

FROM HERE TO ETERNITY: ENVIRONMENTAL LAW AND FUTURE GENERATIONS

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In formulating environmental regulation, policy makers must often consider tradeoffs between current costs and benefits far in the future. One controversial technique for weighing future consequences is exponential discounting, which is used to convert future benefits into their equivalent present-day values. In this article, Professor Farber assesses the appropriateness of using exponential discounting to place a present-day value on future harms, which often may have the effect of minimizing catastrophic events far in the future. Professor Farber concludes that some form of discounting is appropriate, given that society cannot allocate finite resources equally over an infinite number of future time periods.

Professor Farber reaches this conclusion through a model which relies on three simple assumptions. The first is that we are always willing to invest something to obtain a future benefit. The second is that the value of a future time period is the sum of its parts. And finally, that the relative appeal of permanent versus temporary solutions remains the same. Based on these assumptions, Professor Farber argues that exponential discounting necessarily follows. Professor Farber then considers several other factors that can affect this model, such as the perpetuation value of environmental resources and the use of hyperbolic discounting, where the discount rate itself declines over time.

“One generation passeth away, and another generation cometh, but the earth abideth forever.”¹ This quotation indicates that the disparity between our personal time scales and that of the planet was recognized even in the Biblical era. Ancient though this insight may be, only recently has the incongruity between human and planetary time become a pressing practical

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1. Ecclesiastes 1:1 (King James).

concern. For until recently, “[s]eldom has the world consciously faced a set of decisions likely to affect our descendants one, two, or three centuries from now.”² In contrast, “the world community is now faced with issues of intergenerational equity on an unprecedented scale.”³ Evaluating these intergenerational effects is one of the great challenges facing environmental regulation.

The importance of this issue is brought home by the greenhouse effect.⁴ Absent decisive action, carbon dioxide concentrations will almost certainly double within this century and double again by the year 2150.⁵ The effects cannot be known with certainty, but range somewhere between the merely significant and the utterly catastrophic.⁶ Whatever actions we take today, however, will have most of their effects far in the future. For instance, according to one model, the annual benefit of reducing carbon emissions by a thousand tons today rises to the \$500 level only after a delay of fifty years.⁷ The benefit peaks in fifty additional years at over \$1,000 year, and then gradually tails back to the \$500 level over the next three centuries.⁸ Thus, the major benefits of current control measures will take hold only after a fifty-year delay, but will then extend over several centuries. Dealing with such long-term consequences poses great conceptual problems.

Such long-term issues seem increasingly common in environmental law. Destroying an endangered species does not deprive merely our own generation of the benefit of its existence, but every generation from now until the end of time. Similarly, once destroyed, complex ecosystems like rain forests may be impossible to ever replace. If genetically modified organisms or portions of their genomes escape our control, they may become permanent features of our landscape. Such actions have consequences lasting many generations. Determining how much weight to give these future consequences in our decision making is critical.

2. J. Golemborg et al., *Introduction: Scope of the Assessment*, in *CLIMATE CHANGE 1995: ECONOMIC AND SOCIAL DIMENSIONS OF CLIMATE CHANGE* 17, 23 (James Bruce et al. eds., 1996).

3. *Id.*

4. For background on this issue, see Jason F. Shogren & Michael A. Toman, *Climate Change Policy*, in *PUBLIC POLICIES FOR ENVIRONMENTAL PROTECTION* 125 (Paul R. Portney & Robert N. Stavins eds., 2d ed. 2000).

5. Lakshman Guruswamy, *Climate Change: The Next Dimension*, 15 *J. LAND USE & ENVTL. L.* 341, 372 (2000). Guruswamy is a critic of the Kyoto Accord, and his estimate can be considered conservative.

6. *See id.* at 372–81.

7. *See* RICHARD NEWELL & WILLIAM PIZER, *DISCOUNTING THE BENEFITS OF CLIMATE CHANGE MITIGATION: HOW MUCH DO UNCERTAIN RATES INCREASE VALUATIONS?* 2 (Pew Ctr. on Global Climate Change, Econ. Technical Series, 2001). This model is quite sophisticated. On the economic side, it takes into account investment, savings, and productivity changes. It also includes a lag before increased carbon dioxide levels begin to affect climate, followed by a decline as the increased CO₂ is absorbed into the ocean, with damages from global warming assumed to be proportional to the square of the temperature change multiplied by the level of growth.

8. *Id.* I have changed the scale from benefits/ton to benefits/1000 tons to avoid the appearance of minimizing the significance of global warming or the benefit of control measures.

One possible solution is provided by economics. An economic technique called exponential discounting converts future benefits into their equivalent present-day values.⁹ The crucial parameter is called the discount rate. Results are extremely sensitive to this parameter: changing it from two percent to seven percent reduces the present value of an event in the year 2402 by a factor of 200 million.¹⁰ Economists have devoted considerable attention to the problem of choosing the correct rate for such long-range problems.¹¹ But even with a low discount rate, discounting still has a dramatic effect on the evaluation of environmental effects far in the future. As one economist remarks, “[t]he logic of exponential discounting forces us to say that what we might otherwise conceptualize as monumental events ‘do not much matter’ when they occur in future centuries or millennia.”¹²

Because of this unpalatable implication, many have questioned the use of discounting. “[E]ven the best minds” in economics, it is said, feel a “sense of unease about discounting”—the reasons being its technical complexity and its disturbing ethical ramifications.¹³ A survey of notable economists concluded: “[t]here does not now exist within the economics profession, nor has there ever existed, anything remotely resembling a consensus, even—or, perhaps one should say, especially—among the ‘experts’ on the subject.”¹⁴ Not surprisingly, the subject of discounting has also attracted much recent attention from legal academics¹⁵ as well as philosophers.¹⁶ Discounting over long periods raises profound ethical questions about our obligations to future generations.¹⁷ Many people have an intuitive sense that discounting is morally problematic because it seems to

9. For a more detailed explanation of this technique, see *infra* Part I. On the dispute regarding its application to the greenhouse effect, see Shogren & Toman, *supra* note 4, at 138–39.

10. NEWELL & PIZER, *supra* note 7, at 11.

11. See *infra* notes 44–65 and accompanying text.

12. Martin L. Weitzman, *Why the Far-Distant Future Should Be Discounted at Its Lowest Possible Rate*, 36 J. ENVTL. ECON. & MGMT. 201, 201 (1998).

13. Paul R. Portney & John P. Weyant, *Introduction*, in DISCOUNTING AND INTERGENERATIONAL EQUITY 5 (Paul R. Portney & John P. Weyant eds., 1999).

14. Martin L. Weitzman, *Gamma Discounting*, 91 AM. ECON. REV. 260, 261 (2001). This observation was based on a survey of over 2000 economists, and a smaller survey of fifty especially notable ones.

15. See, e.g., Jeffrey Gaba, *Environmental Ethics and Our Moral Relationship to Future Generations: Future Rights and Present Virtue*, 24 COLUM. J. ENVTL. L. 249 (1999); Lisa Heinzerling, *Discounting Our Future*, 14 LAND & WATER L. REV. 39 (1999) [hereinafter Heinzerling, *Discounting Our Future*]; Richard L. Revesz, *Environmental Regulation, Cost-Benefit Analysis, and the Discounting of Human Lives*, 99 COLUM. L. REV. 941 (1999). My own earlier thoughts on discounting can be found in DANIEL A. FARBER, ECO-PRAGMATISM: MAKING SENSIBLE ENVIRONMENTAL DECISIONS IN AN UNCERTAIN WORLD 133–62 (1999) [hereinafter FARBER, ECO-PRAGMATISM].

16. See JUSTICE BETWEEN AGE GROUPS AND GENERATIONS (Peter Laslett & James S. Fishkin eds., 1992). For an excellent recent survey of the philosophical issues, see Lawrence Solum, *To Our Children's Children*, 35 LOY. L.A. L. REV. 163 (2001).

17. Among these questions: Is it meaningful to speak about the *rights* of people whose existence is contingent on the very decisions whose effects we are trying to assess? Should the interests of all generations count equally, or do more remote generations count for less? Will our descendants be richer than ourselves (and therefore undeserving of wealth transfers), or poorer (and therefore entitled to complain about our current profligacy)? For further discussion, see *infra* Part II.

treat our more distant descendants as so much less worthy of concern than ourselves.¹⁸

Indeed, as recently as three years ago, I rejected the use of discounting for multigenerational benefits.¹⁹ I am now convinced, however, that such discounting does not suffer from any fundamental ethical flaw. Rather, in deciding how much to sacrifice today for the future, as a general matter we simply *cannot* give future consequences the same weight as current ones. Despite some lingering sense of unease, in the end we must face up to the need for discounting of some kind in a broad range of circumstances.²⁰

As this article will demonstrate, discounting follows inexorably from some simple assumptions about how to value environmental benefits over time. The assumptions ultimately come down to the following: each future year of the benefit has some value, the value of a future period is the sum of its parts, and the relative appeal of permanent versus temporary solutions remains the same over time. Taken together, these bare-boned assumptions turn out to be enough to prove the validity of exponential discounting.²¹ Weakening the model's assumptions makes room for other forms of discounting, which place a higher value on the distant future.

These results are important for three reasons. First, the assumptions are quite weak, and they imply exponential discounting without making debatable assumptions about the economy's future or taking any philosophical position about future generations or about how to value the environment. Under plausible circumstances, exponential discounting begins to look unavoidable. Second, even if we ultimately conclude that these assumptions have limited applicability, the model is still a valuable thought experiment. The possibility of deriving exponential discounting from such innocuous assumptions suggests that exponential discounting may be less morally suspect than is often believed. Third, the model helps us identify and classify the situations where exponential discounting does not apply. Thus, we can better map out the boundaries of exponential discounting.

Parts I and II of the article provide background on discounting and its controversial normative status. Part I explains the distinction between the two major rationales for discounting, one based on opportunity costs and the other based on individual preferences for more immediate benefits.²² Part II builds on this description of discounting by providing a brief overview of the ethical debate over discounting and future generations. It is intuitively appealing to think that all generations should be treated equally—or to put it another way, that we should not devalue environ-

18. See *infra* notes 97–99 and accompanying text.

19. See FARBER, *ECO-PRAGMATISM*, *supra* note 15, at 150 (arguing that discounting might be the wrong technique in intergenerational situations).

20. See *infra* notes 112–16 and accompanying text.

21. See *infra* note 175 and accompanying text.

22. See *infra* notes 43–45 and accompanying text.

mental benefits far in the future as opposed to those closer at hand. A number of legal scholars have developed such arguments against discounting,²³ and I do not deny their appeal. However, as part III shows, this ideal of cross-temporal equality runs into some serious logical difficulties.

Part III is the article's core. It demonstrates that discounting environmental benefits is not only ethically permissible but often unavoidable. In a nutshell, if we consider the future as effectively unlimited in duration, we cannot devote our current finite resources in equal shares over an infinite number of time periods. This means that our primary focus must be on our more immediate descendants. To avoid becoming entangled in the debate over cost-benefit analysis,²⁴ I will simply assume that we have determined by *some* means—whether cost-benefit analysis or pure intuition—how much of our current resources we are willing to sacrifice to obtain future environmental benefits. It turns out that, with the very modest assumptions discussed above, we are forced to allocate decreasing current resources as the corresponding benefits recede into the future. Obtaining the conventional economic discount function requires only one small additional assumption about the attraction of permanent versus temporary solutions.²⁵

Thus, in a wide range of circumstances, some form of discounting now seems normatively appropriate, even for events in the far future. Even with a very low discount rate, however, the usual form of exponential discounting would mean that our effective planning horizon would extend only a few centuries, which may be problematic. It behooves us, then, to consider some of the limitations of this conclusion.

Part IV explores two ways of limiting the scope of exponential discounting by modifying the model. First, a slight modification in the model could diminish the scope of discounting. The modified model would encompass the possibility that the value of some aspect of the environment might rest, not just on its discrete value during disaggregated time periods, but on its current potential for indefinite existence—its capacity to sustain itself.²⁶ When some part of the environment has this kind of “perpetuation” value, discounting does not have as much impact, because only part of the value of the species is tied to specific time periods. Second—and perhaps of greater practical significance—by abandoning another of the model's assumptions, we are led to a technique called hyperbolic discounting. In hyperbolic discounting, the discount rate itself declines over time,

23. See *infra* notes 84–91 and accompanying text.

24. On the debate over cost-benefit analysis, see Matthew D. Adler & Eric A. Posner, *Rethinking Cost-Benefit Analysis*, 109 YALE L.J. 165 (1999); David M. Driesen, *The Societal Cost of Environmental Regulation: Beyond Administrative Cost-Benefit Analysis*, 24 ECOLOGY L.Q. 545 (1997).

25. See *infra* notes 126–30 and accompanying text.

26. See *infra* text accompanying note 125.

which avoids some of the radical foreshortening caused by traditional exponential discounting.²⁷

Hyperbolic discounting is not without problems, but it offers an appealing way of evaluating future environmental benefits. Even with hyperbolic discounting, there are limits on how far our concerns may stretch into the future, and the present still counts proportionately more than the needs of future generations. But hyperbolic discounting does give genuine weight to consequences well beyond the lives of our children and grandchildren. In the vastness of geological time, a few centuries or even millennia may mean nothing. In the real world of policymaking, serious consideration of effects even a mere decade or two in the future cannot be taken for granted.²⁸ Barton Thompson worries, with good reason, “that people have difficulty making *any* sacrifices to avoid uncertain future losses.”²⁹ It would be a tremendous advance if our society took seriously the impacts of our actions over the next several centuries, even if we leave the truly distant future to fend for itself.

I. AN INTRODUCTION TO DISCOUNTING

Global warming and endangered species provide obvious examples of discounting’s utility because of the multigenerational effects of our actions. Long-term delayed harms are ubiquitous, however, in environmental law. As Lisa Heinzerling points out:

Radioactive substances are perhaps the most dramatic example of such a long-lived threat. . . . [I]n planning for the disposal of the most radioactive of our radioactive wastes, EPA has dictated that the disposal site must be one that will remain undisturbed for at least 10,000 years.

Other persistent contaminants include [PCBs, DDT], chlordane, dieldrin, and dioxin. These can persist in the environment, and in human tissue, for many years. . . . [T]oday’s use and disposal of radioactive substances, chlorinated organic compounds, and

27. Hyperbolic discounting involves rates that decrease over time and thus put more weight on the long-term future. See Elizabeth Atherton, *From Discounting to Incorporating Decisions’ Long-Term Impacts*, 11 RISK: HEALTH, SAFETY & ENV’T 125, 137 (2000). For discussions about the use of declining rates in discounting, see Maureen Cropper & David Laibson, *The Implications of Hyperbolic Discounting for Project Evaluation*, in DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 13, at 163–71; Weitzman, *supra* note 12, at 207. Hyperbolic discounting has the advantage of tracking individual time preferences better than conventional discounting. It also extends the period during which future effects “matter,” which may be ethically desirable. For further discussion of the desirability of hyperbolic discounting, see *infra* notes 146–58 and accompanying text.

28. See William D. Nordhaus, *Discounting and Public Policies That Affect the Distant Future*, in DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 13, at 145 (commenting on the difficulty of “getting elected officials with two-year electoral cycles to focus on problems beyond their election horizons”).

29. Barton H. Thompson, Jr., *Tragically Difficult: The Obstacles to Governing the Commons*, 30 ENVTL. L. 241, 262 (2000).

heavy metals will continue to pose threats to human health for many decades, in some cases centuries, to come.³⁰

For this reason, discounting plays a key part in the economic analysis of environmental regulation.

The basic idea of discounting is not only simple but almost simple-minded. If \$1 invested at compound interest today will produce \$2 in five years, we “discount” the future \$2 at the same interest rate, concluding that its “present value” is \$1. Making this adjustment allows us to compare different investments whose payoffs have varying time profiles.³¹ Thus, discounting is closely related to compound interest.

Because exponential discounting is essentially the reverse of compounding, we might call it an application of “compound *dis*interest.” The longer the period of time, the less interested we are in the same cost or benefit. Like looking into the wrong end of a telescope, discounting makes distant objects look smaller.³² This can have important policy implications because the costs and benefits of environmental regulation are often distributed differently over time: the major costs are frequently incurred immediately, thereby receiving their full monetary value in the analysis, while the concrete benefits of regulation spread out into the future and are therefore subject to discounting. For this reason, as Lisa Heinzerling has pointed out, critics of environmental regulation often use discounting to minimize the benefits of regulation.³³

Choosing a discount rate is not merely a technical exercise; it is closely linked with the normative arguments for discounting.³⁴ In this section, I will begin by showing the dramatic practical import of discounting. I will then consider the problems involved in choosing a discount rate and examine how federal agencies have handled the discounting question.

A. *The Significance of Discounting*

The basic point is this: discounting favors regulations with benefits in the present or near future over regulations with later benefits. Discounting also generally favors regulations that produce short-term benefits and long-term costs.

30. Lisa Heinzerling, *The Temporal Dimension in Environmental Law*, 31 ENVTL. L. REP. 11,055, 11,067 (2001).

31. To take a simple example, suppose we are comparing two different contracts. Given the existence of the investment return described in the text, if one contract pays \$1.50 today, we know that it is a better deal than another which pays \$2 in five years, because we can take the \$1.50, invest it, and have more than \$2 dollars next year. The shorthand way of saying this is that present value of the first contract is \$1.50, while the present value of the other is only \$1.

32. For an overview of the economics of discounting, see Atherton, *supra* note 27. For illustrations of the dramatic effects of discounting, see *infra* notes 36–42 and accompanying text.

33. See Lisa Heinzerling, *Regulatory Costs of Mythic Proportions*, 107 YALE L.J. 1981, 1984–85 (1998) [hereinafter Heinzerling, *Regulatory Costs*].

34. See Heinzerling, *Discounting Our Future*, *supra* note 15, at 59.

Even a modest discount rate favors small benefits today over much larger benefits in the distant future. Suppose you are a cost-benefit analyst faced with the following question: if society is willing to spend \$3 million to save a life today, how much should it spend to save a life in twenty years? During the 1980s, the Office of Management and Budget (OMB) would have said \$450,000. Until 1992, it used a ten-percent discount rate to convert future regulatory costs and benefits into their “present value.”³⁵ Since 1992, the OMB has used a seven-percent rate, which would change the answer to \$780,000, almost twice the earlier figure.³⁶

Over longer time periods, the results of small changes in discount rates are even more dramatic. As Cass Sunstein explains:

If an agency chooses a discount rate of 2%, the outcome will be very different from what it would be if an agency were to choose a discount rate of 10%; the benefits calculation will shift dramatically as a result. If a human life is valued at \$8 million, and if an agency chooses a 10% discount rate, a life saved 100 years from now is worth only \$581. At a discount rate of 5%, one death next year counts for more than a billion deaths in 500 years.³⁷

Thus, what seems at first blush to be a niggling technical issue turns out to have a grave significance in evaluating long-term regulatory decisions.

As noted in the introduction,³⁸ the discount rate has particular impact on the evaluation of long-term global environmental issues such as the ozone layer and climate change.³⁹ For instance, using the OMB's old discount rate of ten percent, if the greenhouse effect were to cost society \$100 billion twenty years from now, it would only be worth spending \$11 billion today to prevent the harm. Under the OMB's newer discount rate of seven percent,⁴⁰ it would be worth spending a more generous \$25 billion. Considering that the major benefits of controlling greenhouse gases would not accrue for at least fifty to one hundred years,⁴¹ discounting could substantially reduce our willingness to invest in control measures today. As Portney and Weyant write, “[n]o matter how familiar one is with the power of

35. OFFICE OF MGMT. & BUDGET, CIRCULAR A-94, at 4 (1972); see also Lisa Heinzerling, *Environmental Law and the Present Future*, 87 GEO. L.J. 2025, 2027 n.10 (1999); Revesz, *supra* note 15, at 978.

36. OFFICE OF MGMT. & BUDGET, CIRCULAR A-94, REVISED (1992).

37. Cass R. Sunstein, *Cost-Benefit Default Principles*, 99 MICH. L. REV. 1651, 1711 (2001).

38. See *supra* notes 4–12 and accompanying text.

39. See Maureen L. Cropper & Wallace E. Oates, *Environmental Economics: A Survey*, 30 J. ECON. LITERATURE 675, 725–27 (1992) (noting the significance of choice of discount rate in the analysis of carcinogen regulation under CERCLA and RCRA, as well as in global environmental issues).

40. OFFICE OF MGMT. & BUDGET, ECONOMIC ANALYSIS OF FEDERAL REGULATIONS UNDER EXECUTIVE ORDER 12,866 § III(A)(3)(a) (Jan. 11, 1996), available at <http://www.whitehouse.gov/omb/inforeg/regpol.html>. The OMB is continuing to use the seven-percent rate under the Bush administration, but allows EPA to use five percent. See OFFICE OF MGMT. & BUDGET, RANKING REGULATORY INVESTMENTS IN PUBLIC HEALTH 420 (Feb. 4, 2002), available at <http://www.whitehouse.gov/omb/inforeg/spec24.pdf>.

41. See Thomas C. Schelling, *Intergenerational Discounting*, in DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 13, at 99.

compound interest, it is hard not to be stunned by the small difference that the distant future makes for present-day decisionmaking.”⁴²

Discounting is often associated with formal cost-benefit analysis, but can be relevant even using other decisional techniques and without monetizing the benefits of environmental regulations. Given a finite budget for environmental protection, we should use our money in the most cost-effective manner possible. If two different interventions produce sets of benefits with different time-profiles, we need to have some way to compare the results in order to choose between these environmental “investments.” One technique is to measure benefits in terms of human lives today, using discounting to give equivalent values for lives saved later. Thus, converting regulatory benefits to monetary terms is not an essential part of the discounting exercise.

B. *Methods for Determining Discount Rates*

Although this article’s primary focus is on whether to discount rather than the choice of rate, background on the issue of discount rates is useful. Understanding the rationales for picking different discount rates helps to illuminate the underlying justifications for discounting at all. And we cannot sensibly discuss the desirability of discounting without some understanding of how the process actually works.

Economists emphasize two explanations for discounting: money could be invested for a greater future return (the opportunity cost of capital), and people are impatient (time preference).⁴³ The two rationales should not be confused. One rationale says that you could invest the price of a candy bar today and buy two candy bars next year with the proceeds, instead of having one candy bar next year. The other rationale says that you would be willing to trade a candy bar today for two candy bars next year, if the exchange is possible. Thus, under one rationale, we are comparing different numbers of candy bars in *one* future year; the other rationale compares candy bars in *different* years. If we think in terms of the market for investment funds, the opportunity cost rationale says what firms are willing to pay for new funds, while the impatience rationale identifies the amount that individuals require as compensation for delaying consumption by investing their funds.

In the economists’ ideal world—fully competitive markets, no distortionary taxes, perfect information, and complete rationality—these rates would be identical. Investment returns would be just large enough to persuade individuals to delay compensation, invest their money, and then consume the proceeds. But reality does not correspond with this idealized condition. Most economists agree that the discount rate suggested by the

42. Portney & Weyant, *supra* note 13, at 5.

43. For a description of social opportunity cost and social time preference, see DAVID W. PEARCE & R. KERRY TURNER, *ECONOMICS OF NATURAL RESOURCES AND THE ENVIRONMENT* 212–17 (1990).

impatience explanation—the “social” discount rate—is substantially lower than the rate indicated by the opportunity cost of alternative investments.⁴⁴ Essentially, the opportunity cost corresponds to the loss of consumption that we might otherwise be able to obtain in the *same* future time period as an environmental benefit, but which is prevented by our investment in the environmental benefit. The social discount rate tells us how to compare consumption or environmental benefits in *different* time periods.⁴⁵

We begin by considering the social discount rate. People should theoretically use a single interest rate for both saving and borrowing over all time periods. This interest rate would correspond to their discount rate. The empirical evidence is quite different. The “real” (inflation adjusted) rate of return on riskless investments is quite low, approximately one percent or so.⁴⁶ But people borrow money at much higher rates even while making low-interest investments.⁴⁷ Some disparities may stem from people’s desire to commit themselves to particular levels of savings, which may make it rational to tie up some funds at a low return while borrowing at a much higher rate.⁴⁸

44. In a world without taxes, the social discount rate and the opportunity cost theoretically should be the same. But the tax system drives a wedge between the two. See Robert C. Lind, *A Primer on the Major Issues Relating to the Discount Rate for Evaluating National Energy Options*, in DISCOUNTING FOR TIME AND RISK IN ENERGY POLICY 21, 24–32 (Robert C. Lind et al. eds., 1982) [hereinafter Lind, *A Primer on the Major Issues*].

45. A nice summary of the current economic thinking on this topic in the intergenerational context can be found in K.J. Arrow et al., *Intertemporal Equity, Discounting, and Economic Efficiency*, in CLIMATE CHANGE 1995, *supra* note 2, at 125. Arrow and his coauthors distinguish between the prescriptive view (based on ethical views of intergenerational equity and stressing the social discount rate) and the descriptive view (based on the time preferences revealed by individual and governmental actions and favoring the use of investment returns as a benchmark). They seem more amenable to the descriptive approach. As usual, however, the separation of efficiency from equity considerations seems to rely on the possibility of costless transfer payments, *see id.* at 133, which seems implausible in the intergenerational context.

Theoretically, society could use the social security trust to transfer benefits backward in time, so as to compensate earlier generations for giving up more consumption than they would prefer. For example, if a cut in energy production now will produce a great increase in wealth for our grandchildren by limiting global warming, we could set up the social security system to pay us extra benefits in retirement, to be funded by our children. This in turn could be made advantageous to our children (compared with the alternative of unchecked global warming) by promising them in turn higher social security payments from our grandchildren, which our grandchildren would find a worthwhile exchange for the benefits of greenhouse gas reduction. But this requires an inviolable pact across several generations regarding social security.

46. See Barbara H. Fried, *Fairness and the Consumption Tax*, 44 STAN. L. REV. 961, 985–86 (1992) (stating that the most reliable estimate of the real, riskless rate of return is 0.5%); Robert C. Lind, *Reassessing the Government’s Discount Rate Policy in Light of New Theory and Data in a World Economy with a High Degree of Capital Mobility*, 18 J. ENVTL. ECON. & MGMT. S-8, S-24 (1990) [hereinafter Lind, *Reassessing*] (stating that the government’s borrowing cost is one to three percent).

47. See George Loewenstein & Richard H. Thaler, *Intertemporal Choice*, 1989 J. ECON. PERSP. 181; *see also* Lind, *Reassessing*, *supra* note 46, at S-19–21 (discussing how compartmentalization of investment decisions results in a single individual exhibiting several disparate rates of time preference).

48. As Robert Lind explains, “it may not be irrational for the individual to keep budgets separated because of problems associated with self-control,” because the “person who regularly raided the children’s college fund to pay off consumer debts might soon find that the children had no money for college.” Lind, *Reassessing*, *supra* note 46, at S-19. For similar reasons, many people “deliberately don’t take more than a certain amount of money to Las Vegas or to a race track.” *Id.* This insight may have

The empirical evidence about environmental discount rates is also conflicting. One survey asked 1,000 households about their views regarding saving human lives. On average, people discounted future lives saved within twenty-five years at an annual rate of around eight percent, but used less than half this rate when the time horizon was a century.⁴⁹ Another study found rates close to zero for longer time horizons.⁵⁰ Moreover, as Lisa Heinzerling notes, these are average rates, and the reported individual rates vary substantially—from zero all the way to infinity!⁵¹ Furthermore, environmental discount rates do not seem to be constant. As Heinzerling observes, the evidence also demonstrates that people use lower discount rates for the distant future than for the immediate future.⁵²

In part because of these difficulties in determining the social discount rate, disparities exist in the discount rates used by various agencies.⁵³ Although the OMB continues to recommend use of a seven-percent rate, it has acknowledged the Environmental Protection Agency's (EPA's) reliance on a three-percent rate for discounting environmental benefits, based on the social discount rate.⁵⁴ The OMB also acknowledges that intergenerational effects may require special consideration. It recommends either applying the standard discount rate but separately discussing issues of equity or using a lower discount rate based on the growth of per capita consumption.⁵⁵ The EPA has recently considered the use of interest rates ranging from 0.5% to 3% for intergenerational discounting.⁵⁶

The other argument for discounting is based on opportunity costs. Rather than spending resources to prevent a given future harm, we might invest them in other public projects or in the private market. These alternative investments might actually make us better off in the future, more than compensating for the future harm we have failed to avoid. There is

important implications regarding the appropriate discount rate for very long-term projects. *See infra* notes 60–65 and accompanying text.

49. *What Price Posterity?*, *ECONOMIST*, Mar. 23, 1991, at 73, available at 1991 WL 4961056.

50. Maureen L. Cropper & Paul R. Portney, *Discounting and the Evaluation of Lifesaving Programs*, 3 *J. RISK & UNCERTAINTY* 369, 375 (1990).

51. *See* Heinzerling, *Discounting Our Future*, *supra* note 15, at 59–60. For instance, in some surveys, about a third of the survey participants applied a zero discount rate to future life-saving, while ten percent applied a negative rate, attaching more value to saving lives in the future than in the present. On the other hand, many were opposed to spending any money at all to save future lives, largely on the grounds that more effective means of doing so would be available in the future. *See id.*

52. *Id.* at 59. These findings, as we will see later, support the use of hyperbolic discounting. *See infra* notes 146–57 and accompanying text.

53. *See* Edward R. Morrison, Comment, *Judicial Review of Discount Rates Used in Regulatory Cost-Benefit Analysis*, 65 *U. CHI. L. REV.* 1333, 1336–37 (1998) (showing that OMB has failed in efforts to standardize rates).

54. Memorandum from Jacob J. Lew, Director, Office of Management and Budget, to the Heads of Departments and Agencies 7 (Mar. 22, 2000) (on file with author). For a discussion of the use of discounting by non-environmental agencies, see Coleman Bazelon & Kent Smetters, *Discounting Inside the Washington D.C. Beltway*, 13 *J. ECON. PERSP.* 213, 219–23 (1999).

55. Memorandum from Jacob J. Lew to the Heads of Departments and Agencies, *supra* note 54, at 8.

56. *See* U.S. ENVTL. PROT. AGENCY, GUIDELINES FOR PREPARING ECONOMIC ANALYSES 52 (Sept. 2000) [hereinafter EPA GUIDELINES].

widespread agreement, even among critics of discounting, that these opportunity costs deserve consideration.⁵⁷ We can account for the loss of alternate investment opportunities by using the rate of return on alternate investments as the rate for discounting benefits.⁵⁸ This provides an accurate measure of opportunity cost, however, only if the lost opportunity actually is an investment whose returns accrue in the same future year.⁵⁹

When considering opportunity costs, it is important to be careful in describing alternate investments. Alternate investments may have different time profiles, and hasty assumptions about alternative investments can result in highly misleading results.⁶⁰ Using the rate of return on private investments or on shorter-term public investments can lead the analyst astray. Using these higher discount rates to measure opportunity cost would implicitly assume that these alternative investment projects have benefits that will continue to compound over a century. As a number of economists have pointed out, this assumption about alternative investments is dubious because of the impossibility of preventing later invasions of principal.⁶¹ Much of the return on short-term projects is taken in the form of increased consumption, so the amount of interest that compounds over the long run is smaller than the return on individual projects.⁶² As William Cline puts it, “[d]iscounting over centuries at today’s return on capital implicitly makes a commitment that is not credible: that society will keep reinvesting at this rate to compensate distant future generations for damages imposed.”⁶³

57. For an example of such consideration, see Tyler Cowen & Derek Parfit, *Against the Social Discount Rate*, in JUSTICE BETWEEN AGE GROUPS AND GENERATIONS, *supra* note 16, at 150–53.

58. See Morrison, *supra* note 53, at 1342.

59. See Lind, *A Primer on the Major Issues*, *supra* note 44, at 50–52. Simply using the rate of return for short-term private investments assumes that environmental projects are funded out of the existing pool of capital rather than by decreasing current or future consumption. But this assumption depends on our general model of the economy and how it responds to increased taxes or other financial demands. Consequently it is hard to know how much expenditures for government regulations “crowd out” alternative investments.

60. For example, Lawrence Summers (later Secretary of Treasury under Clinton and now President of Harvard University) used opportunity costs as a rationale for heavily discounting environmental benefits. He argued that “public non-environmental investments like sewage-treatment facilities, education program[s], or World Bank transport projects have returns of more than 10%,” while private investors require returns of 15% or more on projects. Lawrence H. Summers, *Summers on Sustainable Growth*, *ECONOMIST*, May 30, 1992, at 65. Summers concluded that “[o]nce costs and benefits are properly measured, it cannot be in posterity’s interest for us to undertake investments that yield less than the best return.” *Id.* He added that over long time horizons, “this really matters: [a] dollar invested at 10% will be worth six times as much a century from now as a dollar invested at 8%.” *Id.*

61. See William R. Cline, *Discounting for the Very Long Term*, in DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 13, at 131, 134; Robert C. Lind, *Analysis for Intergenerational Decision-making*, in DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 13, at 173, 178; Jerome Rothenberg, *Intergenerational Ethics, Efficiency, and Commitment: Comments on Schelling and Kopp and Portney*, in DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 13, at 103, 107.

62. There is a more general point here. In considering opportunity costs, we must consider only other opportunities that might actually be implemented. We should choose among the most desirable of the *feasible* alternatives.

63. Cline, *supra* note 61, at 131.

Thus, environmental investments may offer higher long-term returns than alternate investments, even though those investments provide much higher short-term returns.⁶⁴ The result may be to lower the applicable discount rate substantially.⁶⁵ Even so, we are likely to be left with some degree of discounting, unless we assume that the long-term rate of return on private investments will actually be zero. Although this zero-return economic scenario is not theoretically impossible, it would represent a radical change from the experiences of at least the past few centuries. Thus, the precommitment argument probably does not justify a zero discount rate, though it may well justify a rate well below the return for other shorter-time public or private investments.

II. THE ETHICAL DEBATE OVER DISCOUNTING

Thus far, we have seen that two different justifications for discounting exist. One is simply that people attach a lesser value to benefits that lie in the future. This benefit-side rationale gives rise to the social discount rate. This rationale relies on a plausible assertion about human psychology combined with a more controversial normative stance of approval for this psychological trait. The cost-side rationale is that environmental benefits come at the cost of other investments, at least some of which might ultimately leave society “better off” in some sense than receiving the benefit in question. It has fewer normative problems than the benefit-side rationale but involves more complicated economic modeling to determine exactly what opportunity costs are being foregone. This may involve formidable technical problems when we are implicitly being asked to accept a model of the economy over future centuries.

As noted earlier, a voluminous body of scholarship discusses the ethics of discounting, particularly in the multigenerational context.⁶⁶ My purpose here is to acquaint the reader with this debate rather than to try to resolve it. The arguments on both sides have genuine appeal, yet sufficiently strong counterarguments are available to prevent either side from winning a decisive victory. In the multigenerational context, my own sympathies

64. For example, it may be easier to protect a rain forest or the ozone layer—which might produce a two-percent annual return over a century at the cost of \$1 billion in current consumption—than to commit both ourselves and our descendants to fully reinvest the returns on other investments. The rain forest might be more easily preserved intact than a government fund, because of its vividness as a tangible symbol of the heritage of “capital” passed down between generations. See PEARCE & TURNER, *supra* note 43, at 225.

65. By analogy, consider an individual who has a choice between two different investments for retirement. One is a long-term individual retirement account (IRA), which cannot be tapped until the end, while the other alternative consists of a series of short-term bonds. The short-term bonds are expected to pay higher interest rates, but the individual knows he will spend most of the interest as it comes in and reinvest only a portion. In this scenario, it is quite possible that the IRA is the better retirement strategy. The IRA would also make sense if its availability causes the individual to increase his total amount of savings, rather than merely diverting funds from the short-term bonds. Here, the IRA corresponds to a long-term environmental investment; the short-term bonds to private sector investment.

66. See *supra* notes 13–18 and accompanying text.

are somewhat with the antidiscounting forces. Nevertheless, for the reasons discussed in part III, a large territory must be ceded to the advocates of discounting.

As John Donohue explains, opportunity costs provide a major ethical justification for discounting, despite such jarring consequences as the view that future lives are “worth” less than present ones:

While human lives are priceless from a philosophical or religious perspective, the resources that can be used to save lives are limited. If we fail to recognize this economic reality as we go about the process of choosing regulations, we will expend resources in a way that prevents us from saving as many lives as possible. It is not the idea that future lives are less valuable in any moral or ethical sense that leads to the process of discounting at a current rate of interest. Rather, discounting is appropriate in that, if invested, our resources are expected to grow at that rate, so that if we forego spending and invest the money instead, we can save more lives in the future with the amount foregone today.⁶⁷

As we have seen earlier, this opportunity-cost argument is powerful when a feasible alternative investment with the same payout schedule and a higher valued return is present. The argument is particularly powerful where, as in Donohue’s formulation, the ultimate payoff will be used to finance a larger amount of a similar environmental or health benefit. Although this argument is fairly unimpeachable in theory, we have seen that in practice it may be difficult to determine the true opportunity cost of a long-term environmental measure because doing so requires that we forecast both the future growth of the economy and the incremental effect of allowing consumers or firms to retain additional funds in the present.⁶⁸

When we move beyond examination of opportunity cost, the arguments for discounting become more controversial. Nevertheless, advocates of discounting have deployed a number of arguments in favor of discounting benefits. None of these arguments is above criticism, but they do have a certain combined force. There has been considerable dispute over the propriety of discounting among philosophers⁶⁹ and economists. In the interests of brevity, however, I will focus on the debate among legal academics. Apart from the question of opportunity cost considered above, advocates of discounting have deployed three primary arguments, all of which are disputed by critics.

67. John J. Donohue III, *Why We Should Discount the Views of Those Who Discount Discounting*, 108 *YALE L.J.* 1901, 1905 (1999).

68. See *supra* note 62 and accompanying text.

69. For recent explorations of the philosophical issues, see JUSTICE BETWEEN AGE GROUPS AND GENERATIONS, *supra* note 16; Axel P. Gosseries, *What Do We Owe the Next Generation(s)?*, 35 *LOU. L.A. L. REV.* 293 (2001). Where major programs and long time-spans are involved, the identity of virtually every member of a future generation may be changed by our decisions. Although the resulting philosophical puzzles are intriguing, I agree with Derek Parfit (who first raised the whole problem of duties to “potential persons”) that they have little practical relevance. See Derek Parfit, *Comments*, 96 *ETHICS* 832, 855 (1986).

The first argument for discounting is antipaternalism. Richard Revesz argues that “most decisions that we make have future consequences”—including every time “we borrow money” and “every current expenditure [which] affects the amount that will be available for future expenditures.”⁷⁰ For the government to second-guess these decisions “would open the door to government regulation of essentially every financial decision that we make,” which would “constitute a serious affront to individual autonomy.”⁷¹ In contrast, Lisa Heinzerling notes that the modern administrative state often intervenes to correct for perceived deficiencies in individual decisions.⁷² In any event, Revesz seemingly questions the relevance of private savings decisions to intergenerational discounting: “[H]ow one individual decides to time her expenditure of a fixed set of resources over her lifetime is a fundamentally different question from how society allocates a given set of resources among individuals in different generations.”⁷³

A second normative argument is that failure to discount benefits will lead to indefinite postponement of environmental benefits. Investment returns provide an argument for postponing environmental benefits, perhaps even indefinitely. This argument is a variant of the opportunity-cost argument. It begins with the premise that if “invested, our resources are expected to grow at [the market] rate, so that if we forego spending and invest the money instead, we can save more lives in the future with the amount foregone today.”⁷⁴ The logic behind this premise, which supports postponing our lifesaving effort from today until tomorrow, also supports another postponement, from tomorrow to the day after. By the same logic, we can save even more lives if we further postpone our action and continue allowing the investment to grow, and so on *ad infinitum*. Thus, without discounting, we will continually put off the realization of the environmental benefit. Discounting critics retort, however, that this is an unrealistic hypothetical. For instance, Heinzerling argues that the cost of obtaining an environmental benefit may increase if we delay and the problem becomes worse, and that in any event regulatory agencies do not have the option of investing funds for later use.⁷⁵

A related argument is that rejection of discounting “would appear to require truly extraordinary sacrifices from the present for the sake of the (infinite) future,”⁷⁶ as each generation will have to impoverish itself to invest the maximum possible for the benefit of numerous future generations. But this argument makes the controversial ethical assumption that we have

70. Revesz, *supra* note 15, at 986.

71. *Id.*

72. Heinzerling, *Regulatory Costs*, *supra* note 33, at 2048. Of course, not everyone approves of these interventions.

73. Revesz, *supra* note 15, at 1015.

74. See Donohue, *supra* note 67, at 1905.

75. See Lisa Heinzerling, *Discounting Life*, 108 YALE L.J. 1911, 1912 n.4 (1999); see also Revesz, *supra* note 15, at 990 (commenting that environmental harm may become irreversible or costs of correction may rise sharply over time).

76. Sunstein, *supra* note 37, at 1714.

a moral duty to maximize the total welfare of all generations. It also makes the debatable practical assumption that current generations could be motivated to implement such a plan.⁷⁷ Finally, there are limits to how far this impoverishment of the present for the benefit of the future could go: “Technological and other advances made by the current generation benefit future generations as well, and hence impoverishment of the current generation would inevitably harm those who will come later.”⁷⁸

Another argument for discounting is distributional rather than efficiency based. This argument posits that later generations will be wealthier than those alive today. Hence, if we fail to discount their interests, we will be transferring resources from a relatively poor current generation to a relatively rich future generation.⁷⁹ There are several possible replies to this argument. The valuation of environmental benefits or the cost of obtaining the benefits may also rise, neutralizing the difference in wealth levels. The benefits may accrue to parts of the world that even in the future will be poorer than today’s advanced economies.⁸⁰ Furthermore, economic growth may not take the predicted upward path.⁸¹ If it turns out that future generations are not wealthier than we are, perhaps due to the effect of environmental degradation, then this argument for discounting fails.

My impression is that economists are generally optimistic that the economic growth of recent centuries will extend into the indefinite future, and the odds may be in their favor. Still, by the very nature of the question, this is an essentially untestable hypothesis: we can only know the state of the economy in 2500 when that year rolls around; until then, we have no good way to test our predictions.⁸² Although I am inclined to be optimistic about future economic prospects, we cannot eliminate the possibility of some catastrophe such as a global, social, or ecological collapse. Nor can we be sure that new scientific advances will continue to fuel economic growth. Thus, we should not accept continued future growth as an unquestioned dogma.

A final argument for discounting is offered by Donohue:

I do not have to spend time worrying about my neighbor’s children because my neighbor can take care of them just fine, and I apply the same thinking, absent exceptional circumstances, to distant future generations. I am not willing to spend a lot of money to help very remote future generations, because I think they will be just fine without my concern and resources—indeed, there is every reason to

77. See Revesz, *supra* note 15, at 993–94.

78. Sunstein, *supra* note 37, at 1714.

79. For discussion of this argument, see Donohue, *supra* note 67, at 1909; Revesz, *supra* note 15, at 1003–07.

80. On the other hand, to the extent we are concerned about such distributional consequences, it might make more sense to help today’s citizens of less developed countries, who are probably even poorer than their descendants will be. See Revesz, *supra* note 15, at 1005.

81. *Id.* at 1004–05.

82. See Sunstein, *supra* note 37, at 1714.

think that their lives will be far more pleasant than those of the current generation.⁸³

But Donohue seems willing to abandon this argument precisely in the circumstances of greatest interest for purposes of this article. He suggests that special treatment—“using a low or even zero discount rate, or subsidizing an important investment”—“might be appropriate in the case of some irreversible environmental damage, much as my attitude towards the welfare of my neighbor’s children would be changed if my neighbor could not for some reason take care of them.”⁸⁴

Thus, even scholars like Donohue who are friendly to discounting seem less sure of its validity over multiple generations. Similarly, Revesz has recently offered a detailed critique of intergenerational discounting. His views deserve to be taken particularly seriously because he is a strong advocate of discounting in the intragenerational context. He begins by rejecting the indefinite postponement argument and the impoverishment argument.⁸⁵ He also points out that surveys show an “essentially unanimous opposition to the core component of the traditional discounting model,” the use of a fixed discount rate.⁸⁶ Revesz then rejects the time preference justification for discounting, because it “would be difficult to construct an attractive ethical theory that privileged” the first generation so heavily over later generations.⁸⁷ And so on, through the other affirmative arguments for discounting, though he accepts the modest role for opportunity costs discussed earlier.⁸⁸

This leaves Revesz with the problem of what to put in place of discounting as a measure of intergenerational obligations. It is here that opponents of discounting seem to run into trouble in terms of providing a concrete alternative. Revesz finds the concept of sustainable development unsatisfying.⁸⁹ In a landmark article discussed by Revesz, Edith Brown Weiss has argued that each generation is in some sense a trustee, obligated to preserve the planet’s natural heritage for the benefit of future generations. As she puts it:

We hold the natural and cultural heritage of our planet in trust for future generations. As trustees we have a fiduciary obligation to conserve this heritage for future generations. Our fiduciary obligation consists of two duties: to conserve options by conserving the diversity of the natural and cultural resource base; and to conserve

83. Donohue, *supra* note 67, at 1910.

84. *Id.*

85. Revesz, *supra* note 15, at 989–94.

86. *Id.* at 995.

87. *Id.* at 998.

88. *See id.* at 1000–09.

89. *Id.* at 1009–14.

the quality of the trust's corpus by leaving the planet in no worse condition than we received it.⁹⁰

In a somewhat similar vein, Revesz observes, the economist Robert Solow has argued that each generation is obligated to ensure that future generations' welfare does not slip below their own.⁹¹

Revesz believes that the sustainability standard is too narrow. If we knew that future generations would be wealthier than we are regardless of our environment misdeeds, these definitions of sustainability would leave us free to ignore their interests entirely. Revesz asks us to consider the hypothetical situation in which a tiny investment, like one dollar, can prevent a catastrophic harm of several hundred billion dollars in a century.⁹² Even with a high discount rate, this investment would be worth making. But the sustainability standard, as he interprets it, would not require us to make the investment, if society will actually be wealthier than we are in a century even allowing for the catastrophic harm.⁹³

Having rejected sustainability as a standard, Revesz is then left with a vague set of principles for intergenerational issues: take realistic account of opportunity costs, "prevent catastrophic harms and the destruction of unique natural resources," attend to distributional issues if the aggregate effect of environmental policies leads to inequity, and also attend to corrective justice—the higher duty to correct harms for which we are responsible than to bestow benefits on later generations.⁹⁴ These principles are plausible but a long way from providing a usable normative framework.

As Revesz's approach illustrates, the case for multigenerational discounting is not without difficulty, but the alternatives are also less than completely satisfactory. Working out a satisfying normative theory is so hard in part because our intuitions about responsibilities to later generations are unclear. Although deep discounting of the interests of future generations is jarring, so is the opposite view that those generations have a moral right to identical treatment. The "equal rights" view seems inconsistent with the ways in which we normally think about relationships between generations. Arguably, the language of "rights" may not even be appropriate when considering unborn descendants.⁹⁵ Nor is the idea of complete

90. Edith Brown Weiss, *The Planetary Trust: Conservation and Intergenerational Equity*, 11 *ECOLOGICAL L.Q.* 495, 581 (1984). Concern about intergenerational equity is also embodied in the concept of sustainable development, though that concept is itself frustratingly vague. See John Dernbach, *Sustainable Development: Now More than Ever*, 32 *ENVTL. L. REP.* 10,003, 10,013–14 (2002); Christopher Stone, *Is There a Precautionary Principle?*, 31 *ENVTL. L. REP.* 10,790, 10,791 (2001). The trust notion can be traced back in Western thought at least to the eighteenth century. Both Jefferson and Burke held that the living have a trustee-like duty to later generations. See JED RUBENFELD, *FREEDOM AND TIME: A THEORY OF CONSTITUTIONAL SELF-GOVERNMENT* 22 (2001).

91. Revesz, *supra* note 15, at 1011.

92. *Id.* at 1013.

93. *Id.* at 1013–14.

94. *Id.* at 1015–16.

95. See Gaba, *supra* note 15, at 279–80. The current generation may well be morally constrained by the interests of future generations, but "rights talk" does not seem particularly useful here. If your great-grandparents squandered the family fortune, you might be unhappy, but it seems unreasonable to charge

equality with the current generation particularly compelling. We would not necessarily consider it irresponsible for Bill Gates to leave his children only moderately rich. Neither would we be likely to say that those children have a “right” to inherit his full wealth. So the current generation are not truly trustees who are morally obligated to preserve the entire trust untouched for the benefit of their descendants.⁹⁶

Still, even if complete equality between generations does not correspond with our intuitions, deep discounting of the interests of later generations continues to seem disturbing. The degree of harshness depends on the discount rate and the length of time. At a one-percent rate, one life today is equivalent to a million lives in the year 3402, but at a ten-percent rate it takes only 145 years to equate the two.⁹⁷ Using a rate below one percent could push the equivalency further into the future, but eventually it would come.

Surely, one would think, there must be some limit on how deeply we discount the future as compared with the present. Two critics of discounting highlight the unfairness of such deep discounting by asking the reader to imagine “finding out that you, having just reached your twenty-first birthday, must soon die of cancer because one evening Cleopatra wanted an extra helping of dessert.”⁹⁸

This is a powerful example. A discounting advocate, however, might argue that our intuitions might be leading us astray here (even putting aside the unrealistic nature of the hypothetical). The intuitive aversion to deep discounting may arise partly because we have trouble truly imagining what it would be like to have detailed control of far-future events, because this is so contrary to our experience. As a result, we imagine that people in the far future would be entitled to feel a sense of outrage at having their interests so sharply discounted by us. While this is not implausible, it may or may not be correct; the situation is too far outside of normal human experience for us to have much confidence in our intuitions.⁹⁹

them with violating a *personal* obligation toward you or with violating your “rights.” For this reason, Gaba advocates a “virtue-based” approach to analyzing problems of intergenerational equity. *See id.* at 283–85.

96. *But cf.* Weiss, *supra* note 90, at 495 (arguing that the current generation holds the natural resources of the planet in trust for future generations and must act as prudent “trustees” for future beneficiaries, taking care to preserve the “corpus”).

97. Cowen & Parfit, *supra* note 57, at 145.

98. *Id.*

99. It may be helpful to pose a hypothetical that turns the tables—one in which we ourselves are “the future.” Consider Cleopatra and her dessert again. The original dessert hypothetical is a bit unfair, because it rests to some extent on the sense that human lives and desserts are incommensurable, rather than our dismay over the low exchange rate. Let us suppose instead that Cleopatra, while floating down the Nile on her royal barge, sees a child starving by the bank of the river. She can save the child’s life by giving him her dessert. But a seer informs her that two millennia in the future, one of the child’s descendants would be a U.S. Senator, who would cause the deaths of a thousand people by needlessly delaying funding for research on a life-saving vaccine. Thus, her choice is whether to save one life immediately at the expense of a thousand lives twenty centuries later. Assume Cleopatra believes with absolute certainty that this result will follow. Would the one thousand “victims” of today have any just cause for outrage if Cleopatra chose to save the child? Might we not conceivably even think instead that it would be cold-

Making all due allowances for possible flaws in our intuition, the Cleopatra hypothetical does retain some sting. Exponential discounting over long periods of time does lead to conclusions that affront our sensibilities, at least at first blush. As Revesz, Heinzerling, and others have pointed out, many of the conventional arguments in favor of such discounting turn out to rest on disputable (though not necessarily incorrect) premises. As we will see below, however, exponential discounting is not so easily dismissed. Indeed, if we are willing to make some seemingly innocuous assumptions about how to allocate current resources to fit future needs, exponential discounting is all but unavoidable.

III. THE LOGIC OF EXPONENTIAL DISCOUNTING

In the debate about discounting, both sides rely on controversial premises. Opponents of intergenerational discounting invoke the rights of future generations and dismiss the relevance to policy makers of voluntary private decisions.¹⁰⁰ Advocates of discounting often seem to assume the validity of some form of utilitarianism. They are also prone to make debatable assumptions about the return on alternative investments, the future growth of the economy, and the probable wealth of later generations.¹⁰¹ These premises are not indefensible, but by their nature they do not lend themselves to definitive resolution. The argument developed here will avoid reliance on any of those premises. Rather, I will treat the decisional process as a black box. Regardless of how we make decisions, environmental policy results in some allocation of current resources to obtain benefits in future time periods. I will argue that, *whatever* takes place in the black box, the process must result in assigning decreased current resources to benefiting much later generations as compared with earlier ones. This argument could be considered “economic” in its methodology, but it is noneconomic in the sense that it makes no assumptions whatsoever about individual preferences or about the economy, its current operation or its future growth.

A. *The Model*

In this section, I will use a simple model to probe the legitimacy of discounting environmental benefits. Consider some recurring environ-

hearted for Cleopatra to allow a live, breathing child to starve to death in the ghostly interests of unborn individuals in the far future? Our initial intuition may be that it is morally unacceptable to trade a thousand lives in the future for a single life today, but this intuition does not, on balance, seem solid enough by itself to justify a rejection of discounting. A somewhat similar hypothetical is posed in Theodore P. Seto, *Intergenerational Decision Making: An Evolutionary Perspective*, 35 *LOY. L.A. L. REV.* 235, 239 (2001). His hypothetical arguably involves “perpetuation value,” *see infra* Part IV.A, rather than pure discounting.

100. *See, e.g.*, Cowen & Parfit, *supra* note 57, at 145; Revesz, *supra* note 15, at 1015.

101. *See supra* notes 58–63, 74–80.

mental benefit that we can obtain in this year and in future years.¹⁰² To be concrete, assume the benefit is the continued existence of a particular species like redwoods or blue whales. Our valuation might include whatever intrinsic value we place on a species, its aesthetic value, any direct economic benefits, and its ecological significance. To avoid the debates about the morality of monetizing the value of the species (or of human lives or other environmental benefits), I usually will not speak of the “value” of the species, or of “willingness to pay,” but rather of “willingness to sacrifice”—meaning the amount of money that our society is willing to expend to save the species.¹⁰³ Thus, the values will be designated W and W^* , standing for varying types of “willingness to sacrifice.” Although this model explicitly relates to endangered species, it applies equally well to any situation involving an irreversible environmental change, where we have the option of either postponing the change for one year or preventing it altogether.¹⁰⁴

Among our possible options are expending some resources now that will temporarily postpone an inevitable extinction for one year (from time T to time $T + 1$), or expending resources to permanently eliminate the threat of extinction starting in time T . For convenience, I will assume that we can target specific expenditures today that would prevent extinction in any given future time period.¹⁰⁵ This is clearly an idealization, but it highlights our potential responsibility for the future.¹⁰⁶

It is important to note that the “willingness to sacrifice” standard is compatible with absolutely any substantive decision-making criterion. We might determine how much we are willing to sacrifice to avoid a future environmental harm through a cost-benefit analysis. Such an analysis could

102. I will sometimes call this an environmental resource, but with no implication that we intend to consume the resource or even that its value is dependent on the continued existence of human beings. It may have intrinsic value completely independent of human existence.

103. It is important to note that willingness to sacrifice refers to the amount we are willing to give up *today* to obtain a future environmental benefit, not the amount that people in the future will be willing to spend when the problem actually arises, nor the amount that alternative investments made today will generate by the year in question.

104. It would be easy to modify the model to apply to reversible changes, where present investments could lead to the presence of the benefit in nonconsecutive future years. Essentially, the current model requires us to assign values to the presence of the benefit in two types of sets of years, $\{T\}$ and $\{t: t > T\}$ (for all $T > 0$). We would obtain the same results if we allowed arbitrary sets of future years, provided the key assumptions (positive value and additivity) applied to all such sets and proportionality continued to apply to the two types of sets covered by the basic model.

105. For example, we might think of this as the payment for a conservation easement covering the species's critical habitat for some particular future time period.

106. The least realistic aspect of the model is the assumption of highly tuned control, so that society could earmark expenditures now for the specific purpose of delaying the change or eliminating its possibility in any given year in the future (either by spending the money now on some measure that will not take effect until a future year, or by saving the money in a trust fund and using it later). This is obviously an idealized version of the decisions that face us concerning later generations, but it has the effect of highlighting the normative question of exactly how we would allocate resources across future generations, putting aside for the moment the practical problems of prediction and control over future events. To the extent we lack the ability to predict or control the future, the argument for discounting can only be strengthened by our uncertainty over the future payoffs of our current actions.

be based either on direct impacts on human welfare or on a technique such as contingent valuation that measures the intrinsic value of environmental resources. But the decision need not be based on cost-benefit analysis at all. Instead, we might base our decisions on a referendum technique,¹⁰⁷ on a philosophical theory about the rights of future generations or the rights of nature itself, on a sustainability principle, on religious principles, or on raw intuition. At the end of the day, however, we have to decide one way or another how much of our current resources and possible consumption we are willing to devote to preserve this particular environment benefit. The following analysis applies regardless of what criteria we use to decide how much to sacrifice.¹⁰⁸

Now for some simple notation. Call $W(T)$ the amount that we would be willing to sacrifice today on some measure needed to keep the species alive from the beginning of year T to the end of that year. The idea here is that, unless we take some particular action now, the species will become extinct at the beginning of year T ; by taking the action we can postpone certain extinction until the end of year T .¹⁰⁹ Call $W^*(T)$ the amount we are willing to sacrifice to keep the species alive from time T onwards to the end of time. Thus, $W(0)$ is the amount we would be willing to pay to keep the species alive this year (but not a moment longer), while $W^*(0)$ is what we would pay to put a permanent solution in place today.

There are actually two valid ways of interpreting the W and W^* functions. As the phrase “willingness to sacrifice” suggests, we might view them as reflecting society’s demand for certain packages of environmental benefits—how much society is actually willing to pay. If so, these functions will be measured in dollars. Alternatively, we might view the functions as measuring society’s values, just as utility functions measure an individual’s values. We could then view the W functions as measured by a standard environmental benefit such as units of “endangered-species-years-of-survival.” Either interpretation of the model is legitimate.

As defined above, $W^*(T)$ represents the value of keeping the species alive from time T until “the end of time.” How literally should we take the reference to the “end of time?” We need a long enough time period that the proportionality assumption roughly holds under the most relevant time periods. That is, if we are interested in how to assign values over the next twenty generations, we need enough additional generations so that the fu-

107. See Raymond J. Kopp & Paul R. Portney, *Mock Referenda for Intergenerational Decisionmaking*, in DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 13, at 87, 88, 91–96.

108. In the interest of brevity, I will sometimes refer to the “value” of preserving the species in some future time period. I do not mean to imply that the intrinsic value of the species is reducible to cash, only that there is some limit on how much we would be willing to sacrifice today to preserve the species during the time period in question, given our other needs.

109. Note that $W(T)$ incorporates only the value we attach to keeping the species alive during that year, not the value of having the option at the end of the year to continue the species’s existence another year. Setting up the problem this way is a bit artificial but avoids the complications of including option value in the analysis.

ture looks roughly as long from the vantage point of the twentieth generation as it does today.

On the other hand, if the world is going to end after generation twenty, then proportionality cannot hold even approximately over that time period.¹¹⁰ But the possibility of human extinction, while preventing the use of this particular model, is of little avail to opponents of discounting. The possibility of human extinction seems morally irrelevant to the rights of such later generations as do exist. If discounting is morally appropriate in a world where the human race lives on forever, it is hard to see how our possible extinction changes its moral character. Why should discounting the interests of generation twenty become immoral (if it is otherwise permissible) simply because of the possibility that an asteroid will wipe out generation thirty? If anything, the possibility of extinction strengthens the argument for discounting: if generation thirty-one may never be born at all, we can reasonably diminish our attention to its potential interests while giving more attention to the needs of earlier generations whose existence is more probable.¹¹¹

Abandoning the assumption of an effectively infinite future would derail the model, but it would also derail many of the arguments against discounting. The really troublesome consequences of discounting, like the Cleopatra hypothetical discussed earlier,¹¹² can be avoided over any fixed time span simply by choosing a sufficiently low discount rate, so that the disproportion between future catastrophe and present value never becomes too great. This solution becomes impossible only if we consider the future to be essentially unlimited, so that even the lower discount rate will eventually have a devastating event. In other words, to show that discounting is unacceptable in principle, its critics implicitly rely on the assumption that discounting could be used for periods indefinitely far into

110. If the world is going to end in twenty generations, then we could divide our willingness to sacrifice equally over the entire time period, at least so long as the period is not so lengthy as to make the value for our own generation unacceptably low.

111. There is also another way of justifying postulating an indefinite future. Suppose that there is a finite probability p that in any given year the value of the environmental benefit will become zero, either because of uncontrollable changes in the environment or because there are no human beings to enjoy the benefit. Instead of our original series of benefits $W(T)$, we will now have a discounted series of expected benefits $(1-p)^T W(T)$ which does extend indefinitely into the future. If we began by putting an equal value on the environmental benefit in all future time periods where it is actually received, this would automatically give us discounting. But opponents of discounting need not concede that conclusion. First, if the issue is extinction of the human race, we may simply not care about scenarios in which humans are extinct; we may limit our planning to scenarios in which human survival occurs. Second, the value of the environmental resource may actually increase over time. We may believe that our descendants will place increasing value on the resource, because of scarcity (fewer environmental goods available), increased wealth (so they are willing to pay more for such goods), or more enlightened preferences (so they give a higher priority to such goods.) If our own valuations take theirs into account, our valuations will also increase with T . Finally, it is not implausible to think that the increasing unlikelihood of the resource surviving into the far future might actually make us think that it would be all the more wonderful if it does. If so, our valuations will move up just as the odds of survival go down, leading to an unchanging expected value for the resource.

112. See *supra* notes 98–99 and accompanying text.

the future. Without this assumption, discounting does not inherently look so bad. But with this assumption, discounting follows almost as a matter of course, as we are about to see.

At this point, we need to make our assumptions explicit. We will later take a harder look at the validity of these assumptions. Superficially, at least, the assumptions seem relatively innocuous:

Positive value. $W(T) > 0$. We assume that $W(T)$ is always positive. This means that we would always be willing to invest *some* amount, however small, to keep the species alive one additional year.

Additivity. $W^*(T) = W(T) + W(T+1) + W(T+2) + W(T+3) + \dots$. The amount we are willing to sacrifice to keep the species alive for the combined period is the sum of the amount we are willing to invest to keep it alive during each part of that period *separately*. Additivity implies that $W^*(T) = W(T) + W^*(T+1)$. In other words, the amount we are willing to pay to keep the species alive from time T onwards equals the amount we would be willing to pay to postpone extinction until the end of year T plus the amount we would be willing to sacrifice to keep the species alive from that point onwards.¹¹³

Proportionality. $W(T)/W^*(T) = k$. Starting at any given time T , we can compare the amount we are willing to invest to keep the species alive for just one additional year with the amount we would be willing to sacrifice to keep it going forever after that time. The assumption here is that the ratio between the two remains constant.¹¹⁴ In other words, it is always *equally* true that “tomorrow is the first day of the rest of your life”—we do not rate that first day compared with the succeeding years any differently, the starting date is next Tuesday, next Christmas, or Halloween of 2502.¹¹⁵

The simplicity of these assumptions may be seen by a visual analogy. Imagine the future as a highway extending into the distance. Positive value means that we can see every foot of the highway, so every patch (no matter how far away) takes up some place in the retinal image (no matter how small). Additivity means that the patches corresponding to different distances do not overlap, and that they together account for all that we can see of the highway—the total image of the highway is just made up of all the highway’s pieces that we can see at various distances in front of us. Proportionality means that the relative proportions of specific parts of the highway do not change as we move closer—if one patch looks twice as big as another from a distance, it will continue to look twice as big as we get closer (even though both patches will look larger in absolute terms).

113. We assume that $W^*(0)$ is finite, which, when combined with additivity and the positive value assumption, means that $W^*(T)$ is always well defined and always less than $W^*(0)$.

114. Because $W(T)$ and $W^*(T)$ are positive, $k > 0$. Because of the additivity assumption, $k < 1$.

115. This is a limited form of what is usually called the “stationarity” assumption. See Atherton, *supra* note 27, at 137.

Although we are not assuming very much, even in the highway situation these assumptions might not always hold.¹¹⁶ Still, these assumptions do seem to be a good approximation of visual perception under normal circumstances, and they seem particularly likely to correspond to our idea of accurate visual perception. The model's assumptions about how we perceive the value of future environmental benefits are equally straightforward, though not invulnerable.

It is important to note the assumptions we are not making here. We are not assuming that people are impatient or that they place a lesser importance on species extinctions that are farther away in time. We are not assuming that the endangered species has a dollar value, in the sense that we would be willing to exchange it for any conceivable amount of money without regret. Nor are we assuming that the alternative to the sacrifice is some kind of investment that would grow over time. The model applies equally whether we have splendid alternative investments or expect zero (or even negative) economic growth. We are only assuming: (1) that we can *somehow* determine how much money we are willing to sacrifice, if we have to, to save the species during various future time periods; and (2) that these amounts (however derived) relate to each other in what seem to be sensible ways.

In short, this model is entirely open-minded about the substance of our value judgments. The assumptions relate only to the outputs of the decision process. Moreover, the assumptions are relatively weak. Nevertheless, it turns out that the first two assumptions are all that we need to deduce a form of discounting. With the help of the third assumption, we get standard exponential discounting at a fixed rate.

Although the proofs are relegated to the Appendix,¹¹⁷ the basic reasoning is simple. Discounting results from repeated applications of the same process. For each year T , beginning with year zero and moving forward, we take $W^*(T)$ and divide it in two parts, $W(T)$ and $W^*(T+1)$. Because of proportionality, a fixed fraction of W^* is removed at each stage. So $W^*(T)$ gets smaller and smaller as T gets larger. Because $W(T)$ is a fixed fraction of $W^*(T)$, it also gets smaller and smaller at a constant rate. This constant rate is the telltale sign of exponential discounting.

Thus, given positive value, additivity, and proportionality, we can derive exponential discounting, without any morally questionable judgments about monetizing the intrinsic worth of the endangered species, or about how that our appraisal of that intrinsic value relates to the passage of time.

116. The positive-value assumption requires that our view be unobstructed by the atmosphere at great distances; it also assumes that we are not myopic. Additivity might not correspond to the way our brains actually process certain images. If the highway is too big to see all at once, then the visual image of the highway at any one time will be smaller than the sum of all of our images of portions of the highway. Moreover, it is at least conceivable that our brains might add some kind of extra element to the image to correspond to the overall gestalt of the road, such as an illusion of brightness at the vanishing point. Proportionality would be affected by astigmatism.

117. See *infra* notes 173–75 and accompanying text.

We also make no assumptions about the availability of other investments. This is a somewhat surprising result. Even if we weaken the assumptions, discounting of some kind seems hard to avoid if we are to make reasoned, systematic choices of how much to sacrifice for future benefits. Before accepting this conclusion, however, we should take a closer look at the assumptions.

B. *Unpacking the Assumptions*

The model rests on three explicit assumptions: *positive value* (we are willing to make some sacrifice, however small, for every increment of environmental benefit); *additivity* (the amount we are willing to sacrifice for the whole is the sum of what we would sacrifice for the parts); and *proportionality* (our relative willingness to sacrifice for any two options is unaffected simply by pushing them an equal distance into the future).¹¹⁸ We need to examine all of these assumptions more closely.¹¹⁹

We begin with the positive-value assumption. That assumption holds that every moment of additional survival for an endangered species is worth *some* added sacrifice on our part, no matter how small.¹²⁰ Society might conceivably have values that do not fit this assumption. For example, we conceivably might think that if an endangered species can only survive for a finite period of time before facing certain extinction, we would prefer to “put it out of its misery” and wipe it out quickly. But this willingness to accelerate an inevitable environmental harm seems peculiar, to say the least. With other environmental benefits, such as saving future lives, the argument for positive value seems even stronger. Even if we could save only a single life in one distant generation we would still want to do so if doing so was cheap enough.

The second assumption, additivity, is more complex. Additivity means that the total value of the benefit over a time period equals the sum of the values it has at each individual moment.¹²¹ This concept is somewhat trickier than it might appear. $W(T)$ is the amount we would be willing to pay to postpone certain extinction from time T to time $T + 1$. We are assuming that if we combine all of these values relating to temporary reprieves for the species, we obtain the value of keeping the species alive

118. See *supra* notes 113–15 and accompanying text.

119. The model also implicitly assumes that we are capable of deciding how much we would sacrifice in multiple situations and that we are going to be consistent in certain respects when we make those judgments. This sometimes might not be true. Perhaps the relevant judgments are so costly that we can make only a few and thus the possibility of comparison would not arise. Or perhaps the decisions are so emotional that consistency seems irrelevant. Alternatively, in the case of a group decision, we may find any kind of large-scale consistency impossible because of the vagaries of collective decision making. Thus, this section does not argue for explicitly discounting environmental benefits in all situations. It instead shows that discounting is independent of questionable moral views about monetizing environmental benefits and about the diminished worth of later events and persons.

120. See *supra* notes 112–13 and accompanying text.

121. See *supra* note 113 and accompanying text.

permanently. But it is possible that we value a species partly as a link with the indefinite future, a kind of connection with eternity. If so, the value of preserving the species forever will be greater than the sum of the values of merely keeping it alive for one additional year at a time: we attach a separate “perpetuation value” to the species’s survival.

In this scenario, $W(T)$ will still decline over time, making some kind of discounting appropriate, but we must also add in the species’s perpetuation value to find $W^*(T)$. It is unclear whether this is a major factor in valuing endangered species; it clearly does not seem to be important for some other environmental benefits. For instance, our desire to have clean air today is probably not affected by whether we expect the air to remain clean far in the future. Similarly, we would presumably want to save some future lives even if we could not save any others later on. But when it is present, perpetuation value could have a major effect on decisions and blunt much of the impact of discounting.¹²²

We might also get a failure of additivity if we interpret the W functions as measuring actual social investments and if we are dealing with large resource commitments. The point is fairly obvious—you might be willing to spend \$2 for a cup of coffee and \$4 for a muffin, but only \$5 to order the combination if that is all you have in your pocket. Similarly, although we might be willing to sacrifice $\$X$ in resources to keep the species alive in year T , and $\$Y$ if its survival until then were assured and all we had to do was to keep it alive after that, we might find $\$X + \Y unaffordable as the cost of preserving it from now until eternity. Hence, as our resources get squeezed, we might find that we are only willing to sacrifice some intermediate amount. But if the resource expenditures are not too large, additivity should hold.¹²³ In any event, such income effects provide little support for critics of discounting. In cases where additivity does not hold because resources constraints are binding, we may not be discounting in a formal sense ($W(T)$ need not decline), but adding impacts on additional generations will have very little effect on our total willingness to sacrifice. So in some sense, the additional generations will not count for much, and we will still be stuck with the practical equivalent of discounting. In other words, including income effects in the model would really provide no extra strength to critics of discounting.¹²⁴

122. For a detailed discussion of perpetuation value, see *infra* Part IV.A.

123. Imagine that you have \$200 in your pocket, and, separately, you would pay \$2 for coffee and \$4 for a muffin. You would normally be willing to pay \$6 for the combination, because they are not substitutes for each other.

124. To be more precise, if income effects are present, we will be willing to spend less on two separate items than the sum of what we would spend for each one alone. In other words, we would have subadditivity: $W^*(T) < W(T) + W^*(T+1)$. This makes it possible for the values of $W(T)$ to be bounded below, so that the value assigned to a one-year postponement of certain extinction no longer has to go to zero. But this conclusion would still only go part way toward limiting the logic of discounting. Note that we still have $W^*(T) > W^*(T+1)$, because paying for $W^*(T)$ also buys at least as much benefit as $W^*(T+1)$. $W^*(T)$ must decline over time, and because it cannot go below zero, it must have some lower limit greater than or equal to zero. Over time, the incremental value of permanent survival, $W^*(T) - W^*(T+1)$, must

There are also some ways of valuing future benefits that might eliminate the need to postulate additivity, though the results may be counterintuitive. Additivity essentially assumes that we are placing some positive value on individual events, which we are then going to add to find the value of sequences of events. We might, however, take a different approach. Suppose that we are faced with choices between various measures, some of which will save lives on a regular basis indefinitely far into the future. We could base our valuation on the average number of lives saved per year rather than the total value of all the lives saved. But note that this approach essentially assigns a zero value to any nonrecurring saving of lives—an action that saves fifty lives today gets an approximately zero value after we average its annual benefit over many centuries. This approach does have the advantage of allowing us to escape discounting, because it gives no greater weight to distant lives than to current ones. But it has the disadvantage of placing nearly zero value on individual lives, whether now or in the future.

Thus, the additivity assumption seems plausible though not incontestable. It is important to note that the additivity assumption and the positive value assumption together require some kind of discounting. Mathematically, the amount we are willing to sacrifice for an additional year of survival must decline over time, because each year takes up part of the finite amount we are willing to sacrifice for having the species preserved forever. When we assign a finite total value to an infinite series of events, such as a decision that will save one life annually forever, we cannot give each of those individual events equal finite value. Indeed, as shown in the Appendix, the value placed on the individual events must tend toward zero as time goes on.¹²⁵

Hence, on average, additivity implies that earlier events must have more weight than later ones. This is a fundamental asymmetry that is built into our valuation of future events. It stems from the fact that, from a decision maker's view, time itself is asymmetrical: it begins with the time of the decision but extends indefinitely into the future. This leads to some form of discounting. Without proportionality, we cannot get to the further conclusion that the discounting occurs at a constant rate. All we can say given positive value and additivity is that $W(T)$ must converge to zero as T goes to infinity.

It is the proportionality assumption that actually gives us exponential discounting. Proportionality is clearly the most stringent assumption. It requires a kind of intertemporal consistency in the way we conduct valuations. Recall that at time zero, we are considering the relative values of preserving the species for only one more year and doing so forever. Then,

therefore tend to zero, which means that the implicit incremental value placed on an additional year of survival tends to zero. Indeed, unless perpetuation value is present, $W^*(T)$ itself will tend to zero, in effect discounting away the species's remaining survival after times sufficiently far in the future.

125. See *infra* notes 173–75 and accompanying text.

we consider how much we would be willing to sacrifice to save the species from extinction during year T and how much we would be willing to sacrifice to save it from extinction from year T forward. Proportionality says that the relative weight of temporary versus permanent preservation remains constant.¹²⁶ This assumption makes sense under at least three circumstances.

First, rather than dealing with endangered species, we might be dealing with some kind of marketable commodities such as financial instruments.¹²⁷ In this situation, if we failed to maintain proportionality, we could be creating an arbitrage opportunity. Essentially, this would mean that we could buy or sell futures in annuity contracts now at prices that do not match the prices that will obtain when the contracts are going to be performed. Assuming properly functioning markets, this situation should not occur. But of course, environmental benefits are not generally tradeable in markets, and markets are in any event imperfect, so this conclusion may not help us much.

Second, if we imagine ourselves as living until time T , it seems that we ought to be consistent in how we weigh relative values now, as compared with how we would weigh them when we get to time T . In short, while we might suffer from myopia while peering into the future, we should not have astigmatism. If we are willing to spend ten times as much to save a species forever as to save it for just the next year, that should be true both now and when we get to time T . Knowing that we will be willing to spend ten times as much for permanent preservation when we actually get to time T , the argument runs, we should take the same view today of the relative values of those time periods.

On an individual level, this seems to make sense. Otherwise, we will make decisions today about how to allocate resources in different time periods which will be different than what we will prefer when we actually get to those time periods. It is easy to imagine situations where we may want to control future impulses, but hard to imagine why our best considered value judgments should be unstable between time periods. On the other hand, this thought experiment is less compelling when we cannot possibly be alive in time T . It is not at all clear that we need to be consistent in how we place relative values on different time intervals during our lives versus some equivalent intervals that are centuries after our deaths. If there is an inconsistency, it is purely hypothetical, not one we ourselves will actually experience.¹²⁸

Third, proportionality may make sense when we are dealing with an environmental benefit that is completely separable in time. For instance,

126. See *supra* notes 114–15 and accompanying text.

127. Think of $W^*(T)$ as the value of a permanent fixed annuity beginning in year T , and $W(T)$ as the value of the payment that year.

128. See *infra* notes 150–58 and accompanying text for discussion of a scenario in which proportionality does not hold; the result is hyperbolic rather than exponential discounting.

suppose that the benefit in question is saving one human life in any given year. With endangered species, we can only “buy” certain packages—we cannot save the species in one year, let it go extinct in the next, and then resurrect it the following year. But we could make such decisions about protecting individual lives, preventing accidents in some years but not in others. So now, the question is how much to sacrifice to save a life in any one year versus the amount we should sacrifice to save a life the following year. The answer might be that the two values should be the same; or it might be that they should be different—but this answer itself arguably should not change for different time periods. In other words, it is not easy to see why any relative regret or satisfaction we might take from accelerating our life-saving effort by a year should depend on the specific date involved.¹²⁹ If we want to maintain this kind of scaling between future benefits, even in the more limited form of our proportionality assumption, then exponential discounting follows.

On balance, the proportionality assumption seems attractive but not compelling. If we adopt it, we are unavoidably lead to exponential discounting. Without it, other forms of discounting are possible, though at the price of a certain kind of inconsistency in our valuations over time.¹³⁰

In the nature of things, it is probably impossible to actually “prove” the necessity of discounting. The model presented here is based on assumptions of various kinds, and we will explore in the next section some situations where these assumptions may not hold. Nevertheless, the assumptions are not very demanding. Unlike the conventional economic arguments for discounting, I have steered clear of any assumptions about the future economy. Whether it will grow or shrink, whether long-term investments are available, whether the price of capital or productivity growth will rise or fall, whether future generations will be wealthier, are all irrelevant to the analysis. I have also avoided any assumptions about the nature of our values. Do we care about the environment for its own sake or merely because of its impact on human welfare? Do we care about the welfare of future generations (including their own possible concern about their own descendants) or merely about each generation’s standard of living or their own valuation of environmental benefits received during its lifetimes? None of these questions matter in terms of the model.

IV. ESCAPING THE LOGIC OF EXPONENTIAL DISCOUNTING

The model of intertemporal planning presented in part III is remarkably general. Unlike most economic analysis, it is not implicitly tied

129. Similarly, if we are willing to sacrifice twice as much to save a life in 2100 as a century later, why would we not also be willing to sacrifice twice as much to save a life in 3100 as a century later?

130. If we drop this assumption, we still will engage in some form of discounting, but it need not be exponential. The argument for hyperbolic discounting as an alternative is made at *infra* notes 154–58 and accompanying text.

to utilitarianism. It only assumes that, however we make moral decisions about the future, we do have some way of deciding how much of our current resources to sacrifice to obtain some future benefits. There is some loss of generality with two of the additional assumptions—that we attach a positive value to all future environmental benefits (positive value) and that valuations over multiple time periods can be added together (additivity). As we have seen, these more technical assumptions may break down in some situations, but this possibility seems to lack any great ethical significance. Similarly, while not inescapable, the proportionality assumption is at least seemingly morally unobjectionable. If there were a truly *fundamental* moral flaw in discounting benefits, it should show up in the circumstances covered by the model—and yet, some kind of discounting seems to be simply inescapable under those fairly elastic circumstances.

Yet, at least under some circumstances, exponential discounting seems to carry with it implications that are at least morally uncomfortable and perhaps simply unacceptable. The model presented in part III limits our maneuvering room, however, if we hope to avoid such morally troubling results. In this section, we will consider some possible ways to find room for other moral intuitions without denying the logical force of the argument for discounting. One scenario involves situations where we care about a resource's vitality in any given time period—the fact that an environmental resource has the potential at that point to extend indefinitely into the future. The second scenario, involving the use of a modified (and more benign) form of discounting, probably has more significance for cost-benefit analysts.

A. *Unboundedness and Perpetuation Value*

A brief recap about perpetuation value may be helpful. The model used in part III assumed that the value of preserving a species forever was simply equal to the sum of its value in every individual year ($W^*(T) = W(T) + W(T+1) + W(T+2) + \dots$). With this assumption, we can deduce that both $W(T)$, the value of the species's existence in any given year, and $W^*(T)$, the value of preserving the species forever starting at time T , must both decline toward zero as T increases.¹³¹ But we also considered a weaker assumption, $W^*(T) = W(T) + W^*(T+1)$.¹³² This means that the value of preserving a species forever starting in year T is the sum of its value during year T plus the value of preserving it forever starting the following year. With this weaker assumption, it still turns out to be true that the value of the species in any given year, $W(T)$, declines toward zero over

131. With the added assumption of proportionality, we can show that the decline takes the form of exponential discounting. See *supra* notes 126–29 and accompanying text.

132. See *supra* note 125 and accompanying text; *infra* notes 174–75 and accompanying text.

time. $W^*(T)$ also still declines; the difference is that it need no longer decline to zero.¹³³

In effect, with this weaker assumption, we are now writing $W^*(T) = W(T) + W(T+1) + \dots + W(\infty)$. As time passes, the earlier terms are stripped away, so $W^*(T)$ decreases toward $W(\infty)$. $W(\infty)$ represents some measure of added value that the species has, not because of its value in any given year, but because of its potential survival to eternity. Despite the well-known advertising slogan, even diamonds are not truly “forever,” and neither are species. Thus, we cannot take the idea of $W(\infty)$ completely literally.¹³⁴ At least, however, it is a suggestive concept, indicating that we might place a special value on the potential of the species to extend its existence beyond any specific time period. It amounts to a kind of fixed bonus that we get for removing a particular threat to the species (or ecosystem or whatever) permanently rather than temporarily.

Does the idea of perpetuation value have any real world significance, or is it merely a mathematical conceit? In assessing the normative significance of the concept, we shall begin by indulging the unrealistic assumption that permanent survival is a possibility, so the species might actually survive forever. It seems to me, though, this can hardly be anything more than speculation, that we might very well attach a special value to this possibility. Arranging for truly permanent survival of the species would allow us the rare privilege of acting in a way that not only has effects beyond our own lives, but to the very end of time. The possibility of “touching infinity” in this way seems like something that people might well value, perhaps quite highly. There is a qualitative difference between “a very long specific time period” and “eternity,” and individuals might be willing to pay a premium for the difference.

In the real world, we do not have the option of purchasing eternal survival for a species (or for anything else). But we may have at least the illusion of doing so. To the extent we cannot psychologically distinguish between “thousands and thousands of years” and “forever,” we may assign some kind of perpetuity bonus to very long-term benefits. In that case, discounting will underestimate the value of permanently eliminating a specific threat to the resource as opposed to a temporary fix, even though the expected life span of the resource is finite. On this interpretation, perpetuity value is what we are willing to pay for the illusion of the species’s eternal survival.

133. See *infra* note 175 and accompanying text.

134. It is conceivable, however, that even though the species faces a certainty of eventual extinction, the expected value of its survival period is infinite. Suppose that the species has a fifty-percent chance of surviving the next century. If it manages to do so, it has a fifty-percent chance of surviving the next two centuries. Similarly, if it does last that long, it will have a fifty-percent probability of surviving the next four centuries, and so on. Then the expected survival time of the species (in centuries) is $\frac{1}{2} + \frac{1}{4} * 2 + \frac{1}{8} * 4 \dots$. Eventually, the species must become extinct; you cannot win an infinite number of coin tosses in a row. But the expected time until extinction is not finite. In this scenario, $W^*(T)$ does not literally buy eternal survival, but it provides the next best thing. It is not hard to imagine that we might place an extra value on the chance for this unbounded leap into the future.

The idea of eternal survival is unrealistic, but there is a closely related and more realistic concept, that of unboundedness. We might say that the future of a resource is bounded if there is a probability of zero that it will survive past some specific time T . Human life is bounded, because (absent some technological revolution) it seems to be completely impossible, not just extremely rare, for any human to live more than about 130 years. A resource is unbounded if it does not have this kind of upper bound. The life expectancy of an unbounded resource may still be finite, because the odds may be overwhelmingly large that it will expire by a specific time, but there is always at least a tiny chance of continued survival.

One possible interpretation of perpetuation value is that the expectation of unboundedness adds to our assessment of the species's value in any given time period. $W(T)$ measures the value of postponing certain extinction for the species. During time period T , the species is imagined to be surviving but doomed. But we might view such a terminal existence as lacking an important part of what we value about the life of the species, its ability (or at least hope) of perpetuating itself, of raising offspring that will have some chance of survival. In other words, one of the things that may make us attach value to a species at a given time T is whether the species still has an open-ended (though not necessarily infinite) future. A doomed species, while evoking our regret and possibly pity, may be lacking in an important aspect of what we value in nature. Perpetuation value is actually the measure of the independent value we place on the existence of hope.

To explore the significance of unboundedness, consider the following scenario. Suppose a species has a fixed probability p of becoming extinct in any given year naturally.¹³⁵ However, its critical habitat is greatly desired by developers, who will destroy it the minute they get the chance. We can purchase conservation easements, thus preventing development, in one year increments (from time T to time $T+1$) or as perpetual easements that will take effect in time T .¹³⁶ $W(T)$ now represents what we are willing to pay today for the one-year easement beginning in time T , and $W^*(T)$ represents the corresponding current price for the perpetual easement beginning in that year. $W(T)$ shrinks toward zero as time goes on. $W^*(T)$ also must shrink. Does it make any sense to think that it might shrink to some value greater than zero, thus exhibiting what we have been calling perpetuation value?

It seems possible that perpetuation value could exist even though the species in question eventually becomes extinct from natural causes. Suppose that although we do value the existence of the species as such, we view natural extinctions differently than human ones. If nature ends the

135. Thus, it certainly will not survive forever, but if it does survive until time T , it has some chance of surviving any arbitrary period afterwards.

136. To avoid complications, we assume that these easements must be purchased today or never; perhaps the law authorizing their creation has a sunset provision.

existence of the species, that is simply part of the scheme of things, but for humans to end the species is morally repugnant. By itself, this does not justify assigning a perpetuation value—as the human misconduct gets to be farther and farther in the future, we might discount its significance toward zero, just as we presumably would do if we were analyzing some crime prevention measure. But we might take a somewhat different perspective. We might think that, by failing to make the easement perpetual, we are in some sense in complicity with the later rapacious developers. This sense of moral taint might diminish as their action takes place farther in the future, but we might feel some basic level of moral taint no matter how far in the future the developers are unleashed, because our sense of taint is based not only on *their* increasingly distant actions but on our own *present* failure to act.¹³⁷

Thus, if we distinguish human-caused from natural extinction, and if leaving the species exposed to human threats gives us a sense of moral complicity, then we might be willing to pay a premium to avoid having any complicity at all. This premium—essentially, the measure of our desire to insure that our “fingerprints” are never to be found on the extinction—would correspond to what we have been calling perpetuation value. This scenario requires that our utility be related not only to outcomes (is the species alive in year T ?) but also to actions (was it killed by humans? are we ourselves completely untainted?). Readers may differ about whether this kind of utility function is either descriptively plausible or normatively attractive, but it does offer an escape from discounting through the recognition of a kind of perpetuation value. In this scenario, what creates perpetuation value is actually a negative, our desire *not* to have any sense of complicity in the bad conduct of a later generation.

Unboundedness can also be a source of value if cooperative efforts are needed to obtain the full value of preserving an environmental resource. Through this mechanism, the possibility of survival after any finite period may affect its value during the time period itself. This effect of unboundedness can be considered a kind of “value” in the sense that we might well be willing to pay something to change the resource from having a fixed cut-off date of T into having a life expectancy of T but no upper bound.

Exploring this idea does not require a formal change in the model itself, but it does require us to assign a different interpretation to the W and W^* functions. In effect, we are now interpreting these functions as being the value of certain current plans to postpone the extinction of the species—the difference is that we are now taking into account the varying

137. In this scenario, our utility function is a function of the time at which extinction actually occurs, E , and of the disutility associated with our present sense of complicity, C , so the function can be written $U(E, C)$, where we can assume that U is strictly decreasing in E . C might also be a decreasing function of the time of extinction, but because the sense of complicity is felt in the present, there is no a priori reason to think that it tends to zero as extinction time increases.

likelihood that the plans will actually be executed by later generations. As we will see below, it may turn out that the plans described by the W functions are relatively ineffective, and that the W^* plans have systematically higher values.¹³⁸

One possible scenario assumes that the easements do not buy the survival of the entire species, but only the survival of a subspecies and the possibility of establishing a cooperative scheme for the survival of the rest. Assume that the cooperation problem takes the form of a prisoners' dilemma—everyone would like the scheme to succeed, but it is to everyone's individual advantage to defect.¹³⁹ If we buy a finite conservation easement up to time T , at price $W(1) + W(2) \dots + W(N)$, then the whole species will be wiped out by developers at time $T+1$. During the easement's lifetime, we have a finite repetition game with respect to preserving the extra subspecies. As is well known, the only rational equilibrium is that everyone defects, so there is no cooperation.¹⁴⁰ But if the game continues an indefinite number of rounds, no round is ever known with certainty to be the last, so cooperation may be possible.¹⁴¹ No matter how large T is, buying a conservation easement that extends only to time T can merely secure the survival of one subspecies. But buying a perpetual easement also makes possible the survival of the full species. As a result, there is a qualitative difference between any finite easement, no matter how long, and a permanent easement, even though the species's expected survival time is itself finite.

An interesting twist on this scenario involves intergenerational cooperation. We could think of the easement, not as guaranteeing the species's survival, but as creating the possibility for additional activities by each succeeding generation to maintain the continued survival of the species. Suppose a conservation easement has some value for each generation, perhaps

138. We can fit this value into the model as follows. The basic assumption is that we have some amount of resources, $W^*(0)$, which we would be willing to pay to preserve the species forever. The model is concerned with how we divide up $W^*(0)$, and in particular, how it relates to the values of $W(T)$, which equal the amounts we would be willing to invest on a plan to postpone the certain extinction of the species by one year. In the kind of model we are about to describe, the values of $W(T)$ are low because a plan to postpone certain extinction can work for only part of the species (the part not requiring any cooperative effort). On the other hand, plans for indefinite postponement can work for the species as a whole, so $W^*(T) > W(0) + W(1) + \dots$. Although we have generally described the W and W^* functions as measuring the value associated with the species existence in a certain future time period, we are now interpreting them as the value of a plan to postpone certain extinction either for one year only or indefinitely.

139. Failure to cooperate, we assume, does not mean immediate extinction but merely increases the probability. Otherwise, after one party defected, the game would be over.

140. See MARTIN SHUBIK, *GAME THEORY IN THE SOCIAL SCIENCES: CONCEPTS AND SOLUTIONS* 254, 286–87 (1982). The rational basis for cooperating is that others may punish you for defecting by ceasing their cooperation in the next round of the game, depriving you of the collective benefit. In the last round of a finite game, however, there is no incentive to cooperate (there being no later round in which reprisals can take place), so no one does. In the next to the last round, everyone knows that there will be no cooperation in the final round, hence there is no incentive to cooperate in this round either, because no matter what you do, there is no reward in the next round. This process of unraveling continues until the first round. As a result, no one cooperates at any stage of the game. Such is economic rationality.

141. See *id.* at 287–88.

by preserving recreational land,¹⁴² and also creates the possibility for further effort to preserve an endangered species. To simplify the analysis, assume that each generation would like to preserve the species for one and only one reason, to make it available during the lives of its own grandchildren.¹⁴³ Suppose we purchase a finite conservation easement lasting until generation ten. Then generation nine has no incentive to preserve the species, because the species will not be present anyway for the benefit of its grandchildren, generation eleven. Hence, it will not bother preserving the species, which therefore will not be available to generation ten. Now, generation eight has no incentive to preserve the full species, because no matter what it does, the species will not survive for *its* grandchildren. Reasoning similarly, generation seven also bails out of the preservation effort, and so forth. The result is that not even the first generation will invest in the species's survival, so the value of the easement is just the discounted value of the recreational use.¹⁴⁴ Again, as with perpetuation value, we get an upward bump with indefinite survival periods, which is more than the sum of the values of survival in any fixed period. Once again, the whole is in some way larger than the sum of its parts.

The careful reader may have noticed that I referred to "discounted values" of the species and subspecies in the previous paragraph. As this suggests, the kind of scenario I have been considering is consistent with some use of discounting. But a conventional discounting exercise is likely to overlook the value that is created by adding an indefinite fringe of future benefits. Creating space for an indefinite extension of cooperative efforts into the future promotes the existence of cooperative norms, which may increase the value that can be created in earlier periods of time. Thus, a "permanent" fix for part of a problem, by increasing the likelihood of cooperative efforts regarding the rest of the problem, may be much more valuable than a temporary fix, even if the so-called permanent fix is expected to expire at some indefinite point in the future. This feedback between investing in longer-term solutions and cooperative norms is likely to be missed by a conventional discounting effort.

This possible feedback clearly has instrumental significance, if we are interested in saving the species. But we might also attach intrinsic value to a sense of community over time. If so, the unboundedness of the species brings with it the possibility of joining in a cooperative project with later generations, helping to create a kind of cross-temporal community that we

142. The reason for this assumption is to assure that under all circumstances, $W(T)$ is greater than zero, as required by the positive value assumption.

143. For purposes of this particular result, it would make no difference if each generation wanted to preserve the good for its children rather than its grandchildren. But the generation-skipping aspect of the model will turn out to be useful in a later application. See *infra* notes 164-66 and accompanying text.

144. As the number of generations tends to infinity, this tends to the discounted value of perpetual recreation use. But if we purchase a perpetual easement, then this unraveling effect does not occur, and at least one possible equilibrium is that every generation cooperates on saving the full species. The result is that $W^*(0)$ is the discounted value of the full species, which is higher than sums of all of the $W(T)$.

value. Hence, perpetuation value might be the measure of this sense of cooperative intergenerational community, rather than being directly associated with the species itself.¹⁴⁵

The idea of perpetuation value is intriguing, but its practical significance is unclear. It is not implausible to think that people might place a fixed negative utility on any current action that dooms a species, no matter when the doom eventually takes place. Or to put it another way, they might attach a value to the fact that the species's future is not subject to a known outer limit and be less willing to sacrifice to save any given generation if they see that down the line the species will "hit a dead end." Whether in fact people's values take this form, or whether they should ideally do so, is less clear. It is also significant that unboundedness might actually affect the feasibility of cooperative efforts, either within or across generations. Whether these intergenerational models actually correspond, even in a rough way, to actual behavior is an untested empirical issue. In any event, if we are willing to recognize the existence of some kind of perpetuity value, our time horizon will not suffer the kind of telescoping that critics of exponential discounting fear.

B. *Hyperbolic Discounting*

The ethical problems relating to discounting are particularly severe because of the mechanics of exponential discounting, which rapidly drives down to zero the weight given events in a few future centuries. Yet, as we have seen, exponential discounting follows naturally from the relatively modest assumptions made in part III. As we have also seen, perpetuation value is one possible alternative to the additivity assumption, although it probably exists for only certain kinds of environmental goods. If we put aside situations where perpetuation values are relevant, we seem to be driven toward exponential discounting. Escaping this consequence would require that we discard at least one of the other assumptions.

One possibility is to drop the third assumption of proportionality. This assumption has considerable normative appeal in considering a single person's lifetime, because it imposes a kind of consistency between how a person assigns relative values to different events over the course of a lifetime. When we are considering multigenerational environmental benefits, however, the proportionality assumption becomes more questionable. This assumption requires that we use a consistent multiplier between tem-

145. Rubinfeld suggests that such cross-generational commitments are essential to the existence of a true democratic polity:

Contrary to their intentions, the present-tense temporality espoused by Jefferson and Rousseau ultimately disables man from thinking of himself politically. To think of ourselves politically requires reference not merely to a collective political entity, but to a *generation-spanning* political entity such as a nation. When each generation looks upon every other generation as it would upon a foreign nation, then there are no nations.

RUBENFELD, *supra* note 90, at 254.

porary benefits and permanent benefits beginning in the same year. It was this assumption that gave us exponential discounting with a fixed rate.¹⁴⁶ Because it requires a particular kind of consistency in how we make value judgments relating to different time periods, this is clearly a stronger assumption than additivity or positive value. This kind of consistency seems attractive if we expect the same decision maker to be alive in the relevant periods, because a lack of consistency leads to incongruous mismatches between the same person's decisions made at different times. But, as discussed earlier, the resulting inconsistency in multigenerational situations is purely hypothetical and perhaps less troubling.¹⁴⁷

If we discard the proportionality requirement, we are no longer forced to use the same discount rate for every period in the future. Instead, we can think in terms of a declining discount rate. Roughly speaking, the effect is that discounting slows down as we get farther in the future, so the far future does not get discounted to the same extent as it does in conventional exponential discounting. This modified form of discounting is called hyperbolic discounting. According to one estimate, the appropriate discount rate would be about three percent for the next twenty-five years, declining to nearly zero for periods more than a century in the future.¹⁴⁸

One argument for hyperbolic discounting is that future growth rates are uncertain. This argument addresses the opportunity-cost rationale for discounting. Exponential discounting assumes that we can accurately forecast the rate of return on alternative investments over the course of a century or more. But in reality, we can only guess at the long-term path of the global economy. Maybe present growth rates will continue or even accelerate. On the other hand, maybe scientists will run out of ideas, or it will prove increasingly difficult to translate new scientific knowledge into economic improvements. Or maybe an increasing amount of investment will be consumed by efforts to deal with pyramiding environmental problems, or maybe the economy will be blighted by war, disease or famine. Thus, it is possible that future growth rates will be very low. It turns out, mathematically, that because of this uncertainty, scenarios with high growth rates become progressively less significant in calculating the appropriate discount factor over longer time periods. Because of this uncertainty about future growth rates, it may be appropriate to use a very low discount rate for long-term environmental effects.¹⁴⁹

Hyperbolic discounting based on this rationale can have significant policy implications. A recent study by Resources for the Future develops a model in which the probability distribution for future interest rates re-

146. See *supra* notes 115–17 and accompanying text.

147. See *supra* note 129 and accompanying text.

148. See Weitzman, *supra* note 14, at 270.

149. See Martin L. Weitzman, *Just Keep Discounting, But . . .*, in *DISCOUNTING AND INTERGENERATIONAL EQUITY*, *supra* note 13, at 29 (arguing that if growth rates are uncertain, lowest possible discount rate should be used).

sembles a random walk.¹⁵⁰ The authors posit a rate of return of four percent in 2000 and base their uncertainty factor on past interest rate fluctuations. The comparison with standard exponential discounting is dramatic:

After only 100 years, conventional discounting at a constant 4 percent undervalues the future by a factor of 3 based on the random walk model of interest rate behavior. After 200 years, the future is undervalued by a factor of about 40. That is, while conventional discounting values \$100 in the year 2200 at 4 cents, the random walk model values the same \$100 at \$1.54—about 40 times higher. Going further in the future, conventional discounting is off by a factor of over 40,000 after 400 years.¹⁵¹

Applying this technique to a standard model of the greenhouse effect, the report finds that the total benefit of removing a ton of carbon dioxide from the atmosphere roughly doubles using this form of discounting.¹⁵² The effect of this technique would be even greater for changes having longer time horizons, such as reducing methane discharges or climate models featuring irreversible ecosystem effects.¹⁵³

Hyperbolic discounting would also be consistent with the way most people intuitively evaluate long-term decisions.¹⁵⁴ As Portney and Weyant report, the empirical studies “show rather consistently that while individuals do appear to attach lower weights to distant benefits, they [sic] not use a constant exponential discount rate.”¹⁵⁵ Instead, “the longer the time period before effects are felt, the lower the implicit discount rate used.”¹⁵⁶ Apparently, people do not view all future generations as equivalent. Members of the current generation clearly are believed to have a more compelling obligation toward the next generation (and perhaps at least to young grandchildren) than to succeeding generations.¹⁵⁷ People rate the present as “very important,” the next century (which they connect with children, grandchildren, and great-grandchildren) as “important,” and everything afterwards (“distant descendants”) as “not that important.”¹⁵⁸ We seem to be in something of the position of the mythical primitive tribe that counts “one, two, three, many,” except that in our case, it’s more like “us, our children, our grandchildren, our later descendants,” with all the later generations getting lumped together. Hyperbolic discounting tracks these preferences about the future.

150. NEWELL & PIZER, *supra* note 7, at 19.

151. *Id.* at 20.

152. *Id.* at 23 tbl.3.

153. *Id.* at 24.

154. For a recent survey of the empirical evidence, see Heinzerling, *Discounting Our Future*, *supra* note 15, at 57–64. Indeed, it has been said that nearly everyone is a hyperbolic discounter. See Richard Posner, *Rational Choice, Behavior Economics and the Law*, 50 STAN. L. REV. 1551, 1567–68 (1998).

155. Portney & Weyant, *supra* note 13, at 7.

156. *Id.*

157. See, e.g., Atherton, *supra* note 27, at 138–39; Cropper & Laibson, *supra* note 27, at 164–67; Cropper & Portney, *supra* note 50, at 375.

158. See Atherton, *supra* note 27, at 138.

Although hyperbolic discounting is appealing in many respects, it does have one troublesome characteristic. The major defect of hyperbolic discounting is that it leads to time-inconsistencies, so that society makes plans it would later prefer not to follow.¹⁵⁹ We can see this simply by thinking in terms of the proportionality assumption. The proportionality assumption holds, for example, that $W(0)/W^*(0) = W(10)/W^*(10)$. Suppose that this relationship does not hold. For the sake of concreteness, say that $W(0)/W^*(0) = 1/2$ but $W(10)/W^*(10) = 1/4$. This means that for times farther in the future, permanent fixes became increasingly attractive relative to temporary fixes. Suppose that the cost (as opposed to the value) of a permanent fix is always three times that of a temporary solution. At present ($T=0$), the value of a permanent fix is only twice that of a temporary solution, so it is not worth paying for an immediate permanent solution. But from our present perspective, implementing a permanent fix looks very attractive in period ten. We can get four times the value at only three times the price of a temporary solution by entering into a contract now to purchase a permanent fix in period ten. But time passes on, as it is wont to do. Eventually, we are living in what used to be labeled period ten. We now find ourselves obligated to pay for a permanent fix rather than a temporary one. But this no longer looks like a good deal. To someone making a decision at that time, period ten is "the present," in other words, it counts as $T=0$. Hence, when we are actually faced with implementing the contract, the permanent fix is only seen as being twice as valuable as the temporary fix (remember that $W(0)/W^*(0) = 1/2$), but it costs three times as much. So now, we are very sorry that we ever entered into the agreement.

The possibility that society might change its policy preferences over time is not in itself troubling. But none of the normal reasons that might justify reevaluating our decision apply: we have not learned anything new, nor have we changed our values. All that has happened is that we are differently situated in time. This seems to be irrational.

In a sense, what hyperbolic discounting overlooks is that if you wait long enough, the future turns into the present, and the far future becomes the near future. But perhaps this is not a serious problem where the plans would not come to fruition until long after the decision maker's death. After all, no individual is ever in the position of regretting a decision made earlier, so no actual individual is guilty of having inconsistent preferences over time. It may simply be a fact of life that people are impatient regarding short-run events but have a more relaxed perspective over the long-haul. The result may be that a future generation is locked into a decision that we prefer but they do not. But it is not obvious that this ought to be a concern for us; from our point of view, they are simply being short-sighted while we are taking a more disinterested view.

159. *Id.* at 137-38.

The solution to the time inconsistency, if we still find it troubling, may be to commit all generations toward taking a long-term view, rather than leaving future generations free to implement their short-term preferences. Every generation might prefer to be free to implement its own short-term preferences, but what it loses by giving up that option, it may gain because other generations also forego *their* right to implement their own short-term preferences. Admittedly, the idea of a binding, eternal covenant between generations is quite unrealistic, except perhaps as an ideal of intergenerational ethics. But the temporal inconsistencies can be handled if governments are able to “lock in” their environmental decisions for a generation at a time. Such an arrangement can leave each generation better off than it would be without the lock-in, and can result in a permanent commitment to a long-term environmental position.¹⁶⁰ Designing institutions that will lock commitments into place for even a full generation at a time is not easy, but we seem to have managed the trick at least in the case of some constitutional provisions.

We can get a general idea of how short-term commitments can address temporal inconsistencies by returning to the grandchild-centered model discussed earlier,¹⁶¹ though this does not technically involve hyperbolic preferences. Suppose each generation attaches a utility of zero to enjoying a resource itself or to having its children enjoy the resource, a utility of one to having its grandchildren enjoy the resource, and a utility of zero for any later generation.¹⁶² We saw before how, if the resource is capable of lasting only a fixed number of generations, the situation unravels and no generation will ever invest in saving the resource.¹⁶³

Now, first suppose that the first generation can fix policy for the resource’s entire potential lifespan. That generation can commit itself and each later generation to preserve the resource and to set aside some small extra savings, which will be used to compensate the last two generations before extinction for preserving a resource they do not care about. Because all generations except the last two would prefer to preserve the resource and the last two are compensated for going along, every generation is better off under this scheme than it would be in its absence. But the idea of such a long, multigenerational commitment may seem far-fetched. Does a less drastic solution exist?

160. See Cropper & Laibson, *supra* note 27, at 170. Their model involves succeeding generations with hyperbolic preferences. In this model, private saving is too low. Each generation is happy with its own level of savings but would greatly prefer future generations to save more. If some method of making an intergenerational commitment is possible, each generation is better off. *Id.* at 167. Thus, hyperbolic discounting may lend itself to a stewardship ethic. For further discussion, see *infra* notes 164–66 and accompanying text.

161. See *supra* note 143 and accompanying text.

162. This model actually fits a certain comedic stereotype; the grandparents are too self-sacrificing to care about themselves, they hate their children, with whom they have quarreled for years, they do not care about future generations who will be born only after they are dead, but they absolutely dote on their grandchildren.

163. See *supra* notes 144–45 and accompanying text.

To explore that question, suppose that each generation can commit only itself and its children, but not its grandchildren.¹⁶⁴ It turns out that no one will ever repeal the scheme, because each generation knows that if it leaves the restriction in place for its own lifetime, its children will not repeal it either, and so its grandchildren (the only ones it cares about) will benefit.¹⁶⁵ Thus, the one-generation-at-a-time commitment works just as well as a permanent commitment.

Of course, this is hardly a realistic model, but it does give the general idea of how commitments that last only one generation at a time can improve the welfare of all generations. For this reason, hyperbolic discounting fits fairly naturally with the idea of a planetary trust, in which each generation agrees to be a little more far-sighted about the environment than it would “naturally” be.¹⁶⁶ So long as it takes more than a single generation to eliminate the trust, no one may ever want to do so, and with hyperbolic discounting, every generation might be better off than it would be in the absence of the trust.

Hyperbolic discounting has genuine appeal. By using hyperbolic discounting and low interest rates, we can take much of the sting out of the use of discounting, because it will take much longer (compared with exponential discounting) before discounting leads us to ignore major future events.¹⁶⁷ As we have just seen, the tendency to discount too quickly in the short-run might be handled through some kind of cross-generational commitment. Hyperbolic discounting thus ameliorates some of the troubling effects of discounting, but it does not entirely eliminate them. Some time periods will still be too distant to make any real difference in our decisions—we will have a very low willingness to sacrifice today even to obtain extraordinary benefits during those remote time periods. If we turn out to have enough information to make discounting practical over such

164. For example, it might use some complex constitutional restriction which would take a whole generation of political organizing to eliminate.

165. The logic is as follows: if the scheme is in effect at its birth, the final generation does not have enough time to repeal the scheme before the resource expires anyway. A generation earlier, if the scheme is in place at that time, the second-to-the-last generation could repeal the scheme effective in the lives of its children, but has no incentive to do so, because any benefit from the repeal accrues only to its children, whom it does not care about. Moving back an additional generation, if the scheme is in effect at its own birth, the third-to-the-last generation will not want to repeal the scheme either. It knows that if it leaves the scheme in effect at its death, the next two generations will also leave it in effect, which ensures that its grandchildren (the final generation covered by the scheme and the only ones it cares about) will have the resource. Continuing to work our way backwards, we ultimately consider the position of the first generation. The first generation now knows that if it institutes the scheme, no later generation will ever want to repeal it, which will ensure that its own grandchildren will obtain the benefit. Thus, once the first generation puts this scheme into effect, it will be maintained and the resource will be preserved until the end, even though every succeeding generation has the power to repeal it.

166. See *supra* notes 88–91 and accompanying text.

167. Under some circumstances, hyperbolic discounting can involve a lower discount rate for environmental benefits than for private consumption goods. The necessary conditions, however, are fairly restrictive: the production of the environmental good must be separate from the use of private capital, the environmental benefit must not be perfectly substitutable with private goods, and (as in the model discussed earlier in the text) there must be a lag before governmental changes in environmental policy can take effect. See Cropper & Laibson, *supra* note 27, at 170.

long time periods, we may be hard-pressed to avoid the troubling sense that future catastrophe has almost no practical significance, if it is far enough down the road.

V. CONCLUSION

Our technology now makes it possible for us to take actions with repercussions many generations in the future. As we have seen, however, no consensus exists about how to weigh such long-term consequences. Economists have a well-developed technique for doing so, known as exponential discounting, but are still immersed in controversy over the critical question of how to choose a discount rate. Apart from these technical controversies, however, exponential discounting can lead to dismaying consequences over long periods of time. In the extreme case, it turns out that human lives far in the future count for less than the next helping of dessert does now.¹⁶⁸ These extreme hypotheticals are unlikely to face us, because they posit an unrealistic level of certainty about the far future. But they do highlight the peculiar evaporation of future values that can result from exponential discounting. Not surprisingly, a vigorous debate over the propriety of this technique has taken place in various forums, including the law reviews.¹⁶⁹

This article has not attempted to present a definitive resolution of the debate, but rather to improve our framework for discussing the issues. As usually presented, arguments for discounting rest on complex assumptions about the economy and its future evolution (such as continued economic growth), as well as about individual time preferences (such as impatience or reduced empathy with more distant generations). The model presented in this article shows that exponential discounting can be derived from much simpler assumptions. Those assumptions merely require that our willingness to sacrifice to obtain environmental benefits in future time periods have a certain kind of simple internal coherence. The model certainly does not prove the moral acceptability of discounting, but it does undermine the common intuition that the technique selfishly favors the present over the future.¹⁷⁰

Like any model, this one is based on assumptions, and one of the benefits of the modeling exercise is to show which assumptions are critical to the conclusion. It turns out that there are two ways of avoiding exponential discounting by modifying the model's assumptions. One way posits that, apart from the mere existence of an environmental resource in any

168. See *supra* note 98 and accompanying text.

169. See *supra* notes 93–99 and accompanying text.

170. See *supra* notes 148–62 and accompanying text. Of course, the model says nothing about the specific choice of discount rate, which is the question so hotly disputed by economists. Moreover, if we choose an extremely low discount rate, discounting may have little effect over realistic planning horizons (presumably of a few centuries or so). Thus, the direct policy implications of the result are attenuated, but it does address some of the conceptual objections to discounting.

specific time period, we also value its potential in that time period to perpetuate itself into the indefinite future. Essentially, the premise is that we value sustainability for its own sake, not merely as a means. Adding this “perpetuation value” in the analysis leads away from conventional discounting. The other way of avoiding exponential discounting connects more readily with existing economic research, and is based on the idea that we draw smaller distinctions between later generations farther into the future. This leads to a model of declining discount rates, also known as hyperbolic discounting.¹⁷¹

In exploring these possible exceptions to exponential discounting, we began to encounter a subtle shift in the way of conceiving intergenerational relations. In thinking about future generations, we often seem to imagine a one-sided relationship: *we* take actions, and *they* suffer or enjoy the consequences. But in thinking about perpetuation value and hyperbolic discounting, we were increasingly drawn into considering scenarios where the active cooperation of future generations is needed.¹⁷² In these scenarios, the goal is not merely to take an optimum action but to establish norms of cooperation or create enduring institutions. These scenarios encourage us to think of ourselves as being to some extent members of a cross-generational community, engaged in a long-term project, much like medieval craftsman working over decades or centuries to build a cathedral. Such scenarios, crudely sketched as they are, capture an important element of the task of preserving the global ecology—an element that seems to have gotten far less attention than it deserves to date. Hopefully, in the next round of the debate over evaluating long-term environmental policies, building an intergenerational community will receive greater attention.

The central conclusion of this essay is that exponential discounting does not ultimately rest on an illegitimate privileging of the present over the future. But on the other hand, exponential discounting is not a logical imperative. In the absence of some knockdown argument one way or the other, we can only do our best to pick an approach which seems most consistent with our overall normative outlook. Perhaps the best analytic framework remains to be discovered. My own guess, however, is that it will incorporate elements of perpetuation value and hyperbolic discounting, rather than relying purely on exponential discounting. In the meantime, it might be best to avoid locking ourselves into any one set of rules for evaluating long-term environmental policies.

171. See *supra* Part IV.B.

172. See *supra* notes 143–45, 164–67 and accompanying text.

APPENDIX

Recall that $W^*(T)$ is the amount we would be willing to limit current consumption in order to keep an environmental benefit from year T onwards. $W(T)$ is the amount we would pay to keep the benefit from the beginning of year T to the end of the year. These amounts could be considered the monetary value of future environmental benefits, but only in the sense of measuring our priorities in using resources. There is no assumption that the intrinsic worth of the environmental benefit has a cash equivalent.¹⁷³ We have three assumptions:

- (1) Positive Value $W(T) > 0$.
- (2) Additivity $W^*(T) = W(T) + W(T+1) + W(T+2) + W(T+3) \dots$
- (3) Proportionality $W(T)/W^*(T) = k$.

We can get a sense of how the results will come out by working through the arithmetic of a simple example. Start with time zero. To keep the arithmetic simple, say that $W^*(0) = 1$, and $k = 1/3$, so we are willing to sacrifice one-third as much to keep the species alive for one additional year only, as to keep it alive from that year to eternity. This means that two-thirds of what we are willing to sacrifice to preserve the species after time zero consists of what we are willing to sacrifice to preserve it from time one onward. Then $W^*(1) = (2/3)W^*(0) = 2/3$. Similarly, $W^*(2) = (2/3)W^*(1)$, and so forth. Hence, we are discounting W^* —the value of continued survival of the species from time T onward—at a constant discount rate of two-thirds.

Now consider what is happening to $W(T)$. We are willing to sacrifice 1 unit to keep the species alive from year zero onward, and one-third unit simply to keep it alive in year zero. We are also willing to sacrifice two-thirds unit to keep it alive from year one onward. This means that we are willing to sacrifice one-third of *that* value to keep it alive for year one alone, or two-ninths of a unit. So $W(1) = (2/3)W(0)$. Next, consider $W(2)$. The remaining “value” will be divided with one-third attributable to year two and the remainder to the time after year two. So $W^*(2) = (2/3)W^*(1) = 4/9$. Hence $W(2) = (1/3)W^*(2) = 4/27 = (2/3)W(1)$. Thus, the amount attributable to any one year is decreasing over time (and fairly quickly so, in this example).

More generally, we have:

$$(4) \quad W^*(T+1) = W^*(T) - W(T) = W^*(T) - kW^*(T) = (1 - k)W^*(T)$$

[by additivity and proportionality]

or equivalently,

$$(5) \quad W^*(T) = (1-k)^T W^*(0).$$

Hence, we are discounting W^* at a rate of $(1 - k)$. This gives us:

$$(6) \quad W(T) = W^*(T) - W^*(T+1) = (1-k)^T (k) W^*(0).$$

173. See *supra* notes 108–11 and accompanying text.

But $kW^*(0) = W(0)$, so we have our main result:

$$(7) \quad W(T) = (1-k)^T W(0).$$

This means that we are discounting $W(T)$ at the same rate as $W^*(T)$.

We obtain similar results if we drop the assumption that time comes only in one year increments, and assume instead that it can be chopped as finely as we like.¹⁷⁴ $W^*(T)$ is now the integral of $W(T)$ from T to infinity. Given our assumption that we can put finite valuations on all of these time periods, all of these integrals converge, and differentiating we get:

$$(8) \quad \frac{dW^*(T)}{dT} = -W(T).$$

Substituting this into our proportionality assumption, we get:

$$\frac{dW^*(T)}{dT} / W^*(T) = -k, \text{ or}$$

$$(9) \quad \frac{dW^*(T)}{dT} = -kW^*(T).$$

The solution to this differential equation is:

$$(10) \quad W^*(T) = W^*(0) \exp(-kT).$$

But remember that $\frac{dW^*(T)}{dT} = -W(T)$, so this gives us:

$$(11) \quad W(T) = kW^*(0) \exp(-kT).$$

$W(0)/W^*(0) = k$, so we now have another version of our main result concerning discounting:

$$(12) \quad W(T) = W(0) \exp(-kT).$$

Thus, we are discounting W —the amount we are willing to sacrifice now to keep the species for an additional interval of survival at time T —at the rate of k . W^* , the amount we are willing to sacrifice to keep the species alive from time T onwards, is discounted at the same rate.

Finally, if we drop proportionality but retain additivity, we still have:

$$(13) \quad W(T) \rightarrow 0 \text{ as } T \rightarrow \infty.$$

To prove this, we show that for any M , $W(T)$ must eventually fall below $(1/M)W^*(0)$. Recall that $W^*(T) = W(T) + W(T+1) + W(T+2) \dots$. There can be at most M number of times T such that $W(T) > (1/M)W^*(0)$ (otherwise their total value would exceed $W^*(0)$). Because there are a finite number of such T , one of them must be largest. Call it N . Then for any $T > N$, $W(T) < (1/M)W^*(0)$. By choosing a large M , we can force this amount as close to zero as we like.

The extent of additivity plays an important role in determining the strength of the conclusions about discounting. We could actually derive

174. We are now also assuming continuity of our W functions, which seems unobjectionable.

the preceding results using only the weaker additivity assumption that $W^*(T) = W(T) + W^*(T+1)$, rather than the full additivity assumption. But with full additivity, we can go farther. Full additivity also gives us the stronger result that $W^*(T) \rightarrow 0$ as $T \rightarrow \infty$. We know that $W(0) + W(1) + \dots$ converges to $W^*(0)$. This means that $W^*(0) - (W(0) + \dots + W(T))$ must go to 0. But given full additivity, this is just an alternative expression for $W^*(T)$. Hence, $W^*(T) \rightarrow 0$.

We cannot derive this result from the weaker additivity assumption ($W^*(T) = W(T) + W^*(T + 1)$). In other words, when only weak additivity holds, we might place a high intrinsic value on the ability of the species to perpetuate itself into the indefinite future, above and beyond the value of its existence in any individual time period. Exponential discounting of the $W(T)$ function would provide misleading results under those circumstances, because it would miss this "perpetuation" value.¹⁷⁵

175. This point is considered at *supra* notes 133–47 and accompanying text. To prevent weak additivity from converting into full additivity, we also need to modify the proportionality assumption to be $W(T)/(W^*(T) - c) = k$. Here, c represents perpetuation value. With this assumption, $(W^*(T) - c)$ and $W(T)$ are both subject to exponential discounting.

