids unnecessary costs
- Enforceable
  - Provides the minimum incentives needed for reasonable compliance
  - Able to be monitored and policed effectively

Source: PC 2003, p. 6.

Both sets of guidelines require that the type of precautionary regulation adopted should be the least restrictive regulation needed to achieve the desired outcome, in order to avoid imposing unnecessary costs on society and on those directly affected. Precautionary measures must be reviewed in the light of scientific developments, and measures must be flexible enough to be modified or discontinued if justified by new information.

The reversal in the evidentiary burden envisaged in both sets of guidelines has the potential to detract from the quality of regulatory decision making if applied indiscriminately. However, the guidelines state that proponents of new products, technologies and processes will be required to prove that regulation is not justified only in cases where a reversal in the burden of proof is judged to maximise benefits to society. Reversal of the evidentiary burden is not proposed to apply across-the-board to all regulatory decisions. This limit on the reversal of the burden of proof may reduce potential negative impacts. In addition, as noted in section 3.1, the standard of proof required to be demonstrated by proponents of an activity is important in determining the economic and social impacts of reversing the burden of proof. While the standard of proof is not defined in the EC or UK guidelines, the EC's target of a high, but not zero,

level of protection suggests that the standard of proof adopted in each case is likely to require a reasonable degree of certainty.

6.2.2 US guidelines

The United States has also developed guidelines for the application of precaution in regulatory decision making. While the US Government denies the existence of a 'precautionary principle' (Graham 2004), the Office of Information and Regulatory Affairs states that:

> The United States employs precautionary approaches throughout the process of risk assessment and management so that the overall level of precaution in a given regulatory decision is appropriate. (OIRA 2003, p. 54)

The US view is that precaution can only be sensibly applied within a framework of risk management, otherwise significant costs and distortions would result (Graham 2004). Decision making that incorporates precaution must be:

- Based on an assessment of costs and benefits, and targeted towards government objectives – 'When Federal decision makers decide the appropriate level of precaution in a specific decision, they need to consider … factors such as technological and economic feasibility, or more holistic benefit-cost balancing, including considerations of countervailing risks, depending on the statutory requirements to protect the public and the environment, and improve societal welfare.' (OIRA 2003, p. 62)
- Transparent and accountable – 'new OMB guidelines for regulatory analysis require agencies to support rulemakings with formal probabilistic analysis of the key scientific and economic uncertainties regarding costs and benefits.' (OIRA 2003, p. 59)
- Based on scientific evidence – 'decisions about how to respond to a potential hazard are intended to be made after – and are informed and guided by – a scientific risk assessment that is grounded in the weight of the scientific evidence' (OIRA 2003, p. 53).
- Subject to review and flexible enough to deal with new information – 'the ability to modify policies as scientific understanding grows is critical to the appropriate application of precaution. The information collection, risk assessment, and risk management phases are not static … The management approach can be adapted in response to improved scientific information that reduces uncertainty in risk assessment (such as the magnitude and likelihood of consequences) as well as uncertainty in risk management (such as effectiveness of interventions and pace of technological advancements).' (OIRA 2003, p. 57)

Like the EC and UK guidelines, the US guidelines demonstrate many of the features of good regulatory practice listed in Box 4. There is an emphasis on weighing the costs and benefits of regulation to the community, through formal risk assessment and cost-benefit analysis. Regulations incorporating precaution must be performance- and outcomes-focused, transparent and accountable, and targeted at achieving statutory objectives. They are open to review and modification when new scientific information becomes available.

Although the US guidelines do not specifically mention a reversal in the burden of proof, some US regulations impose a requirement on proponents of new products, technologies or processes to prove why approval to market or use the product, technology or process should be granted. For example, requirements for pre-market approval prevent the sale or use of certain products, such as food additives, medicines, medical devices, and

pesticides, unless they are proven to meet specified 'safety' requirements. Mandatory operating permits prevent the operation of hazardous waste facilities, nuclear power plants, fishing activities, trade in endangered species and other business activities without some prior demonstration of safety or the absence of significant environmental damage (CEC 2003; Vogel 2003). The standard of proof adopted is generally 'reasonable certainty'.

There appear to be significant areas of agreement between the US and European guidelines for implementing the precautionary principle. Some commentators have argued that the United States and Europe are converging in their approaches to applying precaution (Christoforou 2004; Loefstedt 2004; Wiener 2003). Differences remain in the degree of weight placed upon formal scientific and quantitative assessments compared to more qualitative risk assessments, in the treatment of uncertainty, and in the particular types of risks considered most serious (Christoforou 2004; Tickner and Raffensperger 2001; Vogel 2003; Wiener 2003, 2004).

6.2.3 Precautionary Principle Project guidelines

The Precautionary Principle Project (2005) has recently released guidelines developed following a process of broad international consultation with a range of interested parties. The guidelines require:

- explicit incorporation of the principle into legislation and policy, and establishment of 'adequately resourced institutions to carry out research into risk and uncertainty in environmental decision making' (PPP 2005, np);
- recognition that the principle must be balanced against other relevant principles, such as intergenerational equity, and basic human rights;
- development of operational measures for specific policy areas that identify concrete actions to be taken in specific contexts but permit flexibility when circumstances change;
- a transparent process of assessment, decision making and implementation based on broad public participation and the best available information (scientific and non-scientific);
- assessment of the threats and the environmental, economic and social uncertainties;
- identification and assessment of options, including various courses of action and inaction, and their likely consequences (including any potential risks);
- allocation of responsibilities for providing information and evidence of threat or safety, usually but not always involving a reversal in the burden of proof;
- clear communication of the precautionary measures being taken and their basis;
- proportionality, taking into account economic and social costs of measures;
- equity in the distribution of economic and social costs; and
- adaptive management, involving monitoring, research, periodic evaluation and review, and efficient and effective compliance.

The Project guidelines take a somewhat different approach to that adopted by the three other sets of guidelines considered here. Several of the Project guidelines relate to the steps leading up to invocation of the principle, which, in the EC, UK and US guidelines, are dealt with in the scientific risk assessments undertaken prior to the implementation of precaution. (The scientific assessments factor in uncertainties, information gaps and precaution.) The Project guidelines provide less detail than the other sets of guidelines about the methods to be employed in assessing and comparing precautionary options. Instead, they place a greater emphasis on broad public participation and openness in the

decision making process. Consequently, the Project guidelines may allow greater scope for discretion than the other guidelines although the scope to exercise this discretion may be restrained by the transparency of the process. Furthermore, the Project envisages the development of more specific operational guidelines and measures for specific policy areas.

Despite the differences, there are many areas of agreement and the Project guidelines, like the other guidelines, demonstrate many of the features of good regulatory practice. The guidelines emphasise accessibility, transparency, effective communication, regular monitoring and review, and flexibility to adapt to new information. Precautionary measures must be proportionate to the hazard and all economic, social and environmental costs must be taken into account. These rules imply that some form of modified cost-benefit analysis is required, in common with the EU and UK guidelines. Measures must be based on a formal risk assessment and the precautionary principle must be integrated with, and where necessary weighed against, other relevant principles.

The main potential area of concern with the Project guidelines is its reversal of the burden of proof, except where the burden would fall on 'poorer, vulnerable or marginal groups … [then] either these responsibilities and costs should be placed on relatively more powerful groups, or financial/technical support should be provided' (PPP 2005, np). If applied with an extreme standard of proof, this rule has the potential to block development and the introduction of new products, processes and technologies. The standard of proof adopted is to be determined by the countries applying the Project's guidelines, which 'may have the right to establish their own chosen level of protection for their own biodiversity and natural resources' (PPP 2005, np).

6.2.4 Other guidelines

Other broad guidelines have been developed (eg Deville and Harding 1997; Government of Canada 2002). The guidelines developed by Deville and Harding (1997)[6] for Australia have much in common with the approach adopted in the Precautionary Principle Project guidelines but they provide significantly greater detail on how to apply the various steps in the process. Specific guidelines have been developed for particular policy areas, for example, fisheries management (FAO 1995), genetically modified organisms (OGTR 2005), and child health (WHO 2004).

6.2.5 Findings

Despite the development of guidelines for applying precaution and of methods for dealing with uncertainty, the precautionary principle will remain challenging to apply. Judgements about the range of possibilities, the effectiveness of various options to address the problem, and the assumed probabilities attached to the range of outcomes are unavoidable when there is uncertainty. While some uncertainties may be resolved over time, with research and the development of greater scientific knowledge and understanding, some uncertainties may never be resolved. Judgements must also be made about how much risk is acceptable, and how to balance economic considerations with other factors, such as environmental, health, and social concerns.

Substantial benefits could be obtained from contributions by environmental and resource economists to the formulation of official guidelines for application by Australian decision makers to environmental and natural resource management problems involving

[6] Deville and Harding's guidelines have no official standing.

significant uncertainties. The task may be made easier by using existing guidelines as a starting point for developing guidelines suited to Australian circumstances and policy issues. The benefits from the development of official guidelines include greater consistency and predictability, improved transparency and accountability, and lower costs for businesses and government agencies. In addition, there will be greater confidence that the decision making process was optimal, leading to adoption of the most cost-effective and efficient alternative.

6.3 Modified cost-benefit analysis

Any application of a precautionary approach requires methods to deal with uncertainty. This may require an understanding of the sources of uncertainty and research to quantify the uncertainty where such quantification is possible. A common approach where it is impossible to assign probabilities to potential outcomes or even to identify all possible outcomes by 'making assumptions about consequences and likelihoods to establish credible scenarios' (ILGRA 2002, p. 2). Conventional cost-benefit analysis may need to be modified by incorporating assumptions about the potential hazards and expected responses to various management options. For example, Hahn and Sunstein and the FAO suggest a similar approach:

> Of course, the proper cost-benefit analysis can and should incorporate concerns about precaution. For example, a problem characterized by irreversibilities … can be modelled using standard techniques in cost-benefit analysis. Uncertainties about both benefits and costs can also be incorporated, perhaps by specifying a range of possible outcomes, perhaps by seeking to preserve specified options, or perhaps by identifying the worst-case scenario and showing a degree of risk aversion with respect to that scenario. (Hahn and Sunstein 2005, p. 6)

> A precautionary approach to assessment and analysis requires a realistic appraisal of the range of outcomes possible … A precautionary assessment would, at the very least, aim to consider: (a) uncertainties in data; (b) specific alternative hypotheses about underlying biological, economic and social processes, and (c) calculation of the theoretical response of the system to a range of alternative management actions. (FAO 1995, p. 11)

The past decade has seen the development of new techniques to deal with uncertainty. These include formal modelling of choice under uncertainty (eg Quiggin 2005), formal modelling of policy choice with uncertainty and irreversibilities (eg Pindyck 2000, 2002), option valuation (eg Gollier and Treich 2003), environmental valuation techniques (see eg Bennett 2005; Wills 2006), intergenerational discounting (eg Arrow 1995; Sumaila and Walters 2005), minimax choice rules (see eg Majone 2002; Quiggin 2005; van den Bergh 2004; Wills 2006), and value-of-information theory (eg Macauley 2005). These techniques, perhaps with further development, may be useful in modifying conventional cost-benefit analyses to address uncertainties, information gaps, and large intertemporal disparities in the incidence of costs and benefits.

7. Conclusions

The precautionary principle requires decision makers to deal with threats of adverse environmental and public health consequences in the context of scientific uncertainty. There is no universal definition of the precautionary principle. Variants of the precautionary principle are widely applied, both internationally and in Australia.

This paper argues that weak formulations of the precautionary principle are generally to be preferred to stronger versions. Weak formulations can serve as a useful reminder to

decision makers that inaction is not necessarily the optimal response to uncertainty. Weak versions provide greater guidance to decision makers on thresholds for action. In addition, definitions incorporating 'cost-effectiveness' or 'assessment of the risk-weighted consequences of various actions' provide a legal backing, as well as explicit incentives, for decision makers to take into consideration the costs, benefits and risks of alternative responses to uncertain hazards. Weak versions thus provide greater legal support for the application of implementation guidelines advocated in this paper. Most official versions, including Australian government statements of the principle, fall into the weak category.

The precautionary principle is, and will remain, challenging to apply. Decision makers will often be required to make judgements or assumptions about the range of possible outcomes, the effectiveness of various options to address the problem, and the assumed probabilities attached to the range of outcomes. Subjective judgements of this nature are unavoidable when there is genuine uncertainty. Decisions will also need to be made about what level of risk society is prepared to accept in various contexts.

Although the application of precaution will always involve some degree of subjectivity, the development of clear guidelines for applying the precautionary principle nevertheless has major benefits. Placing the principle within the context of good regulatory practice helps to ensure that decision making is transparent, consistent and accountable; that it utilises all relevant information; that costs, benefits and risks are identified, assessed and compared; and that measures are targeted at, and proportionate to, the problem. This decision making framework will help to avoid many of the potential problems arising from application of the precautionary principle, including the risk of perverse outcomes, over-reaction to trivial risks, and misuse as a rent-seeking (or protectionist) measure.

Without guidelines, Australian applications of the principle may suffer from a lack of clarity about implementation procedures, leading to inconsistencies, uncertainties and legal challenge to environmental and natural resource management decisions. A challenge for agricultural and resource economists is to contribute to the development of guidelines for precautionary decision making in the environmental and natural resource management area. Further research to develop methods to incorporate uncertainty into decision making would be also useful.

References

Andorno R. 2004, 'The precautionary principle: a new legal standard for a technological age', *Journal of International Biotechnology Law*, vol. 1, no. 1, pp. 11–19.

Arrow, K. 1995, 'Intergenerational equity and the rate of discount in long term investment', Paper presented at the IEA World Congress, December, www-econ.stanford.edu/faculty/workp/swp97005.pdf (accessed 13 January 2006).

Australian Government 1992, *Intergovernmental Agreement on the Environment* (IGAE) www.deh.gov.au/esd/national/igae/ (accessed on 11 August 2005).

Bates, G. 2002, *Environmental Law in Australia*, 5th ed., Butterworths, Australia.

Bennett, J. 2005, 'Australasian environmental economics: contributions, conflicts and 'cop-outs'', *Agricultural and Resource Economics*, vol. 49, no. 3, pp. 243–61.

Bodansky, D. 1991, 'Scientific uncertainty and the precautionary principle', *Environment*, vol. 33, no. 7, pp. 4–5, 43–44.

Cameron, J. 1999, 'The precautionary principle: core meaning, constitutional framework and procedures for implementation' in Harding, R. and Fisher, E. (eds), *Perspectives on the Precautionary Principle*, The Federation Press, Sydney.

Caton A. and McLoughlin, K. (eds) 2004, *Fishery Status Reports 2004*, Bureau of Rural Sciences, Commonwealth of Australia.

CEC (Commission for Environmental Cooperation of North America) 2003, North American Environmental Law and Policy, Editions Yvon Blais, www.cec.org/files/PDF/LAWPOLICY/NAELP10_en.pdf (accessed 10 August 2005).

Christoforou, T. 2004, 'The precautionary principle, risk assessment, and the comparative role of science in the European Community and the US legal systems' in Vig, N. and Faure, M. (eds), *Green Giants?: Environmental Policies of the United States and the European Union*, MIT Press, Cambridge and London.

Cooney, R. 2005, 'Precautionary principle, precautionary practice: tackling risk and uncertainty in biodiversity conservation and natural resource management', in Dickson, B. and Cooney, R. (eds) (forthcoming), *Biodiversity and the Precautionary Principle: Risk, Uncertainty and Practice in Conservation and Sustainable Use*, Earthscan (in press), www.pprinciple.net/publications/Chap1_Cooney.pdf (accessed 17 August 2005).

Cross, F. 1996, 'Paradoxical perils of the precautionary principle', *Washington and Lee Law Review*, vol. 53, pp.851–927.

Deville, A. and Harding, R. 1997, *Applying the Precautionary Principle*, The Federation Press, Sydney.

Dorman, P. 2005, 'Evolving knowledge and the precautionary principle', *Ecological Economics*, vol. 53, pp. 169–76.

Dovers, S. 2002, 'Precaution, prediction, proof, and policy assessment', *New Solutions*, vol. 12, no. 3, pp. 281–96.

EC (Commission of the European Communities) 2000, *Communication from the Commission on the Precautionary Principle*, Brussels 02.02.2000 COM (2000) 1.

EEA (European Environment Agency) 2001, *Late Lessons from Early Warnings: The Precautionary Principle 1896–2000*, Environmental issue report no. 22, EEA, Copenhagen.

ESD (Ecologically Sustainable Development) Steering Committee 1992, *National Strategy for Ecologically Sustainable Development*, Australian Government, www.deh.gov.au/esd/national/nsesd/strategy/index.html (accessed 1 December 2005).

FAO (Food and Agriculture Organisation of the United Nations) 1995, *Precautionary Approach to Fisheries, Part 1: Guidelines on the Precautionary Approach to Capture Fisheries and Species Introductions*, FAO Technical Paper 350/1, www.fao.org/DOCREP/003/V8045E/V8045E00.HTM (accessed 20 September 2005).

Fisher, E. and Harding, R. 2001, 'The precautionary principle in Australia: from aspiration to practice' in O'Riordan, T., Cameron, J., & Jordan, A. (eds), *Reinterpreting the Precautionary Principle*, Cameron May, London.

—— 2006 (forthcoming), 'The precautionary principle and administrative constitutionalism: the development of frameworks for applying the precautionary principle' in Fisher, E., Jones, J. and von Schomberg, R. (eds), *Implementing the Precautionary Principle: Perspectives and Prospects*, Edward Elgar, Cheltenham UK (in press).

Goklany, I. 2001, *The Precautionary Principle: A Critical Appraisal of Environmental Risk Assessment*, CATO Institute, Washington DC.

Goldstein, B. and Carruth, R. 2003, 'Implications of the precautionary principle for environmental regulation in the United States: examples from the control of hazardous air pollutants in the 1990 Clean Air Act amendments', *Law and Contemporary Problems*, vol. 66, no. 4, pp. 247–61.

Gollier, C. and Treich, N. 2003, 'Decision-making under scientific uncertainty: the economics of the precautionary principle', *Journal of Risk and Uncertainty*, vol. 27, no. 1, pp. 77–103.

Government of Canada 2002, *A Framework for the Application of Precaution in Science-Based Decision Making about Risk*, Ottawa.

Graham, J. 2004, 'The perils of the precautionary principle: lessons from the American and European experience', *Heritage Lectures*, The Heritage Foundation, www.heritage.org/regulation/hl818.cfm (accessed 8 August 2005).

Gullett, W. 1997, 'Environmental protection and the "precautionary principle": a response to scientific uncertainty in environmental management', *Environmental and Planning Law Journal*, vol. 14, no. 1, pp. 52–69.

—— 2006 (forthcoming), 'The threshold test of the precautionary principle in Australian courts and tribunals: lessons for judicial review' in Fisher, E., Jones, J. and von Schomberg, R. (eds), *Implementing the Precautionary Principle: Perspectives and Prospects*, Edward Elgar, Cheltenham (in press).

Hahn, R. and Sunstein, C. 2005, 'The precautionary principle as a basis for decision making', *The Economists' Voice*, vol. 2, no. 2, article 8.

Hanson, M. 2003, 'The precautionary principle', chapter 7, in Page, E. and Proops, J. (eds) 2003, *Environmental Thought*, Edward Elgar, Cheltenham UK.

Harding, R. and Fisher, E. 1999, 'Introducing the precautionary principle' in Harding, R. and Fisher, E (eds), *Perspectives on the Precautionary Principle*, The Federation Press, Sydney.

ILGRA (Inter-Departmental Liaison Group on Risk Assessment) 2002, *The Precautionary Principle: Policy and Application*, UK Government, www.hse.gov.uk/aboutus/meetings/ilgra/pppa.htm (accessed 12 August 2005).

Knight, F. 1921, *Risk, Uncertainty and Profit*, Houghton Mifflin, Boston.

LaFranchi, S. 2005, 'Surveying the precautionary principle's ongoing global development: the evolution of an emergent environmental management tool', *Boston College Environmental Affairs Law Review*, vol. 32, no. 3, pp. 679–720.

Lieberman, A. and Kwon, S. 2004, *Facts versus Fears: A Review of the Greatest Unfounded Health Scares of Recent Times*, 4th ed., American Council on Science and Health, New York.

Loefstedt, R. 2004, 'The swing of the regulatory pendulum in Europe: from precautionary principle to (regulatory) impact analysis', *Journal of Risk and Uncertainty*, vol. 28, no. 3, pp. 237–60.

Macauley, M. 2005, 'The value of information: a background paper on measuring the contribution of space-derived earth science data to natural resource management', Discussion Paper 05-26, Resources for the Future, Washington.

Majone, G. 2002, 'What price safety? the precautionary principle and its policy implications', *Journal of Common Market Studies*, vol. 40, no. 1, pp. 89–109.

Marchant, G. and Mossman, K. 2004, *Arbitrary and Capricious: The Precautionary Principle in the European Courts*, The AEI Press, Washington DC.

Moore, B. (ed.) 2004, *The Australian Concise Oxford Dictionary*, 4th ed., Oxford UP, London.

OECD Joint Working Party on Trade and Environment 2002, *Uncertainty and Precaution: Implications for Trade and Environment*, OECD, September.

OGTR (Office of the Gene Technology Regulator) 2005, *Risk Analysis Framework*, Department of Health and Ageing, Commonwealth of Australia.

OIRA (Office of Information and Regulatory Affairs) 2003, *Informing Regulatory Decisions: 2003 Report to Congress on the Costs and Benefits of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities*, United States Office of Management and Budget.

O'Riordan, T., Cameron, J., & Jordan, A. (eds) 2001, *Reinterpreting the Precautionary Principle*, Cameron May, London.

PC (Productivity Commission) 2003, *Mechanisms to Improve the Quality of Regulations: Australia in an International Context*, Staff Working Paper, July.

—— 2004, *Impacts of Native Vegetation and Biodiversity Regulations*, Report no. 29, Melbourne.

Peel, J. 2005, *The Precautionary Principle in Practice: Environmental Decision-Making and Scientific Uncertainty*, The Federation Press, Sydney.

Pindyck, R. 2000, 'Irreversibilities and the timing of environmental policy', *Resource and Energy Economics*, vol. 22, pp. 233–59.

—— 2002, 'Optimal timing problems in environmental economics', *Journal of Economic Dynamics and Control*, pp. 1677–97.

PPP (Precautionary Principle Project) 2005, *Guidelines for Applying the Precautionary Principle to Biodiversity Conservation and Natural Resource Management*, www.pprinciple.net/PP_guidelines_brochure.pdf (accessed on 9 January 2006).

Quiggin, J. 2005, 'The precautionary principle in environmental policy and the theory of choice under uncertainty', www.uq.edu.au/economics/johnquiggin.

Sandin, P. 2004, 'The precautionary principle and the concept of precaution', *Environmental Values*, vol. 13, pp. 461–75.

Segal, J. 1999, 'An industry perspective on the precautionary principle' in Harding, R. and Fisher, E (eds), *Perspectives on the Precautionary Principle*, The Federation Press, Sydney.

Sindico, F. 2005, 'The GMO dispute before the WTO: legal implications for the trade and environment debate', Nota Di Lavoro 11.2005, Fondazione Eni Enrico Mattei, www.feem.it/Feem/Pub/Publications/WPapers/default.htm (accessed 8 August 2005).

Sumaila, U. and Walters, C. 2005, 'Intergenerational discounting: a new intuitive approach', *Ecological Economics*, vol. 52, pp. 135–142.

Tickner, J. and Raffensperger, C. 2001, 'The American view on the precautionary principle' in O'Riordan, T., Cameron, J. and Jordan, A. 2001, *Reinterpreting the Precautionary Principle*, Cameron May, London.

Treich, N. 2001, 'What is the economic meaning of the precautionary principle?', *The Geneva Papers on Risk and Insurance*, vol. 26, no. 3, pp. 334–45.

Turner, D. and Hartzell, L. 2004, 'The lack of clarity in the precautionary principle', *Environmental Values*, vol. 13, pp. 449–60.

van den Bergh, J. 2004, 'Optimal climate policy is a utopia: from quantitative to qualitative cost-benefit analysis', *Ecological Economics*, vol. 48, pp. 385–93.

Vogel, D. 2003, 'Comparing environmental governance: risk regulation in the European Union and the United States', Paper prepared for a conference on Environmental Policy Integration and Sustainable Development, Australian National University, Canberra, 19–20 November.

WHO (World Health Organisation) 2004, *Dealing with Uncertainty – How Can the Precautionary Principle Help Protect the Future of Our Children?*, Working paper EUR/04/5046267/11 presented to the Fourth Ministerial Conference on Environment and Health, Budapest, Hungary, 23–25 June.

Wiener, J. 2002, 'Precaution in a multi-risk world' in Paustenbach, D. (ed.), *Human and Ecological Risk Assessment: Theory and Practice*, Wiley-Interscience, New York.

—— 2003, 'Whose precaution after all? A comment on the comparison and evolution of risk regulatory systems', *Duke Journal of Comparative and International Law*, vol. 13, pp. 207–62.

—— 2004, 'Convergence, divergence, and complexity in US and European risk regulation' in Vig, N. and Faure, M. (eds), *Green Giants?: Environmental Policies of the United States and the European Union*, MIT Press, Cambridge and London.

Wills, I. 1997, 'The environment, information and the precautionary principle', *Agenda*, vol. 4, no. 1, pp. 51–62.

—— 2006 (forthcoming), *Economics and the Environment: A Signalling and Incentives Approach*, Allen and Unwin, St Leonards, NSW (in press).

WTO (World Trade Organisation) 1998, *European Commission Measures Concerning Meat and Meat Products (Hormones)*, Report of the Appellate Body, AB-1997-4.

Young, M. 1993, *For Our Children's Children: Some Practical Implications of Inter-generational Equity and the Precautionary Principle*, Consultancy Report for the Inter-governmental ESD Steering Committee, AGPS, Canberra.