

ARTIGOS

NAVIGATING THROUGH THE PRECAUTIONARY PRINCIPLE(S)*

NAVEGANDO PELO(S) PRINCÍPIO(S) DA PRECAUÇÃO

Pedro Bravo

<https://orcid.org/0000-0002-3991-1931>

pedrobravo@usp.br

Universidade de São Paulo, São Paulo, São Paulo, Brasil

ABSTRACT *This paper aims to map the different theoretical options related to the Precautionary Principle (PP). Great part of the literature on it can be systematized by answering to three different questions: is there a basic structure in the PP? If so, in which interpretation of the PP does this structure express itself? Finally, are its damage or knowledge conditions fixed or adjustable? The first question separates realist from non-realist approaches. The second question allows us to discriminate monist, dualist, or pluralist positions in relation to the three interpretations of the PP: decision rule, procedural requirement, or epistemic rule. Finally, the third question distinguishes rigid from non-rigid formulations of the principle. Based on this mapping, one can not only navigate through the different formulations of the PP present both in official documents and in specialized literature, but also deflect some of its common objections, and understand Hans Jonas' eventual connection with PP. Notwithstanding, this mapping does not capture other important themes attached to PP, which motivates a final distinction between narrow and broader forms of PP.*

* Article submitted on: 05/07/2022. Accepted on: 28/10/2022.

Keywords: *Precautionary Principle. Philosophy of Science. Environmental Ethics.*

RESUMO *Este artigo tem como objetivo mapear as diferentes opções teóricas relativas ao Princípio da Precaução (PP). Grande parte da literatura sobre ele pode ser sistematizada ao se responder três questões: há uma estrutura básica no PP? Em caso positivo, em qual interpretação do PP tal estrutura se expressa? Por fim, suas condições de dano ou de conhecimento são fixas ou ajustáveis? A primeira pergunta separa abordagens realistas daquelas não realistas. Por sua vez, a segunda pergunta permite discriminar posições monistas, dualistas ou pluralistas em relação às três interpretações do PP: regra de decisão, requerimento procedimental ou regra epistêmica. Por fim, a terceira pergunta distingue formulações rígidas do princípio daquelas não rígidas. Com base em tal mapeamento, pode-se não apenas navegar pelas distintas formulações do PP presentes tanto em documentos oficiais quanto na literatura especializada, mas também contornar algumas de suas objeções comuns, e entender a eventual conexão de Hans Jonas com PP. Não obstante, esse mapeamento não captura outros temas importantes relacionados ao PP, o que motiva uma última distinção entre formulações estreitas e amplas do PP.*

Palavras-chave: *Princípio da Precaução. Filosofia da Ciência. Ética ambiental.*

All scientific work is incomplete—whether it be observational or experimental. All scientific work is liable to be upset or modified by advancing knowledge. That does not confer upon us a freedom to ignore the knowledge we already have, or to postpone the action that it appears to demand at a given time. Austin Bradford Hill (1965, p. 300).

1 Introduction

The Precautionary Principle (PP), which aims to protect the environment or human health from uncertain threats, has returned to public debate because of COVID-19 pandemic. For example, a scientist asserted that United Kingdom's slow response to it and the negative consequences implied by that could have been avoided if PP were to be adopted (Vaughan, 2021). PP applications, though, date from way before the pandemic (Harremões, 2001, pp.14-15; Langston, 2008) and are used in a variety of contexts, as mining in Brazil

(Lauda-Rodriguez; Ribeiro, 2019) and dual-use research in general (Kuhlau *et al.*, 2011).

Because of its prominence, one could have the impression that there is not too much room for disagreement about the PP. Unfortunately, it is not the case: back in the end of the last century, philosopher Per Sandin (1999, pp. 902-905) had already compiled nineteen different formulations of it, and criticism about the PP is very diverse (Larrère, 2003; Sandin *et al.*, 2002; Stirling, 2017) including even ignorance strategies (Bravo de Souza, 2021). In face of this context, in this paper I aim to map the different theoretical options related to the PP. I show how one can navigate through its various formulations present both in official documents and in specialized literature. Despite its limitations, this exercise also indicates how one can deflect some objections commonly addressed to it, and how to understand Hans Jonas connection with the PP.

In order to attain that objective, this paper is divided into the following sections. The first three ones correspond to answering the three questions that systematize great part of the literature on the PP: is there a basic structure in it? (Section 2); if so, in which interpretation of the PP does this structure express itself? (Section 3); finally, its damage or knowledge conditions are fixed or adjustable? (Section 4). The diagram below synthesizes these questions and anticipates the possible answers.

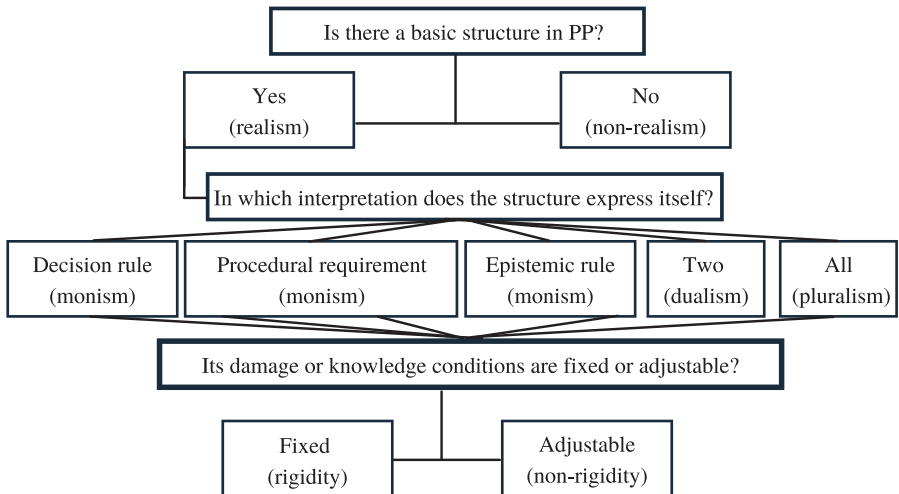


Diagram 1 - Mapping the PP

As it will be shown, while Diagram 1 covers a great part of the PP literature, it does not deal with some themes that are often associated with the PP. In Section 5, therefore, I will comment on how it is possible to understand the PP in a broader way drawing upon Kevin Elliott's (2022) work. By doing that, one can have a more comprehensive view about its nature. Notwithstanding, there are other subjects related to it that will not be explored further here, as its justification or more general objections.

2 Is there a basic structure in the PP?

It is not difficult to find the objection according to which the PP does not have a core because of its diverse formulations both in official documents and in specialized literature (Cf. Jordan; O'Riordan, 1999, p. 16). Therefore, the first relevant question to discriminate PP approaches is: is there a basic structure in it? I will call *realism* the theoretical option which answers affirmatively and *non-realism* the one which answers negatively.

Realist authors claim that there is a basic structure in the PP which is present in its different formulations (Aven, 2010; Cezar; Abrantes, 2003; Gardiner, 2006; Manson, 2013; Randall, 2011; Steel, 2015; Trouwborst, 2006; Wedy, 2020). This structure is commonly characterized by three or four elements and would be implicit in official documents containing the PP. The three elements are: (i) the knowledge condition, (ii) the harm condition, and (iii) the recommended precaution¹. These elements can be expressed in a conditional sentence whose antecedent is (i) and (ii), and the consequent is (iii). For further reference, let us define it as *narrow PP*. Accordingly,

Narrow-PP: *if* there is a menace to the environment or human health (ii), which is uncertain (i), *then* (iii) some precaution is recommended.

Specifically, (i) refers to how much is known about a threat often related to the environment or human health and whose evidence strength is characterized as one of uncertainty². Now, there are different ways to flesh out what uncertainty

1 Authors who add a fourth element to this structure either refer to the status of the recommended precaution (Sandin, 1999), whether it is mandatory or just suggested for example, or to shifting the burden of proof (Wedy, 2020, p. 60). Shifting the burden of proof can mean regulations that require evidence of safety before a product is released. Notwithstanding, the status of the recommended precaution can be easily accommodated in condition (iii) by qualifying it. And shifting the burden of proof can also be accommodated as a possible measure in (iii) instead as a fourth element, for there are precautions applications in which it is impossible to apply this clausula, as when responding to natural disasters (Cf. Resnik, 2021, p. 96). Either way, it is possible to maintain the aforementioned basic structure of PP with only three elements

2 I have used the term "often", for it is possible to find both in realist authors texts and in judicial decisions the element (i) applied to harms of different natures and, consequently, not just related to the environment or human health (Munthe, 2011, p. 3; Steel, 2015, p. 39; Zander, 2010, p. 106). Since there is still much controversy

is. For example, one can appeal to the decision theory classification of risk (known impacts, known probabilities), uncertainty (known impacts, unknown probabilities) and ignorance (unknown impacts, unknown probabilities) and then attach the PP to uncertainty and ignorance thus understood, or try defining it as a lack of prediction (Steel, 2015). In section 4, I will talk more on this. For now, it suffices to say that the uncertainty dimension in PP is generally below a threshold indicating results which are beyond reasonable doubt (cases where we apply the prevention principle instead of PP).

Element (ii) refers to the gravity of the menace (*e.g.*, “irreversible”, “serious”). It is important to note how it is expressed by qualitative categories which, at first sight, might look vague, but that can be refined (Cf. Manson 2007 about “irreversibility”). Finally, (iii) has to do with the recommended measures by the PP (*e.g.*, “research alternatives”, “interrupt the activity”). These measures must be proportional to (i) and (ii), as prescribed by the principle that says how to balance the PP’s elements: the principle of proportionality.

Present in important texts as the Communication from the Commission of the European Communities on the Precautionary Principle (EU, 2000), the proportionality principle has been notably refined by Steel (2015, pp. 10-30) and Birch (2021). Steel conceives proportionality as composed by the criteria of consistency and efficiency. In order to understand it properly, one must know that a version of the PP in Steel’s approach is a specification of the narrow-PP as defined above. Therefore, by consistency Steel means that the recommended precaution by a version of the PP should not be contraindicated by this very version, whereas by efficiency he means that if there is more than one recommended precaution by a version of the PP, the precaution that is less costly should be preferred.

Birch’s proportionality is composed by four criteria besides consistency: compatibility with fundamental rights, reasonable compensation, adequacy and non-excessiveness. In a similar way to Steel’s approach, the efficiency criteria should be used as a tie breaker; in other words, in those cases where there is more than one recommended precaution that satisfies all the previous criteria. It is important to highlight, finally, that Birch argues in favor of roles for both specialists and lay people in the appraisal of each criterion of his notion of proportionality.

Either way, one of the most developed defenses of the PP basic structure and, consequently, of the PP allegedly unity was provided by Steel (2015, pp. 44-68). Steel not only shows how these elements and his concept of scientific uncertainty are able to express PP's different formulations (catastrophic PPs, PP as *maximin* rule, PP as *minimax regret* rule³), but also replies to Miriam Thalos' (2009; 2012) non-realistic objections. It is fruitful then to comment on their debate in order to grasp realist and non-realist positions⁴.

Indeed, for Thalos (2009, pp. 43-45; 2012, pp. 172-173), there is not a basic structure on the PP by three main reasons. The (1) first reason is the existence of four different meanings to the prefix *pre* of precaution that simply do not intersect: (1.1) *pre* as referring to acting cautiously beforehand, (1.2) *pre* as prioritizing some values in detriment of others, (1.3) *pre* as how to do plans in a way to be prepared for an uncertain future, and (1.4) *pre* as to avoid injustices. The (2) second reason is that the PP takes different forms in accordance with different action patterns (Thalos, 2009, pp. 46-48; 2012, pp. 174-175). More specifically, in what she calls front-loading action pattern, the PP caution would occur before a certain action, as it happens during hunting with a firearm. In the coordinative action pattern, though, the PP caution could occur throughout diverse actions, and it could be updated as soon as new data emerges, a situation illustrated in agriculture. Finally, the (3) third reason states that the PP could be applied even when there are probability reliable estimates and not only when this condition does not hold.

Steel (2015, pp. 47-48) replies to three objections above. Regarding (3), he affirms that his notion of scientific uncertainty can incorporate the idea that the PP can be applied even when there are probability estimates, for his concept of it refers to lack of prediction and not about probability estimates existence. Concerning (2), the PP is, according to him, compatible with both Thalos' action patterns and, in particular, is in a mutual reinforcing relationship with the coordinative one, for this flexibility allows one to obtain less costly precautions. Finally, the reply to (1) goes as follows: (1.1) and (1.3) are consequences of what it means to act before there is overwhelming evidence, which is the very

3 Catastrophic PP was proposed differently by Cass Sunstein (2005) and Lauren Hartzell-Nichols (2012), whose definition I discuss in Section 4. On Sunstein's one, see its development on Wedy (2020, pp. 113-120). PP as *maximin* rule was proposed by Sven Hansson (1997). PP as *minimax regret* was formulated by Anthony Chisholm and Harry Clarke (1993). To understand what these decision theoretic rules mean, see Peterson (2009, pp. 43-52).

4 Another recent non-realist approach was proposed by Per Sandin and Martin Peterson (2019). Differently from Thalos, their non-realism states that there is a set of ideas underneath PP label that connect to each other by family resemblances. In other words, it is possible that one idea associated with PP is similar to another one which is then similar to a third one, but there may be no similarities between the first and the third one.

nature of the PP; (1.2) is not present in the PP according to Steel, because it is difficult to make it compatible with proportionality; and (1.4) is at play when one evaluates threat severity in the PP.

Before moving to the possible positions about the interpretations of the PP, it is important to note that the distinction between realist and non-realists in this context does not equate to a positive or a negative stance on it. In fact, one can be a realist about the PP structure and consider it to be useless or vague⁵. Respectively, one can be a non-realist and consider it to be fruitful and relevant in certain contexts. Either way, asserting the existence of a structure in the PP is an important step towards further refinements of it.

3 In which interpretation of the PP does the structure express itself?

Classifications of PP in accordance with the type of rule it expresses are recurrent in the PP literature. Indeed, if it expresses an action or a group of actions, it is a *decision rule*. If it refers to which conditions these actions should be taken, it is a *procedural requirement*. Finally, if it refers to what we should believe or belief formation, it is an *epistemic rule* (Ahteensuu; Sandin, 2012, p. 972; Rechnitzer, 2020; Sandin, 2007).

In legal documents, one arguably can visualize the first interpretation in the Wingspread Declaration: “When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically” (Precautionary Principle Conference, 1998). The second one can be seen at Rio-92 Principle 15: “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” (UNCED, 1992; my italics). Lastly, the third one can be found in excerpts of the precursor of PP, the *Vorsorgeprinzip*: “Vorsorge further means the early detection of dangers to health and environment by comprehensive, synchronized (harmonized) research, in particular about cause-and-effect relationships” (Boehmer-Christiansen, 1994, p. 37).

It is important to note how the three interpretations above vary in accordance with the third element in the PP basic structure, the recommended precaution. In other words, each interpretation prescribes precautionary measures regarding

5 See Steel (2015, pp. 21-25) for a reply to the vagueness objection in the context of estimating the social cost of carbon.

distinct objects when there are uncertain threats to the environment or human health: respectively, action, conditions to act, and beliefs.

To illustrate that, the PP as a decision rule could prescribe the following action: “paralyze the potentially harmful activity”. The PP as procedural requirement could be instantiated in shifting the burden of proof, for it refers to how certain actions should be taken and not a specific action. The PP as an epistemic rule could be illustrated in the preference to commit type I errors (false positives) over type II errors (false negatives) (Lemons *et al.* 1997)⁶. Therefore, I propose that these interpretations can be derived from the PP basic structure. By relying on that, it is possible to discriminate different kinds of realism that one can have due to the interpretations one finds plausible.

For example, someone that finds only one of the PP interpretations to be plausible will adopt some form of *monism*. Martin Peterson (2007), in particular, considers only the epistemic interpretation to be legitimate. Among other formulations, it is expressed in the preference for false positives. According to him, the PP in other interpretations is inconsistent. Other PP interpretations are inconsistent for Peterson because of a theorem that he proves in Peterson (2006). Roughly, assuming that the PP is a decision rule applied to situations in which it is only possible to rank in a qualitative way the probability (*e.g.*, x is probable, x has a non-negligent probability, x is more probable than y) and the utility of the consequences of act, Peterson proves that different PP formulations are inconsistent with general conditions used in decision theory. The PP is consistent with those conditions in the specific sense of recommending, for example, that act x is preferable to y while a certain condition recommends the contrary⁷.

- 6 Type I error and type II error are both errors that can occur in hypothesis testing. Roughly speaking, a type I error is the chance of rejecting the null hypothesis when it is true (false positive) and a type II error is the chance of accepting the null hypothesis when it is false (false negative). Both errors' chances cannot be minimized together, so there is a trade-off in deciding which error is worse. Common scientific practice considers type I error more serious than type II. In Oreskes and Conway's (2014, p. 17) words: “Western scientists built an intellectual culture based on the premise that it was worse to fool oneself into believing in something that did not exist than not to believe in something that did”.
- 7 Among the critics that Peterson has received in the literature, I highlight the one presented by Thomas Boyer-Kassem (2017a). In special, he shows how one condition (the Archimedean condition) of Peterson's theorem implies the possibility of counterbalancing or compensating an increase in the probability of a non-fatal consequence by a decrease of the probability of a fatal one. By allowing it, this condition is committed to the idea according to which fatal and non-fatal consequences are commensurable. Now, PP, for Peterson himself (2006, p. 597) has the contrary intuition: “The intuition underlying PP is that some outcomes are so bad that they ought to be avoided (if possible) even if the potential benefit of accepting such a risk is enormous”. Agreeing or not with that idea on the PP, Peterson presupposes it. If he presupposes it, then he should not commit himself with the Archimedean condition. But, if he does not presuppose it, then there is not how to prove his theorem. Therefore, his results appear to depend on ideas that in his terms are contrary to the PP intuition. See Peterson (2017) for a reply and Boyer-Kassem (2017b) for a rejoinder.

As Resnik (2021, p. 91), other authors find just the decision rule interpretation plausible. In his words, it is instantiated in the following definition: “In the absence of the degree of scientific evidence required to establish accurate and precise probabilities for outcomes related to a decision, take reasonable precautionary measures to avoid, minimize, or mitigate plausible and serious harms”. Resnik (2021, pp. 95-98) goes against the epistemic interpretation for he understands it as shifting the burden of proof, a *clausula* that must be recommended by the PP only in the cases where it is possible and reasonable. Indeed, in cases of potential natural disasters, there is not a way to apply it. On the other hand, the procedural requirement interpretation would devoid the PP of meaning and would be unhelpful in decision-making, whence his decision rule monism.

Katie Steele (2006, p. 29) herself favors a procedural requirement monism: “I claim that the PP is best conceived as providing broad guidelines for formulating or specifying a decision problem”. In her proposal, the guidelines are: a comprehensive modelling of the decision space that conducts both to the consideration of feasible alternatives and to better uncertainty representation; a perspective consistent with the sustainability ideal by paying attention to factors as inter and intragenerational equity on action evaluating; and the inversion of the burden of proof. Regarding other interpretations, Steele (2006) mentions some of the objections directed to PP framed in a decision theoretic way (see note 2).

Even if it is less common, it is also possible to adopt two of the three PP interpretations. In such a case, there will be some form of *dualism*. Stephen John (2019), for example, seems to adopt such posture when providing an understanding of the PP where there are epistemic and procedural elements, though he does not advance any objection to the PP as a decision rule. Distinctly, by restricting the PP to the management of risks and not its assessment *and* management, the Communication from the Commission of the European Communities on the Precautionary Principle (EU, 2000) seems to adopt a dualism where there are the decision and procedural interpretations⁸.

Lastly, the adoption of the three interpretations leads to *pluralism*. Authors such as Hugh Lacey (2014, pp. 687-691) and Steel (2015) endorse it. For Lacey,

8 Despite both risk management and risk assessment being part of risk analysis, the assessment is defined as the moment when one tries to understand the nature and amplitude of a risk, while the management part is characterized as the moment where decisions are taken about how to deal with the risks already identified in assessment (Douglas, 2009, pp. 139-140). Because of this, it is common to hear the assertion that the assessment is neutral, where management is not. For critics to such a framework, see, besides Douglas (2009), Mayo (1991) and Silbergeld (1991).

the evaluation of the harm dimension of the PP must be done in light of the value perspective of social justice, democratic participation and sustainability (epistemic rule); moreover, this evaluation can prescribe interventions before the introduction of a technological innovation (decision rule) and it must be done within democratic deliberations (procedural requirement). More interestingly, the PP in Lacey's approach is contained in what he calls *context-sensitive strategies* way of researching, that is to say a theoretical and empirical guidance to research that is not restricted to the "underlying structure of phenomena, process and interactions among its components, and to the laws expressed in mathematical form that rule them", as *decontextualizing strategies* do (Lacey; Mariconda, 2014, pp. 652-653).

In Steel's (2015) approach, the PP as a procedural requirement occurs by limiting decision rules that can or cannot be used: effectively, those that do not allow any decision in face of uncertainty – paralyzing rules in his words – must not be used. The statement that the presence of uncertainty should not be a reason to inaction in face of threats to the environment or human health also has an epistemic side. In particular, Steel (2011; 2015, pp. 172-178) argues that the procedure to adopting uncertainty factors in toxicology incorporates that idea, for it allows to estimate doses of references, that is to say "[...] doses to which the population can be exposed daily without risk of harmful effects to the health during the whole life" (Oga *et al.*, 2008, p. 76; my translation), even from great uncertainty involved in the extrapolation from non-human animals experiments to human animals. Finally, the PP as a decision rule would occur in the PP basic structure variation, as I show in the following section.

4 Are damage or knowledge conditions fixed or adjustable?

The third question that allows to map the different theoretical options regarding the PP deals with the *rigidity* or *non-rigidity* of its harm and knowledge conditions. On one hand, rigid formulations of the PP only admit that the principle applies to cases where there is a specific severity of the harm condition *and* a specific rigor of the knowledge condition. On the other hand, non-rigid formulations allow PP applications to a continuum above or below some threshold for *at least one* of these conditions.

Manson's (2013, p. 612) "catastrophe principle" is an example of a rigid formulation of the PP. Indeed, its harm condition applies to catastrophes and its knowledge condition is just possibility. Not surprisingly, such a version of the PP faces difficult problems, as Manson himself demonstrates. Hartzell-Nichols' (2012, pp. 160-161) "catastrophic Precautionary Principle" is arguably a rigid

formulation of the PP too. In her approach, the harm condition applies to threats of catastrophes which are defined as threats where “many millions of people could suffer severely harmful outcomes”, while her knowledge condition applies to cases where the mechanism that explains the catastrophe is well understood, and its functioning conditions are accumulating.

Non-rigid formulations of the PP where just one condition varies are commonly found in legal documents. The United Nation’s World Charter for Nature (1982), for example, fixes the harm condition on “significant risk”, but the knowledge one is applied to potential adverse effects which are not fully understood. Similarly, famous PP formulation at Rio-92 Declaration (UNCED, 1992) fixes “serious or irreversible harms” on harm condition, but “lack of full scientific certainty” on the knowledge one⁹. In their document about the PP, the World Commission on the Ethics of Scientific Knowledge and Technology (2005) formulates a fixed harm condition, “morally unacceptable harm”, as well, but a non-rigid uncertainty condition: “[harm that is] scientifically plausible but uncertain”. “Potential adverse effects which are not fully understood”, “lack of full scientific certainty” and “scientifically plausible but uncertain” can be all satisfied by knowledge conditions whose rigor varies, whence the non-rigidity present in these formulations.

Finally, authors such as Resnik (2021) and Steel (2015) propose non-rigid definitions of the PP where both conditions can vary. In Resnik’s (2021, p. 91) approach, both conditions can be satisfied by various options above a minimum threshold. The minimum threshold for the knowledge condition is plausibility, that is to say consistency with “well-established scientific facts, hypotheses, laws, models, or theories”. The minimum threshold for the harm condition is for it to be “serious”, a condition to be interpreted case by case.

In Steel’s proposal (2015), an affirmation according to which a specific condition of knowledge and harm is sufficient to justify a precaution is called a *version of the PP*. For instance, “if a scientifically plausible mechanism [knowledge condition] exists whereby an activity leads to a catastrophe [harm

9 “Lack of full scientific certainty” is a problematic knowledge condition. Consider that since at least 19th century philosophers, in general, do not believe in the existence of certainty in science, but only in fallible beliefs (*i.e.*, beliefs for which there is no conclusive justification) (Hoyningen-Huene, 2013). Now, such a condition would imply that PP applies to every situation. Notwithstanding, a more charitable interpretation of it is possible by remembering Rio-92 context and other legal vocabulary along which PP would be at play, as the World Trade Organization’s Agreement on the Application of Sanitary and Phytosanitary Measures, whose article 5.7 talks about “[...] cases where relevant scientific evidence is insufficient”. With that in mind, law Professor David Wirth (2013, p. 1171) says: “Particularly in countries in which governmental regulation is subject to judicial review, a scientific predicate for regulation characterized as ‘insufficient’ generally would suggest that the measure would not withstand scrutiny by a neutral third party such as a court. Presumably for reasons like this, Rio Principle 15 and other authorities speak of “lack of full scientific certainty”.

condition], then that activity should be interrupted gradually or significantly” is a version of the PP and “if there is some scientific evidence [knowledge condition] that an activity leads to a significant and irreversible harm [harm condition], then a feasible alternative must replace that activity” another.

Wingspread Declaration’s PP (Precautionary Principle Conference, 1998) is also non-rigid in a similar way to Resnik and Steel. Its damage condition, though, does not have a minimum threshold; indeed, it is only stated that the PP is to be applied when “an activity raises threats of harm” without any qualification to this threat. Knowledge condition, differently, refers to “cause and effect relationships [that] are not fully established scientifically”, which may be understood as the maximum threshold below which the PP is applied.

Be as that it may, the above discussion on the rigidity or non-rigidity of the conditions that trigger the PP has four important consequences. First, it allows to deflect objections according to which the PP applies to any possibility of threat (arguments from mere possibility, in Sven Hansson’s (2004) words). Not only does this discussion shows that this objection is directed only at a rigid formulation of the PP whose knowledge condition rarely appears in the literature, but it also indicates the PP definitions that avoid it, as Resnik’s (2021, pp. 80-82) PP where plausibility is the inferior threshold on the knowledge condition.

The second consequence is allowing to differentiate the PP from the *prevention principle*. That is possible by noting the superior thresholds to the epistemic condition on the above definitions. For instance, if we take Wingspread’s PP as an example, the prevention principle would be applied to the cases where cause and effect relationships are fully established scientifically.

The third consequence is to accommodate another classification of the PP in literature: the one that divides it between weak and strong interpretations. For Cass Sunstein (2005, pp. 24-27), for example, the weak interpretation on one hand would state that one must not wait for scientific certainty to take a measure relating to an uncertain threat; on the other hand, the strong one would affirm that regulatory measures are always necessary when there is a possible threat. Without going into the problematic details of Sunstein’s definitions (Cf. Steel, 2015, pp. 17-43) about it), I note that it can be accommodated into the distinction between rigid and non-rigid formulations of the PP. For the weak interpretation is a non-rigid formulation whose knowledge and harm conditions vary, whereas the strong one is a rigid formulation whose conditions are fixed.

Lastly, the distinction between rigid and non-rigid formulations also allows one to make the relationship between the PP and a recurrent name in its literature more exact, German philosopher Hans Jonas. Despite not using

the term, certain aspects of Jonas' (2006) moral theory are often related to the PP (Reber, 2016; Waldman *et al.*, 2017; Whiteside, 2006). One of the ways to approach them is to look at Jonas' *heuristics of fear*. When discussing it in context of increasing technological threats, Jonas argues that the bad prognostic should receive more weight than the good one in face of the possibility of infinity loss. Among other reasons, he argues that this heuristic is plausible for technology autonomy makes it very difficult to correct it after it is on work and, more importantly, for we *must* preserve humanity's existence and essence. Using the framework above only to make sense of these passages in the PP context, one can understand his claims as defending a version of it where "catastrophe" is the harm condition, "possibility" the knowledge one, and whose recommend precaution is an obligation to avoid the catastrophe. Therefore, Jonas' PP would be a very specific, rigid version of it (Cf. Coyne, 2021, pp. 150-153 for a similar interpretation). But Jonas' PP would also be one whose proportionality takes into account more elements (*e.g.*, the imperative to preserve humanity's existence and essence) than previous ones.

5 Narrow and broader PP

Even if the above discussion captures much of the PP literature, it does not do justice to other themes often associated with it. In face of it, one could discard these other themes and say that the only ones that matter to the PP are those that were described in the last few sections. One also could, nonetheless, understand the discussion so far as dealing with the narrow and more specific way of conceptualizing PP, and, without denying its importance, advocate in addition to it that a broader form of the PP. Kevin Elliott (2022) is one of the authors who adopt such fruitful strategy.

Roughly speaking, Elliott argues that the PP can be better understood as a general concept around which better approaches to handle uncertainty in environmental research and policy making are proposed. He then states that what unifies the PP advocates are four elements in previous approaches to which they are against: (i) selective ignorance (*e.g.*, how certain chemicals are widely researched whereas others are not); (ii) asymmetries of knowledge, power, and policy (*e.g.*, traditional preference in the scientific community to make false-negative rather false-positive errors); (iii) too much confidence in quantitative analyses (*e.g.*, overreliance on experts subjective estimates); and (iv) lack of respect for local forms of knowledge (*e.g.*, research that does not deal with workers real conditions).

According to him, the narrow PP, which can be interpreted in the definition provided in Section 2, addresses (ii) to (iv). The broader PP, though, addresses all elements and it is composed by four categories:

Broader-PP: In cases of uncertain threats to the environment or human health, facilitate “(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” (Elliott, 2022, p. 710).

(1) refers to activities that influence environmental research and public policy, as public hearings, consensus conferences and citizen science (Mayer; Wynne, 1993; Ravetz, 2004). (2) states that better precautionary decisions are made when a wide range of alternatives is considered and researched (O’Brien, 2000; Tickner; Geiser, 2004). (3) was already mentioned in sections 2 and 3. Lastly, (4) makes reference to changes in decisions about how to research and communicate scientific results so that science can better protect the environment (Elliott, 2014; Grandjean, 2005; Raffensberger; Barrett, 1999).

Elliott (2022) demonstrates how the broader PP addresses from (i) to (iv) and counterbalances the reactive character of the narrow PP. I am not going to delve into details here. Instead, presupposing the accuracy of his arguments, I would like only to show how his (4) element accommodates another commonly mentioned theme in the PP literature as well: improving science education (Cranor, 2003; Elliott, 2014; Tickner, 2005). Even if it is occasionally vaguely defined, the aim to improve science education in the PP literature can be refined by connecting it with (i) to (iv). To illustrate it, take ethical training on the consequences and alternatives of a technological research project in a hypothetical semester course. It can address (i) because the research will be oriented in a different, more precautionary way; (ii) for it can allow one to question the foundation of preferring to make false-negative errors, for example; (iii) because it would permit one to consider more carefully how likely those consequences are in face of their possible societal impact; and (iv) thanks to the exposition to the benefits of collaboration. The Elliott’s broader PP, therefore, is a robust concept to integrate common aspects of the PP without denying the importance of its narrow form.

Conclusion

In this paper, I mapped the different theoretical options related to the PP. Great part of its literature can be captured by three questions about its structure:

is there a basic structure on the PP? If so, in which interpretation does this structure express itself? Finally, its harm or knowledge conditions are fixed or adjustable? As shown, the first question differentiates realists from non-realists; the second one discriminates monists', dualists' and pluralists' formulations of the PP, and, lastly, the third question allows one to separate rigid from non-rigid formulations. Although the examination of these questions covers much of the PP literature, I argued that it is also fruitful to consider broader versions of the PP.

Despite its limitations, this mapping also indicated how one can deflect some objections commonly addressed to the PP, as the criticism according to which it applies to mere possibilities of harm. It also showed how to understand Hans Jonas connection with the PP and to differentiate the PP from the prevention principle. The distinction between weak and strong interpretations of the PP was accommodated by it too.

Concerning future applications, I suggest that this mapping could also be used to precisely list whose versions of the PP are more commonly criticized. That may shed some light on the scope of the PP criticism and whether it is only restricted to rigid versions of it, for example, or not. The somewhat diffuse literature on precautionary science could benefit from this paper as well, since it may provide ways to connect it with the PP. Hopefully, it may also help to make decisions that do not postpone actions to mitigate uncertain threats to the environment and human health.

Acknowledgements: This work was funded by grant #2019/10200-3, São Paulo Research Foundation (FAPESP). Part of it was presented at a Scientiae Studia Philosophical Association meeting. I would like to thank my colleagues and two reviewers for their important criticism. In particular, I thank Pablo Mariconda, Natalia Manzoni, Otto Rosa and Kevin Elliott.

References

- AHTEENSUU, M.; SANDIN, P. "The Precautionary Principle". In: S. Roeser *et al.* (eds.). 2012.
- AVEN, T. "Misconceptions of Risk". Chichester, UK: John Wiley & Sons, 2010.
- BIRD, A.; LADYMAN, J. (eds.). "Arguing About Science". Nova York: Routledge, 2013
- BIRCH, J. "Applying the precautionary principle to pandemics". Preprint. 2021. Available at: <https://philpapers.org/rec/BIRATP>. Last access on March 30, 2022.
- BOEHMER-CHRISTIANSEN, S. "The precautionary principle in Germany: enabling government". In: T. O'Riordan; J. Cameron (eds.). 1994.
- BOYER-KASSEM, T. "Is the Precautionary Principle Really Incoherent?" *Risk Analysis*, 37, 11, 2017a, pp. 2026–2034.

- _____. “The Precautionary Principle Has Not Been Shown to Be Incoherent: A Reply to Peterson: Response”. *Risk Analysis*, 37, 11, 2017b, pp. 2039–2040.
- BRAVO DE SOUZA, P. “Agnotologia e o Princípio da Precaução”. *Principia: an international journal of epistemology*, 25, 2, 2021, pp. 289–304.
- BRAVO DE SOUZA, P., “Communication from the Commission of the European Communities on the Precautionary Principle”. Brussels: Commission of the European Communities, 2000.
- BROWNSWORD, R., SCOTFORD, E., YEUNG, K. (eds.). “The Oxford Handbook of Law, Regulation and Technology”. Oxford: Oxford University Press, 2017.
- CEZAR, F. G., ABRANTES, P. C. C. “Princípio da precaução: considerações epistemológicas sobre o princípio e sua relação com o processo de análise de risco”. *Cadernos de Ciência & Tecnologia*, Brasília, 20, 2, 2003, pp. 225–262.
- CHISHOLM, A; CLARKE, H. “Natural resource management and the precautionary principle”. In: E. Dommen, E. (ed.). 1993.
- COYNE, L. “Hans Jonas: life, technology and the horizons of responsibility”. New York: Bloomsbury Academic, 2021.
- CRANOR, C. “What Could Precautionary Science Be? Research for Early Warnings and a Better Future”. In: J. Tickner. 2003.
- DOMMEN, E. (ed.). “Fair Principles for Sustainable Development: Essays on Environmental Policy and Developing Countries”. Cheltenham: 1993
- DOUGLAS, H. E. “Science, policy, and the value-free ideal”. Pittsburgh: University of Pittsburgh Press, 2009.
- ELLIOTT, K. C. “Ethical and Societal Values in Nanotoxicology”. In: B. Gordijn; A. M. Cutter. 2014.
- _____. “Precautionary Principles”. In: B. Hale, A. Light, L. Lawhon. 2022.
- GARDINER, S. M. “A Core Precautionary Principle”. *Journal of Political Philosophy*, 14, 1, 2006, pp. 33–60.
- GORDIJN, B., CUTTER, A. M. “In Pursuit of Nanoethics”. Dordrecht: Springer, 2014.
- GRANDJEAN, P. “Non-precautionary aspects of toxicology”. *Toxicology and Applied Pharmacology*, v. 207, n. 2, p. 652–657, 1 set. 2005.
- HALE, B., LIGHT, A., LAWHON, L. “The Routledge Companion to Environmental Ethics”. New York: Routledge, 2022.
- HANSSON, S. O. “The Limits of Precaution”. *Foundations of Science*, 2, 2, 1997, pp. 293–306.
- _____. “Great Uncertainty about Small Things”. *Techné: Research in Philosophy and Technology*, 8, 2, 2004, pp. 26–35.
- HARREMOËS, P. *et al.* (eds.). “Late lessons from early warnings: the precautionary principle 1896–2000”. Copenhagen: European Environment Agency, 2001.
- HARTZELL-NICHOLS, L. “Precaution and Solar Radiation Management”. *Ethics, Policy & Environment*, 15, 2, 2012, pp. 158–171.
- _____. “From ‘the’ Precautionary Principle to Precautionary Principles”. *Ethics, Policy & Environment*, 16, 3, 2013, pp. 308–320.

- HILL, B. “The environment and disease: association or causation?” *Proc Royal Soc Med*, 58, 1965, pp. 295-300.
- HOYNINGEN-HUENE, P. “Systematicity: the nature of science”. New York: Oxford University Press, 2013.
- JOHN, S. “The Politics of Certainty: The Precautionary Principle, Inductive Risk and Procedural Fairness”. *Ethics, Policy & Environment*, 22, 1, 2019, pp. 21–33.
- JONAS, H. “O princípio responsabilidade: ensaio de uma ética para a civilização tecnológica”. Tradução de Marijane Lisboa e Luiz Barros Montez. Rio de Janeiro: Contraponto, 2006.
- JORDAN, A., O’RIORDAN, T. “The precautionary principle in contemporary environmental policy and politics”. In: C. Raffensberger; J. Tickner. 1999.
- KABASENCHE, W. *et al.* “Topics in Contemporary Philosophy 9: The Environment, Philosophy, Science and Ethics”. Cambridge: MIT Press, 2012.
- KUHLAU, F. *et al.* “A Precautionary Principle for Dual Use Research in the Life Sciences”. *Bioethics*, 25, 2011, pp. 1-8.
- LACEY, H. “O princípio de precaução e a autonomia da ciência”. *Scientiae Studia*, 4, 3, 2006.
- _____. “Tecnociência comercialmente orientada ou investigação multiestratégica?” *Scientiae Studia*, 12, 4, 2014, pp. 669–695.
- LACEY, H; MARICONDA, P. “O modelo das interações entre as atividades científicas e os valores”. *Scientiae Studia*, 12, 4, 2014, pp. 643-68.
- LANGSTON, N. “The Retreat from Precaution: Regulating Diethylstilbestrol (Des), Endocrine Disruptors, and Environmental Health”. *Environmental History*, 13, 1, 2008, pp. 41-65.
- LARRÈRE, C. “Le principe de précaution et ses critiques”. *Innovations*, 18, 2003, pp. 9-26.
- LAUDA-RODRIGUEZ, Z. L.; RIBEIRO, W. C. “Risco, princípio da precaução e justiça ambiental em conflitos por mineração”. *Desenvolvimento e Meio Ambiente*, 51, 2019.
- LEMONS, J. *et al.* “The Precautionary Principle: Scientific Uncertainty and Type I and Type II Errors”. *Foundations of Science*, 2, 2, 1997, pp. 207–36.
- LEWENS, T. “Risk: Philosophical Perspectives”. New York: Routledge, 2007.
- MANSON, N. A. “The concept of irreversibility: its use in the sustainable development and precautionary principle literatures”. *The Electronic Journal of Sustainable Development*, 1, 1, 2007.
- _____. “Formulating the Precautionary Principle”. In: A. Bird; J. Ladyman (eds.). 2013.
- MAYER, S., WYNNE, B. “How Science Fails the Environment”. *New Scientist*, 1876, 1993.
- MAYO, D. G. “Sociological Versus Metascientific Views of Risk Assessment”. In: D. G. Mayo, R. D. Hollander (eds.). 1991.
- MAYO, D. G., HOLLANDER, R. D. (eds.). “Acceptable evidence: science and values in risk management”. New York: Oxford University Press, 1991.

- MUNTHER, C. “The Price of Precaution and the Ethics of Risk”. Dordrecht: Springer, 2011.
- O’BRIEN, M. “Making better environmental decisions: an alternative to risk assessment”. Cambridge: MIT Press, 2000.
- OGA, S. *et al.* “Fundamentos de Toxicología”. 3 ed. São Paulo: Atheneu, 2008.
- O’RIORDAN, T., CAMERON, J. (eds.). “Interpreting the Precautionary Principle”. Londres: Earthscan, 1994.
- ORESQUES, N.; CONWAY, E. “The Collapse of Western Civilization: a view from the future”. New York: Columbia University Press, 2014.
- PETERSON, M. “The Precautionary Principle Is Incoherent”. *Risk Analysis*, 26, 3, 2006, pp. 595–601.
- _____. “Should the precautionary principle guide our actions or our beliefs?” *Journal of Medical Ethics*, 33, 1, 2007, pp. 5–10.
- _____. “An introduction to decision theory”. New York: Cambridge University Press, 2009.
- _____. “Yes, The Precautionary Principle Is Incoherent”. *Risk Analysis*, 37, 11, 2017, pp. 2035–2038.
- PRECAUTIONARY PRINCIPLE CONFERENCE. “Wingspread Declaration”. Wingspread, 1998. Available at: <http://sehn.org/wingspread-conference-on-the-precautionary-principle/>. Last access on March 30, 2022.
- RAFFENSBERGER, C., TICKNER, J. (eds.). “Protecting Public Health and the Environment: Implementing the Precautionary Principle”. Washington, DC: Island Press, 1999.
- RAFFENSBERGER, C., BARRETT, K. “Precautionary science”. In: C. Raffensberger; J. Tickner. 1999.
- RANDALL, A. “Risk and Precaution”. Cambridge: Cambridge University Press, 2011.
- RAVETZ, J. “The post-normal science of precaution”. *Futures*, 36, 3, 2004, pp. 347–357.
- REBER, B. “Precautionary Principle, Pluralism and Deliberation: Science and Ethics”. Hoboken, USA: John Wiley & Sons, 2016.
- RECHNITZER, T. “Precautionary principles”. *The Internet Encyclopedia of Philosophy*, 2020. Available at: <https://www.iep.utm.edu/pre-caut/>. Last access on March 30.
- RESNIK, D. B. “Precautionary Reasoning in Environmental and Public Health Policy”. Cham: Springer International Publishing, 2021.
- ROESER, S. *et al.* (eds.). “Handbook of Risk Theory”. Dordrecht: Springer Netherlands, 2012.
- SANDIN, P. “Dimensions of the Precautionary Principle”. *Human and Ecological Risk Assessment: An International Journal*, 5, 1999, pp. 889–907.
- _____. “Common-sense Precaution and Varieties of the Precautionary Principle”. In: T. Lewens, 2007.
- SANDIN, P. *et al.* “Five charges against the precautionary principle”. *Journal of Risk Research*, 5, 4, 2002, pp. 287–299.

- SANDIN, P., PETERSON, M. “Is the Precautionary Principle a Midlevel Principle?” *Ethics, Policy & Environment*, 22, 1, 2019, pp. 34–48.
- SILBERGELD, E. “Risk Assessment and Risk Management: An Uneasy Divorce”. In: D. G. Mayo; R. D. Hollander (eds.). 1991.
- STEEL, D. “Extrapolation, uncertainty factors, and the precautionary principle”. *Studies in History and Philosophy of Biological and Biomedical Sciences*, 42, 2011, pp. 356–64.
- STEEL, D. “Philosophy and the Precautionary Principle: Science, Evidence, and Environmental Policy”. Cambridge: Cambridge University Press, 2015.
- STEELE, K. “The precautionary principle: a new approach to public decision-making?” *Law, Probability and Risk*, 5, 1, 2006, pp. 19–31.
- STIRLING, A. “Precaution in the governance of technology”. In: R. Brownsword; E. Scotford; K. Yeung (eds). 2017.
- SUNSTEIN, C. R. “Laws of Fear: Beyond the Precautionary Principle”. Cambridge: Cambridge University Press, 2005.
- THALOS, M. “There is no core to precaution”. *Review Journal of Political Philosophy*, 7, 2, 2009, pp. 41–49.
- _____. “Precaution has its reasons”. In: W. Kabasenche *et al.* 2012.
- TICKNER, J. A., GEISER, K. “The precautionary principle stimulus for solutions- and alternatives-based environmental policy”. *Environmental Impact Assessment Review*, 24, 7–8, 2004, pp. 801–824.
- TICKNER, J. A. “Precaution: Environmental Science and Preventive Public Policy”. Washington: Island Press, 2003.
- _____. “Commentary: Barriers and Opportunities to Changing the Research Agenda to Support Precaution and Primary Prevention”. *Human and Ecological Risk Assessment: An International Journal*, 11,1, 2005, p. 221–234.
- TROUWBORST, A. “Precautionary Rights and Duties of States”. Leiden: Martinus Nijhoff, 2006.
- UNCED. “Rio Declaration on Environment and Development”. United Nations Conference on Environment and Development. Rio de Janeiro, 1992.
- UN. “World Charter for Nature, adopted by the General Assembly 28 October 1982, A/Res/37/7”. 1982.
- VAUGHAN, A. “UK’s slow response to covid-19 was a ‘serious’ error, say MPs”. *New Scientist*, 3356, 2021.
- WALDMAN, R. L. *et al.* “O Princípio da Precaução e o Princípio de Responsabilidade de Hans Jonas”. *REVISTA QUÆSTIO IURIS*, 10, 1, 2017.
- WEDY, G. “O princípio constitucional da precaução como instrumento de tutela do meio ambiente e da saúde pública: de acordo com o Direito das Mudanças Climáticas e o Direito dos Desastres”. 3ª ed. Belo Horizonte: Fórum, 2020.
- WHITESIDE, K. H. “Precautionary politics: principle and practice in confronting environmental risk”. Cambridge: MIT Press, 2006.

WIRTH, D. “The World Trade Organization Dispute Over Genetically Modified Organisms: The Precautionary Principle Meets International Trade Law”. *Vermont Law Review*, 37, 4, 2013 pp. 1153-1188.

WORLD COMMISSION ON THE ETHICS OF SCIENTIFIC KNOWLEDGE AND TECHNOLOGY (COMEST). “The Precautionary Principle”. Paris: UNESCO, 2005.

ZANDER, J. “The Application of the Precautionary Principle in Practice”. Cambridge: Cambridge University Press, 2010.

