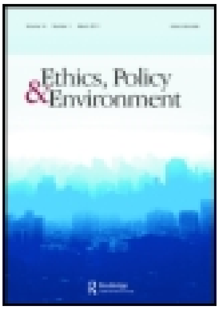

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The Precautionary Principle and the Dilemma Objection

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FEATURE ARTICLE

The Precautionary Principle and the Dilemma Objection

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ABSTRACT *The dilemma objection charges that 'weak' versions of the precautionary principle (PP) are vacuous while 'strong' ones are incoherent. I respond that the 'weak' versus 'strong' distinction is misleading and should be replaced with a contrast between PP as a meta-rule and PP proper. Meta versions of PP require that the decision-making procedures used for environmental policy not be susceptible to paralysis by scientific uncertainty. Such claims are substantive because they often recommend against basing environmental policy decisions on cost–benefit analysis. I argue that the second horn of the dilemma fails as a result of disregarding the role of proportionality in applications of PP.*

Introduction

Since the 1980s, the precautionary principle (PP) has become an increasingly prevalent element of international environmental policy agreements, from chlorofluorocarbons to biodiversity to climate change (Fischer, Jones, & von Schomberg, 2006; Raffensberger and Tickner, 1999; Trouwborst, 2006; Whiteside, 2006). Yet vigorous debate continues on just what PP asserts and whether it is reasonable. Perhaps the most commonly voiced objection to PP takes the form of a dilemma: the principle can be given either a weak or a strong interpretation, and in the first case it is trivial and in the latter it is incoherent (Burnett, 2009; Clarke, 2005; Engelhardt & Jotterand, 2004; Goklany, 2001; Graham, 2001; Harris & Holm, 2002; Manson, 2002; Marchant & Mossman, 2004; Powell, 2010; Soule, 2004; Sunstein, 2001, 2005; Turner & Hartzell, 2004). On the one hand, PP would be trivial if it merely claimed that full certainty is not a precondition for taking precautions, since this is something that every account of rational decision-making already accepts. On the other, PP would be incoherent if it asserted that no activity should be allowed that may lead to significant harm. For in that case, PP would prohibit the same precautionary measures it prescribes, as those measures themselves come with some risks of harmful consequences. In this essay, I defend PP against this objection and argue that both horns of the dilemma are unsound.

A proper consideration of the issue requires a clarification of the relationship between so-called 'weak' and 'strong' versions of PP. I argue that 'weak' versions of PP are not rules that directly guide policy decisions. Instead, they are meta-rules that place constraints on what types of decision rules should be used, advising policy makers to avoid decision

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procedures that are paralyzed by scientific uncertainty. So-called ‘strong’ versions of PP, by contrast, are decision rules designed to satisfy the requirements of MPP. Thus, I use the term meta-precautionary principle (MPP) in place of ‘weak’ PP, and PP instead of ‘strong’ PP. Given this preliminary clarification, let us return to the two horns of the dilemma.

Given that ‘uncertainty’ is understood to include cases wherein knowledge of the probabilities of relevant outcomes is importantly incomplete, MPP is far from trivial and often recommends against cost–benefit analysis approaches advocated by many critics of PP. Consequently, the first horn of the dilemma is mistaken: MPP is a substantive and informative proposition. However, MPP only places restrictions on what sorts of rules should guide environmental policy-making and does not directly guide environmental policy decisions, which leads to PP proper and the second horn of the dilemma. I argue that the second horn of the dilemma is unsound because it overlooks a central and longstanding component of applications of PP, namely proportionality. The intuitive notion underlying proportionality is expressed by such proverbs as, ‘the cure should not be worse than the disease,’ and, ‘never use a cannonball to kill a fly.’ I explain how these ideas can be more precisely articulated in the form of two principles that I call *consistency* and *efficiency*. Then I use a detailed case study concerning climate change to show how PP, applied in a proportional manner, is coherent, thereby undermining the second horn of the dilemma. Finally, I use the climate change example to illustrate key differences between cost–benefit analysis and PP.

The Dilemma

The charge that PP, depending on how it is interpreted, is either vacuous or obviously mistaken has been made in a variety of ways by numerous authors. The most sophisticated and detailed exposition of this dilemma is given by Sunstein (2001, 2005), who distinguishes weak (and trivial) from strong (and incoherent) versions of PP. Weak versions of PP assert that scientific certainty of impending harm should not be a precondition for precaution. Another way to put the same idea is to assert that precautions in the face of uncertain environmental hazards are permissible (McKinnon, 2009; Soule, 2004). These two formulations are equivalent because if scientific certainty is not necessary to justify precautions, then precautions are permissible in its absence, and vice versa. Regarding such propositions, Sunstein writes:

> The weak versions of the Precautionary Principle state a truism—uncontroversial in principle and necessary in practice only to combat public confusion or the self-interested claims of private groups demanding unambiguous evidence of harm, which no rational society requires. (2005, p. 24)

Having thus disposed of weak versions of PP, Sunstein proceeds to the second horn of the dilemma, which targets the strong version of the principle. Such statements of PP insist that precautions are not merely permitted but are in fact required when confronted with serious yet scientifically uncertain threats to the environment or public health.

> For the moment let us understand the principle in a strong way, to suggest that regulation is required whenever there is a possible risk to health, safety, or the

> environment, even if the supporting evidence remains speculative and even if the economic costs of regulation are high. To avoid absurdity, the idea of 'possible risk' will be understood to require a certain threshold of scientific plausibility. (2005, p. 24)

The fundamental problem with strong versions of PP, Sunstein argues, is not that they disregard economic costs or that they are too vague. Instead:

> The real problem is that the principle offers no guidance—not that it is wrong, but that it forbids all courses of action, including regulation. It bans the very steps that it requires. (2005, p. 26)

The reason for this is that regulations that aim to protect against some potential environmental hazard may themselves pose dangers to human health or the environment. For example, a regulation prohibiting genetically modified crops might result in reduced food production; measures to slow global warming may result in the impoverishment, and consequently impaired health, of some people; a ban on nuclear power could result in heavier reliance upon coal burning power plants and hence in more air pollution (Sunstein, 2005, pp. 27–32). Therefore, Sunstein concludes that PP is 'literally incoherent' and that it is 'paralyzing' instead of protective (2005, pp. 4, 34). To explain why the incoherence of strong versions of PP is often overlooked, Sunstein proposes that a variety of biases and cognitive limitations typically cause people to focus on only one or a few dangers at a time (2001, chapter 2; 2005, chapters 2, 3 and 4).

Many other critics of PP make similar arguments. For example, several critics draw a distinction between weak but toothless and strong but unreasonable versions of PP (Burnett, 2009; Clarke, 2005; Manson, 2002; Marchant & Mossman, 2004; Powell, 2010; Soule, 2004; Turner & Hartzell, 2004). Sunstein's claim that strong versions of PP are incoherent is very similar to what some critics call 'the precautionary paradox,' according to which PP generates contradictory results through prohibiting technologies that have the potential to improve human health or well-being (Clarke, 2005; Engelhardt & Jotterand, 2004; Goklany, 2001; Graham, 2001; Harris & Holm, 2002; Manson, 2002; Turner & Hartzell, 2004). Moreover, some critics claim that the dilemma demonstrates that PP is politically appealing only because of its ambiguity, which allows proponents to shift back and forth from weaker to stronger versions of it (Marchant & Mossman, 2004, 14). In sum, the dilemma, with triviality as one horn and incoherence as the other, is a, and perhaps *the*, central objection to PP.

A Meta-Decision Rule

In this section, I address the first horn of the dilemma targeting the so-called 'weak' PP, which I suggest is better characterized as MPP. Such formulations of PP state that scientific uncertainty should not be a reason for inaction in the face of serious environmental threats. In one well-known formulation:

> Where there are threats of serious or irreversible damage, lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation. (Article 15 of the 1992 Rio Declaration on Environment and Development)[1]

The claim that scientific uncertainty should not be a reason for delaying precautions in the face of serious threats of environmental degradation has implications for what decision rules should be used in environmental policy making. In particular, it entails that a decision rule should be avoided if it is susceptible to paralysis by scientific uncertainty. However, a prohibition on scientific uncertainty as reason for delay does not specify which reasons *should* determine environmental policy decisions or how. Thus, such a claim does not constitute a rule in its own right for selecting among alternative environmental policies in any particular context. For these reasons, I propose that the formulation of PP just cited is best construed as a meta-rule: it places a restriction on what rules should be used to guide environmental policy decisions, but it is not itself a rule capable of indicating which among several possible policy options should be adopted.

To show that MPP is *not* trivial, it suffices to show that it conflicts with some decision-making procedure that is actually advocated or used for evaluating environmental regulations. The central theme of MPP is that scientific uncertainty should not be grounds for failing to take precautions in the face of serious environmental threats, where 'uncertainty' is understood to include cases in which it is difficult or impossible to assign well-grounded and informative probabilities to relevant outcomes (Hartzell, 2009; Trouwborst, 2006, p. 88; Whiteside, 2006).[2] Consequently, MPP conflicts with any decision procedure that makes premises about probabilities of outcomes a prerequisite for justifying action. Moreover, when used as a method for deciding whether a proposed action is justifiable, cost–benefit analysis often has precisely this feature. Cost–benefit analysis is often presented as a procedure for deciding among policy options (Frank, 2005; Lomborg, 2010), and the idea that cost–benefit analysis should be used as a test for proposed regulations is also suggested in Executive Orders issued by the Reagan and Clinton Administrations (orders 12991 and 12866, respectively). Finally, many critics of PP defend cost–benefit analysis as guide for environmental policy (Graham, 2001; Marchant, 2001; Posner, 2004; Sunstein, 2001).[3]

Consider, then, how MPP recommends against using cost–benefit analysis as the central guide for decisions concerning environmental policy. Expected benefits are a probability weighted average of possible benefits. For instance, if a regulation has a .25 probability of saving 10,000 lives, a .5 probability of saving 100,000 lives, and a .25 probability of saving 1,000,000 lives, then its expected benefit in terms of lives saved would be 302,500 ($= .25 \times 10{,}000 + .5 \times 100{,}000 + .25 \times 1{,}000{,}000$). Expected costs would be defined similarly. Uncertainty about the probabilities, then, could lead to uncertainty about whether the expected benefits of a regulation would be greater or less than the expected costs. It may be that for some admissible or scientifically plausible probabilities, the expected benefits exceed the costs while for others the expected costs exceed the benefits. In such circumstances, cost–benefit analysis as the central guide for decision-making can easily result in paralysis, since no action can be unambiguously justified in its terms (Gardiner, 2011, chapter 8; Mitchell, 2009, pp. 87–89).[4] Consequently, MPP recommends against cost–benefit analysis as a general basis for environmental decision-making, and hence MPP is not trivial.

There is, then, a straightforward argument for the non-triviality of MPP. It is a substantive principle because it strongly advises against an influential approach to evaluating environmental regulations that holds justification by cost–benefit analysis to be the central, if not sole, grounds of rational policy making. Moreover, it is an argument that should be relatively obvious given the context of policy debates in which PP arises, as PP is often defended by people who charge that conventional cost–benefit analysis works to transform scientific uncertainty into inaction on environmental problems (Ackerman, 2008a; Ackerman & Heinzerling, 2004). Why, then, does Sunstein claim that MPP can be quickly dismissed as an empty triviality? I suggest two reasons for this.

The first involves an equivocation on 'uncertainty': MPP would be trivial *if* 'uncertainty' merely meant 'probability less than 1.' Sunstein's argument turns on interpreting 'uncertainty' in precisely this way. Consider this passage, which occurs in *Laws of Fear* immediately prior to the passage quoted above that dismisses weak versions of PP as uncontroversial truisms.

> Every day, people take steps to avoid hazards that are far from certain. We do not walk in moderately dangerous areas at night; we exercise; we buy smoke detectors; we buckle our seatbelts; we might even avoid fatty foods (or carbohydrates). Sensible governments regulate risks that, in individual cases or even in the aggregate, have a well under 100 percent chance of coming to fruition. An individual might ignore a mortality risk of 1/500,000 because that risk is awfully small, but if 100 million citizens face that risk, the nation had better take it seriously. (Sunstein, 2005, pp. 23–24)

This passage makes the interpretation of 'uncertainty' as 'probability less than 1' explicit. Yet in the context of PP, 'uncertainty' is understood to cover cases in which outcomes, such as a 1 meter rise in sea levels this century (Jevrejeva, Moore, & Grinsted, 2010), are serious possibilities given current scientific knowledge but possibilities to which no firm probability can be assigned.

At a later point in *Laws of Fear*, Sunstein does consider the possibility that 'uncertainty' in MPP includes situations in which probabilities of relevant outcomes are unknown (2005, pp. 59–61). He responds to this suggestion by interpreting PP as the maximin rule (which states that one should choose the option with the least bad worst case outcome) and arguing that the maximin rule is problematic. But this reply is seriously flawed in two respects. First, it does not address the central point that Sunstein's argument against MPP collapses once one acknowledges that 'scientific uncertainty' in this context is not equivalent to 'probability less than 1.' Secondly, no reason is given to suppose that the maximin rule is the only or best way to interpret PP.

There is a second, more substantive reason why MPP may appear to be trivial, namely that the principle does not recommend any specific remedy or precaution in response to any environmental harm. For example, the version of MPP quoted above merely states, 'lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation,' which is compatible with failing to take action for some other reason, such as economic costs. Indeed, defenders of the PP sometimes dismiss so-called 'weak' versions of PP on the grounds that they are purely negative and as such provide no helpful guidance to policy makers (Cranor, 2001, 2004; Gardiner, 2006; Hartzell, 2009; McKinnon, 2009). Although this concern has some merit, I think it also overlooks the sense in which MPP makes a positive and substantive statement. It is a claim about what sorts of decision rules should be used when evaluating environmental policies. It recommends that decision rules used for this purpose should be ones that are a capable of yielding informative results even in the presence of scientific uncertainty about the probabilities of relevant outcomes. To the extent that conventional cost–benefit analysis lacks this characteristic, MPP recommends against its use and advises policy makers to seek alternative decision procedures. Thus, it is not correct to say that MPP is a purely 'negative' claim, but it is correct to say that it is an exclusively meta-level rule. From this perspective, so-called 'strong' versions of PP are decision rules designed to satisfy the strictures of MPP.

'Weak' and 'strong,' then, are misleading labels for these variants of PP, since they suggest a contrast between principles operating at the same level and along a single dimension, from permissive to strict. That way of framing the matter obscures the central distinction between a meta-rule and rules intended to directly guide decisions. Defending PP amounts to fulfilling the promise of MPP by explicating and defending the cogency of a specific decision rule, or rules, capable of providing substantive guidance in the face of scientific uncertainty. The second horn of the dilemma challenges the feasibility of this project, and it is to this issue we now turn.

Precaution and Proportionality

In this section, I develop the concept of proportionality in order to address the second horn of the dilemma. In section 4.1, I explicate the concept of proportionality in terms of two sub-theses that I label consistency and efficiency. In section 4.2, I explain how this proposal works in relation to the case of climate change, and leads to coherent and informative recommendations in this case.

Consistency and Efficiency

The second horn of the dilemma challenges PP on the grounds that it is incoherent. If applied to the case of climate change, for instance, PP recommends that efforts be taken to significantly reduce greenhouse gas emissions. But this recommended precaution can also be considered from the perspective of PP: perhaps substantial cuts in greenhouse gas emissions would result in a global economic depression, the rise of totalitarian dictatorships, and finally nuclear war (Manson, 2002, p. 273). In the face of such dire possible consequences, the objection concludes, PP must surely demand that we refrain from acting, thereby contradicting its initial mandate.

Critics who level some variant of the incoherence objection, however, fail to take into account a well-known plank of PP that is intended to address the issue of potential harmful side effects of precautions, namely proportionality. The intuition behind proportionality is expressed by proverbs such as, 'the cure should not be worse than the disease,' or, 'never use a cannonball to kill a fly.' More formally, proportionality requires that 'measures be calibrated to the degree of uncertainty and the seriousness of the consequences feared' (Whiteside, 2006, p. 53). Proportionality is a longstanding feature of PP. According to Trouwborst:

> From the start, proportionality has been a crucial feature in the application of the precautionary principle, in the sense that precautionary responses ought to

> correspond to the perceived dimensions of the risks involved. (Trouwborst, 2006, p. 150)

For example, the European Union's Communication from the Commission on the Precautionary Principle lists proportionality as a general principle to be followed in applying PP (Commission of the European Communities, 2000, section 6.3.1; also see von Schomberg, 2006).[5] Assessing the second horn of the dilemma, therefore, requires some examination of proportionality. A good way to approach this concept is through a consideration of the basic structure of PP.

As several authors have noted (Cranor, 2001; Manson, 2002; Trouwborst, 2006), PP can be thought of in terms of three fundamental components: a harm condition, a knowledge condition (where the knowledge demanded may fall short of certainty), and a recommended precaution. Entries in each of these categories can admit of degrees: harms can be more or less severe; the knowledge supporting the existence of the harm and its relation to a particular activity may be more or less firm, and the precaution may be more or less strict. As a result, many versions of PP can be generated from the basic abstract schema of harm plus uncertain knowledge lead to precaution (Manson, 2002). Consider these three examples:

(1) If there is some scientific evidence that an activity leads to an irreversible environmental harm, then an alternative should be substituted for that activity if feasible.
(2) If a scientifically plausible mechanism exists whereby an activity can lead to a catastrophe, then that activity should be phased out or significantly restricted.
(3) If it is possible that an activity will lead to a catastrophe, then that activity should be prohibited.

Versions 2 and 3, require a more severe harm than 1 to be triggered (catastrophe versus irreversible environmental harm), whereas versions 1 and 2 both demand a more substantial body of knowledge than 3. Finally, the precautions demanded by versions 1 through 3 run from less to more strict. Proportionality is not an extra box in this schema; rather, it has to do with the how the levels of harm, knowledge, and precaution interact with the specifics of the case in question (Trouwborst, 2006, p. 151). In particular, I propose that the following two principles lie at the heart of proportionality: *consistency* and *efficiency*.

Consistency states that a precaution should not be precluded by the same version of PP used to justify it. For instance, suppose that a particular precaution is recommended on the basis of version 2 of PP above. Then there should not be a scientifically plausible mechanism through which this precaution itself will lead to catastrophe. I take the proverb that the cure should not be worse than the disease to be an expression of consistency. That proverb counsels against a cure whose potential side effects are as harmful and as well grounded given our knowledge as the malady it seeks to remedy. However, consistency can allow that the precaution is recommended against by an *alternative* version of PP with a *less* demanding knowledge or harm condition. For instance, suppose that while the precaution is recommended on the basis of version 2, there is also some conceivable scenario in which the precaution itself also leads to disaster but no scientifically plausible mechanism for how this scenario could occur, nor any evidence that it would. In this case, the precaution would be recommended against only by version 3 of PP, in which the mere possibility of catastrophe triggers an outright ban. This would not conflict with consistency because the precaution is not recommended against by version 2, which was used to justify it.

Efficiency demands that precautions aim to effectively minimize a target threat while keeping negative side effects to as minimal a level as possible. This is the aspect of proportionality expressed by, 'never use a cannonball to kill a fly': a flyswatter will do just as well and will cause much less collateral damage. In applications of PP, efficiency often results in a recommendation to modify an activity to minimize a harmful impact rather than prohibiting that activity outright. As a result, implementations of PP can select from an array of measures, including further research and monitoring, requiring the use of best available pollution abatement technologies, employing safety margins in estimates of toxicity, and phasing out the use certain harmful chemicals (Whiteside, 2006, pp. 53–55; Trouwborst, 2006, chapter 7).

According to the interpretation proposed here, then, three core themes constitute PP: MPP, the 'tripod' structure of harm condition, knowledge condition, and recommended precaution, and finally, proportionality explicated in terms of consistency and efficiency. On this approach, the harm condition, knowledge condition, and remedy are adjustable, rather than fixed at some pre-specified values. So, each application of PP must decide what the relevant version of PP is (i.e., specify those three components). The version of PP should be chosen to respect both MPP and proportionality. MPP demands that the knowledge condition should not be set in a way that makes uncertainty a basis for inaction, which normally means that the knowledge condition should not be excessively strict. But consistency may push the knowledge condition in the opposite direction, because a very weak knowledge condition makes it difficult to consistently recommend much in the way of precautions. A very weak knowledge condition—as in version 3 above, for instance—makes it easier to argue that the version of PP in question recommends against the proposed precaution. A stronger knowledge condition in turn may have implications for what the harm condition should be. For instance, a global apocalypse might be merely possible, while a much stronger knowledge condition might be satisfied with respect to a harm that is catastrophic in the more limited sense defined in the next section. The recommended precaution will also be driven by consistency in a manner that involves a delicate balance. The precaution cannot be ineffectual, since otherwise the relevant version of PP may recommend against it for the same reason it advises against the status quo. In addition, it cannot generate negative side effects that satisfy the harm and knowledge conditions stated in the antecedent of the version of PP being applied. This makes efficiency centrally important to sound applications of PP, since finding creative ways to make precautions efficient as possible is often important for securing consistency.

One final point about proportionality and uncertainty: consistency requires that knowledge conditions can be ranked to some extent. For instance, mere possibility is a weaker requirement than an established correlation between an activity and harm, which is again weaker than a correlation plus a mechanism grounded in scientific knowledge. But for PP to be applicable to cases involving uncertainty, it is important that these rankings need not require knowledge of probabilities of outcomes. For instance, there is a well-established correlation between GHG emissions and rising global temperatures and a physical mechanism to explain this correlation (Solomon et al., 2007), but it is still very difficult to specify informative and well-grounded probabilities concerning many key outcomes of climate change (Parry, Canziani, Palutikof, van der Dinden, & Hansen, 2007, p. 782).

Proportionality and Climate Change

In this section, I explain how the account of proportionality developed in the prior section clarifies the role of PP in relation to the issue of climate change. In addition to illustrating consistency and efficiency, this case study serves as a basis for answering the second horn of the dilemma. In particular, I explain how version 2 of PP generates informative implications in this case without any threat of incoherence or inconsistency.

In regards to climate change, advocates of PP would recommend substantial reductions in GHG emissions (Gardiner, 2011; Hartzell, 2009; McKinnon, 2009). As explained in the foregoing sections, many versions of PP can be constructed, and questions about proportionality require being clear about which version is being applied in the case at hand. For the present purposes, version 2 of PP given above will suffice: if a scientifically plausible mechanism exists whereby an activity can lead to a catastrophe, then that activity should be phased out or significantly restricted. I understand a 'scientifically plausible mechanism' to be a causally related sequence of events that is (a) grounded in scientific knowledge, such as physical laws, and (b) for which scientific evidence exists of its actual occurrence. I take it as established that these conditions are met in the case of climate change (Solomon et al., 2007), and I think that its potential effects can be reasonably characterized as catastrophic. Here is a partial list of impacts—for Africa, Asia, and Latin America, respectively—of a rise in global temperatures greater than 2°C this century.

- Hundreds of millions of additional people at risk of increased water stress; increased risk of malaria in highlands; reductions in crop yields in many countries.
- About 1 billion people would face risks from reduced agricultural production potential, reduced water supplies or increases in extremes events.
- More than a hundred million people at risk of water shortages; low-lying coastal areas, many of which are heavily populated, at risk from sea-level rise and more intense coastal storms. (Parry et al., 2007, p. 788)

These outcomes would appear to fit Hartzell-Nichols' definition of 'catastrophic' as referring to outcomes 'in which many millions of people could suffer severely harmful outcomes' (2012, p. 160). Furthermore, climate science since the IPCC fourth assessment report, issued in 2007, suggests that the IPCC estimates of several key outcomes, such as sea level rise, are overly optimistic. For instance, the 2007 assessment reports do not take into account a number of important feedback cycles, such as methane released by thawing permafrost (Schuur & Abbott, 2011).

So, climate change is a case in which the antecedent of version 2 of PP is satisfied, which then leads to the question of what precautions should be taken. The remedy specified in version 2 is that the harmful activity, in this case anthropogenic GHG emissions, 'should be phased out or significantly restricted.' For action on climate change, the second of these two options is the pertinent one, as a complete phase out of anthropogenic GHG emissions would be impossible. In discussions of climate change, efforts to reduce GHG emissions are known as 'mitigation,' while the term 'adaptation' refers to measures taken to adjust to adverse effects of climate change—such as rising sea levels—once they have occurred. Given that some harmful effects of climate change are now unavoidable, it is a foregone conclusion that some future resources will have to be devoted to climate change adaptation. The most pressing issue is how much effort should be put towards mitigation. Moreover, in very general terms, it is relatively clear what form mitigation would take. GHG emissions are an example of what economists call a *negative externality*: a cost generated as a by-product of market activities that is distributed across society generally rather than borne specifically by the producers and consumers of the goods involved (Stern, 2007, chapter 2; Nordhaus, 2008). Consequently, those implicated in generating the externality—which in the case of GHG emissions means almost all of us—have no individual incentive to change their behaviors so as to reduce its cost. In theory, the solution to problems generated by negative externalities is straightforward: introduce some mechanism whereby the previously externalized cost is directly attached to the activities that generate it. The simplest way to internalize the social costs of carbon emissions is through a carbon tax, which affixes a tax on the carbon content of fuels (Hsu, 2011; Nordhaus, 2008; Posner, 2004). An alternative approach is a cap-and-trade scheme in which tradable emission permits are auctioned to major GHG sources, such as public utilities, factories, or large-scale agricultural operations. Cap-and-trade schemes focused on GHG emissions have been implemented in the European Union, a group of states in the northwestern US (the Regional Greenhouse Gas Initiative), and the state of California.

Consistency and efficiency would come into play in deciding which mitigation approach should be pursued and how its details should be worked out. In the case of a carbon tax, for example, consistency would demand that the tax not be so high or introduced so abruptly as to create an economic catastrophe, and efficiency would demand that restrictions be designed to achieve as much reduction as possible at the least cost. Harmful economic effects of a carbon tax could be minimized by using the proceeds of the tax to lower other taxes and to provide economic assistance to low income individuals who would be most adversely impacted by rising energy costs (Hsu, 2011; Nordhaus, 2008, pp. 156–158; Sumner, Bird, & Smith, 2009). A carbon tax with provisions of this kind is in fact being launched in Australia in July 2012,[6] and the world's first carbon tax, implemented by Finland in 1990, uses its revenue to reduce income taxes (Sumner et al., 2009). Of course, efficiency demands that the least burdensome *effective* precaution be taken, which would mean that PP would prioritize setting the carbon tax high enough to produce meaningful results, such as stabilizing atmospheric CO_2 equivalent at levels deemed acceptable. Given the global nature of climate change, it is plain that achieving such a goal requires that carbon reduction policies pursued by separate states be coordinated so as to attain effective results overall. This might be achieved through an international 'harmonized' carbon tax (Nordhaus, 2008, chapter 8).

Let us now return to the second horn of the dilemma, which claimed that 'strong' versions of PP are incoherent because they ban the very actions they prescribe. Clearly, any such application of PP would not be compatible with consistency, and hence would not be proportional. In other words, it would be a *mis*application of PP. Given a proper understanding of the role of proportionality in implementing PP, then, the purport of the second horn of the dilemma is rather unclear. Perhaps, the aim is to show that *actual* applications of PP often fail to be consistent. Showing a genuine violation of consistency requires showing that the *same* harm and knowledge conditions used to justify the *actually* recommended precaution can also be used to rule against that same precaution. Yet scenarios given to support the second horn of the dilemma with respect to climate change fail to do this. Consider Manson's self-styled 'wild story' about reductions in GHG emissions resulting in worldwide economic depression, political instability, and finally nuclear holocaust (Manson, 2002, p. 273). Such a scenario *might* deserve serious consideration if the proposed action against climate change were an immediate ban on all use of fossil fuels (Gardiner, 2011, pp. 20–21). But Manson's 'wild story' utterly fails to satisfy the knowledge condition of a scientifically plausible mechanism with respect to actually proposed and implemented mitigation measures such as carbon taxes or cap-and-trade schemes.

Similar issues arise for Sunstein's discussion of the incoherence objection in relation to climate change. According to Sunstein:

> A great deal of work suggests that significant reductions in such [i.e., GHG] emissions would have large benefits; but skeptics contend that the costs of such decreases would reduce the well-being of millions of people, especially the poorest members of society. (2005, p. 27)

Sunstein does not provide additional supporting details or references in the passage above, making it difficult to judge what costs he has in mind. However, in a later chapter Sunstein cites alarming estimates of economic effects of the Kyoto accord, which he attributes to a page from the website of the American Petroleum Institute (2005, p. 173 fn. 26). Despite granting that these estimates are 'almost certainly inflated' due to disregarding 'technological innovations that would undoubtedly drive expenses down,' he nevertheless takes them as sufficient to demonstrate the potentially adverse impacts on the poor of a carbon tax (Sunstein, 2005, p. 173). But Sunstein's reasoning is difficult to understand. No proposal for a carbon tax was included in the Kyoto accord, so it is very puzzling why Sunstein would use 'almost certainly inflated' estimates of the costs of the Kyoto accord as a basis for assessing its economic impacts. Moreover, Sunstein does not consider the possibility, mentioned above, that revenues from a carbon tax could be used to reduce other taxes and to assist low-income households.[7] He also does not consider the possibility of phasing in and gradually 'ramping up' a carbon tax so as to reduce economic disruptions resulting from a shift towards less GHG intensive energy sources (Nordhaus, 2008).

There is in fact little basis for the idea substantial climate change mitigation, for instance by means of a carbon tax, would lead to economic catastrophe. For example, the *Stern Review of the Economics of Climate Change* estimates the expected costs of stabilizing CO_2 equivalent levels at between 500 to 550 parts per million (ppm) to between −1% to 3.5% of global GDP by 2050, with 1% as the most likely number (Stern, 2007, pp. xvi–xvii, 318–321). As a comparison, about 2.2% of the world's GDP was devoted to military spending in 2011, while in the US military spending comprised about 4.7% of GDP.[8] In the most optimistic scenario, then, climate change mitigation would stimulate economic growth in coming decades (for instance, if cost-effective alternative energy technologies quickly emerged), and in the most pessimistic scenario, the costs would still be less than what some nations choose to devote to military spending. Moreover, since climate change is very likely to eventually inflict adverse effects on the world economy, pursuing mitigation now can be expected to generate positive economic effects after about 2080 (Stern, 2007, p. 321). Although some aspects of the Stern review are controversial (see section 5 below), the basic point about the affordability of substantial climate change mitigation is widely accepted among economists. For instance, the climate economist

William Nordhaus states that, 'The claim that cap-and-trade legislation or carbon taxes would be ruinous or disastrous to our societies does not stand up to serious economic analysis' (Nordhaus, 2012). Thomas Schelling (1997, p. 10), and even by Bjørn Lomborg (2001, p. 323) and Richard Tol (2010, p. 91), who oppose substantial climate change mitigation efforts, make similar statements. Actual experience with carbon taxes and cap-and-trade schemes support such assessments. For instance, Sweden enacted a carbon tax in 1990 at a rate even higher than that recommended by Stern, and its economy grew by 36% between 1990 and 2005 (Hsu, 2011, p. 139).

If carbon taxes or cap-and-trade will not result in *economic* catastrophe, might they nevertheless result in a catastrophe of some other sort? Lomborg argues that a cap-and-trade system or carbon tax to reduce GHG emissions would be a bad idea because the money would be better spent on measures to address problems that currently afflict developing nations, such as HIV (Lomborg, 2001, 2007, 2010). One possible reading of this argument is as a counter-scenario in which actions to curb climate change inadvertently lead to catastrophe in the form of millions of deaths due to disease.[9] But again, there is no scientifically plausible mechanism by which action on climate change would preclude action on these other issues or even make such action less likely (Gardiner, 2011, pp. 281–284). The lack of global action in the face of climate change in the past two decades has not been accompanied by any compensatory outpouring of poverty-reduction assistance from wealthier to poorer nations (Singer, 2002, pp. 23–24). So, it is difficult to understand why (say) a carbon tax would lead to reductions in funding for international programs to alleviate disease and poverty. Indeed, if desired, some portion of the revenue generated by a carbon tax could be put towards such purposes. Moreover, Lomborg's argument neglects the link between climate change and global economic inequality. The early adverse effects of climate change are expected to disproportionately target the world's poor, while the costs of mitigating climate change would be initially borne primarily by wealthier nations, which typically have higher per capita GHG emissions. Consequently, for the near future, action to mitigate climate change would constitute a kind of 'foreign aid program' (Schelling, 1997, p. 8), and hence should be supported by those who are genuinely concerned about global inequalities and poverty.[10]

The counter-scenarios just considered, then, fail to demonstrate any conflict with consistency and all for the same reason. Each involves an outcome that might reasonably be described as catastrophic but in each case there is no scientifically plausible mechanism by which actually proposed precautions would lead to that outcome. Thus, in none of these counter-scenarios can the version of PP invoked in support of the precaution (i.e., version 2 from section 4.1) also be used to recommend against that very precaution. At best, these counter-scenarios show that a version of PP with a much *weaker* knowledge condition (e.g., version 3) would recommend against taking prompt action to curb GHG emissions. But that is no conflict with consistency, which requires that the precaution not be prohibited by the *same* version of PP that recommends it. This observation highlights the logical fallacy in Sunstein's rendition of the incoherence objection. In his statement of this objection, Sunstein writes, 'To avoid absurdity, the idea of "possible risk" will be understood to require a certain threshold of scientific plausibility' (2005, p. 24). Yet in his suggested counter-scenario regarding climate change, Sunstein says nothing about what that threshold of scientific plausibility might be and provides no good reason to think that the relevant level of plausibility is attained.

Proportionality and Cost–benefit Analysis

One variation of the dilemma objection asserts that, to the extent that PP is coherent it is merely a version cost–benefit analysis (Goklany, 2001; Marchant, 2001; Posner, 2004, p. 140; Soule, 2004; Sunstein, 2001, pp. 104–105). In this section, then, I explain in reference to the climate change example how cost–benefit analysis and PP differ.

Implementing either PP or cost–benefit analysis involves a comparison of pros and cons. The crucial difference lies in *how* those pros and cons are balanced. From the perspective of PP, the question of whether to implement measures to substantially reduce GHG emissions, such as a carbon tax, turns on the question of whether there is a scientifically plausible mechanism whereby those measures could lead to catastrophe. If the answer to that question is *no*, as appears to be the case, then PP says that those measures should be put into action. In contrast, basing the decision on cost–benefit analysis leads to the very different and more difficult to answer question of whether the expected benefits of the proposed GHG emission reduction measures are greater than their expected costs. To elaborate this point, it will be helpful to explain a basic concept of climate change economics, the social cost of carbon.

The social cost of carbon (SCC) 'is the total damage from now into the indefinite future of emitting an extra unit of GHGs now' (Stern, 2007, p. 28). The Stern review emphasizes that SCC must be calculated *conditional* on the climate policy chosen because SCC rises with atmospheric GHG concentration which mitigation measures, such as a carbon tax, reduce (2007, p. 29). Thus, SCC will be higher if no reductions in GHG emissions are made, or if such reductions are delayed, than it would be if efforts to reduce GHG emissions are taken promptly. SCC is of crucial importance from a cost–benefit perspective because it is an estimate of the cost of the externality generated by climate change and consequently is the key indicator of how much, or how little, should be spent on climate change mitigation. For example, a Pigouvian tax deals with a negative externality by applying a tax to activities that generate that externality at a rate equal to its social cost.

The difficulty of judging whether the expected benefits of substantial climate change mitigation would exceed or fall short of their expected costs, then, can be illustrated by noting the extraordinarily wide range of estimates of SCC. A review published in 2005 found 103 estimates of SCC varying from \$0 to \$273 per ton of CO_2 (Tol, 2005).[11] To get a better sense of the differences, consider three widely discussed climate change mitigation cost–benefit analyses.

- Stern (2007, p. 322): SCC for BAU estimated at about \$85 per ton of CO_2. Recommends aggressive mitigation efforts to stabilize atmospheric CO_2 equivalent concentrations at between 450 and 550 ppm; recommends a cap-and-trade scheme, government support for research on low-carbon technologies, and action to reduce deforestation (2007, pp. xvi–xviii).
- Nordhaus (2008, p. 91): SCC for baseline scenario at about \$7.50 per ton of CO_2. Recommends a global harmonized carbon tax set at approximately \$9.30 per ton of CO_2 in 2010, \$11.50 in 2015, \$24.50 in 2050, and \$55 in 2100, which is expected to limit CO_2 concentrations to 586 ppm by 2100 and 659 ppm by 2200 (Nordhaus, 2008, p. 103).[12]
- Tol (2010, pp. 90–95): SCC for BAU estimated at approximately 55 cents per ton of CO_2. Proposes that the only reasonable mitigation measure would

be a global harmonized carbon tax set at that rate. Tol's analysis appears in a volume edited by Lomborg, which ultimately reaches the conclusion that mitigation should not be a focus of climate change policy (Lomborg, 2010, pp. 395–396).

To get a sense of the practical implications of these differences, note that about 20 pounds of CO_2 are generated from burning one gallon of gasoline. Since there are 2204.6 pounds in a metric ton, one gallon of gasoline generates just less than 0.01 metric ton of CO_2. So, consider what each of the SCC estimates given above would mean if converted directly into a tax on the carbon content of gasoline, adjusting for inflation to 2010 dollars in each case. Stern's $85 SCC would correspond to approximately a $1 per gallon gasoline tax. Nordhaus' 'ramp' would translate to gasoline taxes of approximately 10 cents in 2010, 13 cents in 2015, 27 cents in 2050, and 61 cents in 2100. Finally, Tol's proposal would mean a gasoline tax of about 0.6 cents per gallon. Let us consider these divergent proposals from the perspective of PP.

Given PP, the decision of whether to take action to substantial mitigation efforts should *not* rest on a determination of whether the expected benefits of such action outweigh the expected costs. The scientific uncertainties inherent in climate change and the vagaries of deciding how to convert all possible costs and benefits to some common (typically monetary) metric make such an approach a recipe for perpetual delay, as is amply illustrated by the diversity of cost–benefit analyses described above. By contrast, PP recommends that the decision about whether to mitigate climate change by increasing the price of carbon emissions rests on a question that is much easier to answer, namely whether there is a scientifically plausible mechanism whereby such a policy leads to catastrophe. If there is not, then the process can advance from the issue of *whether* to reduce GHG emissions—thereby, rejecting the Tol-Lomborg position—to questions about the most efficient effective means for doing so.

To select the most efficient effective policy, it is necessary to compare the economic effects of several options, which may vary, for instance, in how carbon taxes would be initially set, how quickly they will be 'ramped up,' and how the revenues they generate will be used. Cost benefit analysis *might* play a role here, but with two important caveats. First, it is not necessary that economic questions about efficiency be framed in terms of achieving an optimal balance of expected costs and benefits. Given the scientific uncertainties, it may be preferable to pursue other approaches specifically designed for cases in which knowledge of probabilities is crucially incomplete (Lempert, 2002; Lempert, Popper, & Bankes, 2003; Lempert, Groves, Popper, & Bankes, 2006). Secondly, PP has significant implications for how any economic analysis of the most efficient means for reducing GHG emissions—whether in the form of cost–benefit analysis or not—should be carried out, especially when it comes to the crucial issue of how costs should be measured. This second point can be illustrated by reference to the three analyses described above.

One major source of disagreement between Stern and Nordhaus concerns the rate at which future costs and benefits are discounted (Nordhaus, 2007; Stern & Taylor, 2007). Much of this dispute is framed in terms of the Ramsey equation, $r = \rho + \eta g$, where r is the social discount rate, ρ is the time discount rate, η is the social marginal utility, and g is the average rate of growth in consumption (Ramsey, 1928). In this equation, r gives the rate (per year) that future costs and benefits will be discounted. The time discount rate, ρ, represents a 'pure' discounting of the future simply because it is the future. Thus, $\rho > 0$ indicates a preference for postponing a cost until later even if the adverse effect of the cost, when it happens, is the same. The growth rate, g, reflects the average rate of economic growth adjusted for inflation. In the context of climate change economics, the significance of g for discounting is that if g is positive, then future generations will be wealthier than current ones, and consequently better able to pay for reductions in GHG emissions or adaptations to climate change. Finally, the marginal social utility, η, modulates the extent to economic growth is significant for discounting. For instance, $\eta = 0$ would entail that g—and hence the difference in wealth between the present and future—does not matter, while $\eta > 0$ would mean that the greater g, the greater the social discount rate r. The Ramsey equation originally arose from the question of how much a nation, or person, should save for the future versus spending now (Ramsey, 1928). Other things being equal, the greater the value of r, the less that should be saved and the more spent. In the context of climate economics, 'saving for the future' primarily means dedicating resources to climate change mitigation. So, the higher the social discount rate r, the less climate change mitigation now the analysis will tend to recommend. Stern sets the values of ρ at 0.1 and η at 1, while Nordhaus sets these parameters at 1.5 and 2, respectively. As a result, r is much higher in Nordhaus' analysis than Stern's, and this discrepancy is one important factor explaining the difference in their recommendations.

In this disagreement, PP mostly comes down on the side of Stern, particularly with respect to the issue of the pure discount rate ρ.[13] That is because PP is sensitive only to the severity of the potential harm—where severity is understood in reference to those who suffer the harm—and the knowledge condition satisfied with respect to that harm. Thus, PP does not allow one to discount the future merely because it is the future, and so a positive value for the 'pure' time discount rate ρ is highly problematic from the perspective of PP.[14] In short, a catastrophe is a catastrophe, no matter when it happens. On the other hand, PP *may* allow discounting on the basis of a positive value of g because increased wealth blunts the severity of economic losses. For instance, a loss of $100,000 is a small matter for a billionaire but a calamity for a middle class family. Thus, future discounting may be reasonable if the costs in question are, say, losses of property due to extreme weather events. But the rationale for future discounting on this basis depends on the harm being compensable by economic means. So, it is problematic from the perspective of PP to convert the value of a statistical life into a dollar equivalent, and then discount the value of future statistical lives on the basis that people will be richer in the future. After all, the primary harm of death is not mitigated by wealth, although some of its economic side effects, such as lost earnings, may be. Finally, PP automatically involves an epistemic form of discounting. Normally, the further into the future the potential harm, the weaker the knowledge condition satisfied with respect to its occurrence. As a result, expensive actions taken to prevent catastrophes very far off into the distant future are usually justifiable only on the basis of versions of PP in which minimal knowledge conditions are combined with very strict precautions. As explained in section 4.1 and illustrated in 4.2, such versions of PP often run into conflict with consistency.

Consider these points in relation to an argument made by Nordhaus against low discount rates. Nordhaus suggests that failing to discount would lead to taking drastically expensive actions now to avoid tiny harms incurred upon a huge number of future people (2008, pp. 183–184). The idea is that, if we do not use a relatively high social discount rate, say around 5% per year, then accumulated small costs incurred by the potentially limitless number of future people can swamp almost all present concerns. From the perspective of PP, this argument makes two mistakes. First, it assumes that many small disparate costs add up to a catastrophe. But the severity of a harm is normally reduced when it is diffused across a long expanse of time and among a large number of people. A tiny reduction in the rate of economic growth per year for a hundred years is not a catastrophe, while the concentration of all those losses into a single year in the form of a massive worldwide economic depression is.

The second difficulty is even more serious. Nordhaus' example is highly implausible because it supposes that we are in a position to know with certainty that a small loss would accrue on an annual basis from now to perpetuity. Yet in almost any realistic situation, our ability to forecast small impacts is narrowly bounded, while exact predictions of very small effects on a time scale of centuries are extremely uncertain. Or, in the language used here, only a very weak knowledge condition would be satisfied with regard to such predictions. Consequently, consistency makes it difficult to justify potentially very seriously harmful actions as precautions against the accumulation of small adverse impacts in the distant future. Consistency is also pertinent to Nordhaus' suggestion that a failure to discount the future could lead to constant war.

> Countries might start wars today because of the possibility of nuclear proliferations a century ahead, or because of a potential adverse shift in the balance of power two centuries ahead, or because of speculative futuristic technologies three centuries ahead. It is not clear how long the globe could survive the calculations and machinations of zero-discount-rate military strategists. (Nordhaus, 2008, p. 184)

In Nordhaus' pre-emptive war scenarios, the possible distant future catastrophes are extraordinarily speculative. Moreover, the recommended 'precaution' in these cases—namely war—has an obvious potential to generate horribly disastrous outcomes. As a result, the reasoning of Nordhaus' hypothetical zero-discount-rate military strategists is in clear conflict with consistency, and is thus deeply mistaken by the lights of PP.[15]

Much more could be said about implications of PP for economic analyses aimed at identifying the most efficient effective means for reducing GHG emissions. As an example, consider that in Tol's model the dollar value of a statistical life in a region is set at 200 times the average per capita income (Tol, 2010, p. 89). Hence, this approach weights the lives of those in wealthier regions much more heavily than those in poorer regions. This is the opposite of what PP would recommend, as wealth reduces the severity of many types of harms, and severity of harm is one of the key elements in PP. Thus, PP would normally require that harms visited upon the poorest and most vulnerable count for more, not less. This example and that of future discounting illustrates an important difference between PP and cost–benefit analysis: PP places substantive restrictions on how costs and benefits should be measured, while cost–benefit analysis does not. This difference is relevant to halting the slide from scientific uncertainty to regulatory paralysis. When scientific uncertainties are a serious challenge, cost–benefit analysis can generate almost any result one wishes through a conveniently chosen combination of assumptions about probabilities and how to measure costs and benefits. Consequently, a principled basis for limiting possible value-measures is crucial for avoiding paralysis by analysis.

Conclusions

Given its prominent role in disputes concerning a variety of pressing contemporary environmental issues, efforts to clarify the PP and its logical implications are especially urgent (Gardiner, 2011, pp. 411–414). The interpretation of PP proposed here can be encapsulated in three core themes.

(1) *The Meta-Precautionary Principle (MPP)*: Scientific uncertainty about the probabilities of relevant outcomes should not be a reason for inaction in the face of serious environmental harms.
(2) *The 'Tripod'* (Trouwborst, 2006, p. 21): The three-part structure of PP, consisting of a harm condition, knowledge condition, and a recommended precaution.
(3) *Proportionality*: Explicated in terms of consistency and efficiency as explained above.

Applications of PP, then, instantiate the harm, knowledge, and recommended precaution in particular cases with an eye to both MPP and proportionality, as illustrated by the example of climate change mitigation. Given this interpretation, both horns of the dilemma objection are unsound. The first horn treats MPP as a rule for selecting among policy options, when it is best understood as a meta-principle that constrains the choice of decision-making rules. The second horn fails due to disregarding the role of proportionality in constraining which instantiations of the 'tripod' are allowable in applications of PP.

Notes

[1] See the United Nations Framework Convention on Climate Change (article 3.3) for a very similar formulation.

[2] For more discussion of the concept of uncertainty, see Aven (2011); Cox (2011); Elliott and Dickson (2011), and North (2011).

[3] Some of these authors place caveats on the use of cost–benefit analysis as a decision guide (Sunstein, 2001). However, their central message is to stress the importance of cost–benefit analysis as a basis for decisions and to criticize alternative approaches, such as PP.

[4] An anonymous referee suggests that this difficulty could be avoided by interpreting the probabilities as subjective degrees of belief. However, that is not correct. If the probabilities are construed as subjective degrees of belief, then the problem is that the science is incapable of telling us whose degrees of belief should be relied upon. Perhaps the thought is that in a state of pure uncertainty—wherein *nothing at all* is known about the probabilities—one should apply the principle of indifference and assign equal probabilities to all outcomes (Bognar, 2011). Even putting aside well-known logical difficulties confronting the principle of indifference (Salmon, 1966), this does not undermine the argument that cost–benefit analysis is susceptible to paralysis by scientific uncertainty. That is because the uncertainty in environmental issues is very rarely pure. Typically, something is known about which outcomes are more or less likely, but that knowledge is incomplete in crucial respects, a point illustrated by the climate change example discussed in this essay.

[5] See Trouwborst (2006, pp. 149–153) for references to many other documents concerning PP that mention or discuss proportionality.

[6] See the Australian government's website for more information (http://www.carbontax.net.au/).

[7] The use of carbon tax revenue to reduce other taxes is in fact suggested by Posner (2004, pp. 155–157), who is the specific target of Sunstein's criticism.

[8] See the Stockholm International Peace Research Institute (www.sipri.org).

[9] For example, this may be what Sunstein intends in the passage quoted above concerning potential harmful impacts of climate change mitigation. Sunstein does cite Lomborg (2001) in that passage along with

Posner (2004) and Nordhaus and Boyer (2000), but only to support the claim, 'Scientists are not in accord about the dangers associated with global warming' (Sunstein, 2005, 27).

[10] See Ackerman (2008b) and Zenghelis (2010) for similar critiques of Lomborg.

[11] The emissions scenarios used to generate these estimates varied although most were intended to represent a 'business as usual' situation.

[12] The SCC estimates of both Nordhaus and Tol are given in units of dollars per ton of carbon rather than per ton of CO_2.The per ton carbon estimates are easily converted to per ton CO_2 given the atomic weights of carbon and oxygen.

[13] This is not surprising considering that the Stern review endorses PP as a guide for climate change policy (Stern, 2007, pp. 38–39).

[14] Hartzell (2009, p. 154) makes a similar point.

[15] The same point holds for Sunstein's suggestion that President G. W. Bush's rationale for his decision to invade Iraq in 2003 involved an application of PP (Sunstein, 2005, pp. 4, 60).

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