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Benefit Transfers and Valuation of Environmental Improvements

Alan J. Krupnick

Growing demand for analyses of the benefits of environmental improvements (or the costs of environmental damages) has increased interest in using estimates of such benefits in one setting to calculate benefits in another setting. At present, some types of these benefits (or costs)—which can be categorized as effects on health, output, economics assets, and environmental assets—are more amenable to such benefit transfers than others. Original studies that value health effects, for example, do not always lend themselves to benefit transfers. Most of the studies that value mortality risk address the risk of accidental death, which is an inappropriate context for valuing deaths from environmental causes. One way to make benefit transfers more feasible and reliable is to design original research with the purpose of obtaining results to be used in benefit transfers.

In the United States and elsewhere, there is a growing demand for analyses that quantify the benefits to society of improvements in environmental quality or the costs to society of environmental degradation. Since the establishment of environmental and natural resource economics as a discipline in the early 1970s, the primary demand for such benefit (or damage) analyses in the

United States has come from two sources: government agencies interested in determining how projects and policies affecting water resources will change the value of and demand for recreation sites, and agencies seeking to comply with Executive Order 12291, which mandates that a cost-benefit analysis be conducted for all major regulations.

Because it would not be feasible to conduct new research to analyze the benefits of every policy and regulation to improve the environment, interest has arisen in developing techniques for benefit transfers—that is, for applying benefit studies made in a specific policy context and location to another context, or location, or both. One of the most successful benefit-transfer exercises to date involves the U.S. Environmental Protection Agency's cost-benefit analysis of regulations for phasing down the lead content of gasoline. In this analysis, the agency used existing benefit studies to estimate the values of reducing premature deaths and of avoiding acute health effects by decreasing individuals' exposure to lead in gasoline. On the basis of these and other estimates, EPA argued that the phasedown made economic sense.

Demand for benefit transfers has increased in recent years. In the wake of several disastrous oil spills, the concept of benefit transfer has been em-

bodied in the U.S. Department of the Interior's Type A natural resource damage assessment model. This model uses original benefit studies of damages to recreational and commercial fishing and hunting from a given type and size of oil spill at given coastal locations to estimate similar damages from similar oil spills at any coastal location.

A fairly new demand for benefit transfers stems from a movement in the United States by state public utility commissions (PUCs) to formally introduce estimates of the environmental costs of alternative means for generating electricity into the decision making of electric utilities. At present, more than half of the states in the country require or are considering requiring electric utilities to account for residual environmental damages from alternative generation technologies when making decisions about which technologies to invest in. Without estimates of these damages, the utilities cannot make investments that minimize the social costs of electricity production.

Another potentially major source of demand for benefit transfers comes from international aid organizations, such as the World Bank and the U.S. Agency for International Development. These organizations are trying to value the environmental effects of projects in developing countries for which they are considering making loans or grants. Because there are few original studies of the benefits of environmental improvements in developing countries, the organizations are attempting to use the results of benefits studies in developed countries to estimate the value of the environmental effects of projects in developing countries.

Given the burgeoning demand for benefit transfers, it is important to consider limitations to the feasibility and usefulness of benefit-transfer exercises involving some types of benefits or damages. Benefit transfers involving environmental damages that result from electricity production, for example, are hindered at the start by the lack

of original studies that provide comprehensive estimates of such damages. Even if such studies were conducted, the use of their damage valuations in other contexts would be challenging for at least two reasons. First, because the extent and nature of environmental damages associated with electric power plants hinge on the location of the plants, analysts would have to develop and codify techniques for using the valuations to estimate the value of damages at each plant site. Second, in assessments of these damages, they would have to include the nonuse values of environmental assets not exchanged in the marketplace. The problem here is that studies of nonuse

Estimates of the environmental damages from electricity production that would result from benefit transfers are not yet credible enough to support the pricing of electricity at least social cost, but could be used to rank generation technologies according to social costs.

values cannot yet support benefit transfers involving the environmental damages resulting from electricity production. Most studies of nonuse values examine very large changes in the quantity or quality of environmental assets—such as the extinction of a species or the loss of an ecosystem—within unique environments. However, the effects of a single power plant on environmental assets at locations where it is acceptable to site power plants are likely to be trivial.

In the context of electricity production, estimates of damages that would result from benefit transfers would not

be sufficient or credible enough to support certain forms of social costing—namely, the dispatch of generating units and the pricing of electricity at least social cost. To rely on benefit transfers to determine the order in which different electricity-generation technologies should be used and the price that consumers should pay for electricity would be to push benefit-transfer techniques and original benefit studies beyond their present capabilities. However, benefit transfers can credibly support a rank ordering of new options for power generation on the basis of social costs—that is, they can indicate to utilities which technologies to invest in so as to minimize such costs. This capability is of significant value.

As in the case of environmental damages resulting from electricity generation, benefit transfers involving the environmental effects of foreign aid projects in developing countries may also have limitations. In using valuations from benefits studies conducted in developed countries to estimate such effects, analysts must take into account the differences between developed countries and developing countries with respect to personal income, institutions, cultures, climate, resources, and so on. Even if these differences can be reflected in estimates of benefits, it is debatable whether benefit transfers are legitimate for valuing certain types of nonmarket commodities in developing countries. This is because the basic tenet of individual sovereignty underlying benefit estimation in the United States and most other developed countries may not be applicable in societies that place emphasis on group welfare. Nevertheless, it may be better to make benefit transfers involving the environmental effects of foreign aid projects than to make no attempt to quantify these effects. Until developing countries conduct their own benefit studies, the careful use of benefit transfers should help analysts determine the impacts of such projects on the environment.

Which benefits can be transferred now?

The benefits of environmental improvements can be categorized as effects on health, output, economic assets, and environmental assets. As regards effects on output and economic assets, benefit transfers can be ignored. Damages to output—for example, damages to crops from air pollution or to commercial fishing from oil spills—are easy enough to estimate by conducting original research. On the other hand, damages to economic assets—damages to buildings from acid rain, for example—cannot reliably be estimated in original studies, let alone in benefit transfers, because inventories of such assets are lacking. In addition, no major studies have examined how owners of economic assets will act to minimize damages to such assets from pollution. Until behavior with regard to protective and mitigative measures is better understood, no benefit transfer to estimate the benefits of reducing damage to economic assets can be reliably made.

The category of benefits most amenable to benefit transfer is effects on health. Once atmospheric or other natural processes are taken into account—for example, in the estimation of the effect of reduced emissions on ambient air quality—it can be assumed that the health effects and the values people place on avoiding these effects are reasonably similar across locations.

Methods for estimating health benefits have been codified for many years. To obtain the mortality benefits from a particular program, for instance, estimates of the value of a statistical life are taken from original studies and multiplied by the number of deaths the program is expected to delay. A similar protocol is followed in using the literature on the values of avoiding acute health effects to estimate the benefits of pollution reductions. Indeed, there are spread sheet models available to obtain estimates of the health benefits of environmental improvements. These models

match estimates of changes in air pollution concentrations to dose-response functions for a wide variety of health effects and then match these functions to unit values for avoiding adverse effects.

Although benefit transfers involving health effects are the easiest to undertake, they are of the crudest type. Few of the spread sheet models used in benefit transfers account for differences between the age, personal income, and other socioeconomic characteristics of individuals at the site considered in the original study and those of individuals at the site being considered in a benefit transfer study. In addition, methods for establishing best estimates and margins of error in estimates of such benefits are ad hoc and differ from one benefit transfer study to another.

Not all original studies that value health effects lend themselves to benefit transfers. Most of the literature on valuing mortality risk addresses the risk of accidental death in prime-age adults. With the possible exception of deaths due to accidental releases of toxic substances, this risk context is inappropriate for valuing deaths associated with environmental causes—for example, deaths due to cancer in which pollution is a factor. One mortality-risk study does address the latency issue so important to valuing deaths due to cancer, but it is silent on the effect of prior health status and age on the willingness of people to pay for reductions in cancer risks.

The most problematic area for benefit transfer is damages to environmental assets such as plant and animal species in natural ecosystems, climate, visibility, and sites where natural geographic features provide recreational opportunities. Consider the difficulties the last two pose for benefit transfers.

Applying recreation values and demand functions from one study to another may present the greater challenge. Analysts may find it hard to account for regional factors (such as the range and quality of substitute recreation sites) and site-specific factors

(such as the amount of congestion at a given recreation area) that affect individuals' valuation of and demand for recreation sites. In addition, they have no acceptable procedures for determining the size of the population affected by a change in the quality or quantity of recreation sites.

Applying recreation values from one study to another is difficult because such values are highly sensitive to site-specific variables.

Benefit transfers involving recreation values present other difficulties as well—among them, the measurement of recreation values in dollars per day. Because unit-day values represent the average values of a wide range of site characteristics and policy scenarios, their application to specific sites is problematic. In fact, it is more difficult than the application of unit values to health effects because of the presumption that individuals' willingness to pay to avoid health damages is less influenced by site variables than is their willingness to pay for recreation. Another difficulty is the somewhat limited usefulness of the recreation literature in estimating some social costs. The majority of this literature focuses on changes in the availability of recreation resources, ignoring changes in their quality.

Benefit transfers involving visibility values present formidable challenges due to the sensitivity of these values to the characteristics of individual regions, sites, and markets. The characterization of the study site is particularly difficult in visibility benefit transfers. Visual range can be characterized in a relatively straightforward way, but the vista being affected by a change in visibility is hard to characterize beyond

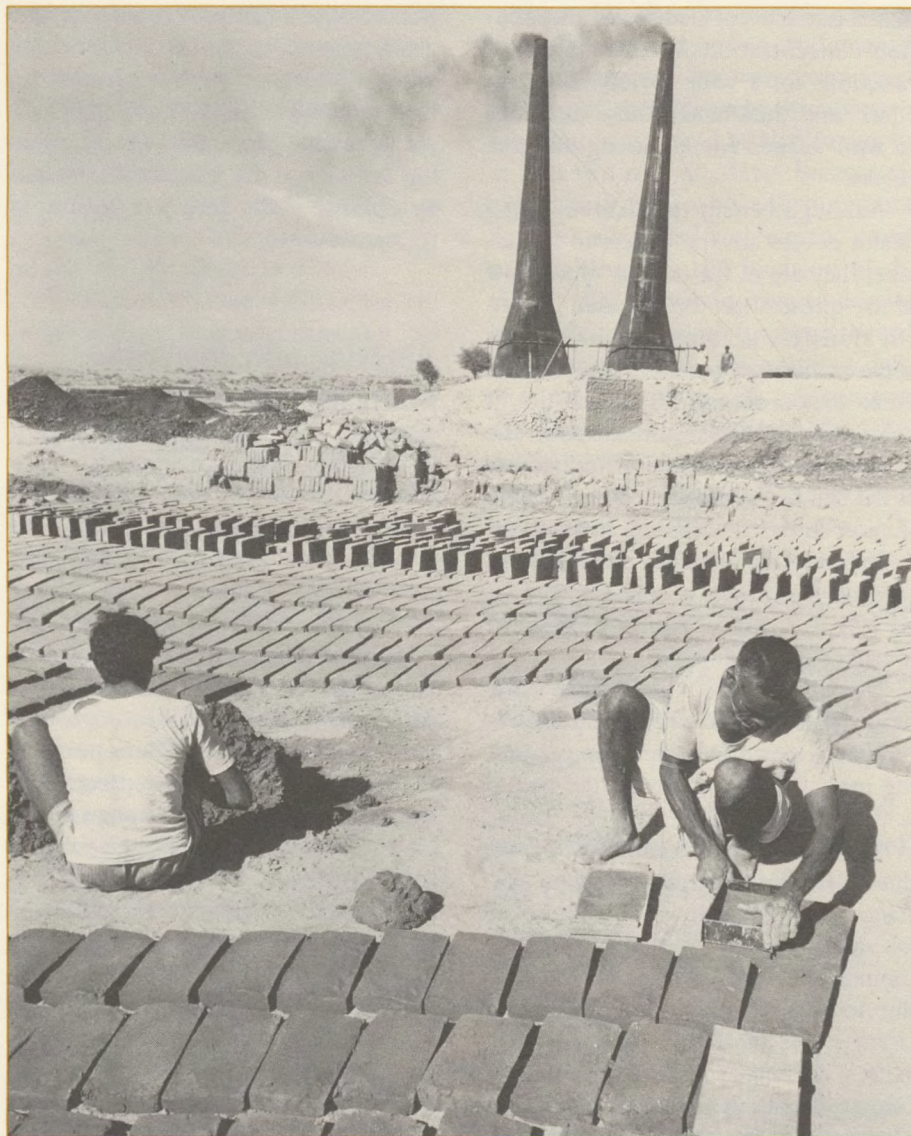


Photo courtesy of the World Bank

International aid organizations are using studies of the environmental damages resulting from development in industrialized countries to value the environmental effects of development projects they are considering funding in nonindustrialized countries. Using valuations from these studies to estimate the potential environmental damages of development projects in a developing-country setting is difficult but necessary until developing countries conduct their own environmental damage studies.

“urban,” “rural,” and “recreational area.” Defining the geographic extent of the population affected by such a change is even more difficult than defining that of the population affected by a change in the quality or quantity of recreation. The market for a particular recreation site can be defined (somewhat arbitrarily) as the residential location of users of the site; but the

market affected by smog in an urban area, for example, is unclear.

Although visibility values are highly sensitive to regional, site, and market characteristics, the literature on visibility benefits is fairly conducive to benefit transfer. Studies of visibility values in a number of cities permit examination of city-specific factors that affect the values and derivation of functional rela-

tionships that terminate in individuals' willingness to pay for improvements in visibility, given a specific baseline visual range and size of change. There are a number of examples of benefit transfers involving visibility. An analysis by the Electric Power Research Institute and Decision Focus Inc. of the benefits of improved visibility in the eastern United States due to reductions in sulfur dioxide (SO_2) emissions is a good example of a benefit transfer in which all the steps of the damage function approach are linked together. The analysis showed the linkages between SO_2 emissions and ambient SO_2 concentrations, concentrations and changes in visibility, changes and individuals' awareness of them, and awareness and willingness to pay for improvements in visibility.

There is significant debate about the protocols used in contingent valuation studies to elicit willingness to pay (WTP) for improvements in visibility. In these studies, individuals are queried about their WTP under a particular set of circumstances. It has been observed that when respondents are shown photographs depicting air pollution, the size of the photographs appears to influence their willingness to pay. In addition, analysts are concerned that respondents are, in part, using visibility as a proxy for health effects.

Protocols for benefit transfers

As noted above, original benefits studies often do not lend themselves to use in other contexts. Because original studies are not conducted with benefit transfers in mind, they often do not report information that would facilitate transfers.

There are some general protocols for using original studies of the benefits of environmental improvements to estimate benefits in other contexts. They emphasize the use, whenever possible, of demand or value functions, as opposed to average unit values. Use of

the function approach puts additional burden on the analyst. For instance, the analyst must gather data on those variables at the site being considered in the benefit transfer study that were found to affect WTP for environmental improvements at the site considered in the original study. Without careful reporting of results in the original study, the demand or value function approach may be impossible.

Protocols are needed to guide varying practices for using multiple studies of a given effect to establish a range of uncertainty.

In the practical application of the broad protocols for benefit transfers, there are many choices to be made and few guidelines to follow. How should analysts proceed when original studies value changes in the output of a product but do not link such changes to changes in the quantity or quality of environmental resources? When the underlying science is poor, should the analyst spend a lot of time on the valuation step when he or she knows that the final benefit estimate is only as good as its weakest component? When original valuation studies have significant problems, either in their own right or for benefit transfers, does the analyst even attempt a benefit transfer?

Protocols are perhaps most needed to guide the widely varying practices for using multiple studies of a given effect (each study with significant flaws) to establish a range of uncertainty. Consider the use of the three existing contingent valuation studies that provide symptom-day values—that is, values for avoiding symptoms of illness for a 24-hour period. The small absolute differences among the values, which plausibly range from \$2 to \$20,

in each of the studies can translate into large percentage differences. Thus benefit estimates depend significantly on the values chosen in each study. In benefit transfers, analysts have established a range of uncertainty for the three studies' symptom-day values in two ways. Some analysts average the midpoint values of the studies and obtain a range of values by averaging each study's estimates of "low" and "high" values, respectively. Others use only midpoint values from the three studies to represent low, middle, and high estimates of unit values. Rather than trying to establish a range of uncertainty, some analysts merely use the values given in the study they deem least flawed.

Analysis and codification of criteria for evaluating original studies would assist analysts in the conduct of benefit transfers. However, the establishment of detailed criteria may not yield many benefits. Beyond ascertaining whether original studies are credible—that is, whether they are based on acceptable theory, whether the theory links up with careful empirical research, and whether essential results are reported—it is not clear what more can be done.

The weighting of criteria for evaluating original studies is crucial. Weighting depends, among other factors, on the use to which the studies will be put, the policy setting in which the studies' valuations will be applied, and the degree to which other data will supplement the valuations. In weighting criteria, a premium should be placed on giving analysts the flexibility to include studies considered most appropriate for the problem at hand. In return for this flexibility, analysts should be responsible for documenting their choice of studies.

Research agenda

To meet the demand for reliable benefit transfers in the context of environmental policy, major research efforts are needed. They could include develop-

ing methods to make better use of existing studies in the benefit transfer process, improving the quality of original studies so that the results of benefit transfer studies will be more credible, routinely including certain design elements in original studies to facilitate benefit transfers, and designing original research with the sole purpose of obtaining results to be used in benefit transfers.

Original studies can be more efficiently used in benefit transfer exercises to the extent that their results can be analyzed as a group—either in a meta-analysis in which the results of each study are treated as a single observation, or (if the data used in each of the studies can be obtained) into new analyses of the combined data sets. Such analyses could, in theory, estimate values or functions that eliminate (or at least reduce) the need for ad hoc consideration of a number of studies of a given effect in order to establish best estimates and a margin of error.

In the context of social costing, original studies that examine willingness to pay (WTP) to avoid further environmental degradation would be of greater use in benefit transfers than studies that examine WTP for environmental improvements.

Obviously good original studies will make for more credible benefit transfers. A "good" study is one that explicitly links what it is valuing to what it is measuring. Studies that value recreation benefits are not particularly good at linking the commodity being valued to the physical measures that affect the quality or quantity of the commodity. As noted above, most of these studies value quan-

titative changes in output, particularly changes in the rate of fish caught by recreational fishers, but rarely link these changes to measurements of changes in environmental assets, such as changes in water quality or in the size of fish populations. Protocols for ensuring that the commodities being valued are linked to the commodities being measured are needed if benefit transfers are to be broadly successful. Studies of the acute health effects of air pollution, for instance, would prove more useful for and more amenable to benefit transfers if they measured changes in the number of days or episodes in which individuals experi-

ence symptoms of illness, instead of measuring lung function.

Researchers engaged in original benefits analyses could also make these analyses more amenable to benefit transfers if they considered how the results of their studies will be used. At a minimum, they could facilitate benefit transfers by reporting mean values for independent variables and the equations used to estimate changes in consumer surplus.

Several changes in the design of original benefits analyses would also be helpful. One beneficial change would be a greater focus on site, regional, and market variables that might influence

valuations. Another would be an examination of WTP to avoid further environmental degradation rather than an examination of WTP for environmental improvements. There is no reason to believe that WTP to obtain a given degree of environmental improvement is equal to WTP to avoid an equal degree of environmental damage, and the latter is more germane to social costing. The premise of formulating environmental policy on the basis of the costs to society of the environmental damages of polluting activities is that at least some environmental conditions will worsen without regulation of polluting activities.

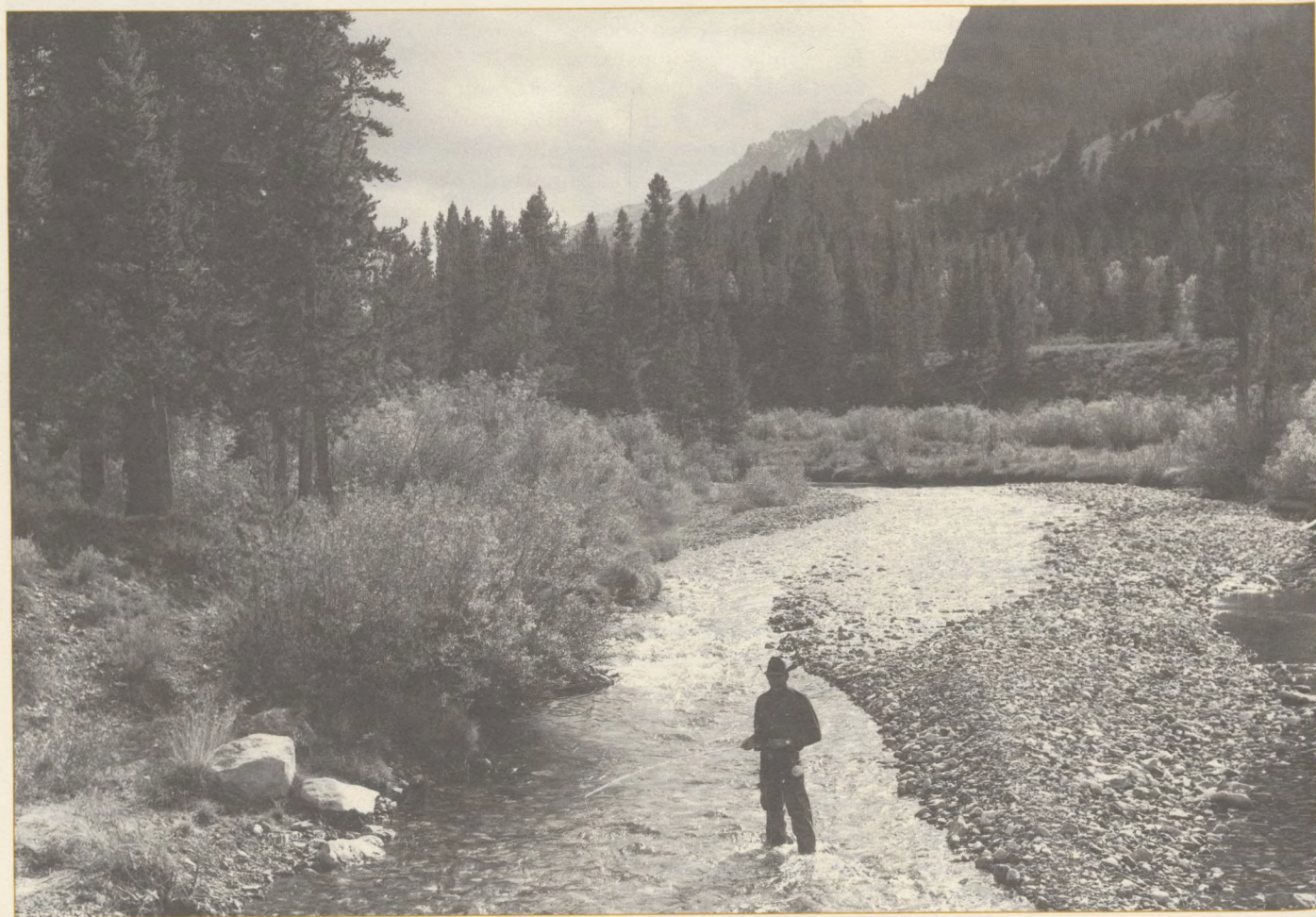


Photo courtesy of the U. S. Department of Agriculture

Most studies of recreation benefits value quantitative changes in output—particularly changes in the rate of fish caught by recreational fishers—without linking these changes to measurements of changes in environmental assets such as changes in water quality. If benefit transfers involving recreation values are to be successful, original studies of recreation benefits must explicitly link what they are valuing to what they are measuring.

Benefit transfers would also be facilitated by designing original benefits analyses for the purpose of obtaining results to be used in transfers. As the characteristics of commodities, regions, sites, and markets are likely to affect willingness to pay to avoid environmental degradation, it would be helpful if original studies included information about these factors. Doing so would help analysts to capture the differences among the factors and to investigate which factors weigh most heavily in valuations.

In the area of health benefits, original valuation studies that provide estimates of willingness to pay for reductions in the risks of premature mortality due to diseases with environmental causes would reduce reliance on the largely inappropriate literature dealing with individuals' willingness to pay some amount of wages to avoid accidental death in the workplace. It is particularly important to establish the effects of age and sex on willingness to pay to reduce premature mortality risks associated with environmental exposures. Original studies that estimate willingness to pay for life-years saved directly would obviate the ad hoc approaches currently being used in benefit-transfer exercises to modify the valuations obtained from the literature on accidental death.

Benefit transfers would also be aided by changes in original studies to estimate individuals' willingness to pay to avoid episodes of illness. Most morbidity studies seek values for single symptoms of illness rather than for illness complexes or episodes. Studies that provide values for the latter would help analysts come up with an overall estimate of the value of multiple acute-health effects over periods in which these effects actually occur, although health science provides little guidance as yet on the relationship between air pollution and episodes of illness.

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Should Congress Allow States to Restrict Waste Imports?

Margaret A. Walls and Barbra L. Marcus

Dwindling landfill capacity in several northeastern states and relatively low tipping fees for depositing municipal solid waste at landfills in midwestern states have prompted waste exports from the Northeast to the Midwest. In response, Congress is debating whether or not to allow states to ban waste imports or charge higher tipping fees for out-of-state waste than for in-state waste. The need for such restrictions on waste imports hinges on whether or not citizens of states that export waste are made to account for the environmental and other costs of landfill operations that are not reflected in the marketplace. With one possible exception, it appears that they already pay the same external costs of these operations that citizens of waste-importing states pay. Thus restrictions on waste imports are unwarranted and may be unwise, as they would raise the overall costs of waste disposal in the United States.

Of the 180 million tons of municipal solid waste generated each year in the United States, the National Solid Wastes Management Association (NSWMA) estimates that 8 percent, or approximately 15 million tons, is disposed of in a state other than that in which it is generated. In 1989, NSWMA identified 132 separate, regular movements of waste—99 between contiguous states and 10 between nearby but noncontiguous states. Thus 83 percent of interstate waste shipments move within what NSWMA terms a traditional "wasteshed," while the remaining 17 percent travel between distant states.

In recent years there has been a general movement of trash from the Northeast to the Midwest. In 1989, New York and New Jersey generated 53 percent of all the waste exported to other states. That same year, Ohio and Indiana were two of the largest importers of waste.

The exportation of waste from the Northeast stems in part from the closing of many landfills in New York and New Jersey and from the inability of these states to site new waste management facilities. The trend also reflects the financial impact of a sharp rise in tipping fees—the fees charged for the disposal of waste at landfills—in New York and New Jersey. Between October 1991 and July 1992, the tipping fee at the Fresh Kills landfill, the only landfill in New York City, rose from \$80 per ton to \$150 per ton. Tipping fees in northern New Jersey have also increased sharply and now range from \$100 to \$150 per ton.

While tipping fees have risen rapidly in the Northeast, they have remained low in the Midwest. In midwestern states, the greater availability and lower cost of land (among other factors) make the costs of building and operating a landfill relatively inexpensive. Even with transportation costs, it remains cheaper for New York and New Jersey to export their refuse to landfills in Indiana, where the average tipping fee is only \$21 per ton, than to dispose of it within their own borders.

State actions and the courts

The Northeast-to-Midwest trend has led some midwestern states to try to ban waste imports, charge higher tipping

fees for out-of-state waste than for in-state waste, or otherwise restrict or discourage the importation of waste. In 1988, Michigan allowed its counties to prohibit the disposal of waste generated outside their borders, including waste from out of state. In 1989, Ohio established higher tipping fees for out-of-state waste than for in-state waste. In an attempt to ensure that imported waste is disposed of at licensed disposal facilities, it also required haulers of out-of-state waste to sign forms that give Ohio jurisdiction over their loads. In the same year, Pennsylvania governor Robert Casey issued an executive order that limited the amount of out-of-state

Many states' restrictions on waste imports have been struck down by the courts as violations of the Interstate Commerce Clause; most attempts to circumvent the clause have been unsuccessful.

waste to 30 percent of the total volume of waste disposed of at Pennsylvania landfills. In 1990, Indiana enacted a law that required haulers of out-of-state waste to carry certification that their cargo included no hazardous or infectious medical waste. The law also required haulers to identify the origin of their loads and to pay tipping fees equal to those charged at the landfill nearest the origin.

Most of the above actions have been struck down by the courts as violations of the U.S. Constitution's Interstate Commerce Clause. This clause explicitly delegates the power to regulate interstate commerce to Congress. Furthermore, Supreme Court decisions have implied that the power of states to regulate interstate commerce is limited in areas where Congress has neither autho-

rized nor prohibited such commerce. The Court has used the implied limit on such power, which is referred to as the "dormant commerce clause," to overrule many state laws that ban waste imports or establish different fees for out-of-state waste and in-state waste.

In the early 1970s, New Jersey became the first state to enact a ban on the importation of waste. Since 1978, when the Supreme Court overturned the ban in *City of Philadelphia v. New Jersey*, states that wish to restrict waste imports have tried to circumvent the Interstate Commerce Clause using three avenues left open by the Court. The first avenue is the evenhandedness doctrine. According to this doctrine, a state can regulate an interstate commercial activity in order to address a legitimate local public interest as long as the regulation treats in-state and out-of-state parties to the activity with impartiality and has minimal effects on interstate commerce. The second avenue is public health and safety. The Court has let stand state laws that regulate interstate commerce if public health and safety are at stake. The third avenue is the market participation exception to the interstate commerce clause. Although the Court has ruled that states may not regulate private firms in a market so as to impede interstate commerce, it has upheld the right of states to participate in a market and favor its own citizens in doing so. For example, a state can participate in the market for education and deny residents of other states the use of public schools or charge them higher fees than its own residents.

States' attempts to use the evenhandedness doctrine or public health and safety considerations to regulate the importation of waste have often failed. For example, in *Fort Gratiot Sanitary Landfill v. Michigan Department of Natural Resources*, the U.S. Supreme Court overturned the law that allowed Michigan counties to reject waste from outside their borders. Although the law treated out-of-state and out-of-county waste evenhandedly, the Court stated that it created too much of an impedi-

ment to interstate commerce. In *Chemical Waste Management, Inc. v. Hunt*, the Court overturned an Alabama statute that cited public health concerns in setting a higher tipping fee for out-of-state hazardous waste than for in-state hazardous waste. It ruled that in-state waste poses the same health problems as out-of-state waste and thus the two should be treated equally.

Some states have been successful in using the market participation exception to restrict the importation of waste. If a state is participating in the market for waste through ownership of landfills rather than simply regulating private firms engaged in waste management activities, it may deny haulers of out-of-state waste access to public landfills or charge these haulers higher fees than haulers of in-state waste. Two important court cases have upheld this position—*Lefrancois v. Rhode Island* and *Swin v. Lycoming County*. As expected, some states are using the market participation exception to alter the mix of private and public landfills within their borders. New Mexico, for example, has enacted a moratorium on the construction of new private landfills except under special circumstances. In doing so, it has increased reliance on publicly owned landfills at which out-of-state waste can be restricted.

Congressional response

The desire of states to control the importation of out-of-state waste is reflected in two recent bills—one that was before the House of Representatives in 1992 and one passed in the Senate in the same year. House bill HR 3962, which was introduced by Congressman Rick Boucher of Virginia in 1992 and later incorporated into the House Resource Conservation and Recovery Act (RCRA) reauthorization bill (HR 3865), would give local governments the authority to determine whether landfills in their jurisdictions should be permitted to import waste. The bill

would allow facilities that are currently importing waste to continue to do so as long as they meet state and federal environmental standards.

Senate bill S 2877, which was introduced by senators Daniel R. Coats of Indiana and Max Baucus of Montana and passed in the Senate in 1992, allows states to prohibit disposal of out-of-state waste upon receipt of a written request from a local government. The legislation requires local governing bodies to hold public hearings prior to making such a request. It does not bar facilities that received out-of-state waste in 1991 from continuing to accept such waste as long as they meet environmental requirements. At the request of local governments, however, governors can freeze the amount of out-of-state waste at such facilities at the 1991 or 1992 level, whichever is lower. The Coats-Baucus bill grants states that imported more than one million tons of waste in 1991—Pennsylvania, Ohio, Indiana, and Virginia—even greater authority to restrict out-of-state waste. Without a local request, these states can freeze out-of-state waste levels and limit out-of-state waste to 30 percent of the total amount of waste deposited at landfills within their borders. With a local request, they can ban disposal of out-of-state waste in those areas of a landfill that do not meet state environmental requirements.

Efficient waste disposal and interstate transport

Waste disposal is economically efficient when the parties involved in disposal activities minimize the total social costs of those activities. Social costs are equal to private costs—tipping fees and transportation costs—plus external costs. The latter are the environmental and other costs of waste disposal that are not reflected in the private marketplace. They can include groundwater contamination, noxious odors, truck noise, and traffic congestion in areas surrounding a landfill.

In considering whether states should be allowed to restrict the importation of waste from other states, an important question to be answered is whether those who dispose of waste in a state other than that in which it was generated are currently made to take external costs into account. If not, this may be a rationale for giving states the authority to ban waste imports or to charge higher fees for out-of-state waste than for in-state waste.

EPA's landfill regulations internalize some of the external costs of landfill operations; these costs are reflected in tipping fees paid by waste haulers, including those carrying out-of-state waste.

Because the landfill regulations promulgated by the U.S. Environmental Protection Agency (EPA) internalize at least some of the external costs of landfill operations, it is likely that generators of waste that is disposed of out of state are already bearing such costs. These regulations require owners of landfills to take steps to prevent environmental and public health and safety hazards. These steps include keeping out hazardous wastes, covering each day's waste deposits with dirt or other materials, and monitoring methane gas that builds up in landfills, as well as monitoring groundwater, which may become contaminated if waste is not properly contained. Landfill owners are also required to have the financial ability to cover the costs of properly closing landfills when their capacity is exhausted and monitoring landfills after they are closed. The cost of these and other EPA regulations, with which all operating landfills must comply by September 1993, is reflected in the tipping fees

paid by waste haulers, including those carrying out-of-state waste.

Some external costs of waste disposal are not addressed by EPA's landfill regulations. Traffic congestion and truck noise are two such costs. Like other external costs, they should be internalized; but because they are created by all waste haulers, there is no reason why there should be a higher tipping fee for disposal of out-of-state waste than for disposal of in-state waste.

Siting costs and a private market solution

Only one external cost appears to be internalized by some citizens but not by others. Citizens whose waste is disposed of in states other than their own are not bearing the cost associated with the siting of new landfills in those states. This cost is likely to be high as residents generally oppose the construction of landfills in their community. The NIMBY (not-in-my-backyard) syndrome is so pervasive that some observers have coined a new phrase: NOPE—not-on-planet-Earth.

Because the costs of siting a new landfill—which include administrative, time, and legal costs—are borne by the community where the landfill is to be located, some communities may be avoiding the creation of new landfill capacity by relying on landfills in other communities. There is some evidence to suggest that this is the case. Between 1986 and 1991, 130 landfills closed in New York while only 18 opened or were expanded. Over the same time period, only 22 landfills closed in Indiana while 15 opened or were expanded. As the result of a surge in new landfills there in the late 1980s, it has been estimated that Pennsylvania has three times the landfill capacity that it needs to handle its own current volume of waste.

To the extent that states like Indiana and Pennsylvania bear the costs of sit-



Photo courtesy of John Henley

Workers at a landfill in Charles City County, Virginia, install synthetic liner material to contain waste. Chambers Development Company, Inc., guaranteed the county a host fee of at least \$1.14 million per year to open the landfill. The fee compensates the county for the costs of siting the facility.

ing new facilities and states like New York do not, there may be a rationale for landfills in Indiana and Pennsylvania to charge more for out-of-state waste than they charge for in-state waste. However, the Coats-Baucus bill, S 2877, does not allow waste-importing states to discriminate against waste shipments on the basis of their origin.

Thus Indiana, for example, cannot charge more for waste from New York than it does for waste from neighboring states. Other bills, including one introduced in the House of Representatives in 1991 by Congressman Al Swift of Washington, would allow waste-importing states to charge higher fees for waste exported from a state that

does not have an EPA-approved solid waste management plan.

In any case, higher fees for out-of-state waste than for in-state waste may be unnecessary because private markets appear to have found a way to address siting costs. Private waste management companies are offering so-called host fees to communities that are willing to accept a new landfill. For example, Chambers Development Company guaranteed Charles City County in Virginia a host fee of at least \$1.14 million per year to open a landfill. This fee is generated from a surcharge of \$4.40 for each ton of waste deposited in the landfill. Because the surcharge rises as the amount of waste disposed of in the landfill rises, Charles City County could reap as much as \$2.3 million per year—nearly \$1 million more than the sum generated by the county's annual tax revenues before the landfill opened. In addition to the host fee, Chambers provides free trash disposal to the county and pays a county-hired engineer to inspect the new landfill.

Other communities have been offered different kinds of compensation to open a landfill. In addition to host fees, landfill operators have paid for community centers, given money to local schools, guaranteed the property values of homes near new landfills, and agreed to hire local workers to staff the new landfills. As in the case of Charles City County, the cost of this compensation is incorporated into tipping fees.

Impact of restrictions on out-of-state waste

At present there appears to be no reason why states should be allowed to restrict waste imports. Because the external costs of landfill operations are generated by both out-of-state waste and in-state waste, tipping fees for out-of-state waste should be no different than those for in-state waste. Although siting costs are often borne only by the citizens in the

communities where landfills are located, this inequity can be righted through host fees.

If, despite the lack of a rationale for restrictions, states that are currently importing waste are allowed to ban waste imports or charge higher fees for out-of-state waste than for in-state waste, the overall cost of waste disposal in the United States would probably rise. In the short run, only the states that export waste would pay higher costs for waste disposal than they do now. In the long run, however, states that import waste would also face higher disposal costs. This is because restrictions on waste imports could halt the construction of large, state-of-the-art, regional landfills, like the Charles City County landfill, that serve a large number of communities. Such landfills must take in enough waste to earn revenues sufficient to cover their operating costs. In many cases, landfills depend on out-of-state waste to remain profitable. If such waste is reduced, generators of in-state waste would likely have to pay a higher tipping fee to cover landfill costs. Ironically, bans on waste imports or higher fees for out-of-state waste than for in-state waste could necessitate the siting of small local landfills in many locations and thus lead to greater siting costs than at present.

Given the probability that restrictions on waste imports would increase overall disposal costs, they should be examined carefully. To internalize the external costs of landfill operations, it may be more prudent to rely on EPA regulation of landfills and private market mechanisms such as host fees than to grant states the authority to prohibit or discriminate against waste imports.

Margaret A. Walls is a fellow in the Energy and Natural Resources Division at Resources for the Future. Barbra L. Marcus was an intern in the division during the fall of 1991 and the summer of 1992. This article is based on research conducted by Walls, Marcus, and research assistant David Edelstein.

Vehicle Emissions Inspection and Maintenance: Where Do We Go From Here?

Winston Harrington and Virginia D. McConnell

Throughout the 1980s, vehicle emissions inspection and maintenance (I&M) programs were established in those regions of the United States with the worst pollution problems. Contrary to expectation, the programs do not appear to have achieved large emissions reductions at low costs. To improve their performance, the U.S. Environmental Protection Agency has proposed a more extensive test of a vehicle's emissions equipment than the test currently used in most I&M programs. Two components of the test favored by the agency appear to be cost-effective in reducing emissions. A third component does not seem cost-effective but may be helpful in establishing the actual emissions reductions brought about by I&M programs.

Policies to curb vehicle emissions are becoming increasingly important as one option for achieving compliance with ambient ozone and carbon monoxide (CO) standards in areas of the United States where these standards have not yet been attained. Such policies are thought to be crucial because cars remain a major source of carbon monoxide, volatile organic compounds (VOCs), and nitrogen oxide (NO_x) emissions despite strict new-car tailpipe standards. These standards required emissions from the tailpipes of new cars to be reduced by more than 95 percent during the 1970s and 1980s. Over time, they were expected to result in a similar reduction in emissions from all the nation's cars. However, the introduction of alterna-

tive gasolines, the failure of vehicle exhaust equipment, and tampering with such equipment have resulted in car emissions that are much higher than originally forecast.

It has become evident that vehicles often emit higher levels of pollutants than manufacturers claim. Even as they come off the showroom floor, vehicles purported to have low emissions have been found to have emissions that are on average one and a half to two times higher than their design standard. Some vehicles have emissions levels fifty times higher than their design standard.

To reduce vehicle emissions and to enforce strict new-car tailpipe standards, vehicle emissions inspection and maintenance (I&M) programs were established throughout the 1980s in those regions of the United States with the worst pollution problems. These programs were designed to identify highly polluting vehicles through the use of a tailpipe idle test that measured exhaust concentration. Using optimistic assumptions about the accuracy of the test and the willingness of car owners to take their vehicles to be tested and repaired so as to meet emissions standards, the U.S. Environmental Protection Agency (EPA) predicted that I&M programs would achieve large emissions reductions at relatively low costs. However, there is considerable evidence that these programs have not lived up to expectation. Emissions reductions have been considerably lower than anticipated. Drivers, mechanics, and state regulators, who bear the costs but perceive few of the benefits of I&M programs, have found

many ways to circumvent I&M regulations. When the time and other costs borne by vehicle owners due to I&M programs are taken into account, it appears that the cost of achieving emissions reductions through I&M programs has also been higher than early studies projected.

Problems with existing I&M programs

Some of the problems with I&M programs relate to the 2500 idle test (referring to the 2,500 revolutions per minute of an idling motor) that most programs employ. This test measures only two kinds of emissions—VOCs and CO—from only one part of a vehicle's emission system: the tailpipe. New evidence suggests that levels of evaporative emissions—that is, vehicle emissions from areas other than the tailpipe—can be as high or higher than levels of tailpipe emissions. Because the 2500 idle test measures neither emissions of NO_x from the tailpipe nor any evaporative emissions, such as VOCs that escape from a vehicle's emissions recycling system due to an improperly working purge canister or lack of pressurization in the fuel tank, EPA has recommended that the idle test be replaced with a more comprehensive emissions test.

A host of other problems beset I&M programs. One is that I&M regulations, as promulgated by EPA in 1978, give states little incentive to enforce them. Another is that many states have waiver policies that allow owners of polluting vehicles to keep operating their cars when, after paying a minimum amount of money on repairs, emissions problems persist. The effect of these policies is to exempt from repair those cars that are most polluting. Yet another problem is that it is difficult to measure the benefits of I&M programs. For most states, data on whether such programs have actually reduced vehicle emissions are lacking. What data are available suggest

that I&M programs have had little effect on the level of these emissions.

Partly in response to criticism of I&M programs by the General Accounting Office, EPA began an audit of the programs around the country in the mid-1980s. It investigated 75 vehicle inspection facilities in four states with decentralized I&M programs—that is, programs in which inspections are conducted at independent gas stations. It found that 69 percent of the facilities passed vehicles that had been intentionally set up to fail the emissions test. The agency also found that improper equipment was used for testing and that as little as 50 percent of the cars registered in states that require vehicles to bear inspection stickers were being brought in for testing.

At present, inspection and maintenance (I&M) programs do not measure vehicles' evaporative emissions, are not well enforced, and, in some states, allow exemptions for some of the most polluting vehicles.

EPA tests revealed a number of technical difficulties in identifying emissions problems. For example, the tailpipe idle test sometimes indicated that cars, particularly those manufactured after 1981, had higher emissions than allowed when in fact they did not. Because the test measures neither NO_x emissions from the tailpipe nor evaporative emissions, many polluting vehicles passed the test while many less polluting vehicles failed it.

Enhanced I&M programs

The poor performance of I&M programs appears to have been acknowledged in

amendments to the Clean Air Act in 1990. The amendments mandate the use of vehicle emissions I&M programs through the remainder of the decade but require enhanced programs in more than 70 regions with the highest ozone and carbon monoxide levels. They also prohibit states from waiving a vehicle owner's requirement to pass the emissions test unless the owner has spent at least \$450 on vehicle repairs to meet emissions standards. Before this prohibition, the minimum amount car owners had to pay for such repairs ranged from \$15 in some states to \$200 in others.

To improve the performance of I&M programs, EPA recommends the use of the so-called high-tech I&M test. This test includes a pressure test and a purge test to measure emissions of VOCs from a vehicle's evaporative system. It also includes the IM240 tailpipe test (referring to the 240 seconds it takes to perform the test) to measure emissions of VOCs, CO, and NO_x from a vehicle's tailpipe. EPA considers the IM240 test to be superior to the 2500 idle test, which does not measure NO_x emissions and is slightly less accurate in identifying vehicles with high levels of VOC and CO emissions than the IM240 test.

In addition, EPA recommends that I&M programs be centralized within regions of states. Under centralized I&M programs, vehicle inspections are conducted at state facilities devoted to that purpose. The agency favors such programs over decentralized I&M programs, under which cars are both inspected and repaired at independent gas stations, because they are less likely to be fraught with cheating.

RFF model of vehicle emissions reductions

The EPA Office of Mobile Sources uses its fleet emissions model, MOBILE 5.0, to predict the emissions reductions that will result from various I&M programs. The model has been criticized on at least two grounds. First, studies have

shown that it underestimates emissions of VOCs from vehicles. Second, it does not accurately measure the emissions reductions that result from ongoing I&M programs because it fails to account for the fact that vehicles not correctly identified as polluting in one year have some probability of being so identified in a subsequent year. In light of these criticisms, researchers at Resources for the Future (RFF) have developed an alternative model to examine the impact on emissions reductions of various emissions tests that might be used in enhanced I&M programs.

The RFF model tracks the emissions performance of vehicles over time. As vehicles age, malfunctioning equipment and worn parts cause both tailpipe and evaporative emissions to increase, sometimes quite drastically. While it is possible that some high-mileage vehicles will have relatively low emissions and some low-mileage vehicles will have relatively high emissions, it is generally the case that emissions increase over the operating life of a vehicle. For this reason, the RFF model assumes that a vehicle's age is an important factor in determining the probability that the vehicle will be scrapped or move from the group of cars identified as "clean" to the group of cars identified as "dirty" in its representative fleet of 1,000 cars of varying ages and with varying emissions characteristics.

In estimating emissions reductions, the RFF model also takes into account the rates at which emissions problems are likely to be identified and solved under any given I&M program. When a vehicle is identified as dirty, it will be either repaired—whereupon it is returned to the inventory of clean vehicles—or scrapped. To the extent that vehicles repaired in any year are still low emitters the following year, the RFF model assumes that the effect of an I&M program is likely to be cumulative. It also assumes that if a polluting vehicle is not identified as dirty in

a given year because emissions tests are not accurate, there is some probability that it will be so identified in subsequent years.

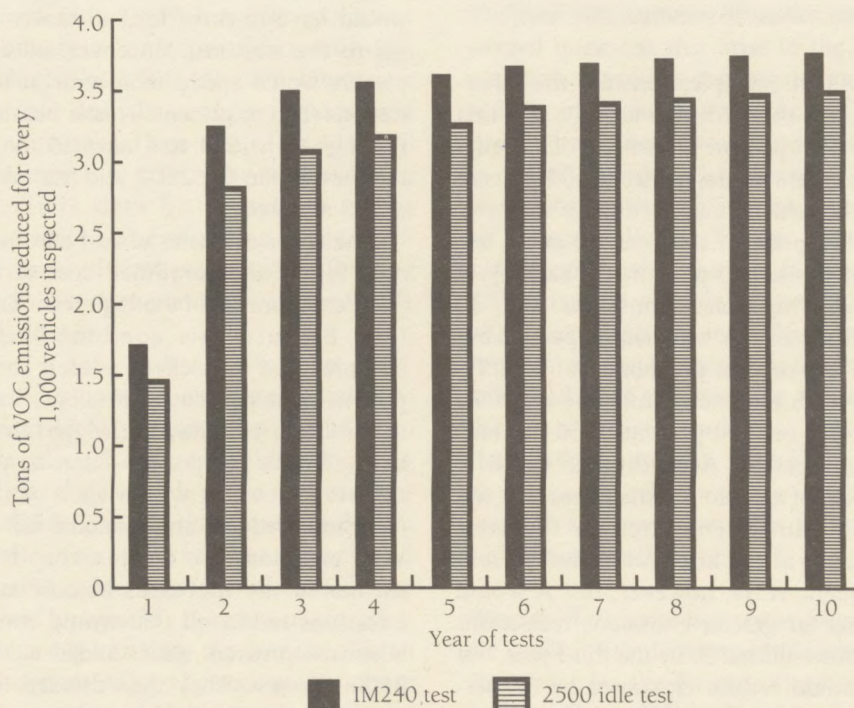
Evaluating the effectiveness of emissions tests

To create enhanced I&M programs, EPA has focused on the development of an emissions test that will more accurately identify those vehicles that exceed acceptable emissions levels. It claims that the new IM240 tailpipe test can identify more high-emitting vehicles than the 2500 idle test. As proof, it points out that the IM240 test can identify 100 percent of super-emitting vehicles—that is, those vehicles that emit more than 10 grams of hydrocarbons per mile—while the 2500 idle test can identify only 95 percent of such vehicles.

Although the IM240 test can identify more high-emitting vehicles than the 2500 idle test, will it have a substantially greater impact on emissions reductions than the 2500 idle test? According to the RFF model, the reductions that can be expected to result from the use of the IM240 test would not be much larger than those that would result from the use of the 2500 idle test (see figure, p. 13). In an ongoing program, as noted above, a vehicle that is not correctly identified as dirty in one year is likely to be so identified in subsequent years. From year to year, then, the difference between the reduction in emissions that would result from a more accurate test and the reduction that would result from a less accurate test would be small.

The greatest determinant of the effectiveness of an I&M program may be the response of drivers, mechanics, and state regulatory agencies to the pro-

Comparison of annual emissions reductions from the IM240 test and the 2500 idle test



gram. The kind of emissions test used in an I&M program will affect the probability that vehicle owners will tamper with emissions control equipment, mechanics will make mistakes during vehicle inspections, or state regulatory agencies will exempt certain vehicles from either testing or repair. Because a test that has some prospect of identifying excess emissions from every vehicle will discourage tampering, mistakes, and exemptions, it is likely to effect greater emissions reductions than a test that works only on some vehicles, even if it is more accurate for that subset of vehicles.

A test that has some prospect of identifying excess emissions from every vehicle inspected will reduce more emissions than a test that works only on some vehicles, even if it is more accurate for that subset of vehicles.

As an example, consider the difference in the performance of a test that has a 30-percent probability of identifying excess emissions from 100 percent of the vehicles inspected (a "30-percent-of-100-percent" test—test A) and a test that has a 100-percent probability of identifying excess emissions from 30 percent of the vehicles inspected but has a 0-percent probability of identifying such emissions from the other 70 percent (a "100-percent-of-30-percent" test—test B). According to the RFF model of emissions reductions, each test would lower emissions by the same amount in the first year of use. In subsequent years, however, test A would effect far greater emissions reductions than would test B. By the third year, test A would reduce emissions by 37 percent, while test B would reduce emissions by only 14 percent.

Marginal costs of the high-tech I&M test

EPA's analysis of the costs of and emissions reductions achieved by the high-tech I&M test, which includes the IM240 tailpipe test and the pressure and purge tests for evaporative emissions, is based on optimistic assumptions. According to the agency, the cost of reducing one ton of VOC emissions by implementing the test in a biennial, centralized I&M program would be between \$500 and \$800. According to the RFF model, however, the cost would be about \$3,300. This estimate is significantly higher than EPA's estimate because, in part, the RFF model accounts for the estimated value to car owners of the time spent driving to and waiting at inspection stations. Time costs are an important consideration because they would be substantially increased if the high-tech I&M test is implemented. Because the test requires the use of expensive equipment, it would have to be performed at more centralized vehicle inspection and maintenance stations. Thus many car owners would have to drive long distances to get to the stations. Moreover, all car owners would spend more time at the stations than at present. This is because the high-tech I&M test takes 15 to 20 minutes, while the 2500 idle test takes only 3 minutes.

The above estimates of cost effectiveness reflect the combined cost of all three components of the high-tech I&M test. Because this combined cost obscures how cost-effective each component is in reducing emissions, RFF researchers calculated the marginal costs of each component—that is, the additional cost at which each of the three tests reduces an additional ton of VOC emissions. To do this, they first estimated the increases in cost and emissions reduction that would result when the pressure test is added to the 2500 idle test. They then divided the increase in cost by the increase in emissions reduction to obtain the marginal

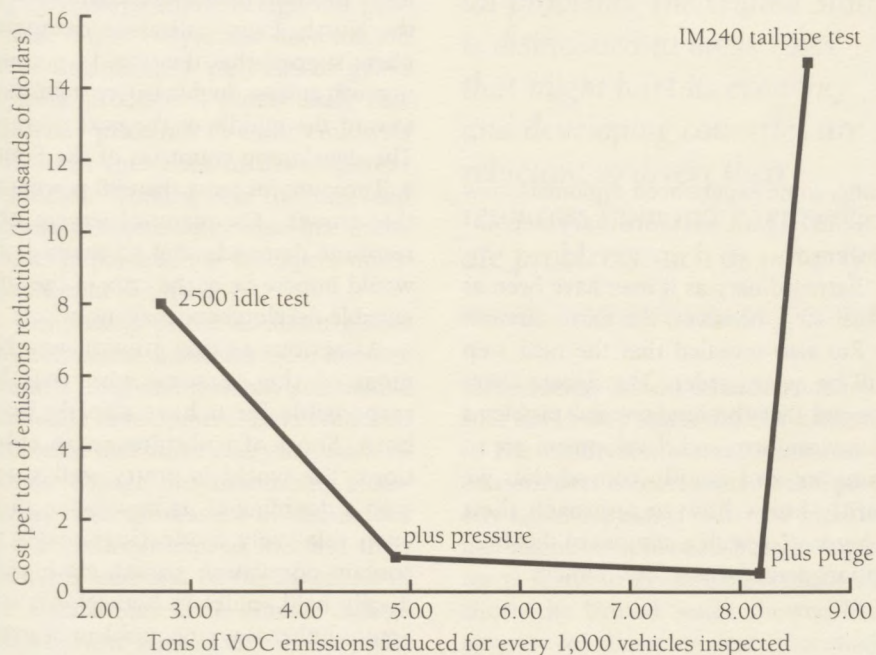
cost per ton of emissions reductions of adding the pressure test. They then calculated the marginal cost per ton of emissions reductions of adding the purge test to the pressure and 2500 idle tests. Finally, they calculated the marginal cost per ton of emissions reductions of adding the IM240 tailpipe test to the purge and pressure tests under a scenario in which the IM240 test replaces the 2500 idle test.

These calculations revealed that only two of the three components of the high-tech I&M test may be cost-effective in reducing vehicle emissions. The marginal costs of adding first the pressure test and then the purge test appear quite low. In fact, the marginal costs of adding both tests are lower than the average cost of the 2500 idle test alone; at a cost of about \$1,000 each per ton of emissions reductions, they both appear to be real bargains. When added to the 2500 idle test, the pressure test achieves an additional reduction in the emission of VOCs of about 2.5 tons for every 1,000 cars inspected; when added to the pressure test, the purge test achieves an additional VOC-emissions reduction of 2.2 tons for every 1,000 cars inspected (see figure, p. 15).

By making it possible to obtain data on the actual emissions reductions due to I&M programs, the IM240 tailpipe test might focus attention on the programs' effectiveness in achieving ambient ozone and carbon monoxide standards.

In comparison with the 2500 idle test, the IM240 tailpipe test does not appear to be cost effective. The RFF model of emissions reductions reveals that, for every 1,000 cars inspected, it reduces only 0.4 tons more VOC emis-

Marginal cost of adding emissions-test components under a biennial inspection and maintenance program



sions than the 2500 idle test. The reduction is so small because the RFF model realistically accounts for the probability that cars incorrectly identified as clean in one year will be identified as dirty in the future. Since the amount of emissions reductions achieved by the IM240 tailpipe test is small, the cost of each ton of emissions reduced through the use of the test is high—\$12,000 as compared with \$6,000 for the 2500 idle test (see figure, p. 15).

Although the IM240 tailpipe test appears to achieve reductions in emissions of VOCs at a high cost, it does have some advantages over the 2500 idle test. First, as noted above, the IM240 tailpipe test measures NO_x emissions, which may be a large contributor to ozone problems in some regions of the country. Second, it measures mass emissions—that is, the number of grams of pollutants a vehicle emits during each mile it is driven. Mass emissions (grams per mile) can

be directly converted into tons of emissions in order to calculate actual emissions reductions; however, pollutant concentrations (parts per million), which the 2500 idle test measures, cannot easily be converted into tons of emissions. Thus use of the IM240 tailpipe test may make it possible to include data on actual emissions reductions in evaluations of the effectiveness of I&M programs in achieving ambient ozone and carbon monoxide standards.

To date, states have been given “credits” toward emissions reductions from I&M programs on the basis of forecasts of these reductions from EPA models of vehicle emissions such as MOBILE 5.0. If these models do not reflect actual vehicle emissions and actual reductions in emissions due to I&M programs, they cannot predict with any certainty the impact of such programs. Efforts by state authorities to ensure that I&M programs are obtaining adequate emissions reductions have

not been undertaken because they do not directly influence the emission-reduction credits granted to states for implementing I&M programs. However, such efforts may be quite important for ensuring that the programs are cost effective.

Data on actual emissions reductions, which might be obtained from the IM240 tailpipe test, would focus attention on the actual performance of I&M programs. Currently, there is little effort to evaluate this performance. There are virtually no studies of the effectiveness of centralized I&M programs. Of the states with decentralized I&M programs, only California has attempted to determine the actual emissions reductions resulting from its program. It has conducted roadside emissions tests and carried out undercover investigations of I&M stations to determine whether they are passing cars that should fail the emissions test. In general, states are reluctant to impose fines on stations that conduct improper inspections and to revoke the license of drivers who tamper with their car’s emissions equipment.

Given the number of as yet unanswered questions that arise in the formulation of policies and regulations to reduce emissions from vehicles, it is not clear whether it would be prudent to use the proposed high-tech I&M test in every state where EPA requires an enhanced I&M program. The full cost of conducting the test is close to \$50 for each vehicle inspected. If implemented on a biennial basis in all regions of the United States where enhanced I&M programs are required, the test might cost more than one billion dollars annually. There may be less expensive but equally effective ways to achieve reductions in emissions from vehicles.

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Environment and Development: The Next Step

Robert W. Fri

Now that analysts have had seven months to ponder the achievements of the Earth Summit, it is time to consider the next step in attaining sustainable development. As the summit revealed, the big issues are formidable—among them, overconsumption in the North, overpopulation in the South, insufficient resource transfers from North to South, and limited resources to devote to global environmental problems. Each of these issues requires a trade-off between long-term global concerns and immediate national interests. Since technological solutions to the dilemma of furthering economic development while protecting the environment are neither quick nor cheap, this political reality suggests that progress may hinge on attention to some modest goals.

The United Nations Conference on Environment and Development (UNCED) took place in Rio de Janeiro this past June. The faithful believed that it was a successful first step toward environmentally sustainable economic development. To be sure, much was accomplished. More than one hundred government leaders came to endorse the goal of sustainable development. And negotiators agreed on a massive agenda for future action, climate and biodiversity conventions, and steps to embed the twin goals of environment and development in the global policy agenda.

All this, say the faithful, was enough to expect from one meeting. They may be right; considering the size and inclusiveness of the affair, it is a near miracle that anything got done. For this reason

alone, some experienced diplomats view UNCED as an extraordinary accomplishment.

Extraordinary as it may have been as a first step, however, the Earth Summit at Rio also revealed that the next step will be even harder. The debate there showed that the fundamental problems of environment and development are so complex and deeply rooted that we hardly know how to approach their solution. To catch a glimpse of this frustration, consider just four of them.

Overconsumption, overpopulation, and other problems

Overconsumption in the North is a prominent theme of the environment and development debate. It is often pointed out that the industrialized countries have used more than their share of scarce environmental and natural resources, leaving too little for the expanding economies of the developing countries. For some, it quickly follows from this belief that the wealthy must consume less. In this view, the good life should be measured not by quantity but by quality. In the words of Maurice Strong, the Secretary-General of UNCED, it should be a life of "elegant simplicity."

There are surely sound and appealing reasons for deploring conspicuous and wasteful consumption, wherever it occurs. Even more to the point, achieving economic well-being without damaging the planet's resource base is the central objective of sustainable development. Nevertheless, making lifestyle changes is slow work, for they must come from new sets of values that can

probably be achieved only at a generational pace.

Overpopulation in the South is no less a problem than overconsumption in the North. Even optimistic demographers suggest that the world's population will at least double before stabilizing toward the middle of the next century. The developing countries of the South will account for more than 90 percent of this growth. For many observers, the resource demands that so many poor would impose lie at the crux of the sustainable development challenge.

As serious as this growth may be, most of the persons who will be responsible for it have already been born. Short of truly draconian solutions, the world is pretty well stuck with a doubling of its population. And even relatively modest proposals to contain population growth clash with deeply held values in both North and South. Either way, the problem of overpopulation will not soon be resolved.

Insufficient resource transfers from North to South are another impediment to the simultaneous achievement of environmental protection and economic development goals. Poor countries need

Although more than twice the present amount of aid flowing from North to South is needed to carry out the UNCED Secretariat's agenda, domestic priorities in the North will limit increases in development assistance.

massive investments to develop economically, and adding the cost of environmental protection only increases the need. The UNCED Secretariat made a very rough estimate that the external financial aid required to carry out its agenda would be \$125 billion annually.

Present aid flows from North to South are less than half that.

Many developed countries are striving to enlarge their foreign aid programs, but in only a few does the aid level approach 1 percent of gross national product. It seems likely that domestic priorities in most countries will limit increases in development assistance. Working over the long haul to enlarge North-South resource transfers is important, but to expect much soon would be unwise.

Conflicting priorities about global environmental problems pose another obstacle to environmentally sustainable economic development. Environmental problems that affect everyone, such as climate change and diminishing biodiversity, were prominent in discussions at the Earth Summit at Rio, but their solutions were not. At the insistence of the United States, the climate change convention signed at the summit lacked specific targets and timetables

In solving global environmental problems, the United States is disinclined to incur costs that might hurt its economy, and developing countries are reluctant to divert their resources from more immediate problems such as poverty.

for reducing carbon dioxide emissions. And the United States did not subscribe to the biodiversity treaty because of concern over access to intellectual property rights associated with new products that might be developed from biological assets found in developing countries. In short, the United States showed little appetite for incurring costs that might hurt its own economy.

Developing countries seem no less inclined to put their own interests first. Although these countries have a genuine concern for global environmental issues, they are reluctant to divert their limited resources from the more immediate problems of poverty and basic public health. Not surprisingly, these countries suggest instead that the North should make room for their economic expansion by reducing its consumption and increasing the flow of concessionary financial and technology resource transfers. Thus do these complex issues fold into one another.

Political reality

These issues are tough enough on their own, but dealing with them is further complicated by political reality. At one level, each of the aforementioned problems forces a trade-off between longer-term global concerns and more immediate national interests. Anyone acquainted with energy or agricultural policy can tell you that, even under the best of circumstances, this trade-off is agonizingly difficult to achieve.

Looking beyond the Earth Summit, however, circumstances are unlikely to be the best. A few cynics have argued that the environment-development debate is little more than a new and especially large tent under which to rehash special interest agendas. Some believe that, under the banner of sustainable development, the industrialized countries will continue to strive for political and commercial advantage over international competitors. Others see the debate as an opportunity for social reformers to pursue their elitist views on everything from lifestyle to family size. And a few pundits have already concluded that the Earth Summit was only another occasion for developing countries to justify concessionary financial and technological assistance from the North.

These positions may seem overstated and even a bit odd, but they are not

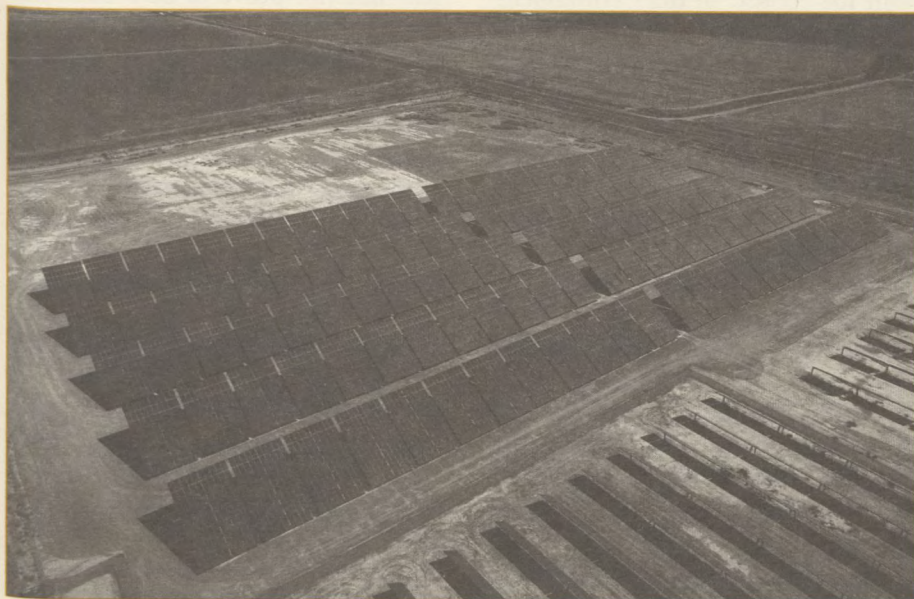


Photo courtesy of Advanced Photovoltaic Systems, Inc.

This array of photovoltaic modules converts sunlight directly to electricity. The solar-power station at Davis, California, was developed by Advanced Photovoltaic Systems, Inc., to demonstrate that photovoltaic systems can supply enough power to meet large-scale utility needs. It is a stepping-stone in the application of photovoltaics to help utilities economically handle peak demands for electricity in an environmentally benign way. If photovoltaics were to provide a positive economic payback while producing a corollary benefit to the environment, investment in the technology would be regarded as a no-regrets strategy.

entirely unsupported by the rhetoric at the summit. Certainly, both North and South found ample opportunity to elbow one another for position in the new world order. Indeed, it is hard to escape the feeling that this maneuvering for advantage accounted for much of the clamor when the United States fumbled a couple of balls, as it clearly did.

Uncritical reliance on technology

Further complicating the debate is a tendency to make the problems sound easier to solve than they really are. This simplicity is achieved by assuming that new technology will allow our limited resource base to feed the consumption of a growing population without serious environmental constraints. Over the long haul, this is a plausible if as yet unproven view. But even this solution is not a quick fix, because both technology and well-functioning markets are needed to make it work. Getting the right technology is not easy, and creating market economies is plainly a formidable matter.

Given limited resources and many attractive ways to use them, projects to garner environmental benefits, even if they have a positive economic payback, are not necessarily preferable to projects to garner other social benefits.

Uncritical reliance on technology becomes more distressing, however, when it is suggested that the technological solution is not only quick but cheap. It is easy to show that the United States (and other countries, for

that matter) can invest in energy-efficient technologies that have a positive economic payback and produce a corollary benefit to the environment—reducing emissions of carbon dioxide, say. If full social cost, not just private cost, is used to measure the payback, then even more efficient technologies are affordable, and even more environmental benefits could be harvested at little or no incremental cost. In the jargon of sustainable development, this is called a “no-regrets” strategy because of its win-win outcome.

No-regrets strategies are immensely appealing, which is why their proponents spend quite a lot of time asking why they are not implemented forthwith. Yet they are not, even when the objective is so apparently desirable as improving energy efficiency in the United States. The reasons for this default remain elusive even in the industrialized North, where functioning markets should result in the correct demand for efficient technology.

In the context of the environment-development debate, however, no-regrets strategies face a more obvious obstacle. These strategies simply cannot get away from the basic problem that decision makers always face—that resources are limited and that there are more than enough attractive ways to use them. Thus, projects that have economic and environmental benefits are surely important, but so are the social benefits associated with improved health care and better education. That no-regrets strategies have a positive cash flow does not automatically make them preferable to all other possible uses of resources.

This is not to suggest that such strategies are unimportant. Pushed to extremes, however, no-regrets strategies can create the dangerous illusion that the big questions have cheap and easy answers. To believe this would not only be an obstacle to post-Earth Summit progress, but also deflect from the careful attention that these difficult issues rightly deserve.

Some modest goals

Absent easy answers to the big issues, modest goals are more likely to produce the kind of progress that the faithful think is already under way. It is not too hard to sketch what these goals are. Helping developing countries to define and balance their own economic and environmental priorities, and using these priorities to guide the planning of both public and private sector investments, would be welcome signs of progress. Such feasible and inexpensive assistance would exert useful leverage over the substantial transfers of financial and technological resources that are already taking place, especially in the private sector.

Equally encouraging would be growing investments in the development of technology to use natural and environmental resources more efficiently and in creating the market and other institutional mechanisms needed to assure use of these technologies. Efficient resource use may not prove to be a complete answer to the big questions of environment and development, much less one with no regrets. However, it will at least reduce the cost of dealing with the hard issues, and so make them more tractable.

As to the big issues, patience seems advisable. Careful research can begin to unravel their complexities. Ongoing negotiation to shape the difficult trade-offs that lie ahead is also needed. Central bankers, corporate chieftains, and others whose interests are at stake must be included in discussions of these trade-offs. Their participation would mean that sustainable development had become part of the policy mainstream, where it surely belongs.

The Earth Summit was the necessary first step toward all these goals. Like most first steps, it set directions and enlarged hopes for ultimate success. But the next step—the one into the underbrush of reality—is the hard part.

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INSIDE RFF NEWS AND PUBLICATIONS

At RFF's 40th, Nobel economist speaks on sustainability

As part of its fortieth anniversary celebration, Resources for the Future (RFF) invited Robert M. Solow, Institute Professor of Economics at the Massachusetts Institute of Technology and Nobel laureate in economics in 1987, to deliver an address to the RFF board of directors and invitees from the natural resource and environmental policy community. On October 8, Dr. Solow spoke to nearly 200 guests at the Resources and Conservation Center in Washington, D.C.; his subject was "An Almost Practical Step Toward Sustainability."

Summer interns sought

Every summer Resources for the Future offers a number of paid internships to students. Interns assist RFF staff with a variety of projects ranging from technical studies to applied policy analyses. Interested persons are invited to apply for RFF internships at this time. Applicants should have outstanding academic records in the undergraduate or graduate programs in which they are enrolled, and have undertaken course work in one or more of the following fields: microeconomics; statistical and quantitative methods; agricultural, environmental, or natural resource management; or environmental sciences.

The deadline for applications is March 15, 1993. The internships begin on or about June 1, 1993 and last from two to three months. Stipends are commensurate with experience and length of stay. For further information about applying for internships, contact the Office of the Vice President, Resources for the Future, 1616 P Street, NW, Washington, DC 20036-1400. Telephone: 202-328-5067.

In his talk, Dr. Solow pulled together several strands of research pursued over the last several decades at RFF and at universities in the United States and abroad. Solow first reminded listeners that traditional measures of economic activity like gross national product (GNP) or gross domestic product (GDP) will not be particularly useful indicators of a country's well-being as long as these measures fail to reflect environmental degradation and the consumption of nonrenewable resources.

Solow then focused on the elusive concept of sustainability. He argued that since at least some drawdowns on current stocks of nonrenewable resources were inevitable, sustainability—if it is to mean anything at all—must mean more than just the preservation of natural resources. To maintain the capacity to meet the needs of future generations requires concern for society's *total* capital, taking into account substitution possibilities between "natural capital" (extractive resources and the natural environment) and other forms of capital. For example, acting fairly toward future generations requires that some of the proceeds from nonrenewable resource depletion be invested in other assets—including human or physical capital—to maintain productive capacity.

To tie these seemingly unrelated strands together, Solow argued that GNP less the depreciation on physical *and* natural capital is a measure of sustainable income for future years. The level of sustainable income could go up from one generation to another if the earlier generation protected its environmental assets, consumed few nonrenewable resources, and invested a great deal in new productive capacity for the future. Similarly, a generation of profligate "grasshoppers" could degrade the environment, consume significant

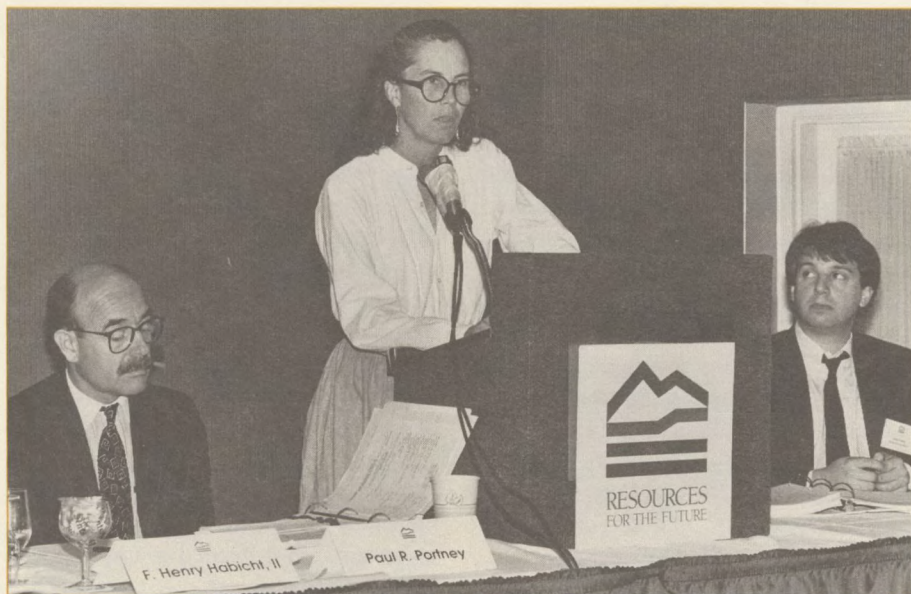
quantities of nonrenewables and let the stock of physical capital degrade; in the process, it would reduce the level of sustainable well-being in the future.

These arguments have important implications for both research and policy. As regards the former, Solow stressed the importance of new research designed to treat the natural environment as an asset and establish its value. Pollution could then be regarded as depreciation of an asset while both pollution abatement or environmental restoration could be viewed as investments in it. Similarly, Solow argued, more research is needed to improve our measurement of the scarcity rents earned by nonrenewable resources. This, too, will lead us toward measures of economic activity that are more satisfactory measures of national well-being.

Concerning the policy implications of Dr. Solow's talk, consider the following. In June of 1992, 130 nations met in Rio de Janeiro to discuss steps that could be taken in the direction of sustainable development and to sign treaties toward that end. This came about in spite of the likelihood that no two of these nations shared identical visions about what sustainable development entailed or a common view on how progress toward that goal might be measured. Solow's stimulating lecture suggested how improved national income accounting might be an important step on the road to a concrete measure of sustainability.

Paul R. Portney

A printed copy of Robert Solow's "An Almost Practical Step Toward Sustainability" can be obtained by sending a written request to External Affairs, Resources for the Future, 1616 P Street, NW, Washington, DC 20036-1400. Please enclose a check for \$3.75 to cover postage and handling.



At the conference on setting U.S. environmental priorities sponsored by the Center for Risk Management, Dr. Mary O'Brien, professor of environmental studies at the University of Montana, proposed that citizens be allowed to choose which environmental and health risks need to be managed first. Also pictured are Paul R. Portney (left), vice president of Resources for the Future, and Adam M. Finkel (right), a fellow at the center.

Center for Risk Management sponsors conference on setting national environmental priorities

On November 15, 16, and 17, 1992, the Center for Risk Management at Resources for the Future sponsored a conference on alternative ways to set environmental priorities for the United States. During the conference, held in Annapolis, Maryland, nearly 100 representatives from state and federal governments, academia, industry, and environmental organizations debated a plan of the U.S. Environmental Protection Agency (EPA) to focus its attention on those risks to human health and natural ecosystems that scientific evidence suggests can be reduced. Participants tackled the question of what weight government should give to risk assessment information, public opinion, economic and equity considerations, and the potential for technological solutions to environmental problems in setting the nation's envi-

ronmental agenda. Among those who presented papers on these and related topics were Alice Rivlin, recently appointed deputy director of the Office of Management and Budget by the Clinton administration; F. Henry Habicht, outgoing EPA deputy administrator; and Barry Commoner, director of the Center for the Biology of Natural Systems at Queens College in Flushing, New York.

Conference participants reached no consensus about how the new EPA leadership might change the plan of the agency's current administration to use a risk-based approach to set priorities—that is, to use scientific information on the size of various environmental and health risks to focus risk reduction efforts on those risks that pose the greatest hazards. Some suggested that there are other ways to

identify these risks and to set risk reduction priorities. At the conclusion of the conference, Habicht admitted that, at present, there is insufficient information for determining which approach or combination of approaches to adopt. He suggested that one of the first actions of the agency's incoming administration should be to help build institutions capable of making such a determination.

Much of the first half of the conference was devoted to a discussion of ways in which a risk-based approach could be improved. Participants questioned the certainty with which science can say that some risks are objectively worse than other risks. Some noted the pitfalls of relying more on expert judgment about the statistical magnitude of various environmental and health risks than on public perceptions about the seriousness of these risks. Others wondered whether a risk-based approach to the setting of risk reduction priorities would hamper the ability of states and local communities to tailor such priorities to their own circumstances, especially in light of their tight budgets.

During the second half of the conference, three proposals were put forward for reducing health and environmental risks without requiring that these risks be assessed beforehand. In setting priorities for risk reduction, Commoner suggested that EPA focus on pollution prevention—a strategy the agency has touted as an ideal means for reducing certain risks, but only after they have been identified as "high priority." Because of the massive changes society would have to undertake to prevent pollution, Commoner argued, decisions about which preventive actions are important should be based on public opinion rather than on risk assessment. Robert Bullard, a professor of sociology at the University of California-Riverside, argued that EPA should focus on reducing environmental and health risks in minority communities where people face a number

of risks from various sources of pollution. Nicholas Ashford, a professor of technology and policy at the Massachusetts Institute of Technology, argued that EPA should not target risks per se but should concentrate on regulating those industries that are ripe for the introduction of innovative control or prevention technologies.

The conference concluded with several participants urging EPA to adopt one or more hybrid approaches to risk reduction that would make use of the best features of risk assessment, the pollution prevention strategy proposed by Commoner, the environmental jus-

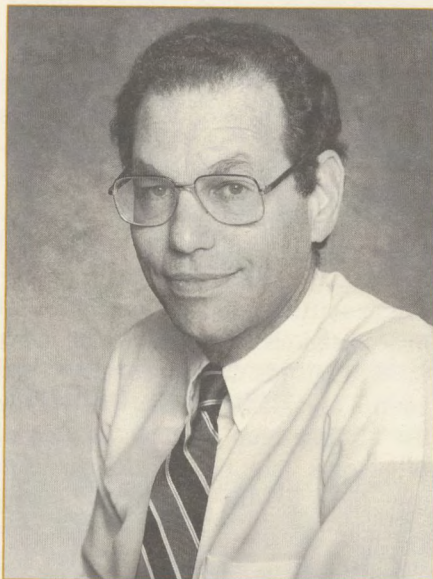
tice ethic championed by Bullard, and the technological innovation policy favored by Ashford. Although there was substantial controversy about the role of risk assessment in setting risk reduction priorities, many participants seemed to agree that it is a good way to identify the worst symptoms of environmental degradation but that it is not the only rational way to ameliorate the worst causes of such degradation.

In late 1993, the Center for Risk Management expects to publish a proceedings volume containing all the conference papers as well as synopses of the various discussions.

New director of the Center for Risk Management arrives

J. Clarence Davies III took over as director of the Center for Risk Management at Resources for the Future (RFF) on December 1, 1992. Before coming to the center, Davies was a senior fellow at the World Wildlife Fund. He recently completed his duties as executive director of the National Commission on the Environment, a blue-ribbon panel convened by the World Wildlife Fund to review the current state of U.S. environmental policy.

During the 1970s, Davies was a fellow at Resources for the Future and served as assistant director of RFF's then Institutions and Public Decisions Division. As director of the Center for Risk Management, one of his tasks will be to help shape the center's research agenda. Davies expects staff members to direct some of their near-term efforts to answering questions raised at a center-sponsored conference on alternative ways to set environmental priorities that was held November 15-17, 1992 (see "Center for Risk Management sponsors conference on setting national environmental priorities" on p. 20 of this issue).



J. Clarence Davies III

Hugh L. Keenleyside, 1898-1992

Hugh L. Keenleyside, an honorary director of Resources for the Future, died on September 27, 1992. A member of the RFF board of directors from 1960 to 1968, he had a number of careers—he was a history professor, diplomat, public administrator, United Nations agency director, power utility chairman, university chancellor, and author.

In 1929, after a series of positions at universities and in book publishing, Keenleyside joined Canada's Department of External Affairs and was dispatched that same year to Japan to open the first Canadian legation there. He served as first secretary in Japan until 1936. In 1940 he was appointed Canadian secretary of the newly formed Permanent Joint Board on Defence and the next year was appointed assistant secretary of state for external affairs. In 1945, Keenleyside was appointed ambassador to Mexico. He returned to Ottawa two years later as deputy minister of mines and resources. His work for the Canadian government ended after 1949, when he headed a Canadian delegation to the United Nations. For the next ten years he served as the director-general of the United Nations Technical Assistance Administration. From 1961 to 1969, Keenleyside was co-chairman of the new British Columbia Hydro and Power Authority. Later he took the post of chancellor of the now closed Notre Dame University in Nelson, British Columbia.

Keenleyside was the recipient of numerous awards, including the Companion of the Order of Canada in 1969 and the Pearson Peace Medal in 1982 for outstanding work in foreign affairs. The University of British Columbia recently established an endowment in his name for studies in Canadian diplomacy.

The author of five books, Keenleyside wrote numerous articles on economic, social, and international affairs.

Discussion papers

RFF discussion papers convey the preliminary findings of research projects for the purpose of critical comment and evaluation. Unedited and unreviewed, they are available at modest cost to interested members of the research and policy communities. Price includes postage and handling. Prepayment is required. To order discussion papers, please send a written request, accompanied by a check, to Discussion Papers, External Affairs, Resources for the Future, 1616 P Street NW, Washington, DC 20036-1400.

The following papers have recently been released.

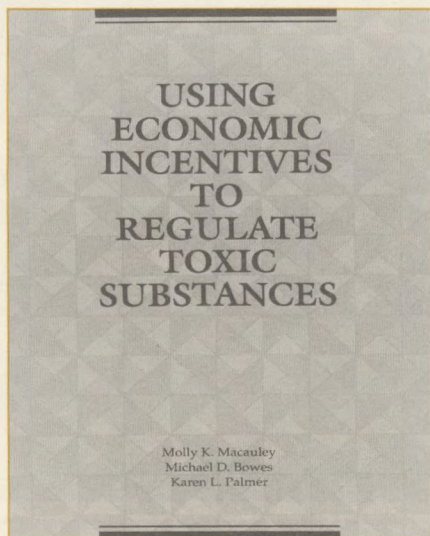
Energy and Natural Resources Division

- "Risk, Liability, and Monopoly," by James Boyd. (ENR93-01) \$5.00
- "Insolvency, Product and Environmental Risk, and Rule Choice: A Market Equilibrium Analysis of Non-Compensatory Damages and Financial Responsibility," by James Boyd. (ENR93-02) \$5.00
- "How Should an Accumulative Toxic Substance Be Banned?" by Michael A. Toman and Karen L. Palmer. (ENR93-03) \$5.00
- "Relative Liability: Implications of the Use of State-of-the-Art and Customary Practice Defenses in Tort Law," by James Boyd and Daniel E. Ingberman. (ENR93-04) \$5.00

Quality of the Environment Division

- "The Analytics of Social Costing in a Regulated Industry," by Dallas Burtraw, Winston Harrington, A. Myrick Freeman III, and Alan J. Krupnick. (QE93-01) \$2.25.

New book



Using Economic Incentives to Regulate Toxic Substances

by Molly K. Macauley, Michael D. Bowes, and Karen L. Palmer

More than 60,000 chemicals enter into the multitude of products and services of everyday life. The sheer variety, ubiquity, and economic importance of these chemicals present a daunting challenge to the regulator attempting to safeguard against their undesirable health or environmental side effects. Regulation of toxic chemicals attempts to bring about these safeguards through command and control, such as rules that restrict the use of chlorofluorocarbons as aerosol propellants. Incentive-based approaches can offer a flexible and possibly lower-cost alternative to command and control. Such approaches include taxes and deposit-refunds on the production and use of toxic chemicals.

Although incentive-based approaches can achieve the same results as command and control at lower costs, this book concludes that their use in the regulation of toxic chemicals must be examined carefully. The authors point out that the risks associated with toxic substances can occur at various stages in the life cycle of a chemical and that

not all products containing toxic chemicals or all uses of these substances pose risks or the same kind of risk. Therefore, they argue that regulatory intervention may have to be highly product- or use-specific to safeguard against risk without unduly restricting relatively harmless applications of toxic substances. The authors warn that regulation of toxic substances should not be too narrow, however. If it is, it may result in the development of substitute products that are more harmful than what they replace.

Macauley, Bowes, and Palmer emphasize the importance of conducting a case study of the life cycle, use, and supply-and-demand market characteristics of any chemical that is to be regulated. They present four such studies, investigating the potential effectiveness of various combinations of deposit-refund schemes, product labeling, taxation, marketable permits, and performance bonds to reduce risks associated with chlorinated solvents, formaldehyde, cadmium, and brominated flame retardants.

January 1993. 161 pages. \$24.95 cloth. ISBN 0-915707-65-9

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Recent contributions and grants

Resources for the Future has recently received a \$177,305 grant from the Japan Foundation Center for Global Partnership in support of the first phase of a project exploring the feasibility of integrating environmental economics with development economics. The project is being conducted in collaboration with the National Institute for Research Advancement in Tokyo.

RFF has received corporate contributions from the following corporations and corporate foundations: AT&T Foundation; Baltimore Gas and Electric Company; BP America Inc.; Chemical Manufacturers Association; Dominion Resources; E. I. du Pont de Nemours & Company; FMC Foundation; General Electric Foundation; New England Electric System; Unocal; and Waste Management, Inc.

The following individuals have recently made gifts of \$100 or more in support of RFF research and education programs: Marilyn A. Altobello; James M. Banner, Jr.; J. Robert Berg; Guthrie Birkhead; Charles E. Bishop; Richard C. Bishop; Gianni A. Carbonaro; Anne P. Carter; Emery N. Castle; Marion Clawson; Ronald G. Cummings; Robert K. Davis; Brigitte Desaignes and Ari

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About contributions to RFF

Resources for the Future sustains its programs through its endowment and through income from foundations, government agencies, corporations, and individuals. RFF accepts grants on the condition that it is solely responsible for the conduct of its research and the dissemination of its work to the public. RFF does not perform proprietary research.

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Forthcoming from
RFF, Spring 1993

Valuing Natural Assets: The Economics of Natural Resource Damage Assessment

edited by
Raymond J. Kopp and
V. Kerry Smith

New appointment

Anna Alberini was appointed a fellow in the Quality of the Environment Division at RFF on October 1, 1992. Alberini received her Ph.D. in economics from the University of California-San Diego in 1992. At RFF she will be working on one project to value the health effects of air pollution in Taiwan and on another to examine the effectiveness of an accelerated vehicle retirement (AVR) program in Delaware sponsored by U.S. Generating Company, an independent electric-power generator. For the first project, Alberini will model data from a contin-

gent valuation survey in which individuals are queried about their willingness to pay to have avoided their last multi-symptom episode of illness associated with air pollution. For the second, she will model data from a survey of vehicle owners who were offered the chance to participate in the Delaware AVR program; data will be collected on the value individuals put on their vehicles, the number of years they expect their vehicles to operate, and the socioeconomic characteristics of individuals who drive old and highly polluting vehicles.

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