# Formulating the Precautionary Principle

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In part one, I identify the core logical structure of the precautionary principle and distinguish it from the various key concepts that appear in the many different formulations of the principle. I survey these concepts and suggest a program of further conceptual analysis. In part two, I examine a particular version of the precautionary principle dubbed "the catastrophe principle" and criticize it in light of its similarities to the principles at work in Pascal's Wager. I conclude with some suggestions for advocates of the precautionary principle who wish their formulation to avoid the pitfalls confronting the catastrophe principle.

## INTRODUCTION

The precautionary principle, enshrined in the laws of various nations and the words of various international treaties, is heralded by its proponents as embodying a radically different approach to environmental decision-making. Given the importance accorded to it, the lack of uniformity regarding its formulation comes as a surprise. Versions of the precautionary principle are many, both in terms of wording and in terms of surface syntactic structure.[1] While it may seem obvious to all of the participants in environmental disputes what is meant by "the precautionary principle," from the perspective of an outsider the content of the precautionary principle can be far from clear.

I first attempt to enhance our grasp of the possible meanings of the precautionary principle by distinguishing its core structure from the details of its various formulations. The framework provides highlights several concepts which stand in need of clarification. Second, I examine a particular (but often-invoked) version of the precautionary principle; I call it "the catastrophe

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[1] For documentation of this variety, see David Freestone and Ellen Hay, "Origins and Development of the Precautionary Principle," in David Freestone and Ellen Hay, eds., *The Precautionary Principle and International Law: The Challenge of Implementation* (The Hague: Kluwer Law International, 1996); and Julian Morris, "Defining the Precautionary Principle," in Julian Morris, ed., *Rethinking Risk and the Precautionary Principle* (Woburn, Mass.: Butterworth-Heinemann, 2000).

principle." Arguments based on the catastrophe principle are self-defeating (for reasons familiar to critics of Pascal's Wager), which suggests that the precautionary principle must be formulated with care lest it suffer the same fate.

## THE STRUCTURE OF THE PRECAUTIONARY PRINCIPLE

One of the most famous statements of the precautionary principle is Principle 15 of the 1992 Rio Declaration of the U.N. Conference on Environment and Development:

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

As this passage indicates, the precautionary principle is supposed to provide guidance with respect to cases in which our scientific knowledge of the harmful effects of a proposed activity is significantly incomplete. The central idea is that even if the normal scientific standards for establishing causal connections are not met in the case of the relationship between an industrial/technological activity and a given harm to the environment, precaution warrants the regulation of that activity. This idea is supposed to run counter to standard decision-making procedures (e.g., cost-benefit analysis), in which possible but unproven causal connections do not count. As one author notes, "the precautionary principle . . . aspires to achieve a radical break-through in the dominant and ineffectual pattern of balancing of risks, costs of regulatory measures and benefits of activities that cause risks."[2]

Because there is a tangle of competing official formulations layered atop this core idea, it is useful to develop a framework within which these various formulations might be understood. A helpful first step is to identify the generic elements of any statement worthy of the appellation "the precautionary principle." With those generic elements in mind, we can then identify a logical structure common to the various competing formulations. It may be that no single formulation of the precautionary principle emerges from the provision of this framework. Indeed, such a result may not even be desirable. Instead, the worth of such a framework is in helping both proponents and critics of any particular version of the precautionary principle see more clearly what the commitments are of those who endorse that particular version.

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[2] Andre Nollkaemper, "'What You Risk Reveals What You Value,' and Other Dilemmas Encountered in the Legal Assaults on Risks," in Freestone and Hay, *The Precautionary Principle and International Law*, p. 75.

To begin the analysis, note that for a given *activity* that may have a given *effect* on the environment, the precautionary principle is supposed to indicate a *remedy*. For the sake of brevity, we can refer to these generic elements as "e-activities," "e-effects," and "e-remedies" respectively. E-activities include things such as commercial fishing, burning fossil fuels, developing land, releasing genetically modified organisms, using nuclear power, generating electrical fields, and disposing of toxic chemicals. E-effects are outcomes such as the depletion of fish stocks, global warming, species extinction, a loss of biodiversity, nuclear contamination, cancer, and birth defects. E-remedies include measures such as an outright ban on the e-activity, a moratorium on it, strict regulation of it, and further research into it.

A review of the many statements of the precautionary principle indicates there is a general, three-part structure shared by every version. The first part is the damage condition; it specifies the characteristics of an e-effect in virtue of which precautionary measures should be considered. The second part is the knowledge condition; it specifies the status of knowledge regarding the causal connections between the e-activity and the e-effect. The third part specifies the e-remedy that decision makers should take in response to the e-activity. The three-part structure shared by all versions of the precautionary principle is the following conditional statement: if the e-activity meets the damage condition and if the link between the e-activity and the e-effect meets the knowledge condition, then decision makers ought to enact the specified e-remedy.

As the chart (p. 276) indicates, the core structure is very general indeed, allowing considerable room for variation. Of course, relevant possible damage conditions, knowledge conditions, and e-remedies may not be included in the corresponding lists of possibilities, but nothing prevents additions to those lists. The important worry is whether the logical structure of the precautionary principle is being adequately represented. Proponents of the precautionary principle will have to decide this concern for themselves. They should note that the generic elements and logical structure of the precautionary principle have been identified in light both of actual usage and suggested applications (as gleaned from various laws, treaties, protocols, etc.). Because these are the primary guides an outside observer has to the meaning of any term, those who object that the suggested framework cannot capture what they mean by "the precautionary principle" are obliged to articulate they do mean.

A benefit of this framework is that it serves to highlight the distinct particulars that can be substituted for the generic elements of the skeleton precautionary principle. For example, whatever irreversibility is, it is not the same as irreplaceability; irreversibility is a property of processes (e.g., ozone depletion) while irreplaceability is a property of concrete items (e.g. the ozone layer). That this framework calls attention to such distinctions points to a further benefit of it. To the extent that the concept of, say, irreversibility is clearer than that of irreplaceability, a version specifying irreversibility in the

damage condition will be a better guide to action than one specifying irreplaceability. Assuming that one desideratum of formulating the precautionary principle is the ability to guide action, we will have a criterion for evaluating competing versions of the precautionary principle, for saying one version is better than another.

What is needed here is a program of conceptual clarification regarding the various potential component concepts at work in the precautionary principle. For example, if we survey the many characteristics the possession of which have been alleged to make an e-effect meet the damage condition, we see plenty of job opportunities for the environmental philosopher. The precautionary principle is variously said to be activated when the consequences in question are serious, harmful to humans, catastrophic, irreversible, such as to result in the loss of something irreplaceable, such as to reduce or eliminate biodiversity, or such as to violate the rights of members of future generations. Doubtless other properties could be added to the list of damage conditions. But what, exactly, are these properties? Though they bear some loose connections (as those, for example, between irreversibility, irreplaceability, and the loss of biodiversity), they are nonetheless distinct.[3] Though some of these concepts have received considerable attention (for example, the concept of the rights and interests of future generations), many have not.[4]

To take just one example of the need for conceptual clarification, the concept of irreversibility at work in debates about environmental decision making is surely not the concept at work in contemporary physics. The latter is well-defined but designed for application in statistical mechanics, in connection with the definition of entropy and the attempt to solve the problem of the "arrow of time."[5] Some have criticized the precautionary principle on the assumption that irreversibility is to be understood in the physicist's sense.

> . . . 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. This is a consequence of the second law of thermodynamics, wherein it is observed that the state of disorder (or entropy) of the universe is constantly increasing. . . . This ultimately negates the utility of including "irreversible" as a criterion distinct from "serious."[6]

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[3] Norman Myers, "Biodiversity and the Precautionary Principle," *Ambio* 22, pts. 2–3 (1993), 74–79.

[4] See Alexandre Kiss, "The Rights and Interests of Future Generations and the Precautionary Principle," in Freestone and Hay, *The Precautionary Principle and International Law*, pp. 19–28. For a stimulating and far-reaching discussion of the concept of our responsibility to future generations, see Hans Jonas, *The Imperative of Responsibility* (Chicago: University of Chicago Press, 1984).

[5] See Lawrence Sklar, *Philosophy of Physics* (Boulder, Colo.: Westview Press, 1992), chap. 3 for a good introduction to the notion of irreversibility at work in modern physics.

[6] Morris, "Defining the Precautionary Principle," p. 14.

# Three Part Structure of the Precauionary Principle

| SUGGESTED DAMAGE CONDITIONS | SUGGESTED KNOWLEDGE CONDITIONS | SUGGESTED E-REMEDIES |
|---|---|---|
| 1. Serious | 1. Possible | 1. Ban or otherwise prevent the e-activity |
| 2. Harmful | 2. Suspected | 2. Put a moratorium on the e-activity |
| 3. Catastrophic | 3. Indicated by a precedent | 3. Postpone the e-activity |
| 4. Irreversible | 4. Reasonable to think | 4. Encourage research alternatives to the e-activity |
| 5. Such as to destroy something irreplaceable | 5. Not proven with certainty that it is not the case | 5. Try to reduce uncertainty about the causal relationship between the e-activity and the e-effect |
| 6. Such as to reduce or eliminate biodiversity | 6. Not proven beyond a shadow of a doubt that it is not the case | 6. Search for ways to diminish the consequences of the e-effect |
| 7. Such as to violate the rights of members of future generations | 7. Not proven beyond a reasonable doubt that it is not the case | 7. |

This criticism is uncharitable. Surely proponents of the precautionary principle don't mean that any e-activity which, when engaged in at a particular time, leads to the universe's being different at a later time must therefore merit an e-remedy of some sort. If we restrict ourselves to the biosphere (as opposed to the universe), the second law of thermodynamics does not apply, because the biosphere is not a closed system; it receives a constant flow of energy from the sun.

Yet, such misunderstandings are invited if no sense other than the physicist's is given to the notion of irreversibility. Consider a decision maker confronted with the proposal to dam a river. He or she knows that the dam will result in the death of all of the native trout, but also knows that in the future the dam can be removed and the river re-stocked with non-native trout. Is the e-effect confronting him or her irreversible or not? Those who promote versions of the precautionary principle which appeal to irreversibility should provide a definition of irreversibility that enables such questions to be answered. Similar cases can be constructed which would test the notion of an e-effect's being catastrophic, irreplaceable, and so on. Environmental philosophers need to roll up their sleeves and start analyzing these concepts.

Remember also that our skeletal precautionary principle is a statement about what ought to be done; it says that if the damage and knowledge conditions are met, then the decision makers ought to impose the e-remedy. It is crucial, then, that any proposed damage condition be connected with disvalue. Few would care to deny that if an outcome is catastrophic, harmful to humans, or in violation of the rights of future generations of humans, then it is, in that respect, a bad thing. But what about irreversibility? If an e-effect is irreversible, does that mean it is, in that respect, a bad thing? Perhaps a case can be made that irreversibility is always (or at least in most cases) a bad feature of an e-effect, but the position remains in want of an argument. Again, there's work here for the philosopher.

As with the damage condition, there is considerable variety concerning the knowledge condition. A source of this diversity is disagreement about whether the precautionary principle mandates shifting the burden of proof from regulators to industrialists and potential polluters. Many advocates of the precautionary principle frame it this way, but not all do.[7] Clearly, questions of burden of proof and of presumption are highly relevant within a legal and political framework. These questions explain why so many environmental defenders favor versions of the precautionary principle in which the burden of proof rests on potential polluters. Those who prefer such versions variously suggest that the polluters must show with certainty, or beyond a shadow of a doubt, or

[7] Carl F. Cranor, "Asymmetric Information, The Precautionary Principle, and Burdens of Proof," in Carolyn Raffensperger and Joel A. Tickner, eds. *Protecting Public Health & The Environment: Implementing the Precautionary Principle* (Washington, D.C.: Island Press, 1999), pp. 74–99.

beyond a shadow of a reasonable doubt, that the e-activity does not cause the e-effect.

Yet, not all advocates of the precautionary principle hasten to put the burden of proof on potential polluters. They seem to think that so long as they make sufficiently weak the conditions that must be satisfied in order for the precautionary principle to be activated, the desired effect (blocking the activities of potential polluters) remains the same. They are happy to admit that it is up to the opponents of any given e-activity to make a positive case that it causes the e-effect, but (they say) the standards these opponents need to meet are not those normally demanded in the policy arena. Regarding the claim that an e-activity causes an e-effect, they need only establish its bare possibility, or have a hunch that it is true, or point to a precedent for thinking that it is true, or have reasonable grounds for concern that it is true. They need not prove it with full scientific certainty, or prove it beyond a shadow of a doubt, or have any scientific evidence for it at all.

What these various specifications actually amount to—for example, what it is to have a reasonable doubt—requires some careful thinking, although here the resources for conceptual clarification are much richer thanks to legal tradition. From the perspective of an advocate of precautionary action, whether it is better to place a high burden of proof on those who would engage in the e-activity rather than a low burden of proof on those who would regulate the e-activity is entirely an issue of pragmatics rather than principles. Which formulation of the precautionary principle is most favorable to the pro-precaution side in any given situation will depend on the particular political and legal context in which that formulation is to be employed.

The last component of the precautionary principle is the e-remedy. In most versions of the precautionary principle, the e-remedy is simply the prohibition of the e-activity. Sometimes, however, other actions are said to be mandated by the precautionary principle. These include encouraging research on alternatives to the e-activity, trying to reduce uncertainty about the causal relationship between the e-activity and the e-effect, and seeing if there are ways of diminishing the negative consequences of the e-effect. Advocates of precaution are well-advised to build into their formulation of the precautionary principle reference to such follow-up actions. Doing so is an important gesture to fairness, for otherwise the precautionary principle risks imposing an obligation that proponents of the e-activity can never discharge. For example, suppose the fact that regulators are unsure of the population of a particular species of marine animal is used as a reason to play it safe by treating that species as endangered. If harvesting of the species is forbidden unless knowledge of its population is gained, then, by implication, gaining the appropriate information about the population should result in permission being granted for harvesting of the species (other things being equal). Another way of making essentially the same point is that the precautionary principle should not be formulated in such a way that it encourages and rewards ignorance.

Note that, within the above framework, any version of the precautionary principle will effectively be absolute and unconditional. The only restriction on the scope of the sorts of activity to which it will apply will be the extremely weak one that the action be such as to count as an e-activity (an activity that affects the environment). Furthermore, if the damage and knowledge conditions are met, the e-remedy is not merely supported or suggested, but made obligatory. Some may object that this approach is not the right way to understand the precautionary principle, but it is the understanding suggested by the printed word and by the contrast drawn between the precautionary approach and traditional cost-benefit analysis. "In several treaties, the precautionary principle is formulated in absolutist terms. It stipulates that once a risk of a certain magnitude is identified, preventive efforts to erase that risk are mandatory."[8] If the impression that the precautionary principle is absolute and unconditional is a mistaken one, its advocates would do well to ask themselves what they are doing to generate that impression.

## THE CATASTROPHE PRINCIPLE

With these points in mind, let us now examine in depth a particular version of the precautionary principle,[9] one in which the damage condition is that the e-effect is catastrophic and the knowledge condition is that there is a possibility the e-activity leads to the e-effect. Let us call this version of the precautionary principle "the catastrophe principle." According to it, if we can identify an e-activity and an e-effect such that the e-effect is catastrophic and it is merely possible that the e-activity causes the e-effect, then the imposition of the e-remedy is justified regardless of the probability that the e-activity causes the e-effect.

The catastrophe principle is clearly suggested in a number of arguments in favor of specific regulations. Consider the following argument for the elimination of nuclear arsenals. It is based on the nuclear winter scenario, according to which multiple nuclear explosions would create a blanket of dust and debris that would block out the sun and drop global mean surface temperature enough to result in the destruction of most life forms.[10] In this argument the e-activity

[8] Nollkaemper, "'What You Risk Reveals What You Value,'" p. 73.

[9] See Stephen P. Stich, "The Recombinant DNA Debate: A Difficulty for Pascalian-Style Wagering," *Philosophy and Public Affairs* 7 (1978): xx-xx for a presentation of essentially the same point as is made in this section. An abbreviated version of the argument made in this section can be found in Neil A. Manson, "The Precautionary Principle, The Catastrophe Argument, and Pascal's Wager," *Ends and Means: Journal of the University of Aberdeen Centre for Philosophy, Technology, and Society* 4, no. 1 (Autumn 1999): xx-xx.

[10] See R. P. Turco, O. B. Toon, T. P. Ackerman, J. B. Pollack, and Carl Sagan, "Nuclear Winter: Global Consequences of Multiple Nuclear Explosions," *Science* 222, no. 4630 (1983): 1283–92; and Paul Ehrlich e. al., "Long-Term Biological Consequences of Nuclear War," *Science* 222, no. 4630 (1983): 1293–300 for detailed accounts of the nuclear winter scenario.

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is engaging in nuclear war, the e-effect is nuclear winter, and the e-remedy is eliminating nuclear arsenals.

> There are real uncertainties involved in the nuclear winter predictions. They are based on models of poorly understood processes. Many of the complex scientific problems will take many years to resolve and some of the key uncertainties will remain unless there is a nuclear war. Science cannot provide certainty on this issue. However, one doesn't require certainty to take decisions about risks. . . . With nuclear winter there would be no second chance. The potential costs are so enormous that it hardly matters for our argument whether the probability that the nuclear winter predictions are basically correct is 10 per cent, 50 per cent, or 90 per cent. . . .[11]

The authors imply that it does not matter how low the probability is that the nuclear winter model is correct. Because the result of a nuclear winter would be human extinction, uncertainties about whether nuclear war causes nuclear winter should not deter us from eliminating nuclear arsenals.

Here is another application of the catastrophe principle, this time from the possibility of global warming to the drastic reduction of the production of greenhouse gases.

> The IPCC [Intergovernmental Panel on Climate Change] scientists predict, based on their computer models of climate, increases of temperature more than ten times faster than life on Earth has experienced in at least 100,000 years, and probably much longer. . . . But the IPCC scientists may be wrong. . . . such are the uncertainties of the climate system that they could, nonetheless,—just conceivably—be wrong. . . . But do we want to gamble on that tiny possibility? If the world's climate scientists are in virtual unanimity that unprecedented global warming will occur if we do nothing about greenhouse-gas emissions, would we not best serve our children and theirs if we took heed—even if there are uncertainties? . . . Nobody—repeat, nobody—can deny that there is at the very least a prospect of ecological disaster on the horizon where the greenhouse effect is concerned. Those who choose to ignore the prospect, therefore, willfully elect to ignore the environmental security of future generations.[12]

In the last two sentences, the author suggests an argument for drastic reductions in greenhouse gas emissions goes through so long as we grant the mere prospect of ecological disaster (though for him that argument is only a fallback position, as he thinks the conclusions of the IPCC are almost certainly true). He says that global warming would be just such a disaster, maintaining in an

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[11] Owen Greene, Ian Percival, and Irene Ridge, *Nuclear Winter: The Evidence and the Risks* (Cambridge, England: Polity Press, 1985), pp. 154–55.

[12] Jeremy Leggett, "Global Warming: A Greenpeace View," in Jeremy Leggett, ed. *Global Warming: The Greenpeace Report* (New York: Oxford University Press, 1990), pp. 460–61.

earlier part of his article that "with the emergence of the global-warming threat . . . industrial and other human activities have thrown a shadow over the very future of our species." (Wry commentators might argue that human extinction would be no catastrophe, but we can flatter ourselves that the extinction of *homo sapiens* would be as bad as it gets!)

These are not the first arguments from the mere possibility of an extreme outcome to the practical requirement of a course of action. In his *Pensees* Blaise Pascal (1623–1662) contends that one is compelled by rational self-interest to believe in God. So long as the probability that God exists is nonzero, the infinite nature of the reward if one correctly believes that and acts as if God exists makes belief in God rational—no matter how low that probability is.

> . . . in this game you can win eternal life which is eternally happy; you have one chance of winning against a finite number of chances of losing, and what you are staking is finite. That settles it: wherever there is infinity, and where there is not an infinity of chances of losing against the chance of winning, there is no room for hesitation: you must stake everything.[13]

Pascal thinks the infinite nature of the reward obviates determining the probability that one will, in fact, gain the reward. The question of one's grounds for thinking God actually exists is divorced from the rationality of acting as if God exists. Thus, Pascal thinks there is no need to argue over the evidence for God—which is good, he thinks, because such disputes will never come to an end. Let the scholars dispute God's existence, Pascal tells us. People in the real world need to act. They want to know what to do, and they must decide now, before it is too late.

Pascal's Wager has been subjected to a number of philosophical criticisms, but for the purposes of assessing the catastrophe principle we may focus on one in particular: the so-called "many gods" objection. Consider Odin. If Odin is jealous, then on Pascal's reasoning one has equal reason not to believe in God. After all, if Odin exists and God does not, and one worships God instead of Odin, one will pay an infinite price, making belief in God a risk not worth taking. Now Odin might not strike us as a very plausible deity, but if one admits it is possible that Odin exists, then, according to the logic of Pascal's Wager, one has just as much reason to believe in Odin as in God. But one cannot believe in both. Given that both Odin and God are possible deities, Pascal's reasoning leads to contradictory practical demands, and so it cannot be valid.

The "many-gods" objection brings to light the following general point regarding the catastrophe principle: even if an e-effect is catastrophic, that fact cannot rationally compel us to impose an e-remedy unless we also know that

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[13] Blaise Pascal, *Pascal's Pensees: Translated with an Introduction by Martin Turnell* (London: Harvill Press, 1962), pp. 202–03.

the e-remedy itself does not lead to catastrophic results; otherwise, we shall have to apply the catastrophe principle once again, negating the result of our first application. Thus, even if we grant that the e-effect is, say, human extinction, it does not follow that we should impose the e-remedy (much less that we should disregard the probability that the e-activity causes the e-effect). Why? Because it could be that the e-remedy will bring about an outcome which also leads to human extinction (or some other equally catastrophic outcome). And the same goes for any e-activity which might lead to an e-effect that, while not possessing infinite disutility, is nonetheless very, very bad. We could be doomed if we do and doomed if we don't.

Consider a wild story. The Kyoto Treaty is ratified by the U.S. Senate and signed into law by President Bush. All signatories to the treaty abide strictly to its demands. A global economic depression results. Massive social unrest ensues. Totalitarian dictatorships arise in Russia and the United States. War starts and nuclear weapons are launched by both sides. The predictions of the nuclear winter model prove to be perfectly accurate. Within five years, cockroaches rule the planet. The moral? We had better not do anything about greenhouse gas emissions. This conclusion is absurd. To pursue the analogy with religious belief, the scenario is not a "live option." As it stands, however, the catastrophe principle dictates this conclusion, because it fails to exclude any catastrophic possibilities from its realm of application. The catastrophe principle only requires the mere possibility of catastrophe, and since mere possibilities are so easy to construct, any application of the catastrophe principle will confront a fatal problem: the reasoning it employs can be used to generate a demand for a contradictory course of action. In other words, as it stands, the catastrophe principle is useless as a guide to action.

In light of this problem, it is natural to suggest amplifying the catastrophe principle as follows: "If an e-effect is catastrophic, if it is possible that a given e-activity causes that e-effect, and if it is not possible that imposing the given e-remedy will cause some other catastrophic e-effect, then the e-remedy should be imposed." This modification, however, would render the catastrophe principle ineffectual as a tool for action, because it would be practically impossible to show that there do not exist any catastrophic outcomes that might possibly come about as result of imposing the e-remedy.

The preceding considerations fail to impugn any of the conclusions that might be reached via application of the catastrophe principle. There are cogent arguments for the view that nuclear weapons stockpiles should be eliminated: they are not worth the expense, it is morally wrong to be prepared to kill millions of people, and so on. Even if the catastrophe principle is a defective vehicle for arriving at policy destinations, this does not mean those policy destinations might not be reached in some other way. Furthermore, given the framework provided in the first part of this paper, it is clear that many other versions of the precautionary principle can be formulated besides the catastro-

phe principle. That there are fundamental problems with the latter fails to show that a workable version of the former cannot be constructed. The plausibility and workability of each version will have to be determined on a case-by-case basis.

Still, a broader lesson can be drawn here: if the precautionary principle is assumed to apply to any activity whatsoever that might harm the environment, then surely it is arbitrary and unreasonable to exempt e-remedies themselves from scrutiny. As recent history has shown, well-intentioned safety measures (e.g., making passenger-side airbags mandatory in new automobiles) can lead to damaging consequences. Even if regulatory activity is not directly harmful, it can shift public behavior in harmful ways. For example, prohibiting nuclear power diverts energy production into other modes of production: coal-based, hydroelectric, and so on. To the extent that these means of energy production are damaging to the environment, the prohibition of nuclear power carries a risk, though of course that risk may be greatly outweighed by that of nuclear power itself. At best it is only a general rule of thumb that regulation and prohibition are less damaging to the environment than commercial and technological development. That such a rule of thumb holds is not a sufficient reason for a blanket exemption of these activities from the scope of the precautionary principle. Such an exemption would be *ad hoc* and would expose those who use the precautionary principle to the charge of special pleading.

## CONCLUSION

Given its large and growing role in contemporary debates about environmental decision making, a clear formulation of the precautionary principle is needed. As we have seen, however, the array of possible formulations is vast. The formulation(s) ultimately selected from this array should meet several specifications. First, the component concepts should be clearly defined. Second, the damage conditions identified should be such that a state possessing one of those features does, indeed, have great disvalue—if not always, then most of the time. Third, since the burden of proof is determined by the knowledge condition, the knowledge condition must be chosen in light of the particular political and legal systems in which the formulation will be applied. Fourth, included within the e-remedy should be some sort of pledge to continue research, for otherwise the formulation might have the effect of rewarding ignorance. Fifth, the formulation chosen must not be self-defeating—that is, it must not be such that the imposition of the e-remedy itself gets ruled out on grounds that it is in violation of the formulation. Readers may explore for themselves whether any formulation of the precautionary principle meets all of these specifications.