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The Environment, Information and the Precautionary Principle

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ON 9 April 1996, it was reported in *The Australian* that the New South Wales government had cancelled plans for a $180m gold mine, even though an independent inquiry had recommended that the mine be approved. The report continued:

> The NSW Minister for Urban Affairs and Planning, Mr Knowles, said the Government had always maintained it would 'only support mining at Lake Cowal if there was clear evidence that the mining could take place without any threat to the wetlands or the wildlife species'. 'While the commission could recommend conditions to mitigate or minimise environmental risk, they were unable to guarantee that there would be no threat to the wetlands or downstream impact on species', Mr Knowles told *The Australian.*

In view of scientific uncertainty about the impacts of projects on the environment, is it reasonable to require that developers guarantee the absence of environmental damage? After all, absolute certainty is unattainable in modern science. Would not the demand for such a guarantee before projects proceeded put a stop to all developments that affect the environment (Brunton, 1994)?

The Precautionary Approach to Environmental Change

The precautionary approach in environmental management emerged in the preparation of clean air legislation in West Germany in 1970. 'Precaution' embodied the ideas that damage to the natural world should be avoided in advance, and that, when irreversibility is feared, there should be action before scientific proof of damage is available (Boehmer-Christiansen, 1994:35-8). More recently, policy statements incorporating these ideas have been included in international agreements, including the European Union's 1991 Treaty of Maastricht and the 1992 Framework Convention on Climate Change.

Precaution was proposed as a guiding principle of Australian environmental policy in the nationwide Ecologically Sustainable Development discussions undertaken between 1990 and 1992. The first clear statement of the precautionary principle as a rule for environmental management in Australia was included in the In-

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tergovernmental Agreement on the Environment (IGAE) signed by Paul Keating (then Prime Minister), State premiers, chief ministers and a local government representative in May 1992 (Harding & Fisher, 1994).

The precautionary principle is one of four guiding principles cited in the IGAE (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.

To many, this formulation would seem uncontroversial. Advocates of the precautionary principle argue that, faced with the possibility of environmental changes which threaten humanity's life-support systems, a risk-averse society needs to institutionalise caution by placing the burden of proof on those who wish to change the environmental status quo (O'Riordan & Cameron, 1994). Thus, in the absence of scientific certainty about the consequences of natural resource use, a logger or miner or resort developer should be required to provide appropriate proof either that the proposed development will not result in some defined level of environmental damage, or that environmental damage will be minimised. Alternatively, the developer could be required to show that the possible environmental loss is less than the likely benefits of the project to the community.

Interpreted as a demand for proof of zero environmental damage, the precautionary principle would have required the aboriginal immigrants of 50,000-60,000 years ago to leave Australia to the giant kangaroos, marsupial lions and diprotodonts (Flannery, 1994). The principle therefore requires qualifications such as (i) and (ii) in the formulation above. But the qualified principle raises major social choice and definitional problems. Who is to decide what constitutes 'serious environmental damage', what is 'irreversible', and on what evidence? How are 'risk-weighted consequences' to be assessed? The implied degree of discretion on the part of decision-makers would not seem to make for certain or stable environmental management rules. Nor is it clear why the IGAE specified 'serious *or* irreversible environmental damage' (emphasis added). Young (1993:14) defines 'serious' as 'could have extremely adverse implications for future generations', and 'irreversible' as 'no known substitutes exist for the resource being used'. Precautionary principle advocates give no reasons why we should worry about 'serious' environmental damage which can be reversed, or irreversible damage that is not 'serious'.

In its non-absolute form, the essence of the precautionary approach is not a rejection of scientific and economic analyses, but the reversal of the burden of

proof. While the principle stems from the inadequacy of scientific knowledge, its qualified application sensibly requires the use of the best available science and economics to establish the appropriate standards of proof that would-be developers must meet. However, interpretations of the precautionary principle differ according to beliefs and ethical stances. Decision-makers who are optimistic about the ability of human technology to replace or repair damaged environmental assets will require lower standards of proof about environmental damage than technology pessimists. 'Deep greens', meanwhile, who believe that non-human species have rights independent of human interests, will require developers to meet the highest standards.

Some advocates of the precautionary principle reject the privileged position for science and scientists implied in the preceding paragraph. According to Hunt (1994:121), the precautionary literature encompasses two distinct approaches to the problem of scientific uncertainty. One approach, expressed above, renders the implementation of the precautionary principle dependent on the use of science and economics to establish and assess standards of proof. The alternative, more radical, approach, expressed in Hunt (1994) and Harding and Fisher (1994), is based on the view that scientific (and economic) knowledge, and the concomitant uncertainty, are malleable social constructs. Those adopting this perspective believe that what is known and what is uncertain scientifically depends substantially on culture and who is making the claim, as well as on established scientific testing procedures. They therefore see the present social construction of scientific (and economic) concepts as impeding a full understanding of the consequences of environmental changes. For these people, precautionary policy involves as much cultural and political change as science; they advocate a decision process that puts decisions on 'how much' precaution into the hands of a wider set of stakeholders than at present (Harding & Fisher, 1994:259).

Uncertainty about Economic-Environmental Systems

The economy and the natural environment interact in four ways. The environment is a source of inputs into production. It serves as a receptacle or sink for production and consumption wastes. It provides amenities which directly affect human well-being. Finally, the environment provides human life support, the result of the combined functioning of the climate, chemical element cycling, water cycling and living organisms.

The interactions between the economy and the different services of the environment are sometimes so complex that we are uncertain about the consequences of human actions affecting the natural environment. Such uncertainty arises primarily as a result of:

- environmental complexity due to biological diversity and variations in the physical environment, leading to imperfect scientific understanding of the functioning of the natural world and of ecosystems in particular;

- economic complexity due to the numbers of human agents and goods, the diversity of technologies, preferences and institutions, and the ability of people to learn from experience and to change their preferences and institutions; and

- consequences which extend far into the future. Thus, current decision-makers are ignorant of the identity and personal preferences of future people affected by current actions, and of the future technologies and resource costs which, together with future generations' preferences, will determine their happiness or unhappiness with the world we bequeath to them.

With so many possible interactions within and between the economy and the environment over space and time, it is simply impossible to know all the future consequences of current use of the environment.

What sort of uncertainty is involved? Common (1995:173) distinguishes two types. What we will term 'ordinary uncertainty' applies when the range of possible outcomes is known but their probabilities are not known. 'Radical uncertainty' applies when the possible outcomes of actions cannot all be identified. Young (1993:17) cites an example of radical uncertainty: the use of chlorofluorocarbons (CFCs) as refrigerants and propellants. CFCs were adopted because of their chemical inertness and stability, which were thought at the time to create minimal ecological risks. *Ex post*, scientists realised that these very properties allowed CFCs to reach the stratospheric ozone layer. Another example is the impact of proposed bans on tropical timber imports from Southeast Asia. There are likely to be unforeseen environmental and economic outcomes in both exporting countries (like Malaysia) and importing ones (like Australia), as timber producers and consumers adjust. Unforeseen changes are also likely due to the commercial responses to the ban (such as illegal trade through third countries) and political responses (such as retaliation by the timber exporters).

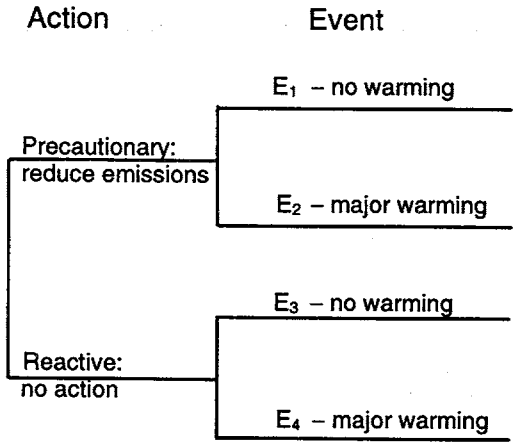
A decision tree can be used to depict the distinction between ordinary and radical uncertainty. Figure 1 depicts the actions available to the decision-maker, the uncontrollable events that can occur, and the relationship between actions and events. In the simplistic greenhouse policy decision tree depicted in Figure 1, the decision-maker has just two present options: to act now to reduce human emissions of greenhouse gases which may lead to major global warming within a few decades, or to postpone action, which avoids present costs. Each option is followed by one of two possible climatic events: either major warming will occur or it will not. In the future, the decision-maker will choose an action tailored to whichever of the specific climatic events, E_1-E_4, has occurred.

The decision tree in Figure 1 would be correctly structured if it included all the possible actions and all possible action-event scenarios. This is the situation for ordinary uncertainty. However, in the case of greenhouse gas emissions, this is not the case. Uncertainty about greenhouse science, future technologies and people's future responses to climate change means that the event branches and corresponding climatic and economic outcomes on the right hand side of Figure 1 are not all

known. Thus, the greenhouse policy problem involves radical uncertainty: the decision-maker cannot identify all the possible action-event scenarios, let alone their probabilities.

Figure 1

Greenhouse policy decision tree



Given that uncertainty results from environmental and economic complexity and from long-lived consequences, one would predict that the degree of radical uncertainty increases with the extent and diversity of the ecosystems and economic systems impacted by environmental changes, with the numbers of people involved (both as actors and as sufferers), and with the duration of the consequences. These are in fact the characteristics of the most important global environmental problems, such as CFC and greenhouse gas emissions, major forest clearing and marine pollution. At the other end of the scale, activities that are highly localised in space and time and affect very few people, such as noise pollution between neighbours, are likely to be subject to relatively minor uncertainty.

The most important environmental problems, and hence the greatest uncertainty, commonly result from accumulation of the small-scale activities of large numbers of individuals, such as consumers, drivers, farmers and loggers. The fact that the individual actors are small makes the problem more, not less, serious, since smallness in relation to the overall magnitude of the problem encourages free-riding by both actors and sufferers. For example, any effort that I make to control my car's emissions makes no discernible difference to city pollution or global CO_2 levels. As well, since my car's contribution to these problems is not identifiable, I will suffer no penalty for not acting and obtain no reward if I act to reduce my emissions. So the benefit I expect, either as a sufferer from pollution or as a controller

of pollution, is zero. • Since reducing my car's emissions is costly, I am better off doing nothing.

Uncertainty is most troubling when the possible outcomes of current actions may involve serious *and* irreversible damage to ourselves or to the community. Decisions to undergo risky major surgery have this character for individuals. Major decisions on our use of the natural environment may have serious and irreversible consequences for whole communities if an irreplaceable natural resource or ecological life support system is irreversibly altered. The construction and operation of the Chernobyl nuclear plant in Ukraine is one example. The decline of civilisations whose irrigated agriculture succumbed to increasing salinity appears to be another.

The functioning of the economic system is dependent on social institutions such as moral codes and property rights. Given the interdependence between the economy and the environment, it follows that humanity's future is dependent on both the maintenance of environmental assets which provide human life support and the maintenance and enhancement of social institutions. It is much more difficult to envisage serious and irreversible environmental damage in a society where social institutions are inclusive and effective in signalling people's concerns to others and in motivating people to respond positively to those concerns. Such societies have institutions designed to identify major threats to the society, to inform members of those threats, and to motivate people to alter their behaviour in response to those threats. So, to sustain itself in the long term, a society needs to maintain and enhance both its environmental capital and its social capital: the two are complementary.

The precautionary principle is a proposed addition to our stock of social institutions. Can a set of social institutions including the precautionary principle do a better job of informing people about possible consequences of their use of the environment, and of motivating them to respond appropriately, than our current set of social institutions? In the search for an answer, we need to compare the information requirements of precautionary policies with our knowledge of economic-environmental systems.

The Information Requirements of Precautionary Policy

Consider the policy options for dealing with greenhouse gas emissions. It is feared that major global warming is occurring due to increasing atmospheric concentrations of greenhouse gases resulting from human activity. The serious, possibly life-threatening, consequences contemplated include expansion of the tropical cyclone belts to higher latitudes, extension of deserts due to changes in rainfall patterns, and substantial rises in the global sea level. The uncertainty about greenhouse imposes an unavoidable choice between doing something now to avert possible damage, and postponing action until evidence appears of how the climate is changing. A precautionary approach would involve taking the former option: action to reduce human greenhouse gas emissions now, despite uncertainty about global warming due to those emissions, and about the costs of any global warming which does occur. The

latter, 'reactive', option would involve reacting to climatic changes if and when they occur.

At first glance, if we believe that people are risk averse, the precautionary option seems sensible: better to act now to avert possible future disasters that may cause irreversible damage to society. But a precautionary policy makes little or no sense if the decision-maker is faced with radical uncertainty regardless of the option chosen. With radical uncertainty about the outcomes of precautionary policy, it is impossible to estimate the impact of precautionary measures upon future global warming. Yet choosing precaution over reaction implies that the decision-maker knows something about events and outcomes, namely, that a precautionary policy of (say) reducing greenhouse gas emissions now will eliminate or greatly reduce the possibility of severe future damages due to global warming. If the decision-maker does not know that a precautionary policy will be effective, then it is possible that the precautionary approach leads to the worst of both worlds: society incurs the present costs of precautionary actions, but still suffers the future costs of unanticipated (given precautionary measures) disasters (Chisholm & Clarke, 1992). To put it another way: if the chances of very costly climatic changes, such as substantial rises in sea level, are little affected by costly reductions in current emissions, why incur such costs now? The adoption of precautionary policy is not consistent with radical uncertainty about its outcomes.

If precautionary measures are subject to ordinary, rather than radical, uncertainty, precautionary policy may be justified by considering its impact on the range of possible events and outcomes. Consider the case of a mining project such as the proposed gold mine at Lake Cowal. Suppose that the possible consequences of a ban on mining are well understood, but the environmental impacts of the mine are highly uncertain. The decision-maker faces a clearer choice than before: between a well-defined range of consequences of a ban on mining, and a wide and ill-defined range of mining outcomes. In such circumstances, precautionary policy might be implemented by requiring convincing evidence that (say) environmental protection measures will greatly reduce the extent of environmental damage regardless of future events.

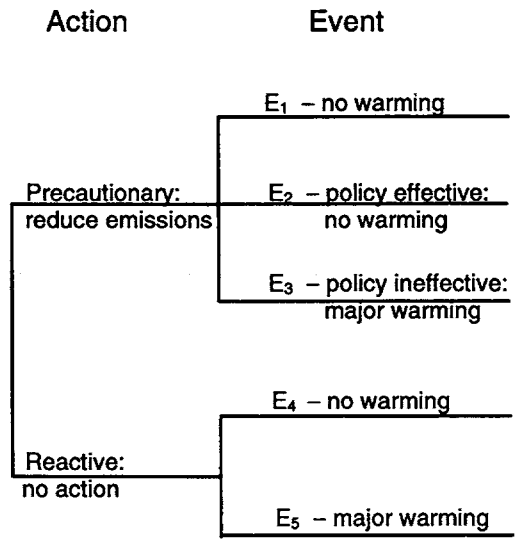
Figure 2 illustrates the possibility of ineffective precautionary policy. It incorporates the same climatic outcomes as Figure 1, and adds the possibility that precautionary emissions reductions may be either effective or ineffective in reducing global warming.

To choose between precautionary and reactive policy, the decision-maker needs information about, first, the magnitude of the present costs of precautionary measures, and second, the future consequences, costs and benefits of precautionary and reactive policies. In the greenhouse policy choice depicted in Figure 2, both are subject to radical uncertainty. In the case of current actions to control emissions, the uncertainty about cost is due to the major economic and social dislocation which could attend severe restrictions on the production of greenhouse gases, in particular CO_2. In the case of future consequences, limited scientific understanding

of global climate change, and ignorance of future technologies and human responses to climate change, cause major uncertainties.

Figure 2

Greenhouse policy decision tree when policy may be ineffective



Thus, in the case of greenhouse, a risk-averse society could make matters worse by adopting precautionary policy.

This is an important point. It is commonly believed that precautionary policy, involving the minimisation of currently observable environmental damage, is sensible if people are risk averse. This is almost certainly the case with relatively well-understood environmental systems, such as municipal sewage disposal or local air pollution. Such situations involve mostly ordinary uncertainty; the chances of very costly surprise outcomes of precautionary policy are negligible. On the other hand, with the radical uncertainty characteristic of extensive and complex economic-environmental systems, precautionary policy can be ineffective, can lead to unpleasant surprises, and therefore can be more damaging than reactive policy.

Planners' Preferences, Judgements and Incentives

Radical uncertainty about greenhouse means that there is no 'right' choice between precautionary and reactive policies. Decisions, precautionary or reactive, will often turn out to be incorrect with the wisdom of hindsight. The correct *ex ante* policy choice depends heavily on the responsible decision-maker's preferences and subjective evaluation of possible alternatives.

Consider the greenhouse policy choice depicted in Figure 2. Assume that the decision-maker knows the possible events, but not their probabilities or the associated costs and benefits. Under what circumstances will the precautionary option make sense? It depends on the decision-maker's degree of risk aversion and beliefs about the efficacy of precautionary measures. Assume that she is so risk averse that she cares only about the worst possible outcomes of the precautionary and reactive policies: she will choose whichever policy minimises the maximum possible total cost. For the precautionary option of reducing current greenhouse emissions to minimise the maximium possible cost, she must believe that the worst of the possible outcomes of precautionary policy, E_3, will cost less than the worst of the possible outcomes of reactive policy, E_5. Yet precautionary policy involves the additional costs of current precautionary measures. Thus, if there is a perceived slight chance that precautionary policy may be ineffective, an extremely risk-averse decision-maker may choose reactive policy. A less risk-averse decision-maker will also give some weight to the other possible events and their costs and benefits. He is willing to accept a perceived low chance of the high costs of ineffective precautionary policy in return for a perceived higher chance of effective policy which avoids the high costs of global warming: he will prefer precautionary policy.

Policy choices will depend on decision-makers' perceptions of the probabilities and consequences of global warming. A decision-maker who is pessimistic about climate change and its consequences, but optimistic about the effectiveness of precautionary emissions reductions, is likely to choose precautionary policy. Conversely, a decision-maker who is optimistic about climate change, but pessimistic about the effectiveness of emissions reductions, will prefer reactive policy. The greater the degree of radical uncertainty, the smaller is the scientific and economic basis for the precautionary-reactive policy choice, and the greater must be the reliance on the preferences and subjective judgement of the person responsible for the choice. This is not a concern when the chooser also bears all or most of the important consequences of the choice; an individual contemplating risky heart surgery has strong incentives to consider all the possible outcomes of both the precautionary and reactive options. However, the subjectivity of decisions made under radical uncertainty increases the degree of discretion enjoyed by political and bureaucratic environmental planners, who do not personally bear all the consequences of their decisions. Because current citizen-voters will have extraordinary difficulty in establishing the possible long-term consequences of precautionary-reactive policy choices, politicians and bureaucrats will have more than their usual scope for pursuing personal goals inconsistent with democratic preferences.

A Democratic Bias towards Precautionary Policy?

Aaron Wildavsky (1988:223-7) argues that planning in Western democracies is biased towards precautionary policies. The possible disasters that we recognise loom much larger in our imaginations than disasters that we cannot imagine or the everyday harms to which we have grown accustomed. It is reported that lay persons overestimate the probabilities of events that are widely publicised and thus easily

imagined, such as nuclear accidents and dramatic climate changes due to greenhouse warming; conversely, the probabilities of unspectacular and rarely-reported events such as strokes and domestic accidents are underestimated (Slovic et al., 1990). This leads to demands for precautionary policies to avert the recognisable disasters, with inadequate recognition that those policies may reduce society's ability to respond to the unforeseen and to reduce the incidence of the mundane. In the case of greenhouse, many people may perceive the possibility of serious and irreversible damage due to climate changes and rises in sea level, and demand emissions reductions as a result. They are less likely to recognise that the resulting reduction in community income and wealth can reduce expenditures on other ways of saving people's lives and property, and on the research and development which equips society to handle the unforeseen. For example, the search for a cure for the unforeseen disaster of AIDS is underpinned by research in molecular biology, which occurred before AIDS revealed itself.

When a politician or a public servant is making a decision on environmental policy, most citizens' information gathering and signalling will be influenced by free-rider logic: since we do not expect our vote to make any difference to the planner's decision, there is little incentive to collect information beyond that which is to hand, and a considerable likelihood that votes will express beliefs rather than judgments based on facts. Since the public is likely to be more aware of the possible costs of not acting on greenhouse than of the costs of acting and getting it wrong, environmental planners' self-interest encourages them to act now. It takes a strong politician or bureaucrat, dependent on the public's votes and its tax dollars, to resist demands to 'do something' by way of precautionary action in response to well-publicised environmental dangers.

Harding and Fisher (1994), advocates of the precautionary principle, are also concerned about the self-interest of environmental planners. They fear that, left to the usual policy participants, adoption of a precautionary approach to environmental policy will make little difference to environmental management in practice; the precautionary approach 'requires no changes to environmental practice and decision-making since we are already operating precautiously' (1994:259).

There is evidence that the implementation of precautionary policy is not immune to planners' self-interest. In Germany, where the precautionary principle originated, it commonly involves the development and promotion of cleaner technologies through the adoption of 'best available technology not entailing excessive costs' (BATNEEC). Boehmer-Christiansen (1994:50-2) attributes Germany's technology-led precautionary policy to the dominance of the German advisory and legal processes by the engineering profession rather than by natural scientists.

The Roles of Experts and Citizens

Recall that some advocates of the precautionary principle see environmental problems as, in part, socially constructed (Hunt, 1994; Harding & Fisher, 1994). For these critics of the present approach to environmental problems, part of the solution lies in opening up the decision-making process to hitherto underrepresented

stakeholders. This raises the difficult question of the respective roles of scientific experts and citizens in the process of determining environmental policies and standards of proof. Remember that people are likely to pay more attention to the spectacular than to the mundane. Further, the costs of stress based on people's fears of unknown and unfavourable outcomes, stress which occurs whether or not such outcomes eventuate, may be substantial.[1] Faced with such fears and stresses related to our use of the natural environment, how much weight does a planner attach to expert opinion, and how much to citizens' perceptions?

Politically sensitive environmental planning requires two-way communication between the judgments of experts (meteorologists, biologists, economists, and the like) and the concerns and values of affected citizens. This emphatically does not mean downgrading rigorous science, but rather more systematic assessments of the limitations of science in the face of radical uncertainty. The new field of 'risk communication' emphasises the need to communicate what is 'culturally rational', in terms of fitting in with acceptable standards of morality, decency and due process, as well as what is 'technically rational' as perceived by technical experts (Plough & Krimsky, 1990).

Concluding Comments

The precautionary principle developed in response to uncertainty about the consequences of environmental changes. However, if the degree of uncertainty about the outcomes of precautionary policy is the same as for the outcomes of reactive policy, it is possible that a risk-averse society could make matters worse by such 'blind' adoption of precautionary policy. Its successful application actually requires considerable 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.

The regional or global environmental problems where the precautionary approach is particularly appealing because of perceived threats to human life support, such as greenhouse warming and tropical deforestation, involve large and complex economic-environmental systems where the consequences of environmental change extend far into the future. The functioning of these systems is subject to so much scientific and behavioural uncertainty that the effectiveness of precautionary policies is uncertain. Unfortunately, precautionary policy is likely to be more effective where decision-makers are less in need of guidance, such as in the case of less complex and relatively well understood economic-environmental systems.

Given radical uncertainty about economic-environmental systems, democratic choices between precautionary and reactive environmental policies must take account of both expert knowledge and citizen perceptions. Improved communication about technical and cultural concepts of 'risk' is a prerequisite for any serious at-

[1] For a discussion of concern about the outcomes of technologies which pose hazards for people, see Fischoff et al. (1990).

tempt to implement precautionary policies. In an age of environmental disaster scenarios, perhaps we need an independent body analogous to the Productivity Commission to facilitate honest communication between the parties.

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