**Precautionary Principles**

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**Abstract**

In rough outline, the precautionary principle (PP) states that precautionary actions should be taken to alleviate significant threats to humans or the environment, even if the available scientific information about the threats is limited. In recent decades, various formulations of the PP have received a great deal of attention as sources of guidance for environmental policy making, but many commentators continue to criticize the principle as vague and even incoherent. This chapter suggests that a particularly fruitful way of interpreting the PP is to consider it as a very general concept around which people can rally to demand changes to current environmental science and policy. Under this interpretation, calling for action in accordance with the PP is akin to calling for better approaches to handle environmental decision making under ignorance and uncertainty. One of the advantages of interpreting the PP in this way is that it calls attention to the major problems that its proponents have been trying to highlight, as well as some of the most promising solutions to those problems.

**1. Introduction**

Most contemporary environmental debates involve conflicts over whether there is enough information available to justify potentially expensive actions to prevent environmental threats. Climate change provides the most obvious example, insofar as skeptics have insisted for decades that we do not have enough evidence to justify taking preventive actions that could harm the global economy. A host of other debates follow a similar pattern. Proponents of genetically modified crops argue that they have been shown to be safe, while critics insist that the evidence is inadequate. Beekeepers call for eliminating neonicotinoid pesticides, while the manufacturers insist that there is not enough information to justify doing so. Nanoparticles are being employed in sunscreens and athletic equipment and fabrics, while critics insist that we should not be using them until we have more information about their safety. The US Fish and Wildlife Service (FWS) argues that wolves no longer need to be protected as endangered species, while others argue that the FWS has appealed to flawed and inadequate evidence.

The precautionary principle (PP) was developed to provide guidance in cases like these. It states that preventive actions should be taken to prevent significant threats to humans or the environment, even if the available scientific information about the threats is limited. In recent decades, various formulations of this principle have received a great deal of attention.. The PP has been established as a guiding principle in national and international documents such as the Montreal Protocol of 1987, the Earth Summit’s Rio Declaration of 1992, the European Union’s Maastricht Treaty of 1992, and the Cartagena Protocol on Biosafety of 2003 (Fisher et al. 2006). Nevertheless, it has also received widespread criticism from some academics and policy makers. One of the most common complaints is that it is hopelessly vague and that it falls prey to a dilemma when it is specified. On one hand, if it is interpreted in a strong fashion, such that it calls for banning any potentially harmful activities, then it is unrealistic and paralyzing. For example, critic Cass Sunstein (2005) argues that one could appeal to strong interpretations of the PP as a basis for banning genetically modified (GM) crops and also as a basis for banning efforts to avoid GM crops, because both activities could have harmful consequences. On the other hand, if the PP is interpreted in a weak fashion, such that it merely calls for taking cost-effective steps to lessen the severity of potential threats, then it is obvious and trivial. For example, almost everyone can agree that it makes sense to promote energy efficiency in order to alleviate climate change, because people will save money in the process; the difficult question is whether it makes sense to take more expensive steps to address climate change.

In this chapter, I suggest that one can make sense of both the popularity of precautionary principles and the widespread criticisms of their vagueness by recognizing that various formulations of the PP are unified more by what they are *against* rather than what they are *for*. Those who call for application of the PP are unified in their frustration with current approaches for handling uncertainty and ignorance in environmental research and policy making. They are much less unified in the solutions that they propose for handling these problems in a better fashion. Thus, I propose that one can develop a much better understanding of the debates surrounding the PP by regarding it as a concept that rallies people around the recognition of significant problems that need to be addressed. It is crucial to note that this interpretation of the PP does not preclude other, more precise formulations of the principle as well. Rather, it shows that in addition to the more substantive and precise formulations of the PP that other authors have provided, it is enlightening to recognize the more symbolic role of the PP as a rallying point for criticizing the current state of environmental science and policy making.

The next section of the paper provides an overview of previous attempts to characterize the PP, along with the common criticisms that are leveled against it. In response to these difficulties, I propose that the PP can be fruitfully interpreted as a rallying point for criticizing current approaches for handling ignorance and uncertainty in environmental policy. Section 3 then highlights four of the most significant problems that have generated concerns with current approaches and that have stimulated interest in the PP. Section 4 shows how the range of proposals that have been developed under the umbrella of the PP can be understood more coherently when they are seen as varied efforts to respond to the problems identified in Section 3.

**2. Precautionary Principles**

The origin of the precautionary principle is often traced to Germany in the 1970s (see e.g., Jordan and O’Riordan 1999). In the German context, the PP was often used to justify implementing new technologies to prevent pollution at its source. From Germany, it began to spread into other European Union countries and even into international statements such as the Rio Declaration of 1992. But even though it has been cited as a guiding principle in numerous treaties and agreements, both proponents and opponents of the PP frequently acknowledge that it is vague and difficult to specify (Elliott 2010; Jordan and O’Riordan 1999; Manson 2002; Sunstein 2005; Tickner 1999). Part of the problem is that it is not clear whether the PP actually refers to a single principle, and even if it does refer to a particular principle it is not clear what that principle states.

Many proponents of the PP include a wide variety of concepts and ideas under its umbrella. For example, Joel Tickner’s (1999) attempt to operationalize the PP includes: (1) a general duty to take precautionary action; (2) the setting of goals for reducing hazardous substances; (3) shifting the burden of proof to those who engage in hazardous activities; (4) a structure for making decisions under uncertainty; (5) prevention-based tools for precautionary action; (6) the polluter pays principle; (7) assessment of alternatives; (8) ongoing monitoring, investigation, and information dissemination about hazards; (9) methods for participative and democratic decision making; and (10) strong enforcement. Similarly, Andrew Jordan and Timothy O’Riordan (1999) claim that the PP incorporates a number of themes, including willingness to take action in advance of proof, recognition of the interests of nonhuman entities, shifting the burden of proof onto those who initiate changes, and greater concern for the impacts of policies on future generations. Others have argued that the PP also calls for significant changes to scientific practice so that it is more likely to uncover environmental and public-health hazards (Tickner 2003).

Given all this complexity, it is no wonder that many figures try to narrow down the PP to a more specific statement or principle. But even when it is narrowed in this way, the content of the principle remains elusive. Marko Ahteensuu and Per Sandin (2012) point out that various formulations of the PP fall into at least three categories: (1) decision rules for making choices among environmental policies; (2) procedural requirements for constraining how to make decisions; and (3) epistemic rules that specify how to make scientific inferences under uncertainty. Even when it is interpreted primarily as a decision rule, various commentators have pointed out that different formulations of the PP vary in terms of the types of threats that are taken to justify precautionary action, the level of knowledge needed to justify action, and the specific actions that are called for (Manson 2002; Sandin 1999). In order to alleviate some of this confusion, Daniel Steel (2013; 2015) recently proposed that various “meta” versions of the PP should be distinguished from the PP proper. The meta versions require that environmental decision rules not be paralyzed by scientific uncertainty, whereas the PP itself requires that precautionary actions be taken in a manner that is appropriately proportional both to the level of harm and to the knowledge about potential threats.

While there is undoubtedly value to these attempts to interpret the PP in a more coherent and precise manner, my contention in this chapter is that there is also much to be gained by considering the full diversity of ways in which the PP is used in practice. Why do various formulations of the PP refer to so many different sorts of activities and strategies, and why is it so difficult to regiment the use of this concept? My contention is that the PP is used in so many ways because it was developed primarily as a way to criticize previous approaches to making environmental policy decisions. Calling for decision making “in accordance with the precautionary principle” is akin to calling for decisions that are more public-health friendly, that can be taken even when scientific evidence is ambiguous, and that do not marginalize the concerns of affected stakeholders. But there are all sorts of strategies for improving environmental decisions in this way, which explains why the PP is so difficult to analyze precisely.

In this respect, the PP is much like the concept of sustainability (see Jordan and O’Riordan 1999). Both concepts are notoriously vague, but they have become common buzzwords in environmental discourse (Jamieson 1998; Vucetich and Nelson 2010). In both cases, a number of commentators have attempted to develop more precise formulations of these concepts (see e.g., Norton 2005; Hartzell-Nichols 2012; Steel 2015; Thompson 2007). While these clearer interpretations can help prevent confusion, it is also worth keeping the broader interpretation of these concepts in mind. Efforts to regiment their use can eliminate some of their important connotations and rhetorical value, whereas the broader uses of these concepts provide ways of rallying people around the desire to change the status quo. It may not always be clear exactly what people are demanding when they use these concepts in a broader sense, but their rhetorical power and their ability to generate cohesion among a variety of stakeholders should not be underestimated. And even if these concepts are ultimately set aside because they become too vague, the major problems that they underscore should not be forgotten. The remainder of this chapter elucidates a number of the problems that proponents of the PP are concerned to address and some of the major strategies for addressing these problems.

**3. Problems with Addressing Ignorance and Uncertainty**

Questions about how best to respond to ignorance and uncertainty are central to environmental science and policy making. Some decision theorists carefully distinguish between ignorance and uncertainty, such that decisions under uncertainty occur when the possible outcomes of an action are known but it is not possible to assign numerical probabilities to those outcomes, whereas decisions under ignorance occur when the possible outcomes of an action are not even known (Elliott and Dickson 2011). In this paper I will use the terms more loosely, so that ‘ignorance’ refers to lack of knowledge in general and ‘uncertainty’ refers to limitations in the ability to predict or characterize particular phenomena. Thus, uncertainty in this sense is a type of ignorance and can be generated by various forms of ignorance. The significance of ignorance and uncertainty in the environmental context is that we often know just enough about various environmental challenges to recognize that we face significant potential threats. Nevertheless, we often do not know enough to make confident claims about the likelihood of the threats or the precise factors that cause them or the best ways of mitigating them.

As noted in Section 2, many academics, environmental organizations, and government bodies have called for the PP to be employed as a way of alleviating problems with our current approaches to handling ignorance and uncertainty. These concerns fall into four broad categories: (1) selective ignorance; (2) asymmetries of knowledge, power, and policy; (3) overreliance on quantitative analyses; and (4) lack of respect for local forms of knowledge. Each of these categories encompasses a variety of more specific problems. By examining these four general categories of concern, we can better understand what motivates proponents of the PP. We can also better understand why the principle has been elaborated in so many different ways and what solutions may need to be developed, whether those solutions are ultimately classified under the PP or not.

The first category is selective ignorance. A number of historians, philosophers, and sociologists have argued that we need to pay more attention to the social and political forces that cause us to remain ignorant about socially important topics, such as the life experiences of minorities or the public-health effects of toxic chemicals (see e.g., Kourany and Carrier 2020; Frickel et al. 2010; Gross and McGoey 2015; Proctor and Schiebinger 2008; Tuana 2006). The concept of *selective* ignorance refers to the notion that scientists often have to make methodological choices that lead them to collect extensive information about some topics and questions while they remain ignorant about other important topics and questions (Barrett and Raffensperger 1999; Elliott 2013; Tickner 2003). The partial and selective understandings that result from these methodological choices can have significant ramifications for society.

Consider four common forms of selective ignorance that proponents of the PP have frequently emphasized. First, those who develop new products are typically very concerned to identify and study their potential beneficial effects and uses but often much less interested in identifying their potential harmful effects (Cranor 1999). Second, when the producers of potentially toxic substances do study the harmful effects of their products, they often do so in ways that are either intentionally or unintentionally designed to minimize the chance of identifying any problems (e.g., Michaels 2008; Myers et al. 2009; vom Saal and Hughes 2005). Third, proponents of the PP argue that scientific research on environmental threats often revolves around performing extensive risk assessments of worrisome substances and practices while largely failing to develop safer alternative practices (Elliott 2013; O’Brien 1999; Sarewitz 2009). Fourth, risk assessors often focus on well-known pathways of exposure to hazardous substances while failing to consider pathways and practices that are particularly important to poor or marginalized members of society. For example, Maria Powell and Jim Powell (2011) argue that, despite their good intentions, state regulatory agencies sometimes fail to recognize the unique pollution hazards faced by poor subsistence anglers, who often eat more fish and different parts of fish than regulators anticipate.

A second category of problems for our current approaches to resolving ignorance and uncertainty stem from significant asymmetries associated with knowledge, power, and policy making. Carl Cranor (1999) has highlighted a number of these asymmetries. Some of them, such as the incentives for manufacturers to study the beneficial effects of new products rather than their harmful effects, are also examples of selective ignorance. But many of the other asymmetries identified by Cranor are distinct. For example, he notes that the beneficial uses of a toxic chemical are often very obvious, but the harmful effects are often difficult to identify, in part because the diseases caused by chemicals frequently have long latency periods and are often difficult to pinpoint as being related to particular chemical exposures. This asymmetry is exacerbated by further asymmetries in the norms of science. The scientific community generally prefers to make false negative errors about the existence of effects or phenomena rather than false positive errors. In the case of environmental threats, this means that scientific norms are designed to prevent scientists from falsely pronouncing the existence of threats, even if this means failing to identify some threats that really exist.

Besides these asymmetries associated with our knowledge, Cranor (1999) identifies others that have to do with power and policy making. For example, the manufacturers of potentially harmful products often have a great deal of money and a very strong interest in continuing to sell them, whereas those who will be harmed by the products are often much more diffuse, less organized, less wealthy, and perhaps even unaware of the threats that they face. This power asymmetry is exacerbated by the fact that many of the statutes that regulate toxic substances employ a post-market regulatory framework (Cranor 2011). In other words, the manufacturers of these substances do not bear the burden of proof to show that their products are safe before marketing them; instead, citizens or government agencies bear the burden of proof to show that the products are harmful in order to pull them from the market. These asymmetries of power and policy making exacerbate the asymmetries of knowledge and science mentioned in the previous paragraph, insofar as they provide further incentives to avoid collecting detailed knowledge about environmental health threats and to keep engaging in potentially harmful activities until more knowledge is forthcoming.

A third set of problems emphasized by proponents of the PP concerns the potential for scientists or policy makers to be over-reliant on or overconfident in quantitative analyses of threats. For example, Brian Wynne (2005) has argued that since the latter half of the twentieth century, debates over new technologies have almost always been framed as questions about risk, as if the only relevant question is whether new technologies are safe enough. But this tendency to focus on risk can marginalize or hide legitimate questions about justice and equity and the broader social ramifications of new technologies and the available alternatives to them. Even when risk analyses are appropriate and helpful, an additional problem is that they frequently incorporate quantitative information that is based not solely on empirical data but rather on experts’ subjective estimates. It is often very difficult to determine how much credence to place in these estimates (Elliott and Dickson 2011). Scientific experts are sometimes seriously overconfident in the accuracy of their subjective estimates, and psychologists have found that experts are prone to a variety of heuristics, biases, and cultural influences (Elliott and Resnik 2015; Solomon 2007). As a result, it is often difficult to determine who to trust when various experts disagree or when members of the public challenge experts.

A fourth worry about decision making under ignorance and uncertainty is related to this difficulty of deciding whether to trust publics or experts when their perspectives conflict. Namely, many proponents of the PP argue that policy makers frequently do not pay adequate attention to the local knowledge and expertise of citizens. Scholars such as Brian Wynne (1989) and Alan Irwin (1995) have drawn attention to cases in which particular groups of citizens had unique knowledge of hazards that scientific experts failed to appreciate. For example, Wynne (1989) has famously documented how, after the Chernobyl nuclear accident of 1986, expert predictions of radioactive contamination in sheep failed to take account of important details of sheep behavior and soil type that were well-known to farmers. Similarly, Irwin (1995) has discussed how risk analyses of pesticides have been challenged by agricultural workers because they allegedly did not reflect the on-the-ground conditions under which the pesticides are actually used. This phenomenon is related to the problem of selective ignorance, insofar as experts may not recognize the conditions faced by people who are marginalized or who face unique health threats (Corburn 2005; Ottinger and Cohen 2011).

**4. Precaution as a Response to Problems with Ignorance and Uncertainty**

Once one recognizes the diverse range of problems that various proponents of the PP are concerned about, it should be no wonder that the PP is not easily expressed as a single, straightforward solution to these problems. Perhaps the most common interpretation of the PP is as a guideline for making decisions under ignorance. As Section 2 noted, this guideline typically specifies particular sorts of threats that should be mitigated or eliminated when the available information about their likelihood reaches a particular level (even if that information is still significantly limited). But Section 2 also highlighted a number of other approaches that are often included in discussions of the PP. For example, in his efforts to operationalize the principle, we saw that Joel Tickner (1999) provides a framework that includes a wide variety of activities, including setting goals for the reduction of hazardous substances, shifting the burden of proof to those who want to maintain these activities, assessing alternatives, using the “polluter pays” approach, engaging in ongoing monitoring and information dissemination, and promoting participative and democratic decision making. This section shows how these activities, although not otherwise very coherent or unified, are all geared toward addressing the problems discussed in Section 3.

Consider first the narrow interpretation of the PP (as a guideline for justifying actions to mitigate or eliminate threats under uncertainty). It is helpful for addressing at least three of the problems mentioned in Section 3: overconfidence in quantitative analyses, lack of respect for local knowledge, and asymmetries in knowledge and power. If decision makers can justifiably take various sorts of precautionary actions even when they do not have precise quantitative information about a threat’s likelihood, it eliminates much of the pressure for them to create numerical estimates of risk that go beyond the available data. As Section 2 clarified, interpreting the PP as a decision guideline still leaves room for a great deal of ambiguity, because groups who employ various formulations of the PP can disagree about what sorts of threats justify action, how much knowledge is needed, and what actions to take in response. Nevertheless, many formulations of the PP as a decision guideline would allow decision makers to take action to mitigate threats in response to qualitative information (as long as it is of adequate quality). These formulations of the PP also frequently open the door for citizens with local knowledge to provide information that can justify preliminary steps to start addressing threats.

The interpretation of the PP as a decision guideline also helps to address asymmetries of knowledge and power, because it typically lessens the standards of evidence required for taking protective action. If, as Section 3 noted, the norms of the scientific community and the nature of our social context are such that it is very difficult to obtain compelling information that particular substances or activities are harmful, then it is unwise to require this sort of information before taking action. To do so could have dire effects on society. The PP allows decision makers to take action in response to more realistic kinds of information.

But while the narrow interpretation of the PP as a decision guideline helps to promote clarity about the nature of the principle, it does not fully address the range of problems that proponents of the PP have been keen to address. In particular, it is primarily reactive, in the sense that it provides decision makers with justification for addressing threats despite limited knowledge, but it does not provide clear mechanisms or incentives for alleviating this lack of information. Even Daniel Steel’s (2013; 2015) meta-PP, which he includes in addition to the narrow interpretation of the PP, focuses only on rejecting decision-making procedures that are paralyzed by scientific uncertainty. With this in mind, we can see why it is valuable to consider a richer and more diverse range of solutions to the problems considered in Section 3. The remainder of this section briefly considers four of the major solutions that are often discussed by proponents of the PP: (1) deliberative, participatory approaches to scientific research and policy making; (2) alternatives assessment and goal setting; (3) shifting the burden of proof in science policy making; and (4) policies for aggressively monitoring, investigating, and disseminating information about hazards.

First, deliberative and participatory approaches to scientific research and policy making have the potential to address all four problems discussed in Section 3. In recent years, there have been increasing efforts to create innovative mechanisms and forums for this purpose. These can include citizens’ juries and panels, public hearings, surveys, focus groups, interactive technology-based approaches, consensus conferences, science shops, public hearings, alternative dispute resolution, citizens’ advisory committees and task forces, activist movements, and various efforts at promoting citizen science (Elliott 2011; Elliott 2017; Kleinman 2000). Some of these efforts are more focused on influencing the course of scientific research on environmental issues, while others are geared primarily toward influencing the development of public policy. Proponents of these strategies argue that they have at least three virtues: (1) making environmental policies and decisions more democratically responsive; (2) producing better-informed and higher-quality decisions; and (3) promoting greater social acceptance and adherence to environmental policies (Fiorino 1990).

Unlike the narrow interpretation of the PP as a decision guideline, deliberative and participatory approaches to science and policy are well placed to alleviate selective ignorance in environmental research. For example, in an analysis of selective ignorance in agricultural research, I have previously argued that one of the best mechanisms for uncovering important bodies of information that are being neglected in current research is for NGOs and activist groups to draw attention to these lacunae (Elliott 2013). Efforts at promoting science shops and citizen science are also designed to make academic research more responsive to the needs and concerns of citizens (see e.g., Brown and Mikkelsen 1990; Corburn 2005; Elliott and Rosenberg 2019; Irwin 1995; Ottinger and Cohen 2011). Deliberative and participatory approaches are also helpful for alleviating overconfidence in quantitative information and lack of respect for local knowledge. When scientific findings are scrutinized in deliberative bodies, it provides opportunities for the participants to share their unique perspectives and to highlight questionable assumptions embedded in scientific results. Finally, even though there are no easy ways to eliminate the asymmetries in knowledge and power that plague public policy making, the creation of deliberative and participatory forums provides at least some opportunities for citizen groups to influence regulatory policies so that they are less biased in favor of those who generate potentially hazardous substances or activities.

Another strategy that is often discussed under the umbrella of the PP is alternatives assessment (O’Brien 1999; Tickner 1999). The idea behind this strategy is to aggressively look for alternatives to potentially hazardous activities and to set goals for shifting toward these alternatives. The Massachusetts Toxic Use Reduction Act (TURA) of 1989 is a frequently discussed example of a regulatory approach that emphasizes alternatives assessment. Under the TURA, companies that use large quantities of worrisome chemicals are required to publicly report their use of those chemicals as well as to create a plan that documents why they need to use them and whether there are alternatives. By requiring companies to explore alternatives, this legislation has cut the use of potentially toxic substances and even saved companies money in the process (Tickner 1999). By encouraging those who engage in hazardous activities to consider their options and to look for alternatives, this strategy can help to alleviate the problem of selective ignorance discussed in Section 3. It also addresses some of the asymmetries discussed in Section 3, insofar as it increases the incentives for manufacturers to move away from worrisome products and to look for safer ways to achieve their goals.

Another strategy associated with the PP that is crucial for alleviating asymmetries of knowledge and power is to shift the burden of proof for identifying and regulating hazards (Cranor 1999). One significant way to create this shift is to move from post-market regulatory regimes to pre-market regimes. For example, whereas the Toxic Substances Control Act (TSCA) in the US allows the manufacturers of industrial chemicals to place them on the market without providing evidence that they are safe, the Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) legislation in the European Union requires evidence of safety before products can go on the market (Cranor 2011). The polluter pays principle provides another influential strategy for shifting burdens of proof and thereby altering current asymmetries of knowledge and power. According to this principle, those who create pollution must pay for the social costs that it generates. This makes it much less appealing for polluters to continue producing harmful products, and it provides incentives for them to collect information about their hazardous qualities and the available alternatives.

Finally, proponents of the PP often argue that it calls for aggressively monitoring, investigating, and communicating information about potential hazards (Tickner 1999; Tickner 2003). For example, in an issue of *Human and Ecological Risk Assessment* (Vol. 1, No. 1, 2005) that focused on the implications of the precautionary principle for environmental health research, Philippe Grandjean argued that “The PP has … been misunderstood as anti-science. However, what has been called for [by advocates of the PP] is not an embargo of science, but rather the initiation of ‘new science.’… The ways in which science can support PP-based decisions is … likely to differ from the science that has supported traditional risk assessment” (Grandjean 2005, 14). Articles throughout the issue argued that the PP calls for altering traditional scientific practices that favor making false negative errors over false positives. They also argued that scientists should put more effort into pursuing studies that are of importance to public policy makers (even when those studies cross traditional disciplinary boundaries and yield results that are somewhat difficult to interpret) and finding ways to communicate those results effectively. These strategies are obviously designed to alleviate selective ignorance and asymmetries of knowledge and power.

**5. Conclusion**

This chapter has argued that it is fruitful to understand the precautionary principle as a very general concept around which people can rally to call for better approaches to handling ignorance and uncertainty in environmental research and policy making. Proponents of the PP have highlighted at least four major problems with current approaches: (1) selective ignorance; (2) asymmetries of knowledge, power, and policy making; (3) overreliance on quantitative analyses; and (4) lack of respect for local forms of knowledge. In response to these problems, they call for a variety of solutions. These include: (1) using a decision guideline that allows for regulatory action in the face of uncertainty (the narrow PP); (2) developing deliberative and participatory approaches to scientific research and policy making; (3) implementing alternatives assessment and goal setting; (4) shifting the burden of proof in policy making; and (5) aggressively monitoring, investigating, and disseminating information about potential hazards.

For the sake of clarity, one might argue that the term ‘precautionary principle’ should refer only to decision guidelines that call for action under uncertainty. Proponents of the PP could still call for other strategies, such as alternatives assessment and participatory approaches to research and policy, but these would not be part of the PP itself. But as I suggested in Section 2, the problem with this approach is that it buys clarity about the PP at the expense of failing to do justice to the full rhetorical power and the variety of uses for the concept. Frequently, when commentators call for policy making in accordance with the PP, they are rallying people around new ways of doing science, broader public involvement in policy making, and less dependence on quantitative analyses of hazards.

There may come a point when the PP becomes sufficiently unpopular or polarizing or confusing that it is better to jettison the broader interpretation in favor of more precise interpretations or new principles altogether. But the fruitfulness of the broader interpretation should not be dismissed too quickly. Like the concept of sustainability, it has significant rhetorical power for bringing a variety of stakeholders together to change current practices for the better. And even if the PP is ultimately set aside or made more precise, the problems that it highlights and the solutions that it champions should continue to receive sustained attention.

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