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INSIDE RFF: NEWS AND PUBLICATIONS

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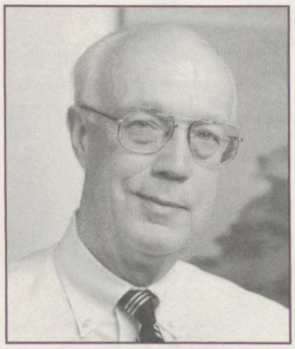

From the president

Tell us about it

As president of Resources for the Future, I spend a lot of time talking to people about RFF. These people have a stake in our research: they come from federal departments and state agencies; they work on Capitol Hill or for law firms or corporations or environmental groups. They want to know what research is in progress and what our people are thinking; their jobs require them to make decisions and to make good decisions they need good information. Along with many others who care deeply about the environment and natural resources, they value RFF's realistic and dispassionate analysis. These people—and you too, we assume, since you receive *Resources*—want to hear from us. And we want to hear from you.

Keeping RFF's constituencies informed about our work is a constant challenge. Even those of you who are familiar with RFF's work in one area—transportation and urban air quality, for example—may be surprised to learn we bring the same depth to a very different subject—the restructuring of the electric utility industry, say. We constantly discuss and review our research programs to make sure that our work is both necessary and meaningful. We are just as determined that our outreach efforts be timely and useful to you.

Last winter, RFF undertook a systematic review of our communication and outreach activities. We wanted to assess the way we deliver information about our research, as well as about RFF itself as an institution worthy of your interest and support. The first phase of this review has helped us to understand better who looks to us for information and what kinds of information you need.

We are pleased to hear how much you respect RFF for its rigor and objectivity. But we are hearing that you want *more* from us. More research reports replete with methodology and technical detail. More nontechnical summaries of research that can be quickly assimilated. More access to RFF's storehouse of current and completed research. More about what our experts *think* on issues of the day.

Currently, we are evaluating our print and electronic publications, so we can respond to our stakeholders' needs. This is not easy or quick. You will see some changes in the current issue of *Resources,* such as the expanded table of contents on the cover. This issue also includes an index of *Resources* for the past several years.

More changes are in the works, so now is a good time for you, as a *Resources* reader and as someone who shares RFF's concern about natural and environmental resources, to tell us how we are doing and what we could be doing better. If you have comments to make about *Resources,* our Internet site, or our other publications, we want to hear from you. Write to us at: *Resources,* Resources for the Future, 1616 P Street, NW, Washington, DC, 20036–1400, or send us e-mail at: tellus@rff.org.

Conducting research and analyzing policy is only part of RFF's mission; the other part is putting that research and analysis into the hands of people who want to use it. This issue of *Resources* is in your hands right now. Let us know how you use it.

Robert W. Fri

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Discounting the Future: Economics and Ethics

Timothy J. Brennan

How much do we care about people whose lives won't begin until long after our own have ended? How much *should* we care about them? These questions come up when we contemplate environmental projects that benefit people who are separated by many years or even by generations from those who pay the costs. Whether the interests of future generations will be at all significant in determining how much we should limit carbon emissions, preserve the ozone layer, or protect endangered species depends on whether a dollar's worth of future benefits is worth less than a dollar's worth of present costs—what economists mean by *discounting*.

Much controversy surrounds the practice of discounting. Divisive caricatures of the discounting wars pit economists, who allegedly view the environment as just another capital asset, against ethicists, who look out for the interests of people born in the future, and environmentalists, who advocate the inherent, noneconomic values in sustaining nature. In reality, discounting battles rage even among economists. Two leading experts on the economics of public projects, William Nordhaus of Yale University and Joseph Stiglitz of the president's Council of Economic Advisers, disagree over the appropriate way to discount the future costs and benefits of climate change.

When an issue has defied resolution for so long, perhaps the difficulty is a misunderstanding of the fundamental questions. Indeed, the difficulty may be that *all* the seemingly contrary positions on discounting have some validity. One cannot hope to resolve discounting debates among economists or to allay the intensifying criticisms of discounting from those outside economics, but reflecting on the central arguments and illuminating the relationships between their economic and ethical sides may add a little light to the heat.

What is discounting?

One way to understand how discounting works is to compare it with the compounding of interest on savings. Most people are familiar with the way compound interest increases the value of one's savings over time, in an accelerating way. For example, $100 invested today at 6 percent interest will be worth $106 in a year. Because the 6 percent interest will be earned on not just the initial $100 but the added $6 as well, the gains in the second year will be $6.36. Over time, these compounding gains become substantial.

While compounding measures how much present-day investments will be worth in the future, discounting measures how much future benefits are worth today.

At 6 percent interest, the $100 investment will be worth about $200 in twelve years, $400 in twenty-four years, and $800 in thirty-six years. It will be worth around $3,300 in sixty years and almost $34,000 in a hundred years. A penny saved is more than a penny earned; after a century, the penny becomes $3.40. In 1626, Dutch explorers bought Manhattan for a mere $24; if that sum had been invested at just over 6 percent per year, it would have yielded more than $40 billion in 1990—about the total income generated in Manhattan that year.

Discounting operates in the opposite way. While compounding measures how much present-day investments will be worth in the future, discounting measures how much future benefits are worth today. To figure out this discounted present value, we must first choose a discount rate to transform benefits a year from now into benefits today. If we choose the same discounting rate as the interest rate in the above example of compounding, $106 a year from now would be equal in value to $100 today. Discounting the benefits of a project that generates $200 in twelve years by a discount rate of 6 percent per year would tell us that those benefits are worth $100 today.

To economists, this is the same as saying that $100 invested at an interest rate of 6 percent will generate $200 in twelve years. For this reason, they often use the terms discount rate and interest rate interchangeably, although *discount rate* properly refers to how much we value future benefits today, while *interest rate* properly refers to how much present investments will produce over time.

The paramount consideration in assessing future environmental benefits is the size of the discount rate: The larger the discount rate, the less future benefits will count when compared with current costs. If the discount rate were 10 percent, $200 in twelve years would be worth only about $64 today; if the rate were 3 percent, the current value would be $140. At a zero discount rate, $1 of benefits in the future would be worth $1 in cost today. Differences in discount rates become crucial for benefits spanning very long periods.

The obvious cases for and against discounting

The close relationship between interest rates and discount rates is the basis for

the obvious case in favor of discounting. Suppose that an environmental program costing $100 today would bring $150 in benefits twelve years from now. If other public or business projects yield 6 percent per year, however, those future benefits of $150 would be "worth" only about $75 today after discounting. By investing the $100 today in one of these alternative projects, we could produce $200 in benefits in twelve years, leaving $50 more for the future.

Whether we view the environmental investment in terms of the present value of benefits ($75 as compared with $100) or in terms of an alternative investment that produces benefits of greater value ($200 as compared with $150), it fails the test of the market. Using a bit of economic jargon, we can call this market test the *opportunity-cost rationale* for discounting. Here, opportunity cost refers to the most value we can get by investing $100 in something other than the environment. According to the opportunity-cost rationale, we should discount future benefits from a current project to see if these benefits are worth *at least* as much to people in the future as the benefits they would have if we invested current dollars in medical research, education, more productive technology, and so on.

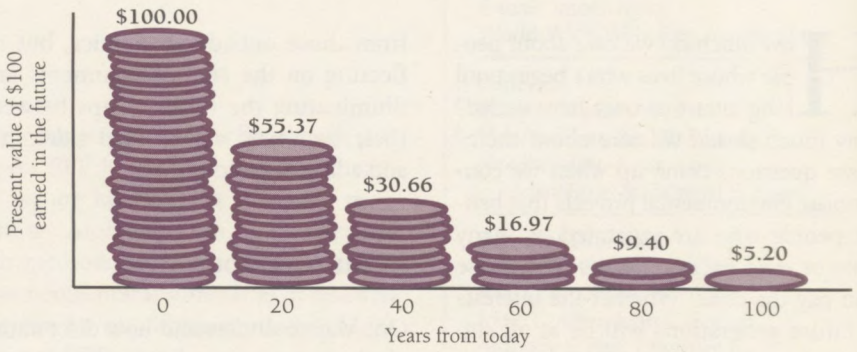
In effect, the opportunity-cost rationale tells us that our discount rate should be the market interest rate. Consequently, looking at the four factors that produce the interest rates that we see in financial markets will help explain what lies behind discount rates. The first factor is the level of economic activity. If investors want a lot of money for a lot of projects, they will have to pay a higher interest rate for loans; during slow economic times, investors will require fewer loans, leading to a lower interest rate. The second factor is inflation. Future dollars will be discounted if one cannot buy as much with them in the future as one can today. The third factor is risk; a guaranteed bird in the present hand may be worth a chancy two in the future bush. The fourth factor, and the most controversial one in environmental assessments, is what economists call *pure time preference*. This preference refers to the apparent fact that people require more than $1 in promised future benefits in order to be willing to give up $1 in goods today.

Critics of the opportunity-cost rationale often find that discounting leads to a present-day valuation of future environmental benefits that they believe is too low. Threats to life and nature from environmental degradation are notoriously hard to measure and, in the views of many, impossible to compare with the "mere" economic benefits that accrue from investing in a business project. Moreover, the benefits from a business investment might accrue to the wealthy or be frittered away today, while the benefits from an environmental project are likely to be distributed more widely across society and into the future.

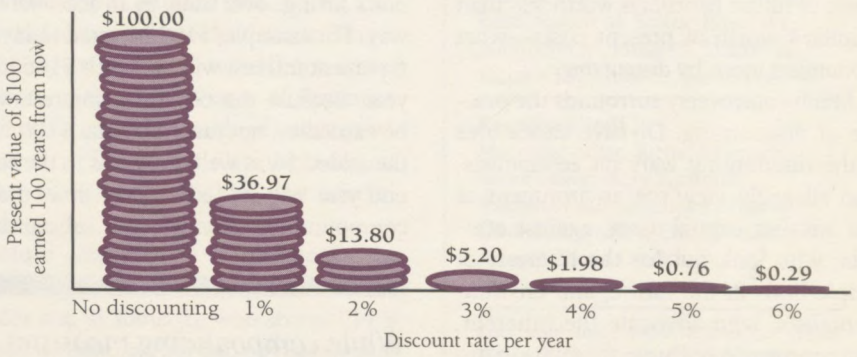
Environmental benefits may or may not be overestimated in policy evaluations, and they may or may not be distributed more equitably than the returns from other investments. Those well-known criticisms, however, apply to cost-benefit tests in *any* context. The specific case

How much we value future dollars today: The effect of time and the discount rate

Discounting operates in the reverse direction of compounding. While compounding measures how much present-day investments will be worth in the future, discounting measures how much future benefits are worth today. The figure below shows how the discounted present value of future benefits can shrink to very small amounts as time goes on. Specifically, it shows how much $100 earned now and in 20, 40, 60, 80, and 100 years is worth today when a 3 percent discount rate is applied.



Along with the passage of time, increases in the discount rate also can dramatically shrink the discounted present value of future benefits. The figure below shows how much $100 in benefits 100 years from now would be worth today at discount rates ranging from 0 to 6 percent.



When we see how small variations in the timing or discounting of future benefits can make large differences in deciding how much the benefits are worth today, it's easy to understand why discounting can lead to such heated policy debates.

against discounting fundamentally concerns pure time preference. A principle in most prominent ethical philosophies is that no individual's interests should count more than another's in deciding how social benefits should be distributed. If all men are created equal, as Thomas Jefferson wrote, there can be no justification for regarding the well-being of present generations as more important than that of future generations simply because of the difference in time. Given that principle, are we really justified in refusing to sacrifice $24 in 1995 if that $24 would bring "only" $4 billion—and not $40 billion—to people living in the year 2359? Substituting lives, or the capacity of wealth to save lives, for dollars makes this question even more vivid and pressing. How could a future life, no matter how distant, be worth less than a present one? Using the language of philosophers and lawyers, we might call the insistence that future lives be valued equally to present ones the *equal standing* argument against discounting future benefits.

Might cases for and against discounting both be valid?

Suppose we ask whether present generations should sacrifice short-run economic growth to undertake a particular program to improve the environment and leave more resources for future generations. Proponents of opportunity cost, who would discount future benefits, might say no, but proponents of equal standing, who would not discount future benefits, might say yes.

When a question has two compelling yet contradictory answers, it may really combine two questions in one. A close look at the question "should we undertake this environmental policy now to benefit future generations?" reveals that it asks a question about obligation (what duty do we have to sacrifice today to benefit future generations?) *and* a question about description (if we should sacrifice, do we help future generations more by implementing the proposed environmental policy or by doing something else?).

The economist's opportunity-cost rationale speaks to the question about description. If the goal is to improve the welfare of future generations, we should choose a policy that achieves the largest improvement for a given present cost. Consequently, we should compare the returns to the proposed environmental policy with those to other investments in order to see which are largest. Consider, for example, other investments with the same present-day costs as the environmental policy. If the discounted future benefits from these alternative policies are larger than the those from the environmental policy, we should consider implementing the alternative policies instead. We may be able to do more for future generations by subsidizing basic scientific and medical research or promoting education than by protecting the environment.

An obvious response would be to ask, "Why not invest in environmental protection *and* medical research?" This response brings us to the question about obligation—whether and how much to sacrifice. Unlike the question that asks us to describe and compare the benefits of one program to another, the obligation question asks us to contemplate our duties to future generations. As such, it fundamentally concerns ethical values rather than economic facts. Accordingly, equal standing is a more appropriate perspective from which to answer this question than is opportunity cost.

Proponents of the equal-standing principle have no problem with discounting for inflation or risk. But they find the pure-time-preference component of discounting to be morally controversial, even though the pure-time-preference discount rate is half the 6 percent discount rate drawn from today's markets. While a 19:1 ratio (present value to future value yielded by a 3 percent discount rate) is less philosophically forbidding than the 340:1 ratio (yielded by a 6 percent discount rate), it still is hard to reconcile with the equal-standing principle.

Violating "Hume's Law"

Separating environmental policy questions into questions about description and about obligation uncovers the root of much of the discounting controversy within economic circles and across disciplinary boundaries. This controversy is a consequence of trying to use facts about how people *do* discount to tell us how policymakers *should* discount. This attempt violates a maxim derived from eighteenth-century British philosopher David Hume, who asserted that facts alone cannot tell us what we should do. Any recommendation for what you, I, or society ought to do embodies some ethical principles as well as factual judgments. For example, to recommend policies if and only if their economic benefits exceed their costs would imply the ethical principle that increasing net economic benefits is the only worthy goal for society.

The fact that we *do* have time preferences may not tell us much about how we ought to regard future generations. Imagine a world where generations do not overlap. In this world, people are like long-lived tulips; every eighty years, a new batch comes to life after the previous batch disappears. Suppose the people in one of those generations happen not to care about any subsequent generations. They would then choose to exhaust resources and degrade the environment without regard for how these actions might lower the quality of life of the people who succeed them. The *fact* of this disregard, however, does not invalidate an ethical principle that people born far in the future deserve a good quality of life as much as people already living.

Using market discount rates to examine ethical questions has made the economics of discounting more complicated than it perhaps needs to be. For example, economists have long argued about whether to calculate pure-time-preference discount rates based on the returns that investors receive before they pay taxes or after they pay taxes and, if after, whether to include corporate income

taxes or personal income taxes in the calculation. If pure time preference has only limited ethical relevance in determining how much we should discount, these issues become relatively unimportant.

Divergence between equal-standing and opportunity-cost discount rates would be less important if policies that always did the best from one perspective did the best from the other as well. Unfortunately, this does not always hold. A policy that generates benefits in the short run may have a higher discounted value in an opportunity-cost sense than a policy that produces benefits much later. If we use a lower discount rate—that is, one reflecting more equal standing—the policy with long-term benefits may come out on top. We might need to do more for future generations; moreover, we might be doing the wrong things now. At opportunity-cost discount rates, development of an urban park may be more beneficial than an equally costly plan to reduce greenhouse gas emissions by taxing gasoline. At low or zero discount rates, the gasoline tax may be the more beneficial policy.

Philosopher Mark Sagoff of the University of Maryland suggests that market discount rates may not be a good indicator of the ethical value that people, upon reflection, would place on protecting future generations. Accordingly, we might resolve the discounting issue by having the government set policy based on people's stated ethical views regarding how to weigh current lives and dollars against future lives and dollars. Through a telephone survey of 3,000 U.S. households, Maureen Cropper, Sema Aydede, and Paul R. Portney of RFF determined that the rate at which people apparently discount lives saved is comparable to after-tax returns in financial markets. For example, people discount lives a century from now at about 4 percent per year. Equal-standing advocates can draw scant comfort from such data, which might tell us how a democracy would react if it followed the public's pure time preferences but, according to Hume, don't tell us what the right time preferences are.

Ethically justified discounting

Reconciling discounting with ethics may seem impossible, but there is some hope. To say that present and future generations have equal standing in an ethical sense does not necessarily imply that they have the same claim on present resources, because the general level of wealth or well-being may be changing over time. If we follow the ideas of a recent Nobel Prize winner in economics, John Harsanyi of the University of California–Berkeley, we should sacrifice today for the benefit of future generations only if the average well-being of people in the future goes up by more than we lose on average today. If present trends continue, advances in technology and knowledge will make people better off in the future than we are today. In that case, more than a dollar of gains to them would be needed to make up for a dollar lost to us. Any future returns should then be discounted by this difference to ensure that future generations' gains in well-being exceed our losses. According to the view proposed by Harvard University philosopher John Rawls, we might not be justified in making *any* sacrifice for future generations if they would be better off than we are now. If we expect future generations to be worse off than we are, however, Rawls' framework suggests that we should make present-day sacrifices.

To say that present and future generations have equal standing in an ethical sense does not necessarily imply that they have the same claim on present resources, because the general level of wealth or well-being may be changing over time.

More promising justifications for discounting come from critiques of the equal-standing idea itself. Philosophers such as Susan Wolf of Johns Hopkins University and Martha Nussbaum of Brown University have pointed out that to say that everyone has equal standing is to say that no one has special standing—including our families, friends, and fellow citizens. Insistence on equal standing denies the value that special interpersonal relationships hold for us and without which we could not be fully human. This argument may provide some support for asserting that generations closer to us should mean more to us than generations far in the future. (Thomas Schelling of the University of Maryland points out the irony of worrying so much about the welfare of future generations while doing so little to improve the welfare of many of the most destitute among us today.)

As long as resource scarcity makes trade-offs between the present generation and future generations inevitable, no consideration of environmental policies to benefit future generations should ignore economic opportunity cost. Ultimately, decisions to implement or not to implement such proposed policies will be the result of political processes, with all their virtues and imperfections. Justifications for the policies, which are tied in large measure to the degree of discounting, unavoidably involve ethical reflection and judgment. An appreciation of the necessary roles of both economics and ethics should clarify the nature of discounting and promote better understanding of our obligations toward future generations and how to meet them.

Timothy J. Brennan, a professor of public policy and economics at the University of Maryland Graduate School, is a Gilbert White Fellow at Resources for the Future. *He thanks Winston Harrington, Eduardo Ley, Michael A. Toman, and especially Dallas Burtraw, Molly K. Macauley, Virginia McConnell, and Paul R. Portney—all of RFF—for illuminating discussions during the development of this article.*

Health-Based Environmental Standards: Balancing Costs with Benefits

Paul R. Portney and Winston Harrington

Balancing the pros and cons of a proposed action seems like a commonsense approach to decisionmaking. But often that is not the approach embodied in environmental legislation. In establishing health-based environmental standards under the Clean Air Act, the Safe Drinking Water Act, and several other major environmental laws, for instance, Congress all but explicitly prohibits the U.S. Environmental Protection Agency (EPA) from balancing the benefits of tighter standards against the attendant costs. Given the 104th Congress's strong interest in using benefit-cost analysis for federal regulation, why have previous legislatures excluded such balancing from the most important standard-setting decisions made by EPA?

Below, we identify two basic arguments that have been put forward for disregarding costs in environmental decisionmaking and raise counterarguments to both. While these arguments and counterarguments require a more thorough analysis than we can devote to them here, our hope is that we will stimulate a more open and enlightened debate about them than we have seen to date.

The right-to-a-safe-environment argument

The right-to-a-safe-environment argument is perhaps the most common response to those (like us) who would seek to balance benefits and costs in standard setting. This argument is, of course, based on the presumption that safe levels of environmental contaminants *can* be found, a presumption that is apparent in our environmental laws. For instance, the Clean Air Act requires EPA to provide "an adequate margin of safety... requisite to protect public health" in setting National Ambient Air Quality Standards. From our perspective, the right-to-a-safe-environment argument has two flaws—the first scientific, the second philosophical.

From a scientific standpoint, the problem is that *no* safe level is likely to exist for most, if not all, pollutants. Rather, lower ambient concentrations of a particular pollutant almost always will imply lower risks of an adverse health effect. In the case of air pollution, even very low levels of pollutants pose some risk of adverse reactions in children and the elderly with chronic respiratory disease.

If air quality standards are required by law to provide an adequate margin of safety, and if even weak concentrations of pollutants pose some risk to some individuals, it appears that only zero concentrations could be permitted under the law, for only zero concentrations would provide a "margin of safety" against adverse health effects. But totally eliminating ubiquitous air and water pollutants is impossible in a modern industrial society like ours (and would be impossible even in a primitive society, at least as long as fires were allowed!).

The philosophical problem with the right-to-a-safe-environment argument is whether it makes sense to treat risk-free levels of air and water quality—even if they could be identified—as inalienable rights, such as freedom of speech. Those who oppose a balancing approach to environmental standard setting often argue that we did (or do) no such balancing in establishing and protecting the basic freedoms that are guaranteed in the Constitution.

But elevating environmental quality to the status of a constitutional right, as some have proposed, would remove neither the necessity for nor the desirability of balancing. Even the basic freedoms that are guaranteed in the Bill of Rights have been subjected to a very crude kind of balancing test. For example, we cannot stand up and scream "Fire!" in a crowded theater; libel laws constrain our ability to write whatever we want to write about a person; and other basic rights are constrained in varying degrees. Such restrictions on the basic rights of Americans reflect a clear balancing mentality—that is, a carefully considered view that some extensions of our fundamental rights could create greater problems (read "costs") than the additional freedoms ("benefits") that the extensions would provide. If the authors and guardians of our Constitution made and continue to make qualitative trade-offs concerning our basic rights, then we see no reason why the freedom to enjoy a clean environment would not be similarly qualified, even after the freedom's elevation to "right"-hood.

No safe level is likely to exist for most, if not all, pollutants. If environmental quality standards are required to provide an adequate margin of safety, it appears that only zero concentrations could be allowed—an impossibility in today's industrial society.

Let's suppose that we are to regard environmental quality as a constitutional right. In that case, should we create a constitutional "right" to affordable housing? This amenity is arguably of greater importance to the average citizen than a risk-

free environment. What distinguishes the rights guaranteed in the Constitution from those that are not guaranteed? And into which group does the right to a clean environment belong?

We respond to the question about distinguishing rights by noting that the freedoms of speech, religion, and so on are freedoms that people can enjoy extensively without reducing the rights of others. They impose no costs except in those extreme cases where the law already makes restrictions. In contrast, a right to shelter would impose costs on others. In this light, the answer to the second question is clear: in its costliness, a right to a clean environment is more like the right to shelter than the right of free speech. If costly rights were guaranteed in the Constitution, the need for constitutional balancing would be the rule rather than the exception.

To put this argument another way, the need to balance environmental quality against other social objectives will not disappear just because we designate environmental quality a "right," but doing so may make balancing more difficult to achieve. For example, the right to a clean environment would conflict with constitutionally guaranteed rights to use and enjoy private property, as recent congressional debates about "takings" of property attest.

But suppose that environmental quality became a right and that we could identify safe levels of environmental contaminants. The question we would then have to ask is whether society could afford the expenditures that would be required to assure safe air (or water) quality for all citizens. To be sure, we should aspire to this goal; but just as we acknowledge that we have too few resources to accomplish other worthy goals, so too we might collectively decide that we cannot afford to reduce all air pollutants to safe levels everywhere. In view of the costs that might be involved, we might do better to expend at least some of our resources on other important social problems.

We illustrate this assertion using some numbers. By our accounting, we would guess that the nation will be spending at least $25 billion annually to control ground-level ozone by the year 2000. If our rough estimates are correct, we will soon spend about as much each year to comply with the ozone standard as we currently spend on all federal food stamp programs for the poor. Now spending the same amount on ozone control as on food stamps may be perfectly appropriate; after all, people in all walks of life are affected by poor air quality. But we believe that the allocation of resources is a subject about which there should be open and informed debate. In our opinion, we ought not to spend more on ozone control than we do on food stamps (or vaccinations, for that matter) simply because we can find a "safe" level at which to set an ozone standard.

Elevating environmental quality to the status of a constitutional right, as some have proposed, would remove neither the necessity for nor the desirability of balancing.

This argument applies to other environmental standards. Even if it were possible to identify a safe level for, say, a drinking water contaminant, it doesn't follow that all communities should be required to meet that level under the Safe Drinking Water Act. Some communities might quite rationally decide to aim at a somewhat less ambitious standard and use the cost savings from doing so to finance another public program. In fact, the current flap in Washington over so-called unfunded mandates—federal regulatory requirements that fall on lower levels of government rather than on corporations—hinges on this point. State and local governments resent being told that they must spend their scarce resources on priorities established in Washington when they face other problems that they sometimes feel are far more pressing.

The costs-are-considered-anyway argument

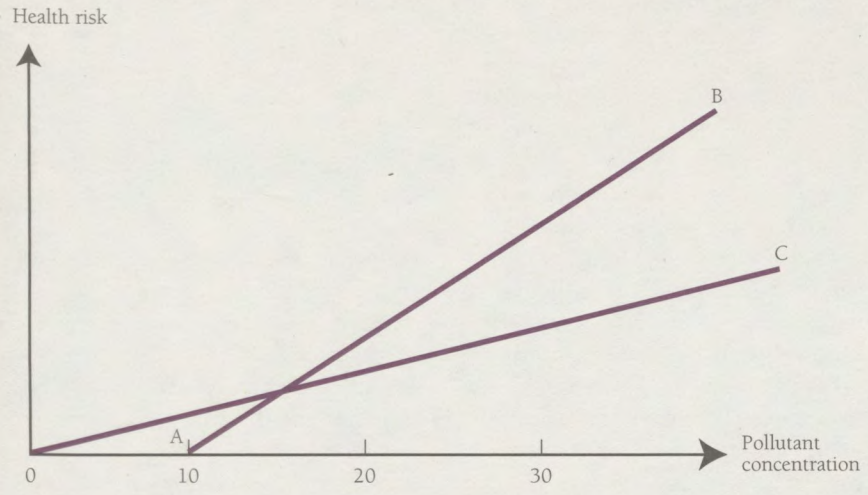
It could be argued that federal regulators inevitably consider costs in real-world environmental decisionmaking, despite the apparent statutory prohibition against doing so. Nonetheless, some people would assert that we should maintain the principle of excluding costs. This argument has two variants.

According to the first variant, we ignore costs in selecting ambient environmental standards, such as standards for the quality of our air and water, but take them into account in writing discharge standards for individual sources of pollution, such as electricity-generation facilities that often put sulfur dioxide into the air or farms that use pesticides that run off into lakes, rivers, and streams. These discharge standards place limits on the amounts of various pollutants that pollution sources can emit into the environment; the limits are intended to bring air and water quality, for example, into attainment with ambient standards. Typically, the discharge standards direct pollution sources to install the "best available technology," when these technological requirements are "affordable" or "economically achievable." In this sense, costs do come into play, ensuring that unaffordable discharge standards will not be imposed.

But what if the affected pollution sources cannot "afford" the technological requirements that would be necessary to meet ambient environmental goals? Short of extending the deadlines for complying with these requirements, EPA has little choice but to close down the affected sources. In short, costs can be taken into account, so long as the ultimate goals of environmental policy will be met; but those costs mean nothing if health-based standards are not met.

Insisting on effective discharge standards is appropriate if truly important

Two possible relationships between exposure to pollution and adverse health effects



Through clinical, epidemiological, or animal toxicological studies, researchers try to identify a dose-response relationship between exposure to a harmful substance and adverse health effects—for example, incidences of cancer and asthma attacks. The line AB illustrates a case in which pollutant concentrations below ten units cause no such known effects. In this case, setting a pollution standard at some level below ten units would provide a "margin of safety" against adverse health effects. If the true dose-response curve is more like the line OC, however, then any pollutant concentration above zero units would give rise to some risk. In this case, no safe level is likely to exist for the pollutant in question, making standard setting much more complicated.

health values, ecological values, or both would be compromised. But suppose that all the firms in a particular industry could afford to install the most sophisticated—and, therefore, the most expensive—pollution-control equipment made. Not everyone would agree that they should be required to do so simply because they can afford it—particularly if the health benefits of installing the equipment were deemed to be of marginal significance (that is, would reduce risk very little). While several of our current environmental statutes imply that any affordable environmental goal should be required, we suspect that many people would disagree. And they might ask whether these same statutes are creating a disincentive to succeed by requiring profitable, well-managed firms to meet stringent technological discharge standards, while treating leniently firms or industries that are on the brink of bankruptcy.

The second variant of the costs-are-considered-anyway argument is both frustrating and harder to rebut. According to this variant, we do not have to change environmental laws in order to balance health considerations against economic and other considerations, because such balancing occurs sub rosa each time that EPA sets health-based standards. So why, the argument goes, make balancing a requirement by law?

EPA *does* appear to take economic effects into account in setting some supposedly health-based standards. For instance, in 1978, when EPA promulgated the National Ambient Air Quality Standard for ozone, it stated that finding a literally "safe" ozone level was impossible and that setting a very tight ozone standard would significantly and negatively affect economic and social activities. For this reason, EPA rejected a zero-level standard. According to the documentation supporting the 1978 revision of the ozone standard, public health was the most compelling factor in the revision, but economic impact also was weighed.

If EPA acknowledges that economic impacts play at least some role in its setting of ambient standards under the Clean Air Act, and if this role is recognized and condoned, then it seems to us that Congress should amend the act, and other environmental laws as well, to explicitly allow balancing of health and economic considerations in standard setting. If that is current practice, and there exists general agreement that such practice is appropriate, then balancing should be explicitly encouraged in the law. Not to do so engenders cynicism about the seriousness of our national intentions as well as contempt for our laws. Moreover, if no "safe" levels of many environmental contaminants can be found (as we suggest above), we cannot understand how Congress can avoid making our environmental laws explicitly require that health effects be balanced against economic and other possible adverse consequences.

Balancing benefit-cost information with other information

We do not intend to suggest that establishing ambient environmental standards should be set on the basis of a formal quantitative benefit-cost analysis alone. Several considerations hinder an attempt to do so.

First, despite great progress in understanding how individuals value better health, reduced risks of premature mortality, aesthetic amenities, and other environmental benefits, economists are still a long way from pinning down precisely the marginal benefits associated with proposed changes in ambient environmental standards. In particular, great uncertainty surrounds estimates of how many lives such changes will save, how many illnesses they will prevent, and how much ecosystem protection they will provide.

Second, the costs associated with tighter standards are much harder to estimate than the public—and even

some economists—realize. One reason is that regulations can impose costs even when no one must make out-of-pocket compliance expenditures. This would be the case if a regulation led, for example, to the withdrawal from the market of a useful product. Another reason is that regulated parties often cannot foresee technological advances that will reduce their compliance costs.

Third, even if we knew the marginal benefits and costs associated with alternative environmental quality standards, we still would not know whether equating the two would result in the "right" standard. Among other things, we might wish to know just who the winners and losers would be under new standards. For instance, suppose that only millionaires benefited from a tighter air quality standard, while the poor paid all the costs. Even if the added benefits from the tighter standard greatly exceeded the costs, we might resist adopting the new standard unless we could find a way to redistribute some of the net gain. In short, distributional considerations and other nonquantifiable factors having nothing to do with economic efficiency also matter a lot in standard setting.

Objecting to formal benefit-cost analysis as the sole basis for public decisionmaking is easy enough. Determining how such analysis *should* be used is far more difficult. We believe, however, that an analogy drawn from decisionmaking in the private sector can be useful in making this determination.

Before making an important investment decision, a good corporate manager will gather reports on the financial soundness of the venture and the expected future profits. Rather than slavishly basing a final decision on these reports alone, the good manager will temper the analytical information with his or her own judgment and experience. The manager may decide, for example, to overrule an apparently unfavorable financial projection out of a conviction that the long-run health of the company requires entry into new markets that will not pay off for some time. Or he or she may decide that the profit potential does not outweigh the risks of the project. In short, the manager understands that analytical information will rarely be complete or accurate enough to base decisions entirely on it. Giving due weight to and acting on information from all sources is the essence of good decisionmaking, and one of the private sector's strengths is its ability to recognize and reward good decisionmaking.

In the public sector, decisionmaking differs in ways that may make the use of formal benefit-cost methods both more difficult and, arguably, even more important. First, benefit-cost analysis in the public sector will probably be neither as complete nor as precise as its private-sector counterpart. Second, the public manager may have to weigh additional objectives, such as the distribution of benefits, that do not easily fit into a formal benefit-cost analysis. Finally, success and failure in the public sector are much harder to identify, making any need to take corrective action that much more difficult to discern.

We are not suggesting that ambient environmental standards should be set on the basis of a formal quantitative benefit-cost analysis alone.

Since feedback from public-sector decisions is often weaker or more ambiguous than that from private-sector decisions, the methods and data used in making decisions become more important. While much of that information will be incomplete or imprecise, it will not be useless as long as its limitations are understood. If public decisionmakers are good at what they do, they will be able to weigh both the content and the quality of information about benefits and costs in the context of available information. Those who believe that decisions would be improved if benefit-cost information were denied to decisionmakers must harbor a pessimistic view of decisionmakers' abilities, a view that sits oddly with a generally expansionist view of the role of regulation.

Taking economic issues seriously

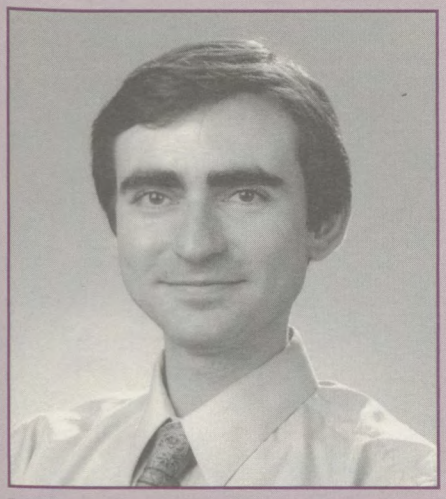
Refusing to admit the need to consider costs may result from our collective desire to believe that difficult trade-offs need not be made. Well, we can't have it all. After more than twenty years of concerted efforts to meet our nation's environmental quality goals, we are still short of the mark in many areas. Moreover, since we now have acted upon the least expensive opportunities to reduce pollution, the remaining options are generally quite costly. Thus, providing all the protection we would like to provide is even less likely than it was two decades ago.

Nothing is wrong with wanting to provide maximum environmental protection to all citizens, just as we would like to provide all the other comforts of a happy and prosperous life. But something is wrong with denying that resources are scarce relative to our prodigious wants and that we must, accordingly, accept unpleasant trade-offs. Since in public rulemakings we openly acknowledge that we cannot find safe levels of environmental contaminants and since we admit the importance of economic considerations, shouldn't we revisit those portions of our environmental statutes that prohibit even the consideration of costs in standard setting? While economic considerations should never take primacy over public health or ecological concerns in policymaking, we believe that the answer to this question is an unambiguous yes.

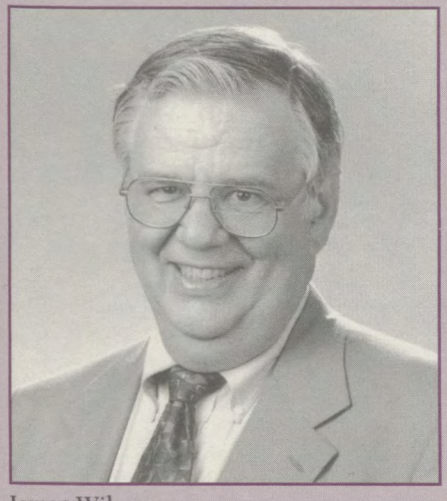
Paul R. Portney is vice president of and a senior fellow at Resources for the Future. Winston Harrington is a senior fellow in the Quality of the Environment Division at RFF. *A longer version of this article appeared in the Spring 1995 issue of* Policy Studies Review.

INSIDE RFF NEWS AND PUBLICATIONS

Two new fellows appointed to RFF



Ian Perry



James Wilson

Ian Parry and James Wilson have joined the research staff of RFF. Parry, who will take up residence in September, was appointed a fellow in the Energy and Natural Resources Division. Wilson, who came on board in April, was appointed a senior fellow in and resident consultant to the Center for Risk Management.

Parry received a Ph.D. in economics from the University of Chicago, where he specialized in public finance and industrial organization. Since completing his degree in 1993, Parry has been working at the U.S. Department of Agriculture's Economic Research Service. At RFF, he plans to study the interactions between environmental policy and the tax system.

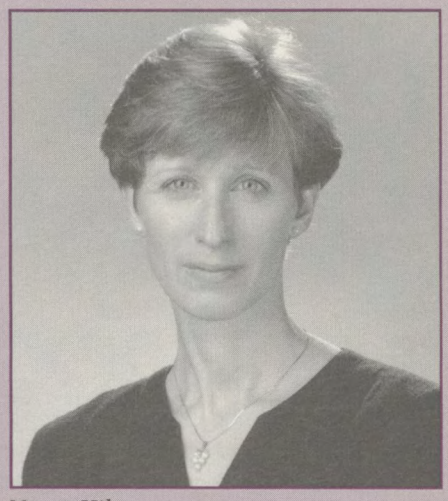
Wilson received a Ph.D. in organic chemistry from the University of Washington, where he was a National Science Foundation Fellow. A former president of the Society for Risk Analysis in 1993 and most recently the director of regulatory issues for Monsanto Company, he will develop and lead the center's risk analysis program. In announcing Wilson's appointment, center Director Terry Davies said that Wilson is "one of a very few individuals who have successfully combined in-depth technical knowledge of risk assessment with knowledge of the uses and limits of risk analysis in public policy."

Congressional testimony on Superfund

On June 22, Katherine N. Probst, a senior fellow in the Center for Risk Management at RFF, presented testimony on the Superfund program at a hearing held by the Subcommittee on Water Resources and Environment of the House Committee on Transportation and Infrastructure. Her remarks focused on two key issues: first, the current liability scheme and the implications of eliminating retroactive liability and, second, the need for clearer cleanup goals in the Superfund law.

Critics of Superfund say that its liability standards are unfair, because companies may be held liable for waste disposal actions that were taken before Superfund was enacted and that were in accord with the rules and regulations in effect at the time. Moreover, they argue that the standards make for lengthy and costly

continued on page 14



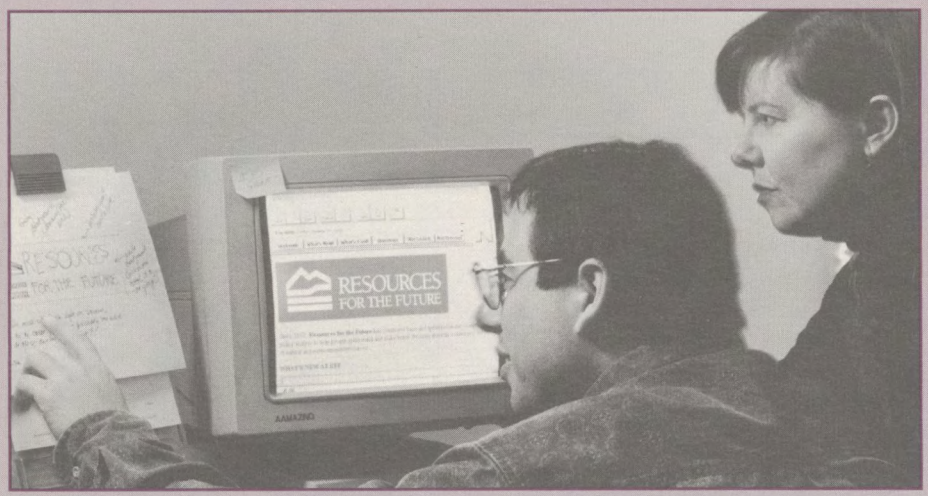
Nancy Hiles

New development director joins RFF

Nancy Hiles joined RFF as its new director of development on April 3, 1995. Formerly the director of development and the senior development officer at the University of Maryland–College Park, Hiles will manage RFF's fundraising activities and seek out new funding sources.

Over the past few months, Hiles has been helping RFF to assess its development program. She noted that foundations and corporations traditionally have been major sources of support for nonprofit organizations such as RFF, but that individual donors increasingly are becoming an important source of funding. In fact, in the United States, giving to nonprofit organizations by individuals has surpassed in dollar amount giving by either foundations or corporations.

Hiles said that RFF will be expanding its individual giving program. "While foundations and corporations, as well as government agencies, will always be important contributors to RFF," said Hiles, "individuals are starting to play a significant role in helping RFF to continue its work. We're excited about making individuals more aware of RFF's goals and activities and in getting them involved in RFF's mission."



Rodney K. Elin of RFF's Computer Services and Ann E. Checkley of the Office of External Affairs are shown here working on RFF's World Wide Web site on the Internet.

RFF on the Internet

Newly available on RFF's World Wide Web home page are institutional news from the pages of *Resources*, recently published articles by RFF researchers, and tips on where to find useful environmental and economic resources.

RFF's home page also posts information about RFF and its activities. General information includes a brief overview of RFF (history, goals, activities, and research areas); portions of RFF's annual report; and descriptions and application announcements for RFF fellowships and internships. A "What's New" section includes a list of upcoming Wednesday noon seminars by RFF staff and invited speakers, press releases, descriptions of new RFF books, recent articles by RFF staff, and the text of congressional testimony by RFF staff.

RFF's home page also provides information about RFF's publications and discussion papers, as well as links to other environmental and economic resources available on the Internet.

According to Edward F. Hand, RFF vice president–finance and administration, RFF plans to make increasing use of the Internet to disseminate a wider variety of information in a more timely fashion. "Since a large part of RFF's mission is to educate," said Hand, "we're always looking for better ways to make RFF research available to the public. Clearly, the Internet is the communications wave of the future. It will play a larger role in our communications efforts."

In the future, Hand said, Internet users will be able to access material available on RFF's home page through FTP and Gopher. In the meantime, users can access RFF's home page by pointing their browsers to http://www.rff.org on the World Wide Web.

RFF granted consultative status with UN council

RFF's application for consultative status with the Economic and Social Council of the United Nations (UN) was approved by the UN Committee on Non-Governmental Organizations on June 19, 1995. As a result, RFF will be placed on a roster of consultants having special competence in some of the council's fields of activity. As a nongovernmental organization with consultative status, RFF could be asked for advice by the council, other UN organs, or the UN secretary general. It also could be asked to participate in UN conferences.

Recipients announced for Joseph L. Fisher Dissertation Awards

In honor of the late Joseph L. Fisher, RFF President from 1959–74, RFF annually awards fellowships to students in economics and other policy sciences disciplines to support their final year of graduate study. To be eligible for the fellowships, students must be writing dissertations on issues related to the environment, natural resources, or energy. In announcing the winners, RFF Vice President Paul R. Portney reported that interest in the fellowships continues to grow, making competition more intense than it has ever been.

Each of the following individuals received a $12,000 fellowship for the 1995–96 academic year to support the completion of the dissertations indicated.

- Brent Hueth, Department of Agricultural and Resource Economics, University of Maryland: "Optimal Implementation of Conservation Projects under Asymmetric Information."
- Loretta Lynch, Department of Agricultural Economics, University of California–Berkeley: "Agricultural Trade and Environmental Contamination: Three Essays Investigating Pest Control, Regulation, and Environmental Issues."
- Linwood Pendleton, School of Forestry and Environmental Studies, Yale University: "A Unified Theory of Recreation Demand Analysis: Finding Common Ground among the Random Utility and Hedonic Travel Cost Models."
- Toddi Steelman, School of the Environment, Duke University: "Public Participation in National Forest Planning: A Case Study of the Monongahela National Forest, West Virginia."
- Richard Woodward, Department of Agricultural Economics, University of Wisconsin–Madison: "The Economics of a Sustainability Constrained Economy."

Gilbert F. White fellows selected

Each year, Resources for the Future awards resident fellowships that honor Gilbert F. White, retired chairman of the RFF board. The fellowships are given to postdoctoral researchers who wish to devote a year to scholarly work in the social or policy sciences in areas related to the environment, natural resources, or energy.

The recipients of the fellowships for the 1995–96 academic year are Brent Sohngen and Todd Strauss. Sohngen, who will soon receive his Ph.D. in natural resource and environmental economics from Yale University, will be measuring the economic impact of climate change on global timber markets by integrating ecology and economics. Strauss, who received his Ph.D. in industrial engineering and operations reseach from the University of California–Berkeley and who is on the faculty of the Yale School of Management, will be studying the response of the electric power industry to the Clean Air Act.

New publication

The RFF Database of Superfund NPL Sites

The *RFF Database of Superfund NPL Sites* includes information on 1,134 nonfederal sites on the U.S. Environmental Protection Agency's (EPA) National Priorities List (NPL). RFF created the database to estimate the financial impact of alternative Superfund liability schemes on the size of the Hazardous Response Trust Fund and on major industry sectors likely to bear the cost of cleanup under the current liability scheme. RFF's estimates of the costs of five different liability alternatives are presented in the book *Footing the Bill for Superfund Cleanups: Who Pays and How?*, published jointly in early 1995 by RFF and the Brookings Institution.

The RFF database can be used to estimate the effects of different liability schemes on needed trust fund revenues as well as the total transaction costs of the responsible parties and the magnitude of cleanup costs borne by key industry sectors. Information on each site includes:

- the name of the site and EPA identification number;
- the industry sector most likely to bear the initial cost of cleanup;
- the number of potentially responsible parties (PRPs) at the site;
- whether the site is an "orphan" site, that is, without a financially viable PRP;
- the type of facility on the site (such as chemical manufacturing facility, wood-preserving facility, codisposal landfill);
- the date waste was last disposed (before 1980 or 1987); and
- estimated total site cleanup costs, based on average cleanup costs for sixteen different types of NPL sites.

The *RFF Database of Superfund NPL Sites* will be available on PC-DOS diskettes, both on 3.5" (1.44 MB) and 5.25" (1.2MB) diskettes. This database also will be available on the Internet: point your browser to http://www.rff.org to access RFF's home page.

PC-DOS diskette / ISBN 0-915707-78-0 / $25.00

To order **books and diskettes**, add $3.00 for postage and handling per order to the price of books and send a check payable to Resources for the Future to:

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RFF looks at Superfund

The RFF Database of Superfund NPL Sites

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Footing the Bill for Superfund Cleanups: Who Pays and How?

Katherine N. Probst, Don Fullerton, Robert E. Litan, and Paul R. Portney

The authors explore the financial implications of changing two components of Superfund's current financing scheme—liability for cleanup costs and a series of taxes to raise revenues for the Superfund trust fund—on key sectors of the economy. They analyze who pays under the current approach, as well as under four alternative liability schemes that were hotly discussed in the 1994 reauthorization debate.

1995 / 176 pages
ISBN 0–8157–2994–4 (cloth) • $32.95
ISBN 0–8157–2995–2 (paper) • $12.95

Analyzing Superfund: Economics, Science, and Law

Edited by Richard L. Revesz and Richard B. Stewart

Superfund is roundly criticized as being wasteful and inefficient, excessively stringent and expensive, and plagued by high transaction costs, serious administrative deficiencies, and long delays. Despite these criticisms, Superfund has been the subject of little dispassionate study. *Analyzing Superfund* brings together some of the most important theoretical and empirical research on four issues central to the evaluation of Superfund: cleanup standards, the liability regime, transaction costs, and natural resource damages. The basic issues that it addresses will endure long after reauthorization is completed.

1995 / 260 pages (index)
ISBN 0–915707–75–6 (cloth) • $39.00

Bequests are resources for the future

Each year, thousands of individuals designate in their wills that a portion of their assets be given to nonprofit organizations. An important part of the American philanthropic tradition, bequests have become a major, stable source of support for these organizations. Indeed, between 1987 and 1994, bequest giving in the United States surpassed both corporate giving and foundation giving for the same period.

Bequests will always be the simplest method of planned giving to support Resources for the Future. They are welcome in any form—cash, specific personal or real property, or a share of the residue of an estate—and in any amount. And they can be unrestricted or designated for a specific purpose. For example, if you wish to memorialize a family member or an honored colleague, you can establish a named fund that will provide support for a program of special interest to you or the honored person.

Bequests to RFF benefit not only RFF but also the giver. Because of the estate-tax charitable deduction, a bequest can significantly reduce the tax burden of your estate. If, for example, you are subject to the top estate rate of 55 percent, a $100,000 charitable bequest saves you $55,000 in taxes, and you exercise the privilege of directing your lifetime accumulations as you wish. A charitable bequest also can provide lifetime income for a selected beneficiary.

Recently, RFF has received several generous bequests from individuals who know well the high caliber of RFF research. RFF Senior Fellow Allen Kneese, former RFF board member Thomas Klutznick, and retired board chairman Gilbert F. White have each made bequest commitments to RFF. They recognize that bequests are the resources for the future that RFF needs to continue its mission.

The RFF Development Office would be pleased to work with you and your legal and financial advisers to help develop a strategy for bequests to RFF that is right for you. If you have a specific question or concern about making a bequest, please call Edward F. Hand at 202–328–5029, or check the appropriate box on the enclosed envelope and return it to RFF. Thank you for your support.

For more information about the RFF Gift Fund, gift annuities, gifts of appreciated securities, bequests, or other types of planned gifts, please contact RFF Vice President–Finance and Administration Ted Hand at 202–328–5029 or check the appropriate box on the enclosed reply envelope for individual contributions.

Testimony
continued from page 11

cleanups. But Probst reported that changing the rules now could have a lasting negative effect on future compliance with environmental laws.

"We should not kid ourselves that eliminating retroactive liability and shifting responsibility for cleanups to the government is going to lead to cheaper, faster cleanups," said Probst. Releasing many private companies from Superfund liability, she noted, would actually *increase* the cost of and time spent on site cleanups.

Probst urged the subcommittee to wrestle with the issue of site cleanup goals. "Getting a clearer sense of what we are trying to achieve," Probst said, "is crucial to restoring the credibility of the Superfund program."

Recent contributions from individuals

The following individuals made gifts of $100 or more between March 11 and June 9, 1995 in support of research and education programs at Resources for the Future:

Anonymous (1)
Gianni Carbonaro
Ron Cummings
W. Kenneth Davis
Robert T. Deacon
Marian S. De Los Angeles
Richard Goodenough
David Harrison Jr.
Robert H. Haveman
Robert C. Holland
Thomas E. Johnson
Donald M. Kerr
George H. T. Kimble
Yoshifusa Kitabatake
Thomas H. Lee
Robert C. Lind
Raymond L. Murray
William F. Pedersen Jr.
Edward L. Phillips and Laurel Murphy
John W. Rowe
William R. Sizemore
Kerry and Pauline Smith
Loren K. Soth
Robert N. Stavins
Joseph Swierzbinski
John E. Tilton
Alexander B. Trowbridge
Pan-Long Tsai
William J. Vaughan
Henry J. Vaux
Peter F. Watzek
Mason Willrich
Dael Wolfle

Recent contributions from corporations and foundations

RFF received contributions from the following corporations and foundations between March 11 and June 9, 1995:

ARCO Chemical Company
ASARCO Incorporated
BHP Minerals International
Consolidated Edison Company of New York, Inc.
The Dow Chemical Company
Duke Power Company
Electric Power Research Institute
GE Fund
Johnson & Johnson Family of Companies
S.C. Johnson Wax
Merck Company Foundation
Mobil Foundation
New England Electric System
Occidental Petroleum Corporation
Olin Corporation Charitable Trust
Public Service Enterprise Group
Southern California Gas Company
TU Electric
Union Carbide Foundation

Matching gifts were provided by The GE Fund and WMX Technologies.

Using Science Soundly: The Yucca Mountain Standard

Robert W. Fri

Using "sound science" to shape government regulation is one of the most hotly argued topics in the ongoing debate about regulatory reform. Of course, no one is arguing that the government should rely on *unsound* science for its decisions. But supposing, as some reform advocates apparently do, that even the best science will sweep away regulatory controversy is equally foolish.

My experience as the chair of a National Research Council (NRC) committee that studied the scientific basis for regulating high-level nuclear waste disposal drove home this conclusion for me. I learned that science alone could resolve few of the key regulatory questions. More often, science could only offer a useful framework and starting point for policy debates. And sometimes, science's most helpful contribution was to admit that it had nothing to say.

A short history of nuclear waste regulation

Both commercial generation of electric power and government production of nuclear weapons result in high-level (long-lasting and highly radioactive) nuclear waste. At present, these wastes are stored at nearly a hundred sites around the United States, but federal policy mandates that the wastes ultimately be placed in a mined underground geologic repository. In 1987, Congress decreed that the first such repository be located at Yucca Mountain, which is near Las Vegas, Nevada.

The basic idea of geologic disposal is to use permanent natural barriers as a principal means of isolating nuclear waste from the environment. Over time, however, some of the radioactive material will escape from even the best repository. At Yucca Mountain, for example, the casks in which nuclear waste will be initially stored will eventually break down, allowing the waste to migrate to the water table, which is located several hundred feet below the repository, and contaminate the flow of groundwater away from the repository site.

This process may take many thousands of years, but the nuclear waste will retain some of its radioactivity for more than a million years. Once the groundwater is contaminated, then the people who use it for drinking and irrigation will be exposed to radionuclides. Given this inevitability, the goal at Yucca Mountain is to design a repository that will limit, over very long periods of time, the human health effects associated with nuclear waste releases to an acceptable level.

Developing a standard that defines this acceptable level is one of Washington's longest running regulatory dramas. After ten years of work, the U.S. Environmental Protection Agency (EPA) first promulgated a standard in 1985. But following a successful court challenge in 1987, the standard was remanded to the agency for revision. Before EPA could issue the new standard, however, Congress enacted the Energy Policy Act of 1992, which mandated a new and different process for setting the standard for the proposed repository at Yucca Mountain.

Congress clearly wanted to curtail the debate over the standard. To do this, it reposed considerable faith in sound science. It required the National Academy of Sciences (through the National Research Council) to evaluate the scientific basis for a Yucca Mountain standard and directed EPA to promulgate a new standard "based on and consistent with" the findings of the academy. At the time, the idea of constraining regulators with the findings of a scientific panel was unfamiliar to the agency and the academy. Since a similar idea is afoot in regulatory reform, the Yucca Mountain experience may be instructive for that debate.

The Yucca Mountain standard

Developing a standard that specifies a socially acceptable limit on the human health effects of nuclear waste releases involves many decisions. As the NRC committee learned in evaluating the scientific basis for the Yucca Mountain standard, a scientifically best decision rarely exists. The trick is to make the best use of the science that is available.

The committee recommended a standard stated in terms of risk of death, in part because future scientific reviews are likely to tighten a standard stated in terms of permissible radiation dose—a situation deemed socially, politically, and administratively undesirable.

The first decision that EPA faces is how to measure safety. This decision entails setting a socially acceptable limit on some aspect of the repository's performance. As a technical matter, for example, the limit could be stated in terms of how much radioactivity the repository releases per year, how much radiation people will be exposed to as a result of releases, or people's risk of dying from this exposure. The committee recommended to EPA a standard stated in terms of risk of death.

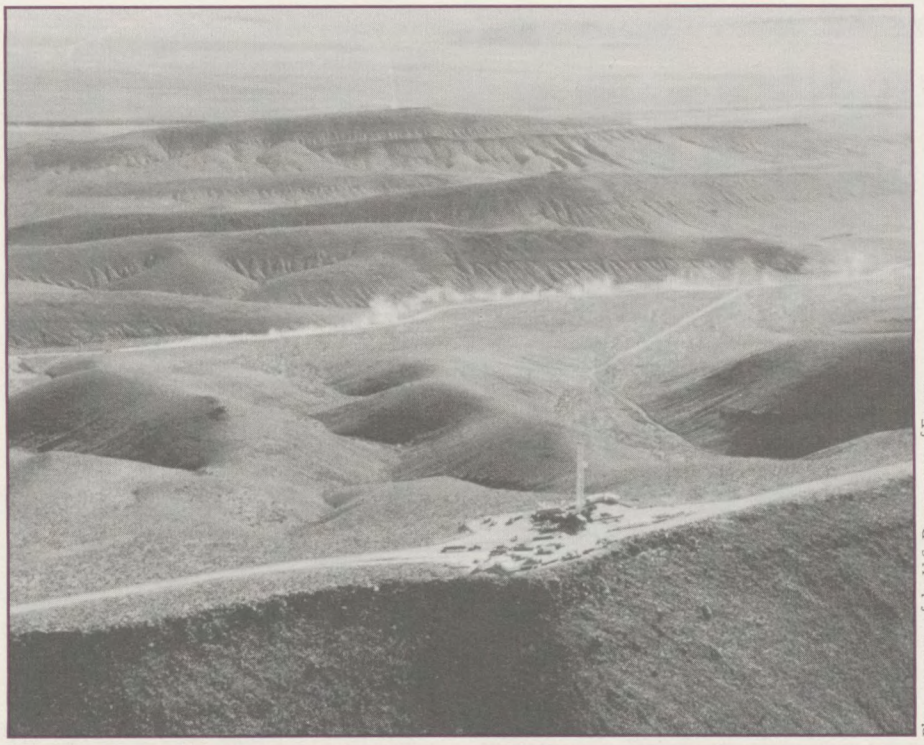

Photo courtesy of the U.S. Department of Energy

The lack of people living in the Yucca Mountain area was one reason for proposing the site as the nation's first geologic repository for high-level nuclear waste. But science cannot predict where people will live thousands of years from now. Policymakers will need to decide what to assume about the distribution of future populations in the area.

The evolving scientific understanding of the relationship between radiation doses and the health effects that they cause certainly influenced this recommendation. Over the years, successive scientific reviews typically have concluded that a given dose of radiation may cause more deaths than scientists had previously believed. As a result of this trend in science, it makes sense to state the standard as a limit on the number of additional deaths attributable to releases from the repository. Doing so would mean that the standard would not have to change as the science continues to evolve. This observation also weighed heavily in the committee's preference for a risk-based standard.

Although a scientific fact lies behind it, this recommendation is clearly not dictated by science. Changing a standard to incorporate new information is technically not a problem. The preference for a stable, risk-based standard rests on the belief that changing so controversial a standard as one that specifies the acceptable level of human health effects associated with nuclear releases is socially, politically, and administratively undesirable.

This intersection of science and policy permeates the other decisions that have to be made in setting the standard for determining whether the Yucca Mountain repository would adequately protect human health. In particular, EPA has to specify what level of protection is to be afforded, to whom, and over what time period. For only one of these decisions does science provide reasonably conclusive guidance.

Establishing the level of risk that the standard will allow is a question of policy, not science. In other contexts, however, EPA and other organizations have set limits on a variety of nuclear risks that range from one additional death per hundred thousand persons to one in a million. At best, this information provides a scientifically defensible starting point for debating the acceptable level of risk at Yucca Mountain. It certainly does not predestine the outcome. Acknowledging this reality, the NRC committee could only recommend a reasonable range of risks for EPA to consider in crafting its regulatory proposal.

To determine whether a repository provides the acceptable level of protection, the risk that repository releases could impose on a specific individual or group must be calculated. How this person or group is defined can determine whether the standard is met. It has a particularly significant effect on whether the standard is met at Yucca Mountain, because the geology of the site lends itself to the creation of spots—for example, places in a groundwater plume—at which radiation tends to concentrate. A clever opponent of the repository could define the person to be protected as someone drawing water for drinking and irrigation only from one of these hot spots. An advocate for the repository would naturally assume that the affected parties were located at a safe distance from these areas.

As a matter of policy, the NRC committee preferred to avoid these extreme assumptions. Given this policy, it looked to science (or at least to careful scientific thinking) to contribute a methodology for calculating compliance with the standard that resists extreme cases. The methodology that the committee chose was the "critical group method," which calculates the average risk to a member of the group at greatest risk.

Guidance for the time period over which the standard should provide protection is provided by the fact that radioactivity associated with high-level nuclear waste will not dissipate for more than a million years. Ideally, then, compliance with the standard would be tested over the full duration of this period in order to determine the time at which the greatest effect on human health occurs. Whether this determination is possible depends on the ability of scientists to evaluate the behavior of the repository over very long periods of time.

Here, for a change, is a question of science rather than policy. The commit-

tee answered it by saying that compliance assessment is feasible for most physical and geological aspects of repository performance on the order of a million years at Yucca Mountain. Still, this answer is based on the expert scientific judgment that the fundamental geologic structure will be relatively stable for this long, not on the testable hypotheses of scientific method. Thus, other experts might reach a different conclusion.

Running out of science

The NRC committee was able to recommend the foregoing elements of the standard with at least one foot in the realm of science. Unfortunately, however, science can contribute little to answering three of the most controversial questions that bothered Congress about the standard in the first place. For two of these questions, the scientific basis for decisionmaking essentially does not exist.

The absence of a scientific basis for predicting the behavior of humans many years into the future is probably a help in deciding whether we should continue to study the risk of human intrusion upon repositories after they close.

What is a negligible risk? The main concern of a standard for a nuclear waste repository is to protect populations living near the repository. In principle, however, a very large and dispersed population could be affected by releases of nuclear waste. In the case of Yucca Mountain, radioactive carbon dioxide gas could escape from nuclear waste canisters and be inhaled by people living far away from the repository. The carbon-14 problem, named after the radioactive isotope present in the waste, is one of the most vexing problems with which EPA must deal. Because carbon-14 releases from Yucca Mountain would be mixed with the global atmosphere, the health risk to any one individual is exceedingly small. On the other hand, the number of people exposed worldwide over the life of the repository is astronomical. If we multiply the very small risk by this very large number of people, we can calculate that many additional deaths could occur over a very long time period.

But how do we interpret a number computed in this way? No adverse health effects may occur at the very low doses of carbon-14 to which people would be exposed; but lacking data to show that this would be the case, experts in the field say that the prudent course is to assume that health effects will occur. Making this assumption could produce a scenario that leads either to abandoning the Yucca Mountain site or to spending a great deal of money to contain carbon dioxide gas.

To the dismay of policymakers, science cannot make this problem go away. Faced with this dilemma, the committee could only observe that the risk to any one individual in the global population would be very small—perhaps ten thousand times lower that the one-in-a-million level at which the basic standard might be set. A responsible decisionmaker could conclude that such risks are so negligible that they should not affect the design of the repository, but he or she would have to do so without much definitive guidance from the scientific community.

Can we guard against future human intrusion at a repository? One way to project significant human exposure to radiation releases from repositories is to assume that someone intrudes after they close. For example, a future oil explorer could drill into a waste canister and bring radioactive material directly to the surface. In crafting its charge to the NRC, Congress specifically asked whether any scientific basis exists for evaluating this risk or for assuming that it can be prevented.

The answer to both questions is no. The committee found no scientific basis for predicting the behavior of humans thousands of years into the future. Since neither the probability of human intrusion nor the effectiveness of preventive measures is predictable, the committee concluded that these issues should not be considered in the assessment of compliance with a risk-based standard. (We did, however, offer an alternative analysis to test the resilience of the repository to an assumed intrusion.)

In this case, the absence of a scientific basis is probably a help to decisionmaking. Admitting the limits of science should greatly reduce the considerable analysis and controversy lavished on speculation about the likelihood of human intrusion. I should note, however, that if regulators were deciding whether to dispose of waste at scattered surface sites instead of in a geologic repository, as at Yucca Mountain, analyzing the risks of human intrusion might be crucial.

What assumptions do we make about exposure scenarios? In all of the above issues, the committee walked the line between science and policy without dissent. But consensus failed when it came to specifying the exposure scenario to use in calculating compliance with the standard.

The exposure scenario describes how radiation that is released from the repository passes through the biosphere to expose humans. The scenario thus must specify whether and how water wells are drilled into the groundwater underlying Yucca Mountain, whether the water is used for drinking or irrigation, how much of a person's food intake is contaminated by this irrigation, and so on. Science can put bounds on many of these assumptions; for example, people can drink only so much water, and plants retain radionuclides at predictable rates. Developing exposure scenarios, even for the distant future, is therefore not entirely a blue-sky exercise.

Still, science cannot predict human behavior. This consideration is important in the Yucca Mountain case, because

the area is sparsely settled—one good reason for locating a repository there. Given this, what should an exposure scenario assume about whether someone is present to be exposed to any release that might occur?

Remember that the committee recommended a standard that would protect the people at greatest risk, while avoiding the trap of extreme assumptions. It would be inconsistent with this principle to base the exposure scenario on, say, the expectation that millions of people will move into the Yucca Mountain neighborhood. A more reasonable assumption is that farmers scattered about the area will comprise the population at greatest risk. Insisting on such a cautious but reasonable approach to narrow the range of assumptions about the distribution of population in the distant future is no small accomplishment. Indeed, doing so would considerably circumscribe the current debate about Yucca Mountain.

Even within this narrowed range of options, however, members of the committee disagreed on the exact population-distribution assumption that should be used. One member felt strongly that the exposure scenario should assume that a subsistence farmer will always be living at the place where exposure to radiation will be highest over the life of the repository. The other members believed that the physical features of the site naturally lead to a dispersed population and that the exposure scenario should take account of this fact.

These alternative views can excite considerable passion on the part of their proponents. In my view, however, such controversy obscures two crucial points. One is that the population-distribution assumption cannot be resolved on the basis of science. No one can predict where people will live in the future; therefore, regulators must make a judgment call in choosing an assumption about population distribution in the exposure scenario. The other point, noted above, is that the debate is over a fairly narrow range of assumptions. Despite the passion attendant on it, this debate is far more manageable than the open-ended debate to which EPA might be exposed if the committee had not narrowed the range of assumptions.

The role of science in regulatory decisions

The lessons that the NRC committee learned in studying the scientific basis for the Yucca Mountain standard may be important to those involved in the regulatory reform debate. The chief lesson is that the soundest science rarely provides black-and-white answers for regulatory decisionmaking; it only brightens a bit the familiar gray space in which decisions are made.

Science cannot protect public officials from hard decisions. Whether the risk from carbon-14 emissions is so small as to be negligible is a tough political call that science cannot—and should not—make.

To be sure, science can sometimes have a conclusive effect on a regulatory decision. In the Yucca Mountain case, the conclusion that the standard should be applied without time limit rests almost entirely on expert scientific judgment. By contrast, the current EPA standard applies only over a 10,000-year duration. Accepting the scientific judgment of the Yucca Mountain study would thus have a profound effect on the design of the standard.

Admitting that science has nothing to say also can powerfully affect decisionmaking. For example, the committee found no scientific basis for evaluating the probability of human intrusion. Therefore, it concluded that the issue should not be considered in assessing compliance with a risk-based standard. If EPA accepts this conclusion, a significant line of argument that could distract the regulatory debate will be closed off.

Mostly, however, the Yucca Mountain study shows that science is helpful, but not conclusive, in arriving at reasonable decisions—such as setting the acceptable level of protection, defining the people to be protected, and specifying the exposure scenarios to be used for compliance analysis. In these instances, the committee avoided asserting that sound science provided a complete answer, but did try to use scientific judgment to define a reasonable starting point and a bounded range of options for EPA to consider. In this way, science can be quite helpful in fostering constructive debate.

Finally, the Yucca Mountain study indicates that science cannot protect public officials from hard decisions. Advocates of the Yucca Mountain repository would like nothing better than for science to make the carbon-14 problem go away. But science cannot do that; it can only note that the risk from carbon-14 emissions to an average individual in the global population is exceedingly small. Whether these risks are so small as to be negligible is a tough political call that science cannot—and should not— make.

In short, the Yucca Mountain study clearly illustrates that excessive faith in the power of sound science is more likely to produce messy frustration than crisp decisions. A better goal for regulatory reform is the sound use of science to clarify and contain the inevitable policy controversy.

Robert W. Fri is president of RFF and recently chaired the National Research Council's Committee on Technical Bases for Yucca Mountain Standards. The views expressed in this article are his own and may not reflect those of the committee or the National Research Council. The complete report, "Technical Bases for Yucca Mountain Standards," is available from the National Academy Press by calling 202–334–3313 or 1–800–624–6242.

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