Consilience

SCHOLARLY ARTICLE

Reducing Uncertainty:
The Need to Clarify the Key Elements of the Precautionary Principle

Aaron Holdway[1]

Abstract:

In the past two decades, the precautionary principle has appeared ever more widely in national and international law and policy concerned with the environment and public health. A general lack of clarity in these policy instruments about how the precautionary principle should be operationalized, however, has undermined the principle's potential as a valuable tool for public policy-makers and decision-makers. This paper builds on the existing literature on the precautionary principle by identifying four key elements that require particular attention if the precautionary principle is to be effectively operationalized. Key considerations for policy-makers are outlined for each of these elements. The paper situates these ideas in the context of the overlapping spheres of science and politics, addressing common misunderstandings about the relationship between expert knowledge and public value choices.

[1] *Aaron Holdway graduated from Queen's University in 2003 with a degree in Chemistry and is currently studying at the Oxford University Centre for the Environment. He can be contacted at aaron.holdway@ouce.ox.ac.uk*

Introduction:

Western society in the last century has seen extraordinary gains in health and standard of living, but these advances have not come without a price. Technological innovations such as DDT, CFCs, PCBs, and asbestos, to name just a few, have caused disastrous consequences for the environment and human health, yet all were given a clean bill of health by the best science of the day. Uncertainty about the magnitude or possible causes of such harm has frequently been used as a reason to postpone decisions to protect against it. The precautionary principle – broadly stated, the idea that where possible risks to the environment and public health have been identified, action should be taken instead of waiting for conclusive evidence of a causal relationship – emerged from a recognition that clear evidence of threats cannot always be obtained before damage occurs. It is often necessary to make decisions in the face of persistent uncertainty and ignorance. Although the precautionary princple has been endorsed in a wide variety of international treaties and increasingly incorporated in health and environmental legislation in many countries, there is a lack of common understanding of what precisely the precautionary principle means in practice. Numerous definitions exist, many of them differing substantively in key elements such as the level of threat required to invoke the principle, the level of evidence required to *avoid* the invocation of the principle (and who bears the burden of proof), the range of precautionary actions that should be considered, and with what force precautionary measures should be applied. Clarifying and elaborating these elements also requires a clear understanding of the roles of science and politics in policy-making and decision-making in instances of scientific uncertainty and ignorance. With the precautionary principle becoming an increasingly important part of national and international environmental law and policy, it is important that future formulations of the precautionary principle provide the above content.

Origin and Increasing Importance of the Precautionary Principle:

The precautionary principle has its conceptual origins in a rejection of the assumptions of the "assimilative capacity approach" to environmental policy[2] – that is, it represents a shift of focus away from trying to determine the level of pollution that the environment can assimilate to a policy of reducing or eliminating the input of pollutants. Failures of this approach, where scientific proof of the harmful effects of activities or substances was inadequate or untimely, led to a shift in emphasis in favour of caution and environmental protection.[3] The precautionary principle thus counters the traditional presumption that activities should proceed unless and until they are proven to be harmful, recognizing that delaying action until this point will often mean that it is too expensive, and perhaps impossible, to avert the threat. The precautionary principle also comes from a recognition that while in the past human actions could generally only have effects over small areas and timescales, new technologies make it possible to harm vast areas and humanity as a whole, including future generations.[4] The principle is not a substitute for a scientific approach but is instead a supplement to aid in policy- and decision-making when scientific knowledge is lacking.

---

[2] McIntyre & Mosedale
[3] Cameron & Abouchar
[4] Andorno

In law and policy, the origin of the precautionary principle is generally traced to the concept of *Vorsorgeprinzip* – literally "principle of advance caring"[5] – in German environmental law in the early 1970s.[6] *Vorsorgeprinzip* states that environmental policy requires a cautionary approach[7] and was introduced to provide a decision-making tool for environmental risk managers.[8] The principle "implied a reversal of the burden of proof from the proponents of the hypothesis of a causal link between a particular activity and harmful effects, to the promoters of the said activity."[9] The precautionary principle was then adopted by other European countries such as Denmark, Sweden, and France, and was extended from environmental matters to also cover issues of public health.[10] The precautionary principle also began to be enshrined in a number of international treaties and policy documents. The first of these was the 1982 UN World Charter for Nature,[11] which stated that "Activities which are likely to pose a significant risk to nature shall be preceded by an exhaustive examination . . . and where potential adverse effects are not fully understood, the activities should not proceed."

The first appearance of the precautionary principle in international law was as a result of German proposals made at the Second International Conference on the Protection of the North Sea, in 1987.[12] The Ministerial Declaration from this conference (the London Declaration) stated that "in order to protect the North Sea from possibly damaging effects of the most dangerous substances, a precautionary approach is necessary which may require action to control inputs of such substances even before a causal link has been established by absolutely clear scientific evidence." It was at the UN Conference on Environment and Development in Rio de Janeiro in 1992, however, that the precautionary principle achieved universal recognition. The two treaties signed at the summit – the Convention on Biological Diversity (CBD) and the UN Framework Convention on Climate Change (UNFCCC) – both included the precautionary principle (though in the CBD, not by name). Principle 15 of the Rio Declaration on Environment and Development (Rio Declaration) declared that "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." Mention of the precautionary principle has also occurred in international agreements related to human health, such as the 1994 World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), which deals with food safety and animal and plant health measures, and the CBD's Cartagena Protocol on Biosafety (2000), which regulates the international movement of genetically-modified organisms. In some cases, parties to agreements that were enacted prior to the establishment of the precautionary principle have endorsed a version of the principle, as was the case with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1994.[13] In total, Trouwborst reports that references have been made to the precautionary principle in more than fifty legally-binding

[5] Petrini & Vecchia
[6] Sunstein
[7] Kheifets, Hester, & Banerjee
[8] Hathcock
[9] Henry & Henry
[10] Andorno
[11] Commission of the European Communities (CEC), p. 11
[12] Freestone & Hey, 1996a, p. 4
[13] Dickson, p. 276

international instruments[14] – that is, in virtually every recently adopted treaty in environmental and public health protection [15,16] – and has thus become a norm of international law.[17,18]

The precautionary principle has also been important at the national level in a number of countries and in the European Union. The founding documents of the EU, the Treaties of Maastricht (1992) and Amsterdam (1997), both make the precautionary principle one of the main criteria for environmental and health policies. The former treaty states that EU environmental policy "shall be based on the precautionary principle." At the national level, the precautionary principle has been included either explicitly or implicitly in the national environmental legislation of a number of countries in addition to those mentioned above, including Argentina, Australia, Canada, Costa Rica, the Netherlands, New Zealand, Norway, South Africa, Switzerland, and the United Kingdom.[19,20,21]

The Problematic Lack of Clarity:

Despite its widespread use, most present formulations of the precautionary principle require a considerable degree of interpretation by decision-makers. As Adams notes, "The precautionary principle is often invoked as if there is common understanding of the term."[22] The Treaties of Maastricht and Amsterdam, for example, cite the precautionary principle as a cornerstone of European environmental policy but do not define the term or provide any guidelines on its application. Those documents that do define the precautionary principle use widely differing formulations. The lack of a clear, widely agreed-upon, operational definition of the precautionary principle undermines the principle's intended purpose, allowing, for example, the adoption of disguised trade restriction practices meant to protect a country's commercial interests rather than its environmental or public health interests. Newton and Oldfield conclude that, under the status quo, "users of the precautionary principle appear to interpret it to further their own aims."[23]

Some commentators have made suggestions on how formulations of the precautionary principle can be improved, including Hickey and Walker;[24] Stirling;[25] Raffensperger and Barrett;[26] Harremoës, Gee, MacGarvin, Stirling, Keys, Wynne, et al.;[27] and Cooney and Dickson.[28] Common items in such guidance include: transparency and accountability in the decision-making process; fairness in considering the distributional impacts of the social and economic costs and benefits; proportionality to the potential threats and the desired level of protection; involving a

[14] Trouwborst, pp. 303-327
[15] Andorno
[16] Freestone & Hey, 1996a, p. 3
[17] McIntyre & Mosedale
[18] CEC, p. 11
[19] Cooney & Dickson
[20] Cameron & Abouchar
[21] Kheifets, et al.
[22] Adams
[23] Newton & Oldfield, p. 36
[24] Hickey & Walker
[25] Stirling
[26] Raffensperger & Barrett
[27] Harremoës, Gee, MacGarvin, Stirling, Keys, Wynne, et al.
[28] Cooney & Dickson

wide range of stakeholders; and subjecting decisions to monitoring and regular review to assess the understanding of the threat and the effectiveness of the precautionary measures employed. Such statements of guidance often recommend the use of tools like risk assessment (to the extent possible), cost-benefit analysis, and multi-criteria analysis, and the employment of clean production methods, best available technology, and best environmental practices. These examples cite important principles for policy-making and decision-making in general, but they largely overlook the need for guidance on the key elements outlined in this paper: level of threat, level of evidence, range of actions, and level of force.

Such guidance rarely appears to be taken up in subsequent formulations of the precautionary principle. Nonetheless, some policy instruments have begun to take steps in this direction, providing more comprehensive outlines of the intentions of the precautionary principle and guidance on how to implement it. The 1995 UN Fish Stocks Agreement, for example, lists specific steps that states should take to ensure precautionary fisheries policies are applied.[29] Similarly, the UN Food and Agriculture Organization's 1995 "Guidelines on the Precautionary Approach to Capture Fisheries and Species Introductions" provide guidance on a broad range of issues related to monitoring, research, and evaluation of new technologies.[30] In a broader policy context, the European Commission's 2000 *Communication on the Precautionary Principle* outlines five principles to guide implementation of the precautionary principle, including consistency and examination of scientific developments.[31] Like the guidance suggested by commentators above, however, these policy instruments still do not address most of the key elements required for effective implementation of the precautionary principle and could be significantly improved by explicitly addressing the four key elements outlined in this paper.

Clarifying the Main Elements:

The difficulties of applying the precautionary principle in complex situations are heightened in many ways by a lack of agreement on the meanings of key elements and terms. This has meant that in practice, "there is considerable lack of clarity about what it actually means to apply the precautionary principle or take precautionary measures."[32] Tucker and Treweek have shown, for example, how different understandings of the principle can lead decision-makers to different conclusions about how to respond to particular development proposals.[33] Sant points out that a lack of shared understanding of what the precautionary principle means in the context of Australian fisheries has contributed to the lack of impact of despite the presence of longstanding precautionary obligations.[34] As Underwood notes, "Given that decision-making must always be done in a context of poor information, conflicting goals, uncertain consequences and political pressure," it needs to be made clear "what makes it appropriate to use a precautionary principle."[35]

To begin the analysis, it is important to define a few key terms.

---

[29] As cited in Freestone & Hey, 1996a
[30] As cited in Cooney
[31] CEC
[32] Cooney, p. 6
[33] As cited in Cooney & Dickson, p. 289
[34] As cited in Cooney & Dickson, p. 289
[35] Underwood

The precautionary principle is often said to be a tool for dealing with uncertainty in scientific knowledge, but "uncertainty" should properly be differentiated into three different epistemic situations: risk, uncertainty, and ignorance. Risk, as formally defined in probability theory, is where all possible outcomes are known in advance and can be assigned probabilistic values. Uncertainty is where outcomes are relatively clear but adequate evidence for assigning probabilities does not exist. Ignorance is where not only the likelihoods of various outcomes are unknown, but where some of the possible outcomes themselves are unknown.[36],[37] In cases where risk prevails, decision-makers can use risk assessment to prevent environmental damage and protect human health. In cases of uncertainty and ignorance, however, conventional risk assessment is too narrow in scope to provide adequate guidance to decision-makers and the precautionary principle is needed.

Much of the misunderstanding surrounding the precautionary principle concerns the distinction between prevention and precaution.[38] Prevention is used in cases of risk; precaution is used in cases of potential risk – that is, uncertainty and ignorance. For example, a 1991 study by the Organisation for Economic Co-operation and Development (OECD) on the precautionary principle notes that "some would like to see [the principle] applied to any substance liable to cause pollution, while others consider that it should be applied only to substances that have adverse effects, or to substances whose emissions actually do create a pollution risk."[39] In cases where a substance is likely to cause pollution or is known to have adverse effects, however, purely preventive measures can be taken, as the situation is one of risk. The precautionary principle is a framework for managing situations of uncertainty and ignorance. It goes beyond prevention by urging policy-makers and decision-makers to anticipate problems before they occur and to act instead of waiting for scientific proof of harm. These distinctions are not always acknowledged, rarely defined, and sometimes not even properly understood in formulations of the precautionary principle.

With a proper understanding of the above terms, we then need to discern the key elements of the precautionary principle and determine what they mean. From the wide variety of existing statements of the precautionary principle, we can identify four key elements that will require elaboration: the level of threat that warrants action, the level of evidence required to avoid taking precautionary action, the range of actions that are to be taken, and the level of force required of the actions. Using these four elements, we can demonstrate the shortcomings of existing definitions and the need for more clarity and specific criteria for putting the precautionary principle into action. Let us consider the four elements in turn.

1. *Level of threat*

Virtually every new development in technology creates some risk in the pursuit of benefits. Decision-makers, then, need to know what constitutes a threat requiring action under the precautionary principle. Some statements of the precautionary principle may appear to give some guidance on what constitutes an "actionable" threat. The Rio Declaration and Australia's Intergovernmental Agreement on the Environment (IGAE) of 1992, for

[36] Gardiner
[37] Wynne
[38] Andorno
[39] As cited in Cameron, p. 37

example, both refer to "threats of serious or irreversible damage" – but what does this mean? The notion of "seriousness" is clearly subjective: "one person's 'unacceptable consequence' is another person's 'regrettable necessity.'"[40] Is irreversibility to be understood in the physicist's sense, such that "all change (and hence all damage) is irreversible in the strict sense that the precise structure of the world that pertained before cannot once again come into being"?[41] It may seem pedantic to make such a point, but the interpretation of irreversibility has practical implications. For example, decision-makers considering whether to approve the construction of a dam that would kill a river's trout may legitimately wonder whether this situation would be considered irreversible if the dam could later be removed and the river restocked with non-native trout.

Other statements of the precautionary principle are even less specific about what level of threat requires precautionary action. For instance, the widely-publicized Wingspread Statement from a 1998 conference sponsored by the US-based Science and Environmental Health Network refers simply to "threats of harm," and the SPS Agreement does not specify a threat at all: "In cases where relevant scientific evidence is insufficient, a Member may provisionally adopt sanitary or phytosanitary measures . . ."

In addition, it should be made clear whether a certain level of scientific evidence of possible harm is required before decision-makers can order that precautionary measures be taken. Stated another way, what level of scientific uncertainty must be demonstrated in order to trigger the principle? A number of possible "levels of proof" can be imagined, ranging from the "reasonable grounds for concern" in the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR Convention) and the European Commission's *Communication*, to the "beyond reasonable doubt" of criminal law. In short, for the precautionary principle to be effectively operationalized, the vagueness surrounding what constitutes a threat requiring action, as well as what level of evidence must be provided before action is taken, must be clarified. Without these clarifications, the precautionary principle is susceptible to abuse, to being used as a cover for making decisions based on other factors, such as using it as a pretext for the adoption of protectionist measures.

2. *Level of evidence required to prove safety*

Clarification and elaboration is also required on the level of evidence required to *avoid* the invocation of the precautionary principle. Many definitions are vague about how much certainty must be demonstrated regarding a product or activity's safety. For example, the UN World Charter for Nature refers to cases where threats are "not fully understood," and the SPS Agreement refers to cases where scientific evidence is "insufficient." Does this mean that industrialists or potential polluters must show that their product or process is safe with complete certainty ("zero risk"), or beyond a shadow of a doubt, or beyond a reasonable doubt, or beyond the balance of probabilities, or some other measure? Definitions like the Rio Declaration, which refer to "lack of *full scientific certainty*" (emphasis added), overlook the fact that it is impossible to prove the "absence of harm."[42] If it is acknowledged that the

[40] Freestone & Hey, 1996b, p. 250
[41] Manson
[42] Turvey & Mojduszka

standard should be "one of weight of evidence rather than of absolute proof,"[43] it should be made clear which of the above degrees of evidence is required.

Equally important is the lack of clarity in many statements of the precautionary principle on who bears the burden of proof. (Turvey & Mojduszka, in fact, say that "the principle is about the burden of proof."[44]) Traditional legal standards require that public regulators provide scientific evidence of harm before restricting the sale of a product or use of a technology. Formulations such as the Wingspread Statement and the Earth Charter, however, explicitly propose to reverse the burden of proof between society and technological innovators, asserting, respectively, that "the proponent of the activity, rather than the public, should bear the burden of proof" and "Place the burden of proof on those who argue that a proposed activity will not cause significant harm." The European Commission's *Communication* also endorses shifting the burden of proof in certain cases, such as approval of products like drugs, food additives, and pesticides before they are placed on the market, and substances "deemed 'a priori' hazardous."[45] Reversing the burden of proof redresses the situation where "the 'perpetrators' of adverse impacts from new technologies often escape accountability, because such impacts are hard to prove and the burden of proof is on those who suffer."[46] But the requirement to establish safety with complete certainty, besides being technically impossible, as already noted, will dramatically increase costs for proponents of new technologies and could indefinitely delay, or indeed make impossible, advances that could be of great benefit to society. Yet it is possible to *divide* the burden of proof – even if this still rests much more heavily with the innovator than with society. This may reduce the "impossible burden"[47] placed on proponents of technology while at the same time still making them play a more active role in assessing the potential risks of their proposed products or actions.[48] Statements of the precautionary principle should thus include guidance on how the burden of proof is to be distributed and what in particular those with the burden of proof must demonstrate.

3. *Actions to be taken*

Similarly vague in most statements of the precautionary principle are the types of actions that constitute precautionary measures and guidance on which actions should be taken if the evidentiary threshold is met. One can imagine a wide variety of possible actions that could (or should) be taken to address the possible harmful effects of a given product or activity. In approximate increasing order of severity, these include: doing nothing; merely considering action; performing further research to improve understanding; in the case of a product, performing pre-market testing; warning people of the possible harm caused by the product or activity (in the case of products, this could include labelling); monitoring the product or activity to look for evidence of the possible harm; taking measures to reduce the impact of the possible harm (for example, by preventing exposure to it); placing strict regulation on the product or activity; placing a moratorium on the product or activity; phasing out the product or

[43] Kheifets, et al.
[44] Turvey & Mojduszka
[45] CEC, p. 21
[46] Van den Belt & Gremmen
[47] Hathcock
[48] Andorno

activity; and placing an outright ban on the product or activity. (Of course, more than one of these actions may be employed in a given situation, either simultaneously or in succession.) Yet most statements of the precautionary principle do not help decision-makers understand which range of options to employ.

For example, we see references to "preventive measures" (for instance, in the Convention on the Protection of the Marine Environment of the Baltic Sea Area) and "cost-effective measures" (Rio Declaration) but are not given any guidance on what exactly these phrases mean in practice. Few versions of the precautionary principle explicitly mention cost-effectiveness (the Rio Declaration and the UNFCCC are two examples). If this is to be included, further guidance would be helpful. If the employment of "cost-effective actions" is taken to mean "adoption of the least costly action among alternatives that are equally effective at reducing harm,"[49] it remains unclear what should be done in cases where effectiveness differs. For example, what if one option is highly effective at reducing harm but is also very expensive and another option is less effective but also less expensive? Should highly effective options be preferred over less effective ones, regardless of the difference in cost? If not, it should be made clear how effective actions must be in order to be considered. Other versions of the precautionary principle are slightly more specific, saying that if a threat of harm is sufficiently uncertain, "the activities should not proceed" (UN World Charter for Nature) or one should "stop it [here, the worst case scenario, from] taking place" (First European Seas at Risk Conference). Yet even here, it is not clear whether decision-makers should adopt a permanent ban on the given product or activity or instead a moratorium, whether such measures could be overturned in the future, and what criteria would need to be met to bring about such a change.

4. *Level of force*

The final element of the precautionary principle that requires clarification is with what force precautionary measures should be applied. One can imagine a range of possibilities, from making action mandatory to merely making it permissible. Some formulations of the precautionary principle give some guidance on this. The SPS Agreement, for example, makes some action mandatory by saying that "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" (emphasis added). The UN World Charter for Nature makes a strong suggestion in saying that "activities *should not* proceed," while the Wingspread Statement makes a softer suggestion in saying that "precautionary measures *should* be taken" (emphasis added in each case). Weaker still, the London Declaration says that certain threats "may require action" – that is, that action should merely be considered. The Final Declaration of the First European "Seas at Risk" Conference says that if the possible harm of an activity is great, "even a small amount of doubt as to the safety of that activity *is sufficient* to stop it taking place" (emphasis added). So we see a variety of levels of force, from making action mandatory, to strongly suggesting action, to merely suggesting action, to merely considering action, to merely permitting action. Many versions of the precautionary principle provide even less guidance. The Bamako Convention (1991) on hazardous waste, for example, only urges parties to "strive to adopt and implement the preventive, precautionary approach." As mentioned above, the level of obligation may be clouded by making references to "economic considerations"

[49] Kheifets, et al.

(Montreal Protocol on Substances that Deplete the Ozone Layer, 1987), "cost-effective measures" (Rio Declaration), "different socio-economic contexts" (Second World Climate Conference, 1990), and application by states "according to their capabilities" (Rio Declaration). It would be helpful, then, if formulations of the precautionary principle made it clear whether action under specific circumstances is mandatory, merely permitted, or something in between.

* * *

It is no longer acceptable simply to express a vague desire to avoid pollution; further platitudinal statements of the precautionary principle will not protect the environment. Now that it has become widely accepted to include the precautionary principle in international agreements, the next step must be to strengthen and clarify the key elements and key terms according to the considerations outlined above.

The Roles of Science and Politics:

If the precautionary principle is to be effectively implemented, it is also important that its proper place in the overlapping spheres of science and politics be understood, particularly the extent to which science can and should drive decision-making and the roles of public officials in considering how to act based on the best science available to them. Indeed, the relationship between the expert knowledge of scientists and the value choices of public officials is at the very heart of the precautionary principle. It is thus important to address a few key points on the roles of science and politics in applying the precautionary principle – points that some definitions and commentators overlook or seem to misunderstand.

First, recognizing the limitations of scientific knowledge, particularly regarding "certainty" and ignorance, is crucial in understanding and effectively implementing the precautionary principle. Society's increasing inclusion of the precautionary principle in national and international law and policy is a response to a recognition that science's "growing innovative powers were increasingly outrunning its capacity to anticipate the consequences."[50] This was coupled with a reluctance of the scientific community to acknowledge this waning ability to predict the impact of its actions. Harremoës et al. note that within the scientific community, it is accepted that scientific "proof" is always provisional.[51] Yet externally it has sometimes been the case that science has been asked to provide the policy process with straight-forward answers and certainty. As mentioned above, however, science cannot provide certainty. Definitions that point to a "lack of full scientific certainty" (for example, the Rio Declaration and the IGAE definition) imply that there are environmental issues for which full scientific certainty exists. As Karl Popper has argued, ultimate truth is unknowable; uncertainty is always with us,[52] and perhaps nowhere more so than the environment. Scientists, policy-makers, and decision-makers must recognize that uncertainty will always be part of environmental policy-making and decision-making and must therefore ensure, via the precautionary principle, that it receives due consideration in these processes. Another acknowledgement that needs to be made is the importance of ignorance. Balzano and Sheppard, for instance, state that "acting on speculative ideas about the existence of risk

[50] Harremoës et al., p. 209
[51] Harremoës et al.
[52] As cited in MacGarvin, 1999a, p. 36

divorced from risk assessment is only guessing and likely to be in error."[53] This overlooks that the greatest contamination problems in the past half century – for example, DDT, PCBs, and CFCs – were created out of ignorance, not uncertainty.[54] Originally declared safe by the science of the day, these chemicals had already created significant damage by the time uncertainties began to emerge. In cases of ignorance, when so many variables cannot be identified let alone quantified, it is irrational to argue for a quantitative risk assessment. To try to overcome these difficulties, the scientific community needs more humility and less hubris, and must focus on ignorance as well as uncertainty.

Second, the nature of the contribution of science to policy-making and decision-making must also be properly understood. A number of commentators in the scientific community have criticized existing definitions of the precautionary principle for marginalizing the role of science (for example, Gray & Bewers[55]). The perception is that the precautionary principle "fails to pay enough respect to science"[56] and even threatens[57] the role of science in policy-making and decision-making by "invoking unsubstantiated perceptions as a basis for action instead of scientific methods."[58] Gray even says that use of the precautionary principle is "entirely an administrative and legislative matter and has nothing to do with science."[59] On the contrary, the precautionary principle is not "anti-science"; it depends very much on science. Yet, it has to do with "the rejection of reductionist, closed, arbitrarily narrow science in favour of sounder, more rigorous and more robust science,"[60] incorporating uncertainty and ignorance into the decision-making framework. The controversy arises because science cannot always provide the insights needed to effectively protect the environment, leaving decisions on environmental management to public officials. Science is thus a tool for policy-makers and decision-makers. It is an essential, but not sufficient, condition for the management of potential environmental risks.[61] Science only provides one part of the basis for employing precautionary measures. In this way, "Science should be on tap, not on top."[62] Furthermore, science is not as objective as is sometimes supposed. As Thomas Kuhn, another important thinker on the nature of science, has argued, "facts" are influenced greatly by our worldview and the observations we choose to make, and the questions we ask (and do not ask) and the theories we construct reflect our prior experiences and the values we hold.[63] Science, in short, is a social construct. It makes an important contribution to policy-making and decision-making, but it cannot be the only basis.

Third, following from the above, the decision whether or not to adopt the precautionary principle is a value judgement, to be made by public officials. It is politicians who must decide what level of risk is "acceptable" to society, what trade-offs society is willing to make, and how different interests should be balanced. (The European

---

[53] Balzano & Sheppard
[54] MacGarvin, 1999b, p. 229
[55] Gray & Bewers
[56] Sandin, Peterson, Hansson, Rudén, & Juthe
[57] Santillo, Stringer, Johnston, & Tickner
[58] Gray & Bewers
[59] Gray
[60] Harremoës et al., p. 210
[61] Stirling, p. 92
[62] Stirling, p. 92, quoting Winston Churchill
[63] As cited in MacGarvin, 1999a, p. 37

Commission *Communication* refers to this as "an eminently political responsibility."[64]) One commentator misses the point: "Unless amended, the precautionary principle leads to a subjective form of risk assessment . . ."[65] In situations of uncertainty and ignorance, where the level of information that science can provide is limited and a clear technical resolution is thus not to be found, decisions about how to act are particularly laden with value judgements and subjective assumptions. Decisions about which risks to assess and which to ignore, how to assess harm, and even what constitutes a harmful impact are all value-based judgments. If society has to share the potential burden of harmful impacts, then policy-makers and decision-makers need to consider the possible social and ethical implications of their actions. Formulations of the precautionary principle should provide more guidance, according to the four key elements described above, to help policy-makers and decision-makers implement the principle effectively.

* * *

With the precautionary principle appearing ever more widely in national and international law and policy, it is increasingly important that a shared understanding of the principle be developed and that practical guidance is added to future formulations of the principle to aid decision-makers in its implementation. The inclusion of the precautionary principle in so many national and international policy contexts affirms the need for a framework to address uncertainty and ignorance in scientific knowledge. Yet, the wide variety of existing definitions is attended by an even greater variety of interpretations. This has made application of the principle largely an *ad hoc* affair and undermines its effectiveness as a tool for protecting the environment and public health.

Yet despite the problems with existing articulations, this paper has demonstrated that a truly useful elaboration of the precautionary principle is within reach, and its attainment should be a priority of decision-makers and the citizens they serve. Those who draft future agreements that cite the precautionary principle should ensure that their formulations clearly address the four key elements outlined in this paper: the level of threat that triggers precautionary action, the level of evidence required to avoid invocation of the precautionary principle, the range of possible precautionary measures, and the level of force with which precautionary measures should be applied. Likewise, parties to existing agreements should call for current formulations of the precautionary principle to be amended accordingly. International agreements often reach the lowest common denominator and end up with imprecise formulations of the principle. But if it is agreed, as has generally been the case, that the precautionary principle is an important tool in protecting the environment and public health, the principle should be allowed to be truly effective by ensuring that formulations clearly state how the principle is to be implemented. The precise form each articulation of the principle takes will depend on the context of the respective agreement, but formulations that explicitly address the level of threat, level of evidence, range of actions, and level of force as described herein offer a better prospect of effective operationalization. As technology moves us continually faster from the realm of human experience, the challenge remains to implement the precautionary principle with the strength of its original vision.

[64] CEC, p. 4
[65] Balzano & Sheppard

Doing so will require a continual re-examination of the most basic concepts of environmental management policy and the relationships between science, technology, politics, law, and moral norms.

References

N.B. Textual references to the precautionary principle in all international agreements cited above are listed in Trouwborst, 2002. The agreements, therefore, are not individually listed below.

Adams, M. D. (2002). The precautionary principle and the rhetoric behind it. *Journal of Risk Research*, *5*(4), 301-316.

Andorno, R. (2004). The precautionary principle: A new legal standard for a technological age. *Journal of International Biotechnology Law*, *1*, 11-19.

Balzano, Q., & Sheppard, A. R. (2002). The influence of the precautionary principle on science-based decision-making: Questionable applications to risks of radiofrequency fields. *Journal of Risk Research*, *5*(4), 351-369.

Cameron, J. (1999). The precautionary principle: Core meaning, constitutional framework and procedures for implementation. In R. Harding & E. Fisher (Eds.), *Perspectives on the precautionary principle* (pp. 29-58). Sydney: Federation Press.

Cameron, J., & Abouchar, J. (1991). The precautionary principle: A fundamental principle of law and policy for the protection of the global environment. *Boston College International and Comparative Law Review*, *14*, 1-27.

Commission of the European Communities. (2000). *Communication from the Commission on the precautionary principle*. Retrieved December 10, 2007, from http://ec.europa.eu/dgs/health_consumer/library/pub/pub07_en.pdf.

Cooney, R. (2005). From promise to practicalities: The precautionary principle in biodiversity conservation and sustainable use. In R. Cooney & B. Dickson (Eds.), *Biodiversity and the precautionary principle: Risk and uncertainty in conservation and sustainable use* (pp. 3-17). London: Earthscan.

Cooney, R., & Dickson, B. (2005). Precautionary principle, precautionary practice: Lessons and insights. In R. Cooney & B. Dickson (Eds.), *Biodiversity and the precautionary principle: Risk and uncertainty in conservation and sustainable use* (pp. 287-298). London: Earthscan.

Dickson, B. (2005). Fairness and the costs and benefits of precautionary action. In R. Cooney & B. Dickson (Eds.), *Biodiversity and the precautionary principle: Risk and uncertainty in conservation and sustainable use* (pp. 275-284). London: Earthscan.

Freestone, D., & Hey, E. (1996a). Origins and development of the precautionary principle. In D. Freestone & E. Hey (Eds.), *The precautionary principle and international law: The challenge of implementation* (pp. 3-15). The Hague: Kluwer Law International.

Freestone, D., & Hey, E. (1996b). Implementing the precautionary principle: Challenges and opportunities. In D. Freestone & E. Hey (Eds.), *The precautionary principle and international law: The challenge of implementation* (pp. 249-268). The Hague: Kluwer Law International.

Gardiner, S. M. (2006). A core precautionary principle. *Journal of Political Philosophy*, *14*(1), 33-60.

Gray, J. S. (1990). Statistics and the precautionary principle. *Marine Pollution Bulletin*, *21*(4), 174-176.

Gray, J. S., & Bewers, J. M. (1996). Towards a scientific definition of the precautionary principle. *Marine Pollution Bulletin*, *32*(11), 768-771.

Harremoës, P., Gee, D., MacGarvin, M., Stirling, A., Keys, J., Wynne, B., et al. (Eds.). (2002). *The precautionary principle in the 20th century: Late lessons from early warnings*. London: Earthscan Publications.

Hathcock, J. N. (2000). The precautionary principle: An impossible burden of proof for new products. *AgBioForum*, *3*(4), 255-258.

Henry, C., & Henry, M. (2002). *Formalization and applications of the precautionary principle* (Discussion Paper 0102-22, Department of Economics, Columbia University). Retrieved December 10, 2007, from http://www.columbia.edu/cu/economics/discpapr/DP0102-22.pdf.

Hickey, J. E., Jr., & Walker, V. R. (1995). Refining the precautionary principle in international environmental law. *Virginia Environmental Law Journal*, *14*, 423-454.

Kheifets, L. I., Hester, G. L., & Banerjee, G. L. (2000). The precautionary principle and EMF: Implementation and evaluation. *Journal of Risk Research*, *4*(2), 113-125.

MacGarvin, M. (1999a). Science, precaution, facts and values. In T. O'Riordan, J. Cameron, & A. Jordan (Eds.), *Reinterpreting the precautionary principle* (pp. 35-60). London: Cameron May.

MacGarvin, M. (1999b). The precautionary principle, science and policy. In R. Harding & E. Fisher (Eds.), *Perspectives on the precautionary principle* (pp. 225-239). Sydney: Federation Press.

Manson, N. A. (2002). Formulating the precautionary principle. *Environmental Ethics*, *24*, 263-274.

McIntyre, O., & Mosedale, T. (1997). The precautionary principle as a norm of customary international law. *Journal of Environmental Law*, *9*(2), 221-241.

Newton, A., & Oldfield, S. (2005). Forest policy and sustainable forest management. In R. Cooney & B. Dickson (Eds.), *Biodiversity and the precautionary principle: Risk and uncertainty in conservation and sustainable use* (pp. 21-38). London: Earthscan.

Petrini, C., & Vecchia, P. (2003). International statements and definitions of the precautionary principle. *IEEE Technology and Society Magazine* (Institute of Electrical and Electronics Engineers), *21*(4), 4-7.

Raffensperger, C., & deFur, P. L. (1999). Implementing the precautionary principle: Rigorous science and solid ethics. *Human and Ecological Risk Assessment*, *5*(5), 933-941.

Sandin, P., Peterson, M., Hansson, S. O., Rudén, C., & Juthe, A. (2002). Five charges against the precautionary principle. *Journal of Risk Research*, *5*(4), 287-299.

Santillo, D., Stringer, R. L., Johnston, P. A., & Tickner, J. (1998). The precautionary principle: Protecting against failures of scientific method and risk assessment. *Marine Pollution Bulletin*, *36*(12), 939-950.

Stirling, A. (1999). *On science and precaution in the management of technological risk*. Seville: European Commission Institute for Prospective Technological Studies.

Sunstein, C. R. (2005). *Laws of fear: Beyond the precautionary principle*. Cambridge: Cambridge University Press.

Trouwborst, A. (2002). *Evolution and status of the precautionary principle in international law*. The Hague: Kluwer Law International.

Turvey, C. G., & Mojduszka, E. M. (2005). The precautionary principle and the law of unintended consequences. *Food Policy*, *30*, 145-161.

Underwood, A. J. (1997). Environmental decision-making and the precautionary principle: What does this principle mean in environmental sampling practice? *Landscape and Urban Planning*, *37*, 137-146.

Van den Belt, H., & Gremmen, B. (2002). Between precautionary principle and 'sound science': Distributing the burdens of proof. *Journal of Agricultural and Environmental Ethics*, *15*, 103-122.

Wynne, B. (1992). Uncertainty and environmental learning: Reconceiving science and policy in the preventive paradigm. *Global Environmental Change*, *2*(2), 111-127.