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Environmental Policy Since Earth Day I: What Have We Gained?

A. Myrick Freeman III

Earth Day I, which occurred on April 22, 1970, is an appropriate starting point for an examination of the economic benefits and costs that have been realized through United States environmental policy. There were federal laws on the books dealing with air and water pollution prior to that date. But those laws placed primary responsibility for the implementation and enforcement of pollution control requirements on the states, and by 1970, they had not accomplished very much.

The first Earth Day reflected a major increase in public awareness of and concern about environmental problems. It was followed in relatively quick succession by the passage of the Clean Air Act of 1970, the formation of the Environmental Protection Agency (EPA) in December 1970, and the passage of the Federal Water Pollution Control Act of 1972, now known as the Clean Water Act. In these two acts, much more stringent pollution control objectives were established, and responsibility for establishing and enforcing pollution control requirements was shifted largely to the federal government.[1] The next ten years saw the enactment of the Safe Drinking Water Act (1974), the Toxic Substances Control Act (1976), the Resource Conservation and Recovery Act (1976), the Comprehensive Environmental Response, Compensation and Liability Act (known as Superfund) (1980) and major amendments to the Federal Insecticide, Fungicide and Rodenticide Act (1972).

[1] For discussion of the context in which the Clean Air Act of 1970 and the Federal Water Pollution Control Act of 1972 were passed and the goals and aims of these acts, see Portney (2000) and Freeman (2000), respectively.

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Broadly speaking, the goals of environmental policy can be based either on a balancing of benefits and costs (economic efficiency) or on some other goal, such as safety, protection of human health, protection of ecosystems or the achievement of technically feasible levels of emissions control. Economic efficiency in environmental policy requires that the marginal benefit of environmental improvement in each dimension be set equal to its marginal cost and that each environmental improvement be achieved at least cost.

In the first two major environmental laws of the early 1970s—the Clean Air Act and the Federal Water Pollution Control Act—Congress explicitly rejected the economic approach to goal setting. With regard to clean air, it emphasized protecting human health. With regard to clean water, it emphasized achieving fishable and swimmable water quality. However, more recently, Congress has written implicit or explicit economic efficiency criteria into three major environmental laws: the Toxic Substances Control Act of 1976, the Federal Insecticide, Fungicide and Rodenticide Act of 1976 and the Safe Drinking Water Act Amendments of 1996. Moreover, as a result of a series of executive orders by presidents of both parties stretching back to the Nixon administration, there has been an expanding set of requirements for federal agencies to perform economic assessments of all major proposed regulations, including an assessment of their benefits and costs (Smith, 1984; Morgenstern, 1997; Hahn, 1996, 1998, 2000). These assessments are commonly referred to as "regulatory impact assessments."

In this paper, I will review the available information on trends in the major indicators of performance of the clean air and water laws over the past three decades and what can be said about the roles of these laws in explaining these trends. My main focus will be on what these improvements are worth to people (their benefits) and what they have cost. In aggregate, federal environmental laws are imposing significant costs on the American society. The most recent comprehensive EPA survey of the annual costs of compliance with existing environmental laws, done in 1990, estimated costs in the year 1990 to be about $152 billion, rising to perhaps $225 billion in 2000 (U.S. Environmental Protection Agency, 1990).[2] (All dollar values presented in this paper are expressed in 2000 prices.) Are the benefits of these far-reaching environmental laws commensurate with their costs?

The Clean Air Act

The goals of the Clean Air Act of 1970 are expressed in two major sets of provisions. First, Congress specified that EPA should establish the maximum allow-

[2] Unfortunately, the EPA has not updated its 1990 analysis, and I know of no other recent, comprehensive and credible estimate of total compliance costs for more recent years. Moreover, some analysts have substantial reservations about the methods used by the EPA to project compliance costs forward from 1990; they suspect that the costs for 2000 were substantially overestimated (Paul Portney, personal communication, July 26, 2001).

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able concentrations in the air for the six major "conventional" air pollutants: sulfur dioxide, nitrogen oxides, particulate matter, carbon monoxide, ozone and lead. These air quality standards were to be set so as to "protect human health . . . allowing an adequate margin of safety. . . ." This language and the absence of any reference to cost have generally been interpreted as meaning that the cost of attaining the standard was not to be taken into account in setting the standard.

The second major provision regarding goals in the original Clean Air Act was the establishment of specific tailpipe emissions standards for new cars, to be met originally by 1975 and 1976. These standards entailed reductions of 84 percent to 90 percent in emissions per mile traveled from the then current uncontrolled levels. These reduction targets were based on a crude calculation of what would be required to reduce the concentrations of these pollutants to levels where no adverse health effects were expected (Seskin, 1978; Tietenberg, 2000, p. 427). In subsequent amendments to the Clean Air Act, these tailpipe emissions standards have been further tightened, but these revisions have not been based on any explicit consideration of human health or cost.

Emissions and Air Quality

To assess the effects of the Clean Air Act on emissions and air pollution levels, it is not enough to show downward trends in measures of pollution. It is necessary to compare what emissions and air quality would have been in the absence of the act with what has actually been observed. As part of a retrospective analysis of the benefits and costs of the Clean Air Act, EPA developed a model of the United States economy to generate estimates of emissions of five major air pollutants both with the act and what they would have been in the absence of the regulations promulgated under the act (U.S. Environmental Protection Agency, 1997a). Figure 1 shows the actual estimated emissions of total suspended particulate matter for the country as a whole from 1950 to 1990 (labeled "Trends") along with the predicted emissions under the "Control" (the law passed) and "No-control" (the law didn't pass) scenarios. It shows that emissions actually declined from 1950 to 1970 and that the decline accelerated during the first decade of the Clean Air Act. Also, during the 20 years covered by the act, actual and predicted emissions were approximately equal. Finally, it shows that an increasing trend in emissions was expected to occur from 1970 to 1990 in the absence of the controls imposed by the act. The two principal sources of the projected increases were electric utilities and motor vehicles.

Figure 2 shows similar estimates of actual, control and no-control emissions of nitrogen oxides from 1950 to 1990. Actual emissions were increasing over the period 1950 to 1980 and were approximately constant from 1980 to 1990. EPA projected that in the absence of the act, the rising trend of emissions would have continued throughout the period. EPA has generated similar figures for emissions trends for sulfur dioxide, volatile organic compounds and carbon monoxide (U.S. Environmental Protection Agency, 1997a). In all cases, the analysis shows that the act had a significant effect in reducing emissions. These data suggest that the

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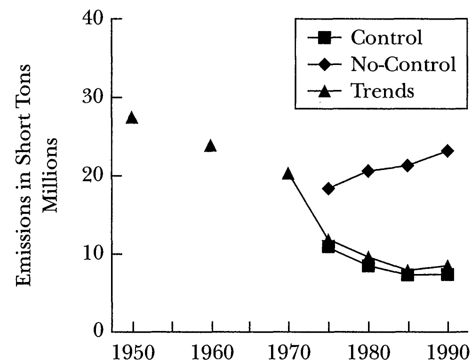
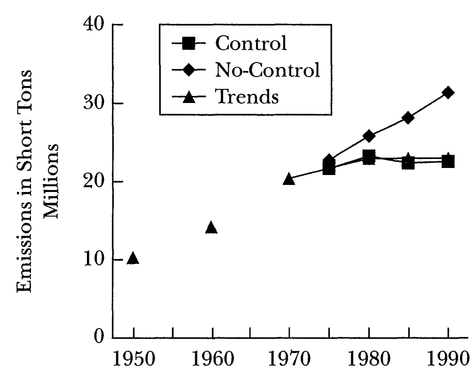
Figure 1
Comparison of Control, No-Control and Trends Total Suspended Particulates Emission Estimates



Source: U.S. Environmental Protection Agency (1997a).

Figure 2
Comparison of Control, No-Control and Trends Nitrogen Oxides Emission Estimates



Source: U.S. Environmental Protection Agency (1997a).

observed decreases in the national average concentrations of these pollutants can reasonably be attributed to the Clear Air Act. For more discussion of emissions and air quality, see Portney (2000) or U.S. Environmental Protection Agency (1998).

A similar modeling exercise undertaken for the prospective analysis of the benefits and costs of the Clean Air Act Amendments of 1990 projected emissions of the major air pollutants both with and without the amendments for the years 2000 and 2010 (U.S. Environmental Protection Agency, 1999). These projections show substantial decreases in the predicted emissions of volatile organic chemicals, nitrogen oxides and sulfur dioxide.

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Benefits and Costs

At the time that the original Clean Air Act was being considered by Congress in the late 1960s, no comprehensive assessments existed of the likely benefits and costs of the act—nor of any alternative changes in air pollution policy. In the ten years or so after its enactment, a number of studies were done of specific benefits from cleaner air, including health, reduced materials damage, public amenities and higher crop yields. In 1982, I published a review and synthesis of the available studies and compared my best estimate of the aggregate benefits realized as of 1978 with the costs as estimated by the Council on Environmental Quality (Freeman, 1982).[3] My estimate of benefits was based on the assumption that in the absence of the act, total emissions would have remained at the 1970 level. I considered costs and benefits separately for mobile sources—primarily motor vehicles—and for stationary sources—primarily industrial and power plants. I provided both best estimates and subjective uncertainty bounds, which were substantial.

As Table 1 shows, I found that the control of stationary sources was yielding substantial net benefits, but the emissions standards for automobiles were not. Almost 80 percent of the benefits were in the form of improvements to human health; and most of that category was due to reductions in premature mortality associated with airborne particulates. At that time, there was a great deal of controversy about the possible link between particulates and premature mortality. Now the evidence for such a link is substantially stronger, although controversy continues.

In Section 812 of the Clean Air Act Amendments of 1990, Congress expressed its concern over the economic consequences of the original Clean Air Act by directing EPA to undertake a "comprehensive analysis of the impact of this Act on the public health, economy, and the environment. . . ." This report is known as the "Retrospective Analysis." Congress also required that EPA publish an update of the original analysis and projections of future benefits and costs every two years thereafter. These reports are known as the "Prospective Analyses." Finally, Congress directed EPA to establish an independent panel of experts to review the methodologies, data and findings of the assessment.[4]

The EPA released its Retrospective Analysis (U.S. Environmental Protection Agency, 1997a) some six years after the deadline for publication. EPA modeled economic activity and the resulting emissions in the United States over the period 1970–1990 both with the Clean Air Act and under the assumption of no requirements other than those already in place in 1970. It estimated the monetary values of the reductions in the adverse effects of pollution brought about by the act. These effects included premature mortality, chronic bronchitis, other respiratory health effects, reductions in IQ associated with elevated blood lead levels in children, reductions in visibility, and damages to materials and crops.

[3] For further discussion of these estimates, see Portney (1990).

[4] In the interest of full disclosure, I served on this panel, which is known as the Advisory Council on Clean Air Compliance Analysis, from its inception in 1992 until 2000.

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Table 1
Benefits and Costs of the Clean Air Act as of 1978
(in billions of 2000 dollars per year)

	Mobile Sources	*Stationary Sources*	*Total*
Benefits	$ 0.8	$56.5	$57.3
Costs	$20.1	$23.8	$43.8

Source: Freeman (1982).

Table 2 shows that in this analysis, the estimated benefits exceeded the costs by a ratio of about 28:1, 45:1 and 48:1 in the three years selected. The EPA also carried out Monte Carlo analyses of benefits and reported sensitivity analyses of various categories of benefits under alternative assumptions. Even the 95 percent lower bound on benefits was an order of magnitude greater than the estimated costs. However, the EPA estimates understate the true uncertainty. The analysis of uncertainty in benefits considered only statistical uncertainties in the estimation of impacts and valuations. It did not include model uncertainties or uncertainties in estimates of emissions and changes in air quality. Also, there was no treatment of uncertainty in the cost estimates.

How plausible are these EPA figures? The EPA's estimates of average annual benefits are an order of magnitude higher than my estimates in 1982. Four factors account for most of this difference: the higher values used by EPA for the value of reducing the risk of premature mortality (based on more recent evidence); greater sensitivity of mortality to particulate matter exposures (again based on more recent evidence); different assumptions about air pollution levels in the absence of the act; and the inclusion of additional years with improved air quality.

The whole stream of benefits estimated by the EPA from 1970 to 1990 comes to $30 trillion (brought forward at 5 percent per year in 2000 dollars). Lutter and Belzer (2000) think that this amount is implausibly high, pointing out that this is "roughly the aggregate net worth of all U.S. households in 1990" (see also Portney, 2000, p. 110). But that comparison is somewhat misleading. A more accurate description would be to say that as of 1970 (the starting point of the Retrospective Analysis), the present value of the stream of future benefits from the Clean Air Act from 1971 to 1990 was about 20 percent of the present value of the future stream of personal income in the United States over that time. Many might feel that this amount is still too high. But I would argue that it is not wildly implausible that people would be willing to give up 20 percent of their income to avoid the increase in air pollution emissions that the EPA had projected for 1970 to 1990 and instead to experience the falling emissions and improving air quality associated with the act.

The EPA report does not provide separate estimates of the benefits of controlling mobile and stationary sources nor of the costs of eliminating lead in

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Table 2

Benefits and Costs of the Clean Air Act for Selected Years

(in billions of 2000 dollars per year)

	1975	*1980*	*1990*
Benefits[a]	$468	$1,225	$1,644
Costs			
Mobile Sources[b]	$7.2	$7.7	$8.8
Stationary Sources[b]	$8.1	$16.7	$23.5
Other[c]	$2.7	$2.9	$2.0
Total	$18.0	$27.4	$34.3

[a] Table I-5.
[b] Table A-9.
[c] Table A-9; monitoring, enforcement and R&D costs by governments.
Note: Column totals may not match due to rounding.
Source: U.S. Environmental Protection Agency (1997a).

gasoline so that program-specific benefits and costs can be compared.[5] But some interesting lessons can still be learned. First, 75 percent of the total benefits claimed by EPA come from reducing premature mortality associated with fine particles,[6] and another 8 percent of the total benefits come from reduced incidence of chronic bronchitis from the same cause. Since fine particles come mostly from stationary sources, the analysis shows that the benefits of stationary source controls on the emissions of fine particles and their precursors (oxides of sulfur and nitrogen) very substantially outweigh the costs. Second, the benefits of eliminating lead in gasoline are about 8 percent of the total, and they accrue primarily after 1985. Even if all of the mobile source control costs were attributed to removing lead, the benefits of lead removal would substantially outweigh the costs, and probably no more than 10 percent of the mobile source control costs reported here are associated with the lead program (U.S. Environmental Protection Agency, 1985). Finally, even if all of the remaining categories of benefits (primarily other respiratory health effects and crop damages) were attributed to controlling mobile source emissions other than lead, their costs would substantially exceed benefits.

[5] This was one of the major criticisms of both the Retrospective and Prospective Reports by the Council. See the Council letters to the Administrator, U.S. Environmental Protection Agency, Science Advisory Board (1997, 1999) available at ⟨http://www.epa.gov/sab/fisclrpt.htm⟩. See also Lutter and Belzer (2000).

[6] Since reductions in mortality figure so importantly in the estimates of the benefits of environmental policies described in this paper, it is useful to say a few words about how the monetary value of these benefits is calculated. The typical approach is to translate individuals' willingness to pay for a small reduction in the risk of death into a value per statistical life protected. This number is the average individual's willingness to pay for a small risk reduction divided by the change in risk. For example, if the average person had a willingness to pay of $50 for a reduction in the risk of death of 0.00001, the value of a statistical life would be $5 million. For a population of 100,000, there would be on average one fewer death per year; and the sum of the individuals' willingness to pay for the risk reduction would be $5 million. For further discussions of the issues involved in the economics of valuation of lifesaving policies and reviews of recent estimates of this value, see Viscusi (1992) and U.S. Environmental Protection Agency (1999).

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The EPA has now published its first Prospective Analysis, which estimates the benefits and costs associated with the Clean Air Act Amendments of 1990 (U.S. Environmental Protection Agency, 1999). It also shows total benefits well in excess of costs. However, the only explicit comparison of benefits and costs for a specific program is for Title VI, which limits emissions of stratospheric ozone-depleting substances such as chlorofluorocarbons. For this title, annual benefits are estimated at $33 billion over the next 75 years compared to annual costs of only $1.8 billion. Even if one looks at only the lower end of the 95 percent confidence interval for benefits, benefits for this title would exceed costs by nearly a factor of four (Table 8-4).

The EPA's estimate of the benefits of Title VI might be biased upward for several reasons. Reducing fatalities from melanoma (a form of skin cancer) is a major component of the benefits of controlling ozone depleting substances, but there is substantial uncertainty about the relationship between ultraviolet radiation and melanoma (U.S. Environmental Protection Agency, Science Advisory Board, 1999). Also, the analysis assumes no changes in behavior to reduce exposure to ultraviolet radiation as a way of mitigating the effects of stratospheric ozone depletion. It further assumes no improvements in cure rates for melanoma due to expanded early detection programs or improved treatment. On the other hand, benefits are understated to the extent that there might be significant ecological impacts due to ultraviolet radiation that are difficult to predict and evaluate in economic terms.

For the remaining parts of the Clean Air Act Amendments of 1990, aggregate benefits exceed costs by 4 to 1. But the 95 percent lower bound on benefits is less than the estimated costs. Moreover, as in the case of the Retrospective Analysis study, the true uncertainties are understated.

Again, it is possible to get some sense of the relative costs and benefits of the stationary source and mobile source programs by digging into the numbers. Title II establishes the emissions standards for vehicles, the reformulated gasoline and clean vehicle requirements and the requirements for inspection and repair of vehicles. The annual costs of Title II in 2010 are predicted to be almost $12 billion (U.S. Environmental Protection Agency, 1999, Table 8-3). Of the estimated $145 billion in annual benefits for that year, about $139 billion are attributed to the health benefits of controlling particulate matter emissions (U.S. Environmental Protection Agency, 1999, Table H-5). Even if *all* of the remaining $6 billion in benefits could be attributed to reductions in ozone concentrations due to Title II (and they cannot be), the total cost of Title II would be twice its benefits.

But even this comparison is too crude to be of much help to policymakers, since it does not identify which components of this complex set of legislative mandates and regulations are to blame for the negative net benefits of the Title II program as a whole. What is needed is an analysis that breaks out both benefits and costs for the specific components of this program (U.S. Environmental Protection Agency, Science Advisory Board, 1999).

All of this discussion takes the numbers in these two reports at face value. But

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it should be no surprise that the numbers themselves are quite controversial. The most controversial feature of the analysis is the relationship between particulate matter and premature mortality used by the EPA in calculating benefits (Crandall, 1997; Lutter and Belzer, 2000; Portney, 2000). The EPA's analysis implies that about 10 percent of all mortality in the United States is associated with particulate air pollution, which, at a glance, looks high. However, the EPA predictions do have some reputable evidence behind them. They are based on a long-term cohort epidemiology study that tracked more than 500,000 subjects from 151 cities over an eight-year period (Pope et al., 1995); and an earlier, smaller study from six cities estimated an even stronger relationship between premature mortality and particulate matter (Dockery et al., 1993). More recently, the Health Effects Institute reanalyzed the data from both studies and confirmed the results (Krewski et al., 2000). The association between premature mortality and particulate matter is also consistent with a number of studies of the relationship between daily mortality rates and daily changes in air pollution. For further discussion of these issues, see U.S. Environmental Protection Agency (1997a, 1999).

Another point of controversy in these EPA studies is the value placed on reducing premature mortality. EPA used a value per life saved of $6.3 million, drawn from an analysis of a set of estimates based mostly on the wage-risk tradeoffs revealed in labor markets. The sample mean willingness to pay for a reduction in risk from the labor market studies is for a roughly 40 year-old healthy worker with a substantial remaining life expectancy. But a major fraction of the people at risk of death due to elevated particular matter is much older, typically 70 and above. The life years to be saved are much fewer for the group experiencing the greatest reduction in the risk of premature mortality. It can be argued that the willingness to pay to reduce the risk of death for people in this group would be less than that of a typical 40 year-old.

Another issue involves the omission of indirect or general equilibrium effects in the estimate of costs. The EPA's cost estimate is the sum of annual direct expenditures on operation and maintenance and the amortized capital investments in pollution control equipment. Not included are the indirect costs that arise through general equilibrium effects in labor and capital markets that are already distorted by income and other taxes (Parry and Oates, 2000). These indirect costs could increase estimated costs by 25 percent to 35 percent (U.S. Environmental Protection Agency, Science Advisory Board, 1999).

While taking note of the issues raised here as well as of other matters, the panel that was established by Congress to review these studies characterized them as "serious, careful stud[ies] that, in general, employ[ed] sound methods and data" and produced conclusions that were "generally consistent with the weight of available evidence" (U.S. Environmental Protection Agency, Science Advisory Board, 1997, 1999).

Another way to assess the welfare implications of the Clean Air Act is to examine the regulatory impact assessments for specific regulations promulgated under the act. Hahn (2000) looked at 136 of these regulatory impact assessments

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carried out between 1981 and mid-1996 from eight different agencies, including those for 45 rules promulgated or proposed by EPA under the Clean Air Act. He put the regulatory impact assessments on a comparable footing by standardizing the discount rate (at 5 percent) and the valuation of reductions in premature mortality (at $5.6 million per statistical life). For the Clean Air Act, he found that in aggregate, the 35 final rules actually promulgated were estimated to produce net benefits of about $660 billion in present value terms. Almost two-thirds of this total is due to one regulation that substantially reduced the lead content of gasoline in 1985. Only 19 of the 35 rules had significant positive net benefits when evaluated separately. Similar results held for the proposed rules. Hahn argued that regulatory agencies in general are likely to overstate benefits and understate costs in these analyses, so that the true picture would be less favorable than his analysis shows.

The New Air Quality Standards for Particulate Matter and Ozone

The most significant recent policy choice made under the Clean Air Act is the revision to the air quality standards for particulate matter and ozone. The EPA is required to review the scientific evidence and consider revisions to each standard every five years. In 1996, the EPA proposed a significant tightening of these standards. In 1997, it released its regulatory impact assessment for the proposed standards. The proposal is interesting for both the legal and economic issues it raised.

The legal requirement that standards be set so as to protect human health with an adequate margin of safety can only be satisfied if the relationship between the concentration of the pollutant and the health effect has a threshold, as illustrated by function *A* in Figure 3. If there is no threshold, as with function *B*, reductions in concentrations all the way down to zero (or at least to the background environmental level) will increase the degree of protection against adverse health effects. For ozone and particulate matter, the scientific consensus is that there is no threshold (U.S. Environmental Protection Agency, Science Advisory Board, 1995; 1996). So how can the EPA comply with the mandate of the Clean Air Act?

The EPA promulgated revised standards for particulates and ozone that were above the zero or background level in July 1997. Affected groups, including the American Trucking Associations, appealed these standards to the U.S. Circuit Court. In *American Trucking Associations v. Browner* (No. 97-1441), the U.S. Circuit Court (1999) stated that "the only concentration for ozone and PM that is utterly risk free . . . is zero," "For EPA to pick any non-zero level it must explain the degree of imperfection permitted," and "EPA . . . has failed to state intelligibly how much is too much." The court also ruled that since the Clean Air Act provided no clear basis for deciding how much air pollution to allow, it was an unconstitutional delegation of legislative power. At the same time, the appeals court rejected the plaintiffs' claim that the Clean Air Act allows the EPA to take costs into account in setting air quality standards. Both parties appealed this ruling to the Supreme Court.

Of course one intelligible way to say "how much is too much" is to take costs

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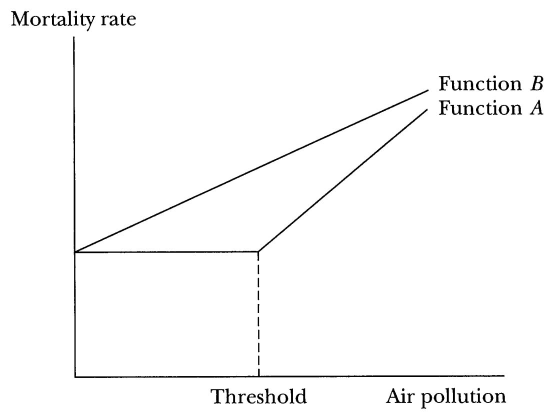
Figure 3
Threshold and No-Threshold Dose-Effect Functions



into account and to balance costs against benefits either formally or informally. In fact, the AEI-Brookings Joint Center for Regulatory Studies (2000) submitted a friend-of-the-court brief in the case signed by 39 prominent economists, including Kenneth Arrow, Milton Friedman and Robert Solow, arguing that point. However, in *Whitman v. American Trucking Associations* (No. 99-1257), the U.S. Supreme Court (2001) ruled that the Clean Air Act does preclude consideration of costs in setting air quality standards and that the limits on the EPA's discretion in setting standards are no more vague than in other statutes that have withstood judicial scrutiny. While this decision leaves the EPA's new standards for particulates and ozone intact, it also leaves the EPA with no guidance about how close to zero to set its pollution standards in future revisions. The U.S. Supreme Court decision has set up an awkward situation in which the EPA is required by the executive order to carry out what is, in effect, a benefit-cost analysis of alternative levels for the standards, but is bound by law to ignore the cost side of the analysis when making its decisions.

Despite this anomalous situation, the regulatory impact assessments done for the particulate and ozone standards are illuminating. The EPA reported estimates of benefits and costs of both partial attainment and full attainment of the proposed standards. This was because they could not identify control technologies that were capable of achieving the proposed standards in all parts of the country. The full attainment costs were based on the assumption that additional control technologies would become available at costs not to exceed about $10,000 per ton of emissions controlled. Although the EPA argued on the grounds of technological optimism that full attainment costs were likely overstated, it seems more likely that the costs are underestimated.

The EPA reported "low-end" and "high-end" estimates of costs and benefits, but did not report a best estimate or expected value. Neither did they incorporate uncertainties in the cost estimates. The results for partial attainment are shown in Table 3. The substantial net benefits for the proposed particulate matter standard

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Table 3
The Annual Benefits and Costs of Partial Attainment of the Proposed Air Quality Standards by $PM_{2.5}$ and Ozone
(in 2000 dollars)

	Benefits	*Costs*	*Net Benefits*
$PM_{2.5}$	$25 to $137 billion	$11.3 billion	$13.7 to $126 billion
Ozone	$0.5 to $2.8 billion	$1.4 billion	−$0.9 to $1.4 billion

Note: $PM_{2.5}$ is fine particles less than 2.5 microns in diameter.
Source: U.S. Environmental Protection Agency (1997b).

come primarily in the form of reduced risk of premature mortality, and, as noted above, there is controversy over the magnitude of this relationship. However, if the EPA's numbers are taken at face value, there is the additional question of whether an even stricter standard might be justified on the basis of marginal benefits vs. marginal costs. The EPA did do an assessment of the benefits and costs of partial attainment of a more strict standard for particulates, but they only reported the high-end value for benefits. The high-end analysis showed positive marginal net benefits. However, the best estimate of marginal net benefits is not reported, leaving open the possibility that they might be negative.

According to the EPA numbers, the net benefits of the proposed ozone standard could be positive. But the high-end estimate of benefits is based on a recent study that shows an association between elevated ozone levels and premature mortality. This finding is even more controversial than the particulate mortality relationship and has not been found consistently in other studies. If ozone does not cause premature mortality, then the proposed ozone standard does not appear to pass a benefit-cost test. Many analysts believe that the EPA substantially underestimated the costs of partial attainment of the ozone standard (for example, Krupnick, 1997). Thus, even the high-end positive net benefits are in doubt.

The Clean Water Act

The original version of the Clean Water Act became law in 1972 and established national goals for water pollution policy: the attainment of fishable and swimmable waters by July 1, 1983, and the elimination of all discharges of pollutants into navigable waters by 1985. The means selected for achieving this goal were a system of technology-based standards to be established by the EPA and applied to discharges from all industrial and municipal (especially sewage treatment plant) sources. These standards were to define the maximum quantities of pollutants that each source would be allowed to discharge. The standards were to be based strictly on technological factors, such as what kind of pollution abatement equipment was available, rather than on water quality objectives. Under the act, regulators did not

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need to estimate the capacity of bodies of water to assimilate pollutants nor to consider the relationship between individual dischargers and water quality. The act called for the same effluent standards to be applied to all dischargers within classes and categories of industries, rather than a plant-by-plant determination of allowable discharges on the basis of water quality considerations.

Economics played only a minor role in this process, in the sense that the requirement to use the best feasible technology was accompanied by phrases such as "at reasonable cost." But the relationship between benefits and costs played no explicit role in determining what levels of pollution abatement would be required under the act.

Accomplishments of the Clean Water Act

Bingham et al. (1998) used a model of pollution discharges and water quality across the United States to predict how much the water quality of our rivers improved because of the Clean Water Act as of the mid-1990s, compared with a baseline that assumed no additional controls on discharges with the passage of the act. The improvement in the number of river miles meeting water quality standards for various uses is relatively small. The number of river miles meeting standards for swimming, fishing and boating increased by only 6.3 percent, 4.2 percent and 2.8 percent, respectively.

In a review of this and other evidence on accomplishments of the Clean Water Act 1972, Freeman (2000) suggests that average water quality was not too bad in 1972 and has improved only modestly since then. However, certain local areas that were quite bad in 1972 have been cleaned up dramatically. Although the Clean Water Act has done a good job on "point sources" of pollution from factories and sewage treatment plants, it has done little to address "nonpoint sources" of water pollution, like runoff from urban and agricultural areas, which seem to be increasing.

Benefits and Costs

At the time of the passage of the original version of the Clean Water Act in 1972, no assessment of the benefits and costs of its major provisions existed. During the next decade, a number of studies of various categories of benefits were carried out, especially for water-based recreation. None of these studies would meet modern standards of benefit-cost assessment. They did not, for the most part, model the relationship between reductions in discharges and improvements in water quality, nor did they establish scenarios for what water quality would have been in the absence of the provisions of the act. Nevertheless, in 1982, I reviewed a number of these studies, synthesized their results and compared them with the limited information available on the costs of water pollution control under the act (Freeman, 1982). I concluded that the total costs of meeting the 1983 and 1985 targets were very likely in excess of the benefits.

The Bingham et al. (1998) study described above also provided estimates of the benefits of the predicted water quality improvements attributable to the Clean Water Act. It used estimates of willingness to pay for various levels of improved

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water quality from a contingent valuation study by Carson and Mitchell (1993) to calculate the benefits of attaining water quality targets for each river.[7] Total willingness to pay for the United States urban population was about $9.9 billion per year. This figure counts only benefits of in-stream uses and the pleasure received from the control of conventional pollutants. It does not include benefits for improvements in water quality in lakes, ponds, estuaries, and marine waters, benefits from the control of toxic discharges, or benefits associated with diversionary uses of water, such as municipal water supply.

However, the EPA estimates that the annual costs of water pollution control in 1990 were about $59.7 billion per year (U.S. Environmental Protection Agency, 1990). This is not directly comparable to the estimate of willingness to pay, since the years are different and the willingness to pay covers only some of the benefits of cleaner water. However, the rough magnitude of these estimates tends to support the conclusion that the Clean Water Act does not appear to have achieved benefits commensurate with its costs.

The assessments of specific regulations promulgated under the Clean Water Act are consistent with this conclusion. Hahn's (2000) study of the regulatory impact assessments carried out between 1981 and 1996 shows that for the eight final rules analyzed, aggregate benefits were about 5 percent of aggregate costs. The same conclusion held for the four proposed rules that were analyzed. Earlier, Hahn (1996, p. 215) had reported that only one of the rules analyzed between 1990 and mid-1995 had positive net benefits.

The Federal Insecticide, Fungicide and Rodenticide Act, the Toxic Substances Control Act and "Unreasonable Risk"

In 1972, Congress amended the Federal Insecticide, Fungicide and Rodenticide Act to allow pesticides to be registered for use so long as the EPA found that they would not "cause unreasonable adverse effects on the environment," "taking into account the economic, social, and environmental costs and benefits" of use. The second phrase, which is part of the definition of "unreasonable adverse effects," is clearly a call to balance benefits against costs in making decisions. In 1976, Congress enacted the Toxic Substances Control Act, which included authorization to regulate the production and use of existing and new chemicals if the EPA finds that they pose an "unreasonable risk of injury to health or the environment." Because of its legislative history and the earlier language in the Federal Insecticide, Fungicide and Rodenticide Act, the Toxic Substances Control Act has also generally been interpreted as allowing a balancing of benefits and costs (Shapiro, 1990; Augustyniak, 1997).

[7] In a contingent valuation study, values of environmental protection are determined from responses to hypothetical survey questions about willingness to pay for specified improvements in environmental quality. For discussion of these methods, see Portney (1994) and the exchange between Diamond and Hausman (1994) and Hanemann (1994) in this journal.

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The evidence on costs and benefits of the rules promulgated under these two acts is somewhat limited, but there are two main pieces of evidence. The first comes from Hahn's (2000) study of rules proposed or promulgated between 1981 and mid-1996. There were only six major rules promulgated during this time period under these acts. Their total present value of costs of almost $24 billion yielded only a little more than $0.3 billion in identified *and monetized* benefits. Hahn (2000, p. 44) reported that in most cases the EPA either identified benefits without quantifying them or did not identify any benefits.

The second piece of evidence is an analysis of EPA decision making under these two acts carried out by Van Houtven and Cropper (1996). This study looked at 245 decisions made between 1975 and 1989 about whether an existing pesticide could be reregistered for use. These decisions involved 19 active ingredients that are known or suspected carcinogens. The authors estimated a model to predict the probability that a specific use of an ingredient would be banned. Explanatory variables included expected numbers of cancer cases avoided for food consumers, those who apply the pesticide, and those who mix or load it, and the estimated costs of the ban. They found that the coefficients on cancer cases avoided for those who apply the pesticide and costs were both significant and of the expected sign, indicating that the EPA was considering both costs and benefits in its decisions. However, the average cost per cancer case avoided by banning uses was more than $70 million. Even if all pesticide-induced cancers were fatal, this cost is an order of magnitude larger than the value of statistical lifesaving typically used in analyses of benefits of regulation. This indicates that if a benefit-cost analysis of the whole package of decisions was done with a reasonable value of statistical life (say in the range of $3 million to $6 million), the program would fail unless other categories of benefits were quite large. However, it remains possible that certain individual decisions could pass a benefit-cost test.

Van Houtven and Cropper (1996) also conducted a similar analysis of EPA decisions under the Toxic Substances Control Act regarding banning the use of asbestos in a number of products. This analysis showed an even higher cost per cancer case avoided, suggesting that costs exceeded benefits here as well.

However, these studies give an incomplete picture of the impacts of these two laws. These laws, with their requirements for prior approval of new chemicals and pesticides, no doubt had a preventive effect that went beyond the specific approvals or denials of applications for uses. It is likely that some manufacturers chose not to develop some potential chemicals and apply for approvals on the expectation that the applications would be denied. To the extent that those potential chemicals would have had social costs that exceeded social benefits, the laws brought unmeasured economic benefits.[8] But it is also possible that these laws discouraged the development of some chemicals that would have been socially beneficial.

[8] I am indebted to J. Clarence Davies for suggesting this point.

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The Safe Drinking Water Act

The Safe Drinking Water Act was first enacted in 1974. It directed the EPA to establish safe standards for drinking water supplied by public water systems above a certain small size. These standards take the form of maximum allowable concentrations for chemical and microbial contaminants. In the first ten years after the passage of the act, the EPA promulgated only one maximum allowable concentration. Congress responded in 1986 by amending the act to include a listing of 83 contaminants and the requirement that maximum allowable concentrations be established for these contaminants within three years. While the EPA was not able to meet the three-year deadline, the task is now essentially complete.

For these water quality standards, are the benefits in the forms of improved human health and reduced risk of disease commensurate with costs of meeting these standards? The EPA was not required by law to address this question, and I know of no comprehensive assessment of this question. However, some revealing partial evidence is available.

A study of the results of the Safe Drinking Water Act done for the EPA by Raucher et al. (1993) sheds some light on the subject. Their analysis was limited to contaminants posing a risk of cancer. They first reported costs and cancer deaths avoided for the program as a whole. The result is a cost per cancer death avoided of about $4.7 million. This value compares favorably with the value of statistical life used by the EPA in several recent assessments ($6.3 million), which suggests that the benefits of the maximum allowable concentrations for carcinogens exceed the costs.

The authors then reported costs and deaths avoided for the ten most cost-effective contaminants (primarily volatile organic compounds). The cost per death avoided for these contaminants was an even more favorable $2.9 million, well below the EPA's value of statistical life. However, from these data it is possible to estimate the cost per life saved associated with the maximum allowable concentrations for the remaining carcinogens (more than 60 substances). This amount is a very high $127 million per death avoided, suggesting that the costs for these maximum allowable concentrations substantially exceeded their benefits. However, this calculation does ignore any benefits associated with reducing health effects other than cancer for these substances and also ignores the benefits and costs of reducing exposures to those substances that do not cause cancer.

Hahn's (2000) analysis of regulatory impact assessments carried out between 1981 and 1996 includes five final rules and three proposed rules under the Safe Drinking Water Act. Both the proposed and final rules taken as a group show aggregate benefits exceeding costs. But almost all of the benefits of the final rules are attributable to only one rule—regarding lead in drinking water (see also Levin, 1997). Again, it is thus possible to infer that the benefits are less than the costs for the other rules.

Amendments to the Safe Drinking Water Act in 1996 directed EPA to undertake an economic analysis of future proposed maximum allowable concentrations

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to determine if the benefits justify the costs and to adjust the maximum allowable concentrations in light of this analysis as necessary. Thus, the Safe Drinking Water Act joined the Federal Insecticide, Fungicide and Rodenticide Act and Toxic Substances Control Act as the only environmental laws that explicitly call for consideration of benefits and costs. The EPA has now finalized a rule for a maximum allowable concentration for radon.[9] As Hahn and Burnett (2001) point out, the EPA's own data show a benefit-cost ratio of only about 0.3 for this rule, and deficiencies in the EPA's analysis likely result in an overestimate of the benefits of the rule.

The Comprehensive Environmental Response, Compensation and Liability Act: Superfund

The Comprehensive Environmental Response, Compensation and Liability Act, commonly known as Superfund, was enacted in 1980 to provide for the cleanup of hazardous waste sites already in existence. Thanks to the Superfund Amendments and Reauthorization Act of 1986, more stringent cleanup requirements are in place today. The primary focus of the cleanup requirements is the protection of human health. The EPA investigates contaminated sites, estimates risks to health, and for those sites deemed to pose a risk to health, establishes a remediation plan based on criteria set forth in the act. Remediation plans are not subjected to a benefit-cost analysis.

Hamilton and Viscusi (1999a, b) have carried out a comprehensive analysis of the risks, costs and cost-effectiveness of the remediation plans for a selected sample of 150 Superfund sites in 1991–1992. The best single indicator of the relationship between the benefits and costs of remediation at these sites is Hamilton and Viscusi's estimates of the cost per cancer case avoided by the selected remediation plan. They found that for the 145 sites for which data are available, the mean cost is about $3.5 million per case avoided. Making the assumption that all cancers are fatal, this implies that a benefit-cost analysis using a value of anything above $3.5 million per death avoided would show that the program was economically justified. However, this result occurs because the aggregate data are dominated by a relatively small number of sites with low costs per cancer case avoided. About 70 percent of the sites have estimated costs per case avoided that are greater than about $112 million, implying that unless there are significant benefits in such categories as avoiding noncancer health effects and ecological and natural resource effects, the majority of the remediation plans are not economically justified, at least not at their present scope and degree of cleanup.

[9] In the closing days of the Clinton administration, the EPA established a new, more strict maximum allowable concentration for arsenic. But within weeks of taking office, the Bush administration withdrew the rule for further study and review of the scientific and economic bases for the standard.

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Conclusions

We have looked at the available evidence concerning the benefits and costs of the six major environmental laws enacted or substantially amended since Earth Day I: the Clean Air Act, the Clean Water Act, the Federal Insecticide, Fungicide and Rodenticide Act, the Toxic Substances Control Act, the Safe Drinking Water Act and the Comprehensive Environmental Response, Compensation and Liability Act. It is not a particularly useful exercise to attempt to aggregate all of the benefit and cost data reviewed here to arrive at a total net benefit estimate to try to see whether environmental regulation as a whole has been positive or negative. There have been some winners and some losers. The important question is what changes can we make to the current set of policies to improve the net benefits.

Among the winners in terms of net economic benefits are the following: the removal of lead from gasoline; controlling particulate matter air pollution; reducing the concentration of lead in drinking water under the Safe Drinking Water Act; the setting of maximum allowable concentrations on some volatile organic compounds under the Safe Drinking Water Act; the cleanup of those hazardous waste sites with the lowest cost per cancer case avoided under Superfund; and probably also the control of emissions of chlorofluorocarbons. These winners share the common characteristics of involving threats to human health, especially mortality, and widespread exposures of people. Even in the case of lead, which is primarily known for its toxic effect on nervous systems, a major portion of the monetizable benefits of controlling lead comes from the reduction in hypertension and the associated risk of cardiovascular disease in adults.

The environmental rules that appear to be losers in terms of net economic benefits include the following: mobile source air pollution control; much of the control of discharges into the nation's waterways, with the exception of some lakes and rivers that were especially polluted; and many of the regulations, standards and cleanup decisions taken under the Federal Insecticide, Fungicide and Rodenticide Act, the Toxic Substances Control Act, the Safe Drinking Water Act and Superfund.

Before turning to the policy implications of these findings, we need to identify some qualifications and caveats. All benefit-cost analyses have uncertainties and omissions. For example, there may be important effects of pollutants on human health that have so far escaped detection. If this is the case, present estimates of the health benefits of environmental cleanup are biased downward. Also, omitted benefits could include the protection of ecological systems and their services, preservation of biodiversity and what are called "nonuse" or "existence" values, meaning the value that people place on a cleaner environment as a goal in itself. Many natural scientists argue that ecosystem and biodiversity values are not given sufficient attention by economists (for example, Daily, 1997). But there is very limited evidence concerning the effects of present-day environmental policy decisions on ecological systems and biodiversity and these values were not a principal focus of most of the environmental laws considered here.

On the cost side, it is sometimes argued that costs are systematically overesti-

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mated because of the inability to anticipate the technological improvements in pollution control, process change and input substitution that are stimulated by the requirements of the regulations themselves (for example, Porter, 1991; Porter and van der Linde, 1995). On the other hand, Hahn (1996) argues that agencies have systematic incentives to underestimate costs and to overestimate benefits. Harrington, Morgenstern and Nelson (2000) found a limited number of cases of underestimation of costs, but for half of the rules they studied, they found overestimation of costs to be the case. Moreover, at least the most extreme versions of technological optimism regarding pollution control are not supported by the evidence (Palmer, Oates and Portney, 1995; Jaffe et al., 1995).

The first and perhaps most important policy implication of this analysis is to emphasize that virtually all environmental policies and programs could be improved by making them more cost-effective, that is, by finding ways to reduce the costs of attaining given targets.

One method to improve cost-effectiveness is to replace command and control policy instruments with market-based incentives, such as tradeable emissions permits, emission taxes and deposit-refund systems. The potential for effluent taxes, fuel taxes and tradeable permits to improve cost-effectiveness is especially relevant for water and mobile source air pollution control. For further discussion of the present potential of market-based environmental tools, see Stavins (2000), Portney (2000) and Freeman (2000). The cost-effectiveness of regulatory programs can also be improved by scaling back or eliminating specific regulations and standards where the costs per unit of measurable performance (for example, cost per cancer case avoided) are high and adopting more strict standards where costs per unit of performance are low. See, for example, Hahn (1996, 2000), Hamilton and Viscusi (1999b) and Raucher et al. (1993).

Another way to improve the economic performance of environmental policy is to give more weight to the comparison of benefits and costs, especially at the margin, in making environmental choices. As we have seen, some laws preclude balancing of costs and benefits in setting standards. But even where balancing is allowed or required—as in the Federal Insecticide, Fungicide and Rodenticide Act, the Toxic Substances Control Act and the Safe Drinking Water Act—the economic performance of environmental regulation has been spotty at best. Standards and regulations have been adopted even when realistic assessments show that the benefits are less than the costs. At a minimum, this result should make one skeptical of the argument that environmental regulatory agencies have been "captured" by polluting interests. Indeed, Hahn (1996) has argued that the substantial number of cases where environmental costs exceed benefits is evidence that regulatory agencies have been successful in increasing their power and expanding their budgets and roles in the American economy.

However, there are alternative explanations for what appears to be overregulation. One is that there may be benefits of regulation that economics has not been able to identify and quantify. It may be that these benefits are recognized by environmental decision makers and by the voters who apparently support these

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policies. Another way to put this is to argue that the American people, by their willingness to continue to support environmental programs that show measurable benefits that are less than costs, are revealing that they are willing to pay more for these environmental improvements than the amount captured by conventional measures of benefits.

Another possibility is that voters believe that at least for the policies they support, the costs are borne by others, the "black hat polluters." If this is the case, then the challenge for policymakers is to describe the opportunity costs of excess regulation to those who actually bear them and commit themselves to maintaining or improving standards in those areas where benefits demonstrably exceed costs. A public perception that the benefits of environmental protection can be realized while costs are borne by others will sooner or later collide with the reality that for the more intractable of our environmental problems—for example, the pollution and congestion externalities associated with private automobile transportation—we all will have to pay for any benefits we expect to receive.

It is difficult to know whether the American public would support a set of environmental policies that is economically rational by conventional measures. The challenge for policymakers may be to build credibility for cost-benefit analysis by making a public commitment to maintaining or improving environmental standards in those areas where benefits demonstrably exceed costs. By offering vocal support for environmental policies that do provide net benefits, and perhaps giving the benefit of the doubt to cases where the measurable net benefits are close to zero, policymakers may be able to build credibility when they need to argue that certain regulations have opportunity costs in excess of their benefits.

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