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Two Conceptions of Irreversible Environmental Harm

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Executive Summary

The concept of "irreversibility" plays a large role in the theory and practice of environmental protection. Indeed, the concept is explicit in some statements of the Precautionary Principle. But the idea of irreversibility remains poorly defined. Because time is linear, any loss is, in a sense, irreversible. On one approach, drawn from environmental economics, irreversibility might be understood as a reference to the value associated with taking precautionary steps that maintain flexibility for an uncertain future ("option value"). On another approach, drawn from environmental ethics, irreversibility might be understood to refer to the qualitatively distinctive nature of certain environmental harms – a point that raises a claim about incommensurability. The two conceptions fit different problems. For example, the idea of option value best fits the problem of climate change; the idea of qualitatively distinctive harms best fits the problem of extinction of endangered species. These ideas can be applied to a wide assortment of environmental problems.

Two Conceptions of Irreversible Environmental Harm

Cass R. Sunstein

I. Introduction

Many environmental problems have an element of irreversibility. If a species is lost, it is probably lost forever; the same might well be true of pristine areas. Genetically modified organisms might lead to irreversible ecological harm; transgenic crops can impose irreversible losses by increasing pest resistance.[1] In recent decades, the problem of climate change has raised the most serious concerns about irreversibility. Some greenhouse gases stay in the atmosphere for centuries, and for that reason climate change threatens to be irreversible, at least for all practical purposes.[2]

The risk of irreversibility is especially troublesome in light of massive uncertainty about the actual damage from climate change. Suppose that we project, with the International Panel on Climate Change, warming between 1.8 and 4.0 C by 2100.[3] There is a large difference between adverse effects at 1.8 C and adverse effects at 4.0 C.[4] Even at a specified increase in temperature, it is exceedingly difficult to know the extent of the harm.[5] If the average global temperature increases by 3.0 C one hundred years from now, the extent of the damage is greatly disputed, in part because of uncertainty about the possibility of adaptation, in part because of uncertainty about the resulting effects on global conditions.[6] There is some risk of catastrophe, and once that risk is incorporated into the analysis, the assessment of what to do changes dramatically.[7] Aggressive

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[1] See generally Benoit Morel et al., Pesticide Resistance, the Precautionary Principle, and the Regulation of Bt Corn: Real Option and Rational Option Approaches to Decisionmaking, in Battling Resistance to Antibiotics and Pesticides 184 (Ramanan Laxminarayan ed.) (Washington D.C.: Resources for the Future, 2003) (proposing option theory as an analytical framework for the Precautionary Principle and applying that framework to the issue of commercializing Bt corn); Justus Wesseler, Resistance Economics of Transgenic Crops under Uncertainty: A Real Options Approach, in id. at 214 (discussing pest resistance as an irreversible cost of transgenic crops).

[2] See W. David Montgomery and Anne E. Smith, Global Climate Change and the Precautionary Principle, 6 Hum. & Ecological Risk Assessment 399, 400 (2000).

[3] See William Nordhaus, A Question of Balance (2008).

[4] See id.; Sudden and Disruptive Climate Change (Michael C. MacCracken et al. eds., 2007).

[5] For a variety of accounts, see id.; for a helpful overview, see Daniel Farber, Climate Models: A Users' Guide (2007), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1030607

[6] For one discussion, see id.; Nordhaus, supra note.

[7] See Martin Weitzman, Structural Uncertainty and the Value of Statistical Life in the Economics of Catastrophic Climate Change (2007), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1021968

measures, in the form of emissions reductions or adaptation, might be justified in order to maintain flexibility in the event that either warming or actual damage turns out to be at the higher end of the range.

Concerned about the problem of irreversibility, sensible nations might consider adopting a distinctive (if admittedly vague) principle for handling certain kinds of risk: the Irreversible Harm Precautionary Principle.[8] Indeed, some such principle seems to underlie prominent accounts of the Precautionary Principle,[9] which point explicitly to the problem of irreversibility.[10] For example, the United Nations Framework Convention on Climate Change proclaims: "Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing [regulatory] measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost."[11] Similarly, the 1992 Rio Declaration states, "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."[12]

In American environmental law, related ideas are at work. San Francisco has adopted its own precautionary principle, with an emphasis on irreversibility: "Where threats of serious or irreversible damage to people or nature exist, lack of full scientific certainty about cause and effect shall not be viewed as sufficient reason for the City to postpone cost effective measures to prevent the degradation of the environment or protect the health of its citizens."[13] At the federal level, the National Environmental Policy Act requires agencies to discuss "any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."[14] Courts have been careful to insist that environmental impact statements should be prepared at a

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[8]See Scott Farrow, Using Risk-Assessment, Benefit-Cost Analysis, and Real Options to Implement a Precautionary Principle, 24 Risk Analysis 727, 728 (2004).

[9]On that principle, see Indur Goklany, The Precautionary Principle: A Critical Appraisal of Environmental Risk Assessment 6 (Washington, D.C.: Cato Institute, 2001).

[10] For general discussion, see Sunstein, supra note.

[11] See Indur Goklany, The Precautionary Principle: A Critical Appraisal of Environmental Risk Assessment 6 (Washington, D.C.: Cato Institute, 2001).

[12] Quoted in Bjorn Lomborg, The Skeptical Environmentalist 347 (New York: Cambridge University Press, 2001).

[13]See San Francisco Precautionary Principle Ordinance, available at http://temp.sfgov.org/sfenvironment/aboutus/innovative/pp/sfpp.htm

[14] 42 USC 102 (c)(5).

time that permits consideration of environmental effects before irretrievable commitments have been made.[15] A number of other federal statutes, especially in the environmental context, specifically refer to irreversible losses and make their prevention a high priority.[16] Within the federal courts, a special precautionary principle underlies the analysis of preliminary injunctions in cases involving a risk of irreparable environmental harm.[17]

For those who emphasize irreversibility, the general attitude in the face of uncertainty is "act, then learn," as opposed to the tempting and often sensible alternative of "wait and learn." For climate change, some people have believed that research should be our first line of defense. In this view, nations should refuse to commit substantial resources to reducing greenhouse gas emissions or to adaptation until evidence of serious harm is clearer than it now is.[18] To be sure, this view seems to have fewer adherents every year.[19] But many reasonable people believe that our initial steps should be relatively cautious, increasing in aggressiveness as knowledge accumulates (and the costs of emissions reductions fall).[20] In this domain, however, there is a problem with any approach of "wait and learn." If precautionary steps are not taken immediately, the results may be irreversible, or at best difficult and expensive to reverse. For climate change, it might be best to take precautions now as a way of preserving flexibility for

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[15] See Metcalf v. Daley, 214 F3d 1135 (9th Cir 2000); Scientists Inst. For Public Info v. AEC, 481 F2d 1079 (DC Cir 1973); Sierra Club v. Marsh, 976 F2d 763 (1st Cir 1985).

[16] See, eg, 33 USC 2712(j) (making special exception to planning requirement for use of federal resources in a situation requiring action to avoid irreversible loss of natural resources"); 42 USC 9611 (i) (same exception for Superfund cleanups); 22 USC 2151p-1 (c)(2)(A) (requiring President to assist developing countries in a way that responds to "the irreversible losses associated with forest destruction").

[17] See Sierra Club v. Marsh, 872 F2 497 (1st Cir. 1989); on the complexities here, see below.

[18] See, e.g., Robert Mendelsohn, Perspective Paper 1.1, in Global Crises, Global Solutions 44, 47 (Bjørn Lomborg ed.) (Cambridge: Cambridge University Press, 2004); Wilfred Beckerman, Small is Stupid 102–103 (London: Duckworth, 1995). The cautious approach of the Bush Administration can be understood in this light. See Global Climate Change Policy Book (Feb. 2002), available at www.whitehouse.gov/news/releases/2002/02/climatechange.html; Chuck Hagel and Frank Murkowski, High Costs of Kyoto, Wash. Post, Jan. 29, 2000, at A17. A number of years ago, Nordhaus and Boyer found that extremely little is lost by a ten-year delay in emissions reductions. See William D. Nordhaus and Joseph Boyer, Warming the World: Economic Models of Global Warming 127 (Cambridge, Mass.: MIT Press, 2000) (describing the net loss as "trivially small"). For a technical discussion, see Alistair Ulph and David Ulph, Global Warming, Irreversibility and Learning, 107 Econ. J. 636 (1997).

[19] See Nordhaus, supra note; Nicholas Stern, The Economics of Climate Change (2007).

[20] See Nordhaus, supra note; William Nordhaus, A Review of the Stern Review of the Economics of Climate Change (2007), available at http://nordhaus.econ.yale.edu/recent_stuff.html

future generations.[21] My goal in this Essay is to explore the idea of irreversibility in environmental protection. In one sense, the idea is unhelpful: All losses are irreversible, simply because time is linear. If Jones plays tennis this afternoon, rather than working, the relevant time is lost forever. If a project to drill oil in Alaska is delayed for five years, there is an irreversible loss as well: The oil that might have been made available will not be made available when it otherwise would have been. When environmentalists emphasize the importance of irreversibility, I suggest that they are best taken as having two separate conceptions in mind.

The first, drawn from economics in general and environmental economics in particular, is connected with the idea of option value, and in particular with the suggestion that when information is missing, it is worthwhile to spend resources to maintain future flexibility as knowledge increases. Irreversibility, in this sense, comes in various shapes and sizes, and it needs to be taken into account in a sensible cost-benefit analysis. In the context of climate change, this kind of irreversibility is important to consider. A key point here is that environmental problems typically involve not irreversibility but irreversibilities: Expenditures on environmental problems may turn out to be irreversible as well, and hence it is necessary to know something about the nature and magnitude of the irreversibilities on both sides. In many contexts, however, an understanding of irreversibility will justify more aggressive precautions than would be indicated if the environmental damage were reversible.

The second conception, drawn from influential critiques of utilitarianism in general and from environmental ethics in particular, emphasizes losses of goods that are *incommensurable*, not in the sense that they are infinitely valuable, but in the sense that they are qualitatively distinctive. The idea here is that environmental amenities – like a friendship, a photograph album, or a historic site – are not fungible with their monetary equivalent. When people fear or deplore certain losses, including environmental ones, this kind of irreversibility is often their animating concern. Economists and economic analysts of law often find this idea puzzling and opaque, in part because it is outside the scope of neoclassical (or behavioral) economics, and because it does not offer any

[21]See Graciela Chichilnisky and Geoffrey Heal, Global Environmental Risks, 7 J. Econ. Persp. 65, 80 (1993).

guidance for how to assess the costs and benefits of environmental harm. While the first conception calls for a kind of "irreversibility premium," embodied in a willingness to spend more on precautions or preparation, the second does not suggest any particular approach. It does, however, call for a certain way of thinking about certain environmental problems, and I suggest that economic analysts will be unable to understand important debates -- in politics, in law, and in ethics -- unless they have a sympathetic appreciation of the second conception of irreversibility. Indeed, I suggest that economic analysis of environmental problems is in an important sense obtuse, if it fails to appreciate the animating concern.

I shall focus throughout on the problem of climate change, because that problem has such evident importance and because it provides a good area for exploring the underlying puzzles. But as we shall see, the exploration of those puzzles bears on a wide range of questions about appropriate precautions, not only in the environmental arena, but in other legal domains and in daily life as well.

II. Uses, Options, and Irreversibility

A. Existence value, option value

Let us begin with the monetary valuation of an environmental good, such as a pristine area. Some people will be willing to pay to use the area; they may visit it on a regular basis, and they might be very upset at its loss. But others will be willing to pay to preserve it, even if they will not use it. In fact many citizens would be happy to give some money to save a pristine area, perhaps especially if animals can be found there. Hence "existence value" is sometimes included in the valuation of environmental goods,[22] and indeed federal courts have insisted that agencies pay attention to that value in assessing damages to natural resources.[23] Taken as a group, citizens of many nations would be willing to pay a great deal to preserve an endangered species or to maintain the existence of a remote island and its ecosystem. In fact valuation of the damage from climate

[22]See David A. Dana, Existence Value and Federal Preservation Regulation, 28 Harv Envtl. L. Rev. 343, 345 (2004); Charles J. Cicchetti and Louis J. Wilde, Uniqueness, Irreversibility, and the Theory of Nonuse Values, Amer. J. Agric. Econ 1111. 1121, 1121–22 (1992).
[23]See Ohio v. U.S. Dep't of the Interior, 880 F.2d 432, 464 (D.C. Cir. 1989).

change must pay attention to the loss of species and animals, if only because human beings care about them.[24]

But some people are also willing to pay for the *option* to use or to benefit from an environmental amenity in the future, even if they are unsure whether they will exercise that option at any time.[25] Suppose that a pristine area might be developed in a way that ensures its permanent loss. Many people would be willing to pay a significant amount to preserve their option to visit that area. Under federal law, option value must also be considered in the assessment of natural resource damages.[26] Many regulations pay attention to option value in the environmental context.[27] For numerous goods, people are willing to pay and to do a great deal in order to ensure that their options are preserved.

Here, then, is a simple sense in which irreversible harm causes a loss that should be considered and that must be included in measures of value. Some skeptics contend that it "is hard to imagine a price for an irreversible loss,"[28] but people certainly do identify prices for such losses, or at least for the risk of such losses.[29] Whether or not we turn that value into some sort of monetary equivalent, or deem willingness to pay to be determinative, it ought to matter.

The idea of option value, as used in the monetary valuation literature just discussed, is closely related to the use of the notion of "options" in the domain that I shall be emphasizing here. The simple claim is that when regulators are dealing with an irreversible loss, and when they are uncertain about the timing, magnitude, and likelihood of that loss, they should be willing to pay a sum—the option value—in order to maintain flexibility for the future. The option might not be exercised if it turns out that the loss is

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[24] See Wayne Hsiung and Cass R. Sunstein, Climate Change and Animals, 155 U Pa L Rev 1695 (2007).

[25]Cicchetti and Wilde, supra note, at 1122 (noting Weisbrod's analogy of such amenities to public goods, in that "individuals who may never purchase the commodity still hold a value for the option to do so"). The independent use of option value is, however, challenged in various places. See, e.g., A. Myrick Freeman III, The Measurement of Environmental and Resource Values 249–51 (Washington D.C.: Resources for the Future, 2003) (suggesting that "what has been called an option value is really just the algebraic difference between the expected values of two different points on a WTP [willingness to pay] locus").

[26]See Ohio v. U.S. Dep't of the Interior, 880 F.2d 432, 464 (D.C. Cir. 1989).

[27]See, e.g., 60 Fed. Reg. 29914 (1995); 60 Fed.Reg. 28210. 29,914, 29,928 (1995); 59 Fed. Reg. 1062, 1078 (1994). But see 69 Fed. Reg. 68,444 (2004) (doubting whether option value should be recognized as separate from others values).

[28]See Frank Ackerman and Lisa Heinzerling, Priceless: On Knowing the Price of Everything and the Value of Nothing 185 (New York: New Press, 2004).

[29]For a helpful overview, see Richard C. Bishop, Option Value: An Exposition and Extension, 58 Land Economics 1 (1982).

not a serious one. But if the option is purchased, regulators will be in a position to forestall that loss if it turns out to be large. The concern about irreversibility, and hence an Irreversible Harm Precautionary Principle, are based on the idea that regulators should be willing to buy an option to maintain their own flexibility. (I am using terms that suggest monetary payments, but the basic point holds even if we are skeptical about the use of monetary equivalents; "purchases" can take the form of precautionary steps that do not directly involve money.)

In the domain of finance, options take multiple forms.[30] An investor might be willing to purchase land that is known to have deposits of gold. Even if the cost of extraction is too high to justify mining, ownership of the land creates an option to mine if the cost falls.[31] A standard "call option" is a right to purchase an asset prior to a specific date at a specified price.[32] (People might pay for the right to buy a share of stock in their favorite company at $50, six months from now.) In another variation, people might seek the right to abandon a project at a fixed price, perhaps on the occurrence of a specified worst-case scenario. (People might agree to perform some service for someone, but obtain the right not to perform in the event of bad weather, bad health, or some other contingency.) Alternatively, people might obtain the right to scale back a project, to expand it, or to extend its life. In another variation, people might seek the right to abandon a project at a fixed price, perhaps on the occurrence of a specified set of events. Alternatively, they might obtain the right to scale back a project, to expand it, or to extend its life. Options that recognize multiple sources of uncertainty, of the sort that can be found for many environmental problems, are termed "rainbow options."[33]

Option theory has countless applications outside of the domain of investments. People would be willing to do and possibly even to spend a great deal to preserve their option to have another child – even if they are not at all sure that they really want to have another child. Or consider narrow judicial rulings, of the sort celebrated by judicial minimalists,[34] who want courts to make decisions that are focused on particular details and that leave many questions undecided. Narrow rulings can be understood as a way of

[30] See Tom Copeland and Vladimir Antikarocov, Real Option 8-13 (2001).
[31] See Richard Brealey and Stewart Myers, Principles of Corporate Finance565 (2002)
[32] Id. at 582.
[33] Copeland and Antikarocov, supra, at 13.
[34]See generally Cass R. Sunstein, One Case at a Time (Cambridge: Harvard University Press, 1999).

"buying" an option, or at least of "paying" a certain amount by imposing decisionmaking burdens on others, in return for future flexibility. Judges who leave things undecided, and who focus their rulings on the facts of particular cases, are in a sense forcing themselves, and society as a whole, to purchase an option to pay for flexibility in the resolution of subsequent problems. Whether that option is worthwhile depends on its price and the benefits that it provides. Or consider the case of marriage and suppose that because of law or social norms, it is difficult to divorce, so that a decision to marry cannot readily be reversed. If so, prospective spouses might be willing to do a great deal to maintain their flexibility before marrying—far more than they would be willing to do if divorce were much easier.

It should be readily apparent how an understanding of option value might explain the emphasis, in the National Environmental Policy Act (NEPA) and other environmental statutes, on irreversible losses. The central point of NEPA is to ensure that government officials give serious consideration to environmental factors before they take action that might threaten the environment.[35] If the government is building a road through a pristine area, drilling in Alaska, or licensing a nuclear power plant, it must produce an "environmental impact statement" discussing the environmental effects. The production of these statements can be burdensome and costly. But when potentially irreversible losses are involved, and when officials cannot specify the magnitude or likelihood of such losses, the public, and those involved in making the ultimate decision, ought to know about them.

B. Options, imperfect knowledge, and precautions

It should now be clear that the idea of option value might help support an Irreversible Harm Precautionary Principle. The most influential essay was written by Kenneth Arrow and Anthony Fisher, who demonstrate that the ideas of uncertainty and irreversibility have considerable importance to the theory of environmental protection.[36] Arrow and Fisher imagine that the question is whether to preserve a virgin redwood

[35]Bradley Karkkainen, Toward a Smarter NEPA: Monitoring and Managing Government's Environmental Performance, 102 Columbia Law Review 903 (2002).
[36]See Kenneth Arrow and Anthony Fischer, Environmental Preservation, Uncertainty and Irreversibility, 88 Q. J. Economics 312, 313-14 (1974).

forest for wilderness recreation or instead to open it to clear-cut logging. Assume that if the development option is chosen, the destruction of the forest is effectively irreversible. Arrow and Fisher argue that it matters whether the authorities cannot yet assess the costs or benefits of a proposed development. If development produces "some irreversible transformation of the environment, hence a loss in perpetuity of the benefits from preservation," then it is worth paying something to wait to acquire the missing information. Their suggestion is that "the expected benefits of an irreversible decision should be adjusted to reflect the loss of options it entails."[37]

Fisher has generalized this argument to suggest that "[w]here a decision problem is characterized by (1) uncertainty about future costs and benefits of the alternatives, (2) prospects for resolving or reducing the uncertainty with the passage of time, and (3) irreversibility of one or more of the alternatives, an extra value, an option value, properly attaches to the reversible alternative(s)."[38] The intuition here is both straightforward and appealing: more steps should be taken to prevent harms that are effectively final than to prevent those that can be reversed at some cost. If an irreversible harm is on one side and a reversible one on the other, and if decisionmakers are uncertain[39] about future costs and benefits of precautions, an understanding of option value suggests that it is worthwhile to spend a certain amount to preserve future flexibility, by paying a premium to avoid the irreversible harm.

Judge Richard Posner has invoked a point of this sort as a justification for aggressive steps to combat climate change.[40] Posner acknowledges that the size of the threat of climate change is disputed, and hence it is tempting to wait to regulate, or to wait to regulate aggressively, until we have more information. But there is a serious problem with waiting, which is "the practically irreversible effect of greenhouse-gas

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[37]Id. at 319.

[38]See Anthony C. Fisher, Uncertainty, Irreversibility, and the Timing of Climate Policy 9 (2001), available at http://are.berkeley.edu/courses/IAS175/Spring2006/pdfs/Fisher.pdf.

[39] I use the word "uncertain" to refer to both risk and uncertainty. "Risk" exists when it is possible to assign probabilities to various outcomes; "uncertainty" exists when no probabilities can be assigned. For the seminal discussion, which has prompted a heated debate, see Frank H. Knight, Risk, Uncertainty, and Profit (1933). For a nontechnical overview, see Jon Elster, Explaining Technical Change 185-207 (1983).

[40]See Richard A. Posner, Catastrophe 161–62 (2004). A more technical discussion to the same effect is contained in Graciela Chichilnisky and Geoffrey Heal, Global Environmental Risks, 7 J. Econ. Persp. 65, 76 (1993), emphasizing the need for a distinctive approach to "risks that are poorly understood, endogenous, collective, and irreversible." Id. at 67. For a more detailed treatment of option value and irreversibility, see id. at 76-84.

emissions on the atmospheric concentration of those gases."[41] Thus Posner reasons that "[m]aking shallower cuts now can be thought of as purchasing an option to enable global warming to be stopped or slowed at some future time at a lower cost."[42] The reduction in cost, as a result of current steps, could result from lowering current emissions or simply from increasing the rate of technological innovations that make pollution reduction less costly in the future. Posner concludes that the option approach makes sense for other catastrophic risks as well, including those associated with genetically modified crops.

The general point here is that, as in the stock market, those involved in environmental protection are trying to project a stream of good and bad effects over time; the ability to project the stream of effects will improve and hence much can be gained from being able to make the decision later in time rather than earlier. If better decisions can be made in the future, then there is a value to putting the decision off to a later date. The key point is that uncertainty and irreversibility should lead to a sequential decision-making process. If better information will emerge, regulators might seek an approach that preserves greater flexibility, at least if that approach is not too costly. The extent of the appropriate "irreversibility premium" depends on the details.

III. Seriousness and Sunk Costs

Even under this account, the idea of irreversibility remains highly ambiguous. Let us consider two possible interpretations. Under the first, an effect is irreversible when restoration to the status quo is impossible or at best extremely difficult, at least on a relevant timescale. For example, the "decision not to preserve a rich reservoir of biodiversity such as the 60 million-year-old Korup forest in Nigeria is irreversible. The alteration or destruction of a unique asset of this type has an awesome finality."[43] If this is the appropriate interpretation of irreversibility, then it is an aspect of seriousness. A second interpretation, standard in the economic literature on options, sees irreversibility in terms of sunk costs. The two interpretations lead to different understandings of the problem of irreversibility and the Irreversible Harm Precautionary Principle.

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[41]Posner, supra note, at 161-62.
[42]Id. at 162.
[43]See Graciela Chichilnisky and Geoffrey Heal, Global Environmental Risks, 7 J. Econ. Persp. 65, 76 (1993).

A. Irreversibility and seriousness

Under the first interpretation, the initial question is whether a clear line separates the reversible from the irreversible.[44] Perhaps we have a continuum, not a dichotomy. The question is not whether some effect can be reversed, but instead at what cost. Areas that have been developed, or otherwise harmed, can often be returned to their original state, even if at considerable expense. Even lost forests can be restored. But sometimes the cost is high, even prohibitive, and sometimes restoration is literally impossible. Consider in this regard the mortality effects of certain environmental hazards. If air pollution would kill 200 people a year, or if climate change would produce tens of thousands of deaths in India, those losses cannot be recovered. Even biological changes in the human body may not be reversible (whether or not they are associated with immediate or long-term harm). Some kinds of air pollution induce changes that endure for decades. In all of these cases, irreversibility is simply an aspect of seriousness. If 200 people will die from certain levels of pollution, the harm is more serious than if 200 people would merely get sick. If air pollution induces biological changes, everything depends on the magnitude of the harm associated with those changes.

At first glance, these points underline the mundane point that permanent or long-term harms are more serious than short-term harms, under a framework suggestion that the extent of appropriate precautions depends on the size of the harms and the cost and burden associated with preventing or (if possible) reversing them. If climate change cannot be reversed at all, we should take more aggressive precautions than we would if it can be reversed only at great expense, monetary or otherwise -- and if it can be reversed only at great expense, we would take more precautions than we would if it would be easy to reverse it.

But there is a larger conceptual point here, which is that whether a particular act is "irreversible" depends on how it is characterized. Any death, of any living creature, is irreversible, and what is true for living creatures is true for rocks and refrigerators too; if these are destroyed, they are destroyed forever. And because time is linear, every

[44] For a useful treatment, see Neil A. Manson, The Concept of Irreversibility: Its Use in the Sustainable Development and Precautionary Principle Literatures, 1 Electronic Journal of Sustainable Development 1 (2007).

decision is, in an intelligible sense, irreversible. If a couple goes on vacation in Greece in July of a certain year, that decision cannot be reversed, and what else might have been done at that time will have been permanently lost. Even if divorce is easy, a marriage is irreversible in the sense that people will have been married for the relevant period. If government builds a new highway in upstate New York in May, that particular decision will be irreversible; nothing else will be done with that land in May, even though the highway can be later replaced or eliminated. This is the sense in which "irreversibility" depends on how the underlying act is characterized. If we characterize it narrowly, to be and to do precisely what it is and does, any act is irreversible by definition.

Environmentalists who are concerned about irreversibility have something far more particular in mind. They mean something like a large-scale alteration in environmental conditions -- one that imposes permanent, or nearly permanent, changes in those conditions. It should be clear that irreversibility in this sense is not a sufficient reason for a highly precautionary approach. At a minimum, the irreversible change has to be for the worse, and it must also rise to a certain level of magnitude. A truly miniscule change in the global temperature, even if permanent, would not justify expensive precautions if it is benign or if it imposes little in the way of harm. For this reason, it is tempting to understand the idea of irreversibility, for environmental purposes, as inseparable from that of seriousness. A loss of a wisdom tooth is irreversible, but not a reason for particular precautions on behalf of wisdom teeth; a loss of an extremely small forest, with no wildlife, hardly justifies a special principle, even if that loss cannot be reversed. A loss of a large forest, with ample wildlife, is a very different matter.

At first glance, then, irreversibility matters only because of its connection with the magnitude of the harm; irreversibility operates as a kind of amplifier. In law, a comparison might be made with the idea that courts will refuse to issue a preliminary injunction unless the plaintiff can show that there is a likelihood of an "irreparable harm" if the injunction is not granted.[45] Irreparability is not a sufficient condition for granting the injunction; the harm must be serious as well as irreparable. And if irreversibility in environmental protection is to be analyzed in the same way, then an Irreversible Harm

[45] On this idea in the environmental context, see Sierra Club v Marsh, 872 F2d 497 (1st Cir 1989); Comment, Injunctions for NEPA Violations: Balancing the Equities, 59 U Chi L Rev 1263 (1992).

Precautionary Principle is really part of a Catastrophic Harm Precautionary Principle,[46] or at least a Significant Harm Precautionary Principle.

If so, the Irreversible Harm Precautionary Principle is important and must be taken into account; but it is not especially distinctive. The principle is also vulnerable, some of the time, to the same objections that apply to the Precautionary Principle as a whole.[47] As we shall shortly see, significant and even irreversible harms may well be on all sides of risk-related problems, and a focus on one set of risks will give rise to others -- perhaps environmental risks as well.

B. Lost amenities, sunk costs, and imperfect knowledge

Analysts of irreversibility and options understand the idea of irreversibility in a different and technical way.[48] Irreversible investments are sunk costs—those that cannot be recovered. Examples include expenditures on advertising and marketing, or even capital investments designed to improve the performance of a factory. In fact the purchase of motor vehicles, computers, and office equipment is not fully reversible, because the purchase cost is usually significantly higher than resale value. Examples of reversible investments include the opening of bank accounts and the purchase of bonds. The problem with an investment that is irreversible is that those who make it relinquish "the possibility of waiting for new information that might affect the desirability or timing of the expenditure, and this lost option value is an opportunity cost that must be included as part of the investment."[49] This, in short, is the economic conception of irreversibility that I mean to emphasize here.

Many people agree that we should characterize, as irreversible harms, environmental effects that are both serious and extremely expensive and time-consuming to reverse. This is the understanding that leads Posner and others to argue for the purchase of an "option" to slow down climate change at a lower rate in the future.

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[46] See Cass R. Sunstein, The Catastrophic Harm Precautionary Principle, *Issues in Legal Scholarship*, Catastrophic Risks: Prevention, Compensation, and Recovery (2007): Article 3. http://www.bepress.com/ils/iss10/art3

[47] See Sunstein, supra note.

[48] See Avinash Dixit and Robert Pindyck, Investment under Uncertainty 6 (1994) ("When a firm makes an irreversible investment expenditure, it exercises, or "kills," its option to invest. It gives up the possibility of waiting for new information to arrive that might affect the desirability or timing of the expenditure, and this lost option value is an opportunity cost that must be included as part of the investment.").

[49] Id. at 6.

Immediate adoption of a policy produces a "sunk benefit." The argument is correct and important, but it neglects an important point: *Irreversibility, in the relevant sense, might well lie on all sides*. Regulation that reduces one (irreversible) environmental risk might well increase another such risk. Efforts to reduce climate change and other dangers associated with fossil fuel use, for example, may lead to increased dependence on nuclear energy, which threatens to produce irreversible harms of its own; in China, nuclear energy has been actively defended as a way of combating climate change.[50] As with the Precautionary Principle in general, so with the Irreversible Harm Precautionary Principle in particular: Measures that the principle requires, on grounds on safety and health, might well be prohibited on exactly those grounds.[51] And there is a more general point. If steps are taken to reduce greenhouse gas emissions, capital costs will be incurred, and they cannot be recouped. Sunk costs are a familiar feature of environmental regulation, in the form of mandates that require technological change. We are often dealing, then, with irreversibilities, not irreversibility.

For many environmental problems, this point complicates the application of the Irreversible Harm Precautionary Principle. As Fisher writes for climate change, in the abstract "it is not clear whether the conditions of the problem imply that investment in control ought to be slowed or reduced, while waiting for information needed to make a better decision, or that investment should come sooner to preserve the option to protect ourselves from impacts that may be revealed in the future as serious or even catastrophic."[52] It is for this reason that some observers have concluded, unlike Judge Posner, that the existence of uncertainty and irreversibility argues for *less*, not more, in a way of investments in reducing greenhouse gas emissions.[53] Those investments may

[50]See, e.g., Ling Zhong, Note, Nuclear Energy: China's Approach Towards Addressing Global Warming, 12 Geo. Int'l Envtl. L. Rev. 493 (2000). It is of course possible to urge nations to reduce their reliance on coal or nuclear power and move instead toward alternatives that would be preferable on risk-related grounds, such as solar power. For a general discussion, see Renewable Energy: Power for a Sustainable Future (Godfrey Boyle ed.) (Oxford: Oxford University Press, 1996); Allan Collinson, Renewable Energy: Facing the Future (London: Cloverleaf, 1991); Dr. Dan E. Arvizu, Advanced Energy Technology and Climate Change Policy, 2 Fla. Coastal L.J. 435 (2001). But these alternatives pose problems of their own, involving feasibility and expense. See, e.g., Lomborg, supra note, at 118–48.

[51] See Sunstein, supra note.

[52]Fisher, supra note, at 11.

[53] See note supra.

themselves turn out to be irreversible. Everything depends on the likelihood and magnitude of the losses on all sides.

Judge Posner's analysis does not use the idea of options in the technical sense. He emphasizes the cumulative effect of emissions on atmospheric concentrations of carbon dioxide.[54] Because of that cumulative effect, a steady or even declining rate of emissions will still cause concentrations to increase. He notes, correctly, that it may be much harder and more expensive to slow climate change in the future than in the present[55]—a point that comes close to the technical understanding of irreversibility in the economic literature. But a full analysis of irreversibility must also attend to the irreversible losses associated with greenhouse gas *reductions*.

Nothing said here supports the increasingly implausible view that the right approach to climate change is adequately captured in the area of "wait and learn." That approach makes sense only if we lose very little when we defer investments while waiting to obtain more information about the benefits. But if a great deal is likely to be lost by deferring such investments, then the judgment should be reversed; and there is good reason to believe that the irreversible losses associated with climate change do indeed justify the irreversible losses associated with greater investments in emissions reductions, world-wide.[56] My conclusion is that if irreversibility is defined in economic terms, pointing to the value of preserving flexibility for an uncertain future, it provides a distinctive and plausible understanding of the Irreversible Harm Precautionary Principle. As we will see, this understanding also helps explains some of the most important functions of NEPA.

IV. Irreversibility and Incommensurability

The first conception of irreversibility misses something important. When people say that the loss of a pristine area, or of a species, is irreversible, they do not merely mean that the loss is grave and that it takes a great deal to provide adequate compensation.

[54] See Posner, supra note.
[55] Id.
[56] See, e.g., Nordhaus, supra note.

They mean that what is lost is *incommensurable* – that it is qualitatively distinctive, and that when we lose it, we lose something that is unique.[57]

The central claims here are that human goods are diverse and that we do violence to our considered judgments about them when we line them up along a single metric.[58] Suppose, for example, that a species of tigers or elephants is lost. The nature of the concern about lost species is not adequately captured in the idea of "option value." The species is not its economic equivalent. People do not value an endangered species in the same way that they value money; it is not as if a species, a beach, a friendship, or a child is indistinguishable from specified monetary sums. If we see species, beaches, friendships, and children as equivalent to one another, or as equal to some amount of money, we will have on odd and even unrecognizable understanding of all of these goods. When people object to the loss of a species or a beach, and contend that the loss is irreversible, they mean to point to its permanence, and to the fact that what has been lost is not valued in the same way or along the same metric as money. Return to the issue of climate change and note that on some estimates, a significant percentage of the world's species will be lost as a result of warmer temperatures.[59] On one view, what makes this loss "irreversible" is that something qualitatively unique, without real substitutes, will be gone permanently.

This claim – a challenge to prominent understandings of utilitarian and economic conceptions of value[60] -- should not be confused. Of course people are willing to make trade-offs among qualitatively diverse goods, and they do so all the time. We will pay a certain amount, and no more, to be able to protect members of an endangered species or to visit the beach, or to help preserve it in a pristine state; we will not pay an infinite sum to see our friends, or even to maintain our friendships; we will take some precautions, but not others, to protect our children. To say that a good is not fungible is not to say that it is infinitely valuable. To say that a good lacks substitutes is not to deny that people will give up some amount, and not more, to preserve it. The emphasis on incommensurability

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[57] See Martha N. Nussbaum, Plato on Commensurability and Desire, in Love's Knowledge (Oxford: Oxford University Press, 1994).

[58] Good discussions can be found in id.; Elizabeth Anderson, Value in Ethics and Economics (Cambridge : Harvard University Press, 1993); Joseph Raz, The Morality of Freedom (Oxford: Oxford University Press, 1985).

[59] See Hsiung and Sunstein, supra note.

[60] See Nussbaum, supra note.

is not meant to deny that tradeoffs are made. The point is only that when a loss is deemed irreversible, it is because it is not believed to be fungible with other human goods. Many of those who are concerned about irreversible harms intend to stress this point. What is gained by an understanding of incommensurability is a more vivid appreciation of why certain losses cannot be dismissed as mere "costs."

These points are closely connected with important claims in environmental ethics.[61] On one view, "not everything is substitutable for everything else through the medium of utility. And a corollary of that fact is the further fact that some things are irreplaceable."[62] A wild and scenic river, for example, might be valued because of its origins and history; a restoration of that river, as for example through an artificial watercourse, would not provide an adequate substitute.[63] Foundations for this view might be found in a claim that natural processes have some kind of intrinsic value, simply because they are natural.[64] If that idea seems implausible or contentious, at least we might be able to agree that certain decisions would produce losses that are in a moral sense irreversible even if that claim seems mysterious from the standpoint of economic theory. To the extent that it neglects this point, economic theory is obtuse, in the sense that it will be unable to appreciate reasonable concerns that animate many debates in law, politics, and ethics. This is not to say that an understanding of incommensurability points to any particular shift in cost-benefit analysis (though it helps to explain why the properly monetized benefits of species loss, or loss of pristine areas, may be very high). But it is to say that an effort to line up all relevant goods on a single metric will make it difficult to understand what is at stake in the domains and politics of law.

It follows that an Irreversible Harm Precautionary Principle, used in private decisions or democratic arenas, might be implemented with a recognition of the qualitative distinctness of many environmental losses -- especially when those losses affect future generations. Here too, however, it is important to see that precautionary steps may themselves impose incommensurable losses, not merely monetary ones. Recall, for example, that environmental protection of one sort may create environmental

[61] For an illuminating discussion, see Robert Goodin, Green Political Theory (1992).
[62] Id. at 60.
[63] Id. at 41.
[64] Id.

problems of another sort. If the diverse nature of social goods is to play a part in the implementations of an Irreversible Harm Precautionary Principle, it must attend to the fact that diverse goods may be on all sides. And here too there is no escaping at least implicit assignment of monetary values to those goods. To say that an environmental loss is not commensurate with money, in a moral sense, is not to say that human beings can avoid some form of monetization. The point is that in the domains of private choice and democratic judgment, any monetary assignment should be undertaken with an understanding of the nature of the goods at stake. As I have emphasized, this point does not provide any lesson for how the important issue of how the assignment of monetary value should occur. But for those concerned about irreversibility in the relevant sense, that is not the only issue. We need to consider "how" goods are valued, not merely "how much" goods are valued.

V. Environmental Injunctions

An understanding of these points helps to explain some longstanding disputes about the issuance of preliminary injunctions in environmental cases. For many years, some courts of appeals had held that when environmental harm was alleged, district courts should adopt a presumption of irreparable damage and indeed a presumption in favor of injunctive relief.[65] On a widespread view, environmental harms are presumed to be irreparable and to provide an appropriate occasion for such relief.[66] In NEPA cases, the result was a likely injunction if the agency had failed to prepare an adequate environmental impact statement: "Irreparable damage is presumed when an agency fails to evaluate thoroughly the environmental impact of a proposed action."[67] Apparently the idea is that if no environmental impact statement is provided, or if any such statement is inadequate, the risk to the environment is presumed to be irreparable, perhaps in the sense of irreversible. But what is the basis for this presumption? And what follows from it? Does it follow that injunctions will issue in any case in which a private or public institution has failed to comply, even as a technical matter, with federal environmental

[65] See Thomas v. Peterson, 753 F2d 754, 764 (9th Cir 1985).
[66] This view is sketched and rejected in Amoco Production Co. v. Village of Gambell, 480 US 531 (1987) .
[67] Save Our Ecosystems v. Clark, 747 F2d 1240, 1250 (9th Cir 1984). For general discussion, see Zigmund Plater, Statutory Violations and Equitable Discretion, 70 Cal L Rev 524 (1982).

law? Does it follow, for example, that the United States Navy must be enjoined from conducting weapons-training operations before it has obtained a permit to discharge ordnance into the sea?

In response to the last question, the Supreme Court offered a negative answer.[68] Rejecting the idea that environmental violations should give rise to automatic injunctions, the Court said that an injunction is an equitable remedy, subject to traditional balancing, and that it would "not lightly assume that Congress has intended to depart from established principles" permitting district courts to exercise their discretion.[69] In a subsequent case, involving the Alaska Native Claims Settlement Act, the Court underlined the point and expressly rejected the presumption of irreparable harm in environmental cases.[70] "This presumption is contrary to traditional equitable principles."[71] Nonetheless, the Court stressed environmental problems raise distinct issues, because "[e]nvironmental injury, by its nature, can seldom be adequately remedied by money damages and is often permanent or at least of long duration, i.e., irreparable."[72] Notably, the Court did not explain what it meant by the intriguing claim that environmental injuries "can seldom be adequately remedied by money damages." But the Court said that if an environmental injury is likely, "the balance of harms will usually favor the issuance of an injunction to protect the environment." [73]

When courts of appeals spoke in terms of a presumption in favor of injunctive relief, they might be understood as adopting a version of the Irreversible Harm Precautionary Principle -- assuming that environmental harm is irreversible in the relevant sense, and requiring a strong showing by those who seek to proceed in the face of that harm. This interpretation helps to explain the simplest exception to the lower courts' presumption: cases in which "irreparable harm *to the environment* would result if such relief were granted."[74] If, for example, an injunction against the use of a logging

[68] See Weinberger v. Romero-Barcelo, 456 US 305 (1982).
[69] Id. at 313.
[70] Amoco Production Co. v. Village of Gambell, 480 US 531 (1987).
[71] Id. at 544.
[72] Id.
[73] Id.
[74] People of Village of Gambell v. Hodel, 774 F2d 1414, 1424 (9th Cir 1985) (emphasis in original).

road would prevent the removal of diseased trees and hence allow the spread of infection through national forests, no injunction would issue.[75]

Here, then, is a clear recognition of the existence of environment-environment tradeoffs, in a way that requires a qualification of any Irreversible Harm Precautionary Principle. And when the Supreme Court rejected the presumption, it did so in favor of traditional equitable balancing, in a way that recognized that serious harms, and perhaps irreversible harms, are on all sides. But even in doing so, the Court endorsed a kin of Irreversible Harm Precautionary Principle through its (too-simple) suggestion that environmental injury "is often permanent or at least of long duration" and its statement that harms to the environment can seldom be adequately remedied by money damages. Indeed, the latter statement seems to be an implicit recognition of the incommensurability problem.

What remains undecided, after the Court's decisions in the 1980s, is the appropriate judicial posture in the face of violations of NEPA.[76] The Court's rejection of a presumption in favor of preliminary injunctions might well be taken to suggest that such injunctions ought rarely to issue in NEPA cases[77] – especially, perhaps, in light of the fact that NEPA is a purely procedural statute, one that imposes information-gathering duties on agencies without requiring them to take that information into account.[78] If courts cannot forbid agencies to act as they choose after producing an adequate environmental impact statement, injunctions might seem an odd remedy in the NEPA setting. But in what remains the most elaborate discussion of the question, then-Circuit Judge Breyer suggested that injunctions are often appropriate in NEPA cases.[79] The discussion endorses an appropriately constrained Irreversible Harm Precautionary

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[75] Alpine Lakes Protection Society v. Schlapfer, 518 F.2d 1089 (9th Cir 1975); Thomas v. Peterson, 753 F.2d at 764 n. 8.

[76] For general discussion, see Comment, Injunctions for NEPA Violations: Balancing the Equities, 59 U Chi L Rev. 1263 (1992).

[77] See New York v. NRC, 550 F2d 745 (2d Cir 1977); Conservation Society v. Secretary of Transportation, 508 F.2d 927, 933-3 (2d Cir. 1974); United States v. 27.09 Acres of Land, 737 F Supp 277, 283-84 (SDNY 1990); Stand Together Against Neighborhood Decay v. Board of Estimate, 690 F Supp 1191 (EDNY 1988).

[78] See Robertson v. Methow Valley Citizens Council, 490 US 332 (1989).

[79] Sierra Club v Marsh, 872 F2d 497 (1st Cir 1989).

Principle, adapted to the NEPA setting, and resting on some combination of the accounts of irreversibility offered here.[80]

Judge Breyer did not contend that a presumption in favor of injunctive relief would be appropriate for environmental cases in general. Instead he argued that NEPA is meant to prevent a particular kind of injury, one that should play a central role in the decision whether to grant an injunction. The purpose of NEPA is to ensure that officials take environmental considerations into account *before* they embark on a course of action. "Thus, when a decision to which NEPA obligations attach is made without the informed environmental consideration that NEPA requires, the harm that NEPA intends to prevent has been suffered."[81] That harm is not adequately described as a harm to the environment as such.[82] The harm is instead the increased risk of harm to the environment that arises "when governmental decisionmakers make up their minds without having before them an analysis (with prior public comment) of the likely effects of their decision upon the environment."[83]

Irreversibility is central here, for it is simply the case that administrators are less likely to destroy a nearly completed project than one that has only started. The relevant harm "may well have to do with the psychology of decisionmakers, and perhaps a more deeply rooted psychological instinct not to tear down projects once they are built."[84] The problem is that "real environmental harm will occur through inadequate foresight and deliberation."[85] Judge Breyer's point, then, is that "the district court should take account of the potentially irreparable nature of this decisionmaking risk to the environment when considering a request for preliminary injunction."[86]

We can understand this analysis in one of two ways, corresponding to the two conceptions of irreversible environmental harm. The first involves the distinctive value of (some) environmental amenities and the risk that once they are lost, they are lost forever. The context in which Judge Breyer wrote, involving a pristine area, helps to clarify what

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[80] See, in this vein, Washington County, North Carolina v. US Department of the Navy, 317 F Supp 2d 626 (EDNC 2004); Crutchfield v. US Army Corp of Engineers, 192 F.Supp. 2d 444 (ED Va 2001).
[81] Sierra Club v. Marsh, 872 F2d at 500.
[82] Id at 504
[83] Id. at 500.
[84] Id. at 504.
[85] Id.
[86] Id. at 501.

may be at stake. The second involves imperfect information and option value. One goal of NEPA is to acquire environmental information at an early stage, in order to ensure that officials do not compromise future flexibility by embarking on courses of action that acquire unstoppable momentum. Injunctions, in the face of NEPA violations, freeze the status quo in a way that promotes that flexibility.

None of this means that in NEPA cases, preliminary injunctions should issue as a matter of course; that view would endorse the Irreversible Harm Precautionary Principle in its crudest form. Sometimes injunctions will themselves impose serious harm, and sometimes the risk to the environment is trivial.[87] But in NEPA cases, it makes sense to consider, as a relevant factor, the risk that an inadequately informed decision to proceed will alter the status quo, ensuring that once an environmental impact statement is produced, it will be too late to have a meaningful effect on the outcome. If delay is not exceedingly costly, and if the risk of environmental harm is serious, injunctive relief is appropriate for NEPA violations. An understanding of the risk of irreversibility helps to explain why.

VI. Qualifications and Conclusions

The basis for an Irreversible Harm Precautionary Principle, along with an understanding of its limitations, are now in place. We lack any kind of algorithm for implementing that principle. But we should be able to see that when a harm is irreversible in the sense that it is very costly or impossible to make restoration, special precautions may be justified; that it often makes sense to "buy" an option to preserve future flexibility; and that the loss of cherished and qualitatively distinctive goods deserves particular attention. But there are three important qualifications, involving the idea of optimal delay, distributional considerations, and what I shall call precommitment value. Let us briefly explore each of these.

A. Irreversibilities and optimal delay

The general notion of optimal delay provides important countervailing considerations. Future generations will almost certainly be both wealthier and more

[87] See Village of Gambell, supra note.

knowledgeable than the current generation. For this reason, they will be in a far better position, and possibly an unimaginably better position, to handle environmental problems that materialize in their time.[88] According to the Thomas Schelling, the nearly inevitable increase in wealth over time means that it "makes no sense to make current generations 'pay' for the problems of future generations."[89] Why should the relatively poor present transfer its limited resources to benefit the future, which is likely to be relatively rich? There is another problem. Expensive investments in precautions – such as greenhouse gas reduction -- may turn out to diminish available resources for future generations, leaving them with less to use to control the damage that actually occurs.[90]

The argument for "wait and learn" is strengthened by these points. But any such argument must also take account of the incontrovertible fact that waiting simultaneously threatens to diminish the flexibility of future decisionmakers, and perhaps severely.[91] Compare the loss of endangered species; because the loss is permanent, we have to be careful about delaying precautionary measures designed to ensure their continued existence.

B. Irreversibilities, distribution, and the least well-off

At first glance, an Irreversible Harm Precautionary Principle might seem to be especially beneficial to disadvantaged people.[92] In the context of climate change, aggressive precautions are projected to give far more to poor countries than to rich ones, partly because rich nations are so much less dependent on agriculture.[93] Nonetheless, there is no simple connection between distributional goals and an emphasis on irreversible harms. Some of the risks associated with genetic engineering are irreversible, but the benefits of genetic engineering are likely to be felt most in poor nations. In the

[88]See Remarks of Vernon L. Smith in Global Crises, Global Solutions 630, 635 (Bjorn Lomborg ed.) (Cambridge: Cambridge University Press, 2004).
[89]Remarks of Thomas C. Schelling in Global Crises, Global Solutions, supra note, at 627.
[90]Remarks of Vernon L. Smith, supra note, at 635.
[91]See, e.g., Cline, supra note, at 56, 57. Cline emphasizes that both the slowness of political processes and the gradual nature of climate change make it nearly impossible to make such changes "on a dime." Id.
[92]See generally Juan Almendares, Science, Human Rights, and the Precautionary Principle in Honduras in Precaution, Environmental Science, and Preventive Public Policy 55 (Joel A. Tickner ed.) (Washington, D.C.: Island, 2003) (discussing advantages to Third World countries offered by the precautionary principle).
[93] See Eric A. Posner and Cass R. Sunstein, Climate Change Justice, Geo LJ (forthcoming 2008).

context of climate change, poor countries, including India and China, cannot easily afford aggressive regulation; they might be better off if they are allowed to continue to emit greenhouse gases.

In short, the analysis of distributional goals must be undertaken separately from the analysis of irreversibility. Sometimes we will hurt the least well-off, rather than help them, if we buy an option to preserve our own flexibility. The cost of the option might be paid mostly by those who can least afford it.

C. Precommitment value

I have emphasized the value of preserving our flexibility. But in some domains, future flexibility is undesirable, and individual and societies are willing to pay a great deal to eliminate it. The tale of Ulysses and the Sirens is perhaps the most familiar example,[94] and the idea of precommitment has many applications. A Constitution can itself be seen as a precommitment device, by which we relinquish our flexibility in order to be governed by firm rules. With respect to terrorism, we might do best if we commit ourselves to taking certain courses of action if we are attacked; the precommitment creates deterrence.

In the environmental context, regulators might be willing to pay for precommitment strategies that will operate as a constraint on any number of problems. These include interest-group power, myopia, weakness of will, and cognitive biases. A single decisionmaker who is a social maximizer might favor a precommitment strategy. In the context of climate change, such a decisionmaker might argue for an approach that diminishes flexibility, believing that weakness of will, or unavailability bias (a form of cognitive error), might lead people to excessive emissions of greenhouse gas unless they adopt such an approach. Alternatively, a precommitment strategy might be adopted on the theory that interest-group pressures will defeat alternative approaches. Indeed, the conventional Precautionary Principle, understood to place a thumb on the scales in favor of environmental protection, might be explained in these terms.[95] Perhaps the principle

[94]See, e.g., Jon Elster, Ulysses and the Sirens: Studies in Rationality and Irrationality (Cambridge: Cambridge University Press, rev. ed. 1986).

[95]See David A. Dana, A Behavioral Economic Defense of the Precautionary Principle, 97 Nw. U. L. Rev. 1315 (2003).

can be understood not as an effort to preserve flexibility, which can be bad, but on the contrary as an effort to ensure a commitment to a course of action that will protect the environment.

The difficulty, for any such explanation, should now be familiar: any precommitment strategy may give rise to problems, including environmental problems, for which a precommitment strategy might also be justified. It is nonetheless important to see that option value is sometimes paralleled by "precommitment value," for which regulators might be willing to spend a great deal.

Conclusion

The concept of irreversibility might be taken to refer to the sheer gravity of certain losses, and ideas about both permanence and magnitude play a large role in intuitions about environmental protection. I have suggested, however, that the concept is best understood in two distinctive ways. On the economic account, the concern about irreversibility refers to people's willingness to pay a premium to maintain flexibility for the future. In many settings, it makes sense to pay for an option to avoid a risk of losses that are irreversible in the sense that they cannot be recouped. The amount of the payment depends on the size and nature of the loss if it is irreversible. If irreversible losses are on both sides, then it is necessary to assess their likelihood and their magnitude. We can find an implicit understanding of option value in the emphasis on irreversibility in NEPA and other federal statutes, along with many international agreements. But because environmental expenditures are typically sunk costs, an emphasis on irreversibility will sometimes argue in favor of delaying, rather than accelerating, environmental protection. Whether it does so depends on what is known about the magnitude and likelihood of the relevant effects. It is necessary to assess both of these in order to know how to proceed.

On an alternative view, the idea of irreversibility points to the qualitative distinctness of certain environmental goods, and the implausibility of suggesting that those goods are fungible with money. Of course such goods are not infinitely valuable. But it is obtuse to think that wildlife or pristine areas are valued in the same way as their cash equivalents. Anyone who believed in such equivalence would have an unrecognizable understanding of how wildlife and pristine areas are properly appreciated

and experienced. This understanding of irreversibility is difficult to operationalize; it does not suggest any particular specification of an Irreversible Harm Precautionary Principle. But it does, I suggest, help to illuminate important areas of federal law, including the courts' relative willingness to issue injunctions in environmental cases.