Can there be science-based precaution?

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Abstract

‘Science-based precaution’ is possible in logic if not in politics, and should be a normal part of risk management. It should balance the risks and benefits of innovation, or equivalently, specify the price one is willing to pay to avoid risk. The Precaution Principle states that the absence of scientific proof does not preclude precautionary action—or, in its stronger version, that it requires such action. This principle is a useful counterweight to the insistence on rigorous scientific proof, but focuses on costs and risks to the exclusion of benefits. It expresses ‘look before you leap’, but not ‘nothing ventured, nothing gained’.

To facilitate adaptive management, we propose a complementary principle: ‘precautionary action should not unreasonably interfere with innovation that promises major benefits, until its dangers and benefits are well understood’. In international trade law, we propose that scientific evidence presented in support of discriminatory measures that would otherwise violate the world trade regime—such as the de facto European Union moratorium on importing genetically modified crops—be required to suffice to support a ‘reasonable belief’ of danger to human health or the environment.

Keywords: precaution, science-based, risk management, standard of proof, reasonable belief, adaptive management, utility function, attitude toward risk, cost/benefit, legal principle, trade law, genetically modified crops

1. An unnecessary conflict

Scientific uncertainty lies at the heart of many of today's most important environmental controversies: climate change, endocrine disruptors, and genetically modified organisms, to name just a few. In different ways, each of these controversies raises similar questions: What level of scientific proof is needed to justify measures to avoid or mitigate environmental threats of uncertain size and probability? How can policy makers distinguish between disagreements over the science underlying the danger, the uncertainty associated with the science, and the political, economic and social costs justified to avoid or mitigate this danger? What is the proper balance between the risks of intervention and the risks of the status quo?

For many people, precaution is the proper basis for risk management, and an essential bulwark against environmental damage due to human activity [1]. Critics disagree. Risk management, they say, must be based on science. To these critics, the idea of precaution has become an ambiguous and heavily politicized obstacle to innovation and the very antithesis of what they regard as sound science [2].

Is there a middle ground? Is ‘science-based precaution’ possible? This is not a mere academic question. It was a central issue in the multi-hundred-billion dollar dispute before the Dispute Settlement Body of the World Trade Organization over the European Union’s de facto prohibition of the importation of genetically modified foodstuffs—a prohibition that embodies the idea of precaution but was ruled a violation of the rules of the World Trade Organization [3]. The ruling in this case is likely to have ramifications for nanotechnology and other advanced technologies as well.

As practical guides to action, both precaution and ‘sound science’ have many deficiencies. The Precautionary Principle exists in multiple versions, does not specify the level of intervention required in any given situation, and does not address the critical issue of trade-offs between risks [4]. On the other hand, ‘sound science’ has been interpreted to mean that measures to protect the environment are not justified until
the underlying science reaches near certainty, an unrealistic and impractical standard of proof that is sometimes used as an excuse to delay regulations that are badly needed to protect public health or the environment [5].

The situation is exacerbated by the politicization of both sides of the argument. ‘Sound science’ has become the slogan of vested interests opposed to any regulation of their activities, however polluting [6]. Critics say that ‘sound science’ is used by politicians to mean ‘science that agrees with my political agenda’ [7]. On the other side, precaution has been used to rationalize obstacles to technological innovation in the absence of serious evidence of potential harm [8]. These differences have strengthened the stereotyped views held by some Americans and some Europeans regarding their counterparts on the opposite side of the Atlantic: Europeans as excessively cautious and risk-averse, Americans as pro-technology, cowboy anti-environmentalists.

The threatened ‘train wreck’ between advocates of precaution-based and science-based risk management is largely unnecessary, in logic if not in politics. Advocates of precaution have already come a considerable way toward framing the issues in a way that can facilitate discussion and resolve disagreements. Recognizing that the best way to apply precaution is to consider multiple alternatives early in the planning of a project, they have developed constructive approaches to decision making in policy issues that involve uncertain science [9]. If adopted, these methods would reduce the need for late go/no-go decisions regarding projects with high environmental impact, long after it has become impractical to consider alternative approaches.

2. The need for a balancing principle

Precaution expresses only one side of the risk versus benefit argument. After all, most policy decisions involve a choice between risky alternatives; life rarely provides a simple choice between a risky proposal and a risk-free status quo. Precaution proclaims, ‘look before you leap’, an attitude only to be applauded. But desirable innovations can be blocked by an excess of precaution. There is a need for a principle that expresses the complementary aphorism, ‘nothing ventured, nothing gained’.

In many situations, the costs and benefits of alternative modes of action are more closely balanced, calling for adaptive management, a well-known approach that treats the application of natural resource policies as experiments from which to learn. More formally, adaptive management is defined as a ‘systematic process for continually improving management policies and practices by learning from the outcomes of operational programs’ [10]. Instead of a once-and-for-all, go/no go decision at the beginning of a project or other undertaking, adaptive management calls for starting in what appears to be the right direction, followed by careful monitoring of the resulting situation, research to improve the knowledge base, and corrective measures as mistakes and deficiencies are revealed. This approach is consistent with the constructive interpretations of precaution discussed earlier, but would be discouraged by those versions of precaution that would block innovation in the absence of evidence of harm.

We therefore propose a new statement to make the desirability of adaptive management explicit, and to complement and balance the Precaution Principle and to guard it against over-reach. We would urge government and business to get behind a new principle of Innovation and Adaptive Management, to the effect that ‘Precautionary action should not unreasonably interfere with an innovation that promises major benefits until the dangers and benefits of this innovation are well understood’; see the article by Weiss in [4]. Like precaution, this is a statement of only one side of the argument. Its purpose is to provide both precaution and innovation with a clear statement to fall back on, restoring consideration of the benefits of innovation in addition to its costs and risks, and thus creating a balanced framework within which reasoned discussion can take place.

3. Precaution as a framework for decision making

The idea of precaution can be expanded in such a way as to help the decision maker to structure a policy discussion, and to provide at least a rough measure of uncertainty and of attitude toward risk. Reduced to its essentials, precaution is an attitude toward risk: an inclination to accept financial, political or social costs today (including the loss of possible benefits), in order to avoid or mitigate future dangers in situations in which the scientific evidence for these dangers is uncertain. The ‘strong’ version of precaution—as expressed, for example, in the Wingspread Principle—constitutes a willingness to accept substantial costs, even at a very low level of such proof.

Insistence on ‘good science’ is also a statement of an attitude toward risk—in this case, a willingness to trust that the danger in question will not turn out to be real, or that methods will be developed to deal with it in the future, so as to put off costs until the reality of the danger is proven to a very high standard. As the size of the putative danger increases, everyone’s willingness to accept costs will increase, until at the extreme (say an asteroid striking the Earth) even the technological optimist would be willing to accept substantial costs at a high level of uncertainty. Conversely, people are likely to be willing to accept additional risks if the possible benefits are very large.

In any particular situation, proponents and opponents of precautionary measures may actually agree on the danger, but disagree on its associated uncertainty. Alternatively, they may agree on both the danger and the uncertainty, but hold differing attitudes toward risk and hence disagree on what should be done to avoid or mitigate that danger. The policy debate on a particular danger should thus be divided into three parts: the science underlying the danger, the uncertainty surrounding that science—i.e., the degree of certainty that the danger will come to pass—and the costs that would be justified to avert or mitigate this uncertain danger.

Policy makers—and ideally, the general public—should insist that advocates and opponents of precautionary action clearly distinguish among the three elements of their position.

1 ‘Precautionary measures should be taken (author’s italics) even if cause and effect relationships are not fully established scientifically.’ The Wingspread Declaration is the declaration of a meeting of non-governmental experts held in Wingspread, WI, in January 1998. See http://www.sehm.org/state.html visited 6 June 2006.
Table 1. Scales of uncertainty.

| Level | Bayesian probability (%) | IPCC scale          | Scale based on legal standards of proof | Legal situation where standard of proof applies |
|-------|--------------------------|---------------------|----------------------------------------|-----------------------------------------------|
| 11    | 100                      | (Not on scale)      | Virtually certain                       | Exceeds criminal standard                     |
| 10    | 99                       | Virtually certain   | ’Beyond a reasonable doubt’             | Criminal conviction                            |
| 9     | 90–99                    | Very likely         | ‘Clear and convincing evidence’         | Quasi-penal civil actions, such as termination of parental rights |
| 8     | 80–90                    | Likely              | ’Clear showing’                         | Granting temporary injunction                 |
| 7     | 67–80                    | Medium likelihood   | ‘Substantial and credible evidence’     | Referring evidence for impeachment             |
| 6     | 50–67                    | ’Preponderance of the evidence’ | Most civil cases                        |
| 5     | 33–50                    | ’Clear indication’  | Proposed criterion for nighttime, x-ray or body cavity searches |
| 4     | 20–33                    | ’Probable cause’, ‘Reasonable belief’ | Field arrest; search incident to arrest; search warrant; Arraignment or indictment |
| 3     | 10–20                    | Unlikely            | ’Reasonable indication’                 | Initiate FBI investigation or trade inquiry   |
| 2     | 1–10                     | ’Reasonable, articulable grounds for suspicion’ | Stop and risk for weapons                  |
| 1     | <1                       | Very unlikely       | ’No reasonable grounds for suspicion’, ‘Inchoate hunch’, ‘Fanciful conjecture’ | Does not justify stop and risk                |
| 0     | 0                        | (Not on scale)      | Insufficient even to support a hunch or conjecture | Action taken could not have resulted in the crime being charged |

They should press these advocates, and indeed their own advisers and trusted experts, to make the degree of uncertainty associated with scientific evidence as precise as possible. When they do so, they may discover substantial agreement on both the science and its associated uncertainty, enabling the discussion to focus on differing attitudes to acceptance of costs and risks. To be sure, this degree of uncertainty can be deliberately misstated for advocacy purposes. Even so, the explicit specification of uncertainty will expose such misstatements to discussion and criticism.

A number of scales of uncertainty are available for this purpose. One of these uses quantitative probabilities, derived not from empirical statistics, but instead from subjective, so-called Bayesian statistics. These represent the odds that, all things considered, assertions regarding the science will turn out to be correct. In the particular case of climate change, this subjective uncertainty derives from the degree of confidence in the accuracy of complex physical and mathematical models [12].

The Inter-Governmental Panel on Climate Change, the huge group of scientific advisers to governments negotiating on global warming, has developed a six-point quantitative scale based on such subjective percentage probabilities [13]. Elsewhere I have proposed a complementary twelve-point scale of certainty, based on a hierarchy of standards of proof used in various branches of US law in specific legal situations, and have assigned arbitrary but plausible quantitative probabilities to each point of the scale [14]. Table 1 compares the IPCC scale with that of the author. Either could be the basis for a clear and understandable expression of uncertainty for policy makers.

4. Precaution as utility function

Once an advocate or adviser has specified the level of uncertainty (s)he associates with a given assertion of scientific fact, it remains to recommend the appropriate action. This is a political and ethical question, not a scientific one, and depends on one’s attitude toward innovation and one’s willingness to accept costs, and to forego possible benefits in order to avoid or mitigate environmental risk. For purposes of illustration, we have sketched a set of notional utility functions, plotting willingness to accept costs to avoid a hypothetical serious and irreversible environmental damage as a function of the certainty that this damage is real. (For simplicity, no benefits are assumed.)

Each of these curves corresponds to a different archetypal attitude towards costs and risks, to which we have assigned names: the scientific absolutist, who insists on rigorous scientific proof in order to justify any intervention; the environmental absolutist, who is prepared to accept very significant costs at even the hint of an environmental danger; and the techno-optimist, the environmental centrist, and the cautious environmentalist, who fall between these extremes. In the graphs of figure 1, the x-axis represents the subjective probability, expressed as a percentage, that a particular danger is real. The y-axis is a qualitative representation of the level of intervention that a policy maker might undertake at a given level of uncertainty. These curves provide a framework for posing questions regarding uncertainty and precaution in order to clarify the distinction between assertions of scientific fact, the uncertainly associated with these assertions, and the question of what to do about the threat they describe.
Unlike cost-benefit analysis, the Precaution Principle focuses on costs and risks. In principle, it could be extended to incorporate foregone benefits as part of the costs of precaution. Conversely, cost-benefit analysis could be brought closer to precaution if cost/benefit ratios were treated as a function of the risk that an uncertain cost may turn out to be real.

5. Precaution as a legal standard

The classic formulation of the Precautionary Principle, taken from the 1992 Rio Declaration on Environment and Development, states 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’ [15].

At the time it was first promulgated, the Principle was an important statement of opposition to the then-prevailing approach that decisions should be taken on the basis of ‘scientific findings’ or ‘in light of knowledge available at the time’\(^2\), an approach whose consequence was that lack of full certainty meant no action at all [16]. This statement of the Precautionary Principle is unexceptionable as far as it goes. No regulator on either side of the Atlantic today would insist on ‘full scientific certainty’ before protecting the public from danger to the environment or public health.

Even so, the Precautionary Principle as a statement of international law presents substantial problems. The first of these lies in the ambiguity of the Principle itself, which is invoked in at least 19 international treaties, but in a variety of different formulations [17]. Some versions refer to the need for cost-effective intervention. Taken literally, this wording seems to require only that the measures taken to avert a given risk to a given level of certainty be cost-effective relative to other ways of achieving the same result. In practice, it seems to have resulted from an effort to ensure that application of the Precaution Principle take into account both costs and benefits. Other versions of the Principle omit any reference to costs, in effect elevating environment over any consideration of economics.

Similarly, some versions of the Principle, like the Rio Declaration quoted above, require precautionary action only in the case of ‘serious and irreversible damage’, while others refer to environmental degradation without qualification. This multiplicity of versions complicates the widespread European view that the Precautionary Principle should be regarded as customary international law, i.e., as a universally valid legal principle that all countries regard themselves as obligated to follow [18, 19]. If this is the case, which version of the Principle is authoritative?

A second, equally important concern about the Precautionary Principle as a legal principle lies in the fact that it does not specify the standard of proof to which the evidence for environmental danger is to be held. Such a standard of proof would
be logically equivalent to the level of scientific certainty required to trigger a precautionary intervention, or conversely, to the level of certainty required to justify an action that may endanger the environment. The failure to define this standard is in effect a refusal to specify the attitude toward risk expected of the regulator. The strong version of the Principle, such as the Wingspread Declaration, even requires action in the face of incomplete evidence—but at what level of proof: a suspicion? a hunch?

This absence of a specified standard of proof, taken together with the multiplicity of texts, makes it impossible to specify just what a state is obligated to do if it accepts the Precautionary Principle. European courts, which consider the principle to be binding, have failed to arrive at a consistent statement of what it requires in any given situation [20]. Indeed, cynics might argue that this failure is deliberate, since it allows the European courts to avoid a definitive resolution of what is for them a difficult political issue. (In part for this reason, the US has resisted blanket international endorsements of the Precautionary Principle and officially regards precaution as only a non-binding ‘approach’ [21].)

The application of precaution in international courts presents a different but related problem. Despite the best efforts of European governments, no non-European international court has thus far accepted the Precautionary Principle as a binding principle of international law. Even so, precaution in the general, non-legal sense has been used in an attempt to justify exceptions to well-established international regimes, such as that governing international trade [22].

The agreement on the application of sanitary and phytosanitary measures (SPS), which is incorporated by reference into the World Trade Organization treaty, provides that ‘members have the right to take sanitary and phytosanitary measures’—including trade restrictions that would otherwise be regarded as discriminatory against particular nations and would hence be forbidden—if such measures are ‘based on scientific principles and (are) not maintained without sufficient scientific evidence’ [23]. Like the Precautionary Principle, this provision does not define the standard of proof to which this scientific evidence should be held. It thus leaves open to interpretation the very issue that will be crucial in any future dispute hinging on the international law governing trade. The European Union, the chief champion of the Precautionary Principle in international fora and the source of one of the best statements of its practical meaning, likewise has avoided any recommendation of the standard to which evidence for precautionary action should be held [19].

Domestic US administrative law may provide a useful answer to the question of standard of proof. If challenged, US regulators in a wide range of fields must be able to convince a court that their actions were not ‘arbitrary and capricious’ [24]. This corresponds to the well-known legal standard of ‘reasonable belief’. This standard, derived from the provision of the Fourth Amendment to the US Constitution that ‘the right of the people to be secure . . . against unreasonable searches and seizures shall not be violated, and no warrants shall issue, except upon probable cause . . .’. This standard is higher than ‘reasonable suspicion’3, another well-established legal standard [25], see also [14].

The proposed standard of ‘reasonable belief’ may have useful application to sticky situations in international trade law, in which exceptions to the international trade regime are justified by a claim of threat to human health or the environment. Such exceptions can give rise to disputes before the Dispute Settlement Board (DSB) of the World Trade Organization (WTO), in which both the political and the economic stakes can be very high. A current example is the dispute recently before the DSB over the European Union’s de facto moratorium banning the import of genetically modified foodstuffs. This moratorium in effect bans imports from particular countries, and is hence a discriminatory trade measure that would be illegal in the absence of such a threat4.

We would urge the DSB to apply a standard of proof of ‘reasonable belief’ to the scientific evidence put forward in support of such proposed exceptions to the world trade regime—in other words, to insist that such evidence be sufficient to induce a reasonable belief that such damage would in fact take place. Such a standard would be consistent with a previous DSB decision dealing with a European Union ban on the importation of beef raised with the aid of certain growth hormones, a case that raised issues similar to those involved in genetically modified crops [27], see also the article by Weiss in [4]. Here the DSB Appellate Body held that a risk assessment must ‘reasonably support’ and ‘have a rational relationship’ to the measure it is supposed to justify—i.e., the import ban—even though it need not embody ‘the view of a majority of the relevant scientific opinion’, if it followed a ‘divergent opinion . . . coming from qualified and respected sources’ [22, pp 75–6].

What of the evidence needed to demonstrate that a proposed project or other intervention is safe? The Precautionary Principle quite properly places the burden of proof on the proponent, but again does not specify the standard of proof to which its evidence should be subjected. After all, it is impossible to prove a negative, i.e., that a proposed intervention is absolutely safe. Here again, we turn to US law for a standard, and propose that proponents be required to show a ‘reasonable certainty of no harm’, the standard set by the US Food Quality Protection Act of 1996, or more or less equivalently, that they be required to make a ‘clear showing’ that their proposal is safe [28].

It is essential that the DSB define some clear standard, so that governments, companies and private citizens may know the standards to which they are to be held. We would urge the DSB to adopt standards of proof along the lines we have here proposed, derived from US law or (if they prefer) from European code law. At a minimum, it should be possible for opposing advocates to agree, and the DSB to endorse the idea that a mere suspicion of danger should not be sufficient to bar a desirable project or innovation.

3 ‘Reasonable, articulable suspicion’ is sufficient to justify a ‘stop and frisk’ by a policeman, but is insufficient to justify a full search or an arrest.

4 WTO members are free to apply whatever standards of risk aversion they prefer, as long as these are clearly announced and apply equally to domestic sources of risk; see [3].
6. Conclusion

The idea of precaution—and its legal expression, the Precautionary Principle—are essential elements of environmental risk management. They have stimulated creative thinking and discussion that have contributed new ideas. Precaution has also stimulated the codification of useful checklists of good environmental practice, and has catalyzed important research on ‘green’ versions of adaptive management that could result in substantial improvements in environmental practice. But it has also been used to justify caving in to popular fears of technology in the absence of reasonable scientific evidence of danger. The Precautionary Principle deserves further refinement, and, we would argue, should be complemented by a new principle that makes explicit the fact that precaution is an essential aspect of adaptive management and is compatible with (and can indeed stimulate) technological innovation.

The most immediate issue, and the one with the most important practical implications, is the standard of proof to be applied to scientific evidence for precautionary action. In the particular case of exceptions to the world trading regime, as for example the European Union’s de facto ban on import of genetically modified foodstuffs, we would propose that scientific evidence of harm to environment or public health should be required to be sufficient to satisfy the standard of ‘plausibility’ or ‘reasonable belief’. This standard would be consistent with US values and with the principles of US administrative and environmental law, and is arguably implicit in past decisions of the Dispute Settlement Board of the World Trade Organization. A weaker standard, on the other hand, would constitute an unreasonable burden, not only on agricultural technology, but also on future technological advances in nanotechnology and other fields as well.

Less immediate but no less important is the one-sidedness of precaution as a general environmental principle, which tempts its supporters to over-reach and use it as a rationale for interventions against supposed dangers that are not supported by tangible evidence. Here the best antidote is a complementary principle that can be used to defend useful innovations against unjustified attack. For this purpose, we have proposed a Principle of Innovation and Adaptive Management, to the effect that potentially useful innovations against unjustified attack. This can be formulated as a legal principle to balance the Precautionary Principle should this become desirable in international fora.

Finally, the debate over precaution has given rise to a framework that makes it easier to convey to decision makers the level of uncertainty associated with any assertion of scientific fact, and to distinguish among the science, the uncertainty connected with that science, and the justification for action. This framework is consistent with both precaution and science, and indeed can be used as the basis for science-based precaution. We recommend it for use by advisers and advocates alike.

In the end, precaution and good science need not conflict. To be sure, environmental decision making must be made in the face of uncertainty, so that good science in environmental management is not always the same as good science in the laboratory. Even so, a scientific outlook should support precaution, and precaution should be based on science. ‘Science-based precaution’ should be a normal, and indeed an essential part of proper risk management.

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