

## Compensating losers when cost-effective environmental policies are adopted

Dallas Burtraw

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*Cost-effective approaches to environmental problems promise significant cost savings relative to traditional approaches. But because changes in environmental policy aimed at cost-effectiveness can adversely affect some members of society, the provision of compensation may be needed to ensure political support and to satisfy concerns about equity. In the context of such policy changes, this provision hinges on the comparative harm inflicted by different approaches, among other factors. One principle for promoting equity and ensuring economic efficiency in the provision of compensation is to link the form of compensation to the form of harm a policy change inflicts.*

U.S. policymakers are taking cost-effective approaches to environmental and other social policy problems more seriously than ever before. Unlike command-and-control (CAC) approaches to environmental regulation, which prescribe detailed measures for achieving a stated level of environmental quality, cost-effective approaches typically allow flexibility in how a given level of quality is to be achieved. In many cases, cost-effective approaches that incorporate economic incentives—taxes, marketable permits, property rights,

and, occasionally, subsidies—can make it possible to meet policy goals at a lower cost than more traditional CAC approaches. For example, the trading of permits for sulfur dioxide emissions, provided for in the Clean Air Act Amendments of 1990, could potentially save the electric utility industry up to \$1.5 billion per year in meeting emissions reduction goals aimed at curbing acid rain. Economists have estimated in a number of studies that cost-effective approaches such as incentive-based (IB) regulation could achieve various environmental goals at a cost savings of 50 to 90 percent as compared with CAC approaches. With the United States currently spending \$115 billion per year to comply with environmental regulations, even small savings can be important because such savings free resources for other uses, including the resolution of other social problems.

Yet—although this point is not widely appreciated—the move to cost-effective policies also generates losers. For instance, not everyone will be made better off by the advent of an emissions trading program under the 1990 Clean Air Act Amendments. The flexibility inherent in the program will enable many utilities to abandon the use of high-sulfur coal. One group that will be adversely affected is residents in regions of the country that

produce high-sulfur coal, where as many as 16,000 coal miners may lose their jobs. That it is possible in theory for society to compensate the losers and still realize a cost savings is of little consolation to those who come out on the short end of the stick as a result of a change in policy.

Recently, as a contribution to *Project 88—Round II*, a bipartisan study on incentive-based environmental policies sponsored by senators Timothy Wirth of Colorado and the late John Heinz of Pennsylvania, researchers at Resources for the Future (RFF) surveyed a number of cost-effective approaches to environmental problems. In each case (and even when a switch from more costly CAC policies was being contemplated), a clear set of losers could be readily identified. This finding has led RFF researchers to think about ways to use some of the cost savings of IB policies to cushion or eliminate losses that others would suffer from society's pursuit of environmental goals.

### **When is compensation justified?**

What are the social motivations for providing compensation to individuals harmed by a policy change? One pragmatic reason—and the one probably most important in actual policymaking—is to build political support for a policy change. When potential losers have the power to block the change, it may be necessary to at least partially offset losses to gain acceptance of the change. This is especially the case when the losers are easily identifiable and well organized, and the gainers are widely distributed and poorly organized.

A less pragmatic motivation stems from concerns about equity. Society may feel compelled to provide compensation when some of its members, especially those who are less fortunate, suffer significant losses from a policy change. Suppose, for example, a particular policy would provide very small benefits to a very large number of people, but would impose all its costs on a small group of very poor people (building a freeway through a poor neighborhood, for instance). Even though total benefits might exceed total costs by a wide margin, society might be uneasy about implementing a policy with perverse equity

implications. Indeed, dealing equitably with those who suffer windfall losses may be necessary not only to achieve equity in the process of change, but to preserve social cohesion and a belief in the fairness of social rules and institutions.

Society may also favor the provision of compensation on the grounds of economic efficiency. Specifically, individuals may be unwilling to endorse policies

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**In actual policymaking, frequently the most important reason for providing compensation is to ensure political support for a policy change.**

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for which total benefits exceed total costs if they are unsure that they will personally receive benefits in excess of costs. If they were reassured that compensation would be offered to at least lessen the burden on those individuals who might be big losers, they might support such policies as a matter of course. Thus a commitment to providing compensation can serve a "social insurance" rationale.

Finally, it is worth noting that some people believe losers from policy changes should always be compensated. They hold that the provision of compensation in all cases would encourage policymakers to take greater care in calculating the actual tradeoffs of policy changes before implementing those changes.

### **How much compensation is justified?**

Generally, the context of a policy change must be considered to determine how much compensation is justified. This determination hinges on several factors. One is the baseline against which the policy change is being measured—that is, the current policy (or lack of one) or another policy that could be implemented in place of the one being contemplated. The baseline determines not only the amount of harm being inflicted but also the identity of the losers from a policy change. For example, suppose a restric-

tion on economically wasteful grazing of livestock on federal land is being proposed. If this restriction is being measured against the baseline of previously allowed grazing on federal land, the losers would be those who had been earning a living by grazing livestock on that land. But if grazing had never taken place on federal land, the losers from the proposed restriction would be the ranchers who might have profitably operated there. Society presumably would feel that the amount of compensation justified is greater in the first case than in the second case.

Thus the baseline is important in calculating the amount of compensation justified as a result of changes in environmental policy aimed at cost-effectiveness, because some policy changes could be measured against different baselines. For instance, in considering changes in policies regarding hazardous waste management, should IB approaches be compared with a baseline of no regulation or with a baseline of the existing inflexible rules under the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (known as Superfund)?

To illustrate this point further, consider the evolution of that portion of the 1990 Clean Air Act Amendments dealing with acid rain. Against the current baseline of no policy at all, the losers from new IB regulations are sure to include those electric utilities' shareholders and ratepayers who would have to bear the costs of controlling sulfur dioxide emissions. However, if the baseline is CAC regulation—especially regulation that requires the use of specific emissions control technology such as sulfur removal systems (scrubbers)—then incentive-based approaches like emissions trading create a different set of losers. In this case, electricity consumers and corporate shareholders would benefit relative to the baseline because they would pay less for pollution control than they would through CAC regulation, while miners of high-sulfur coal would suffer losses due to the shrinking market for their product.

In addition to the baseline, another factor that affects the size of compensation is the degree of surprise contained in



Photo courtesy of the United Mine Workers of America

**Measured against command-and-control regulation, the winners from the adoption of incentive-based regulation to control sulfur dioxide emissions are electric utilities' shareholders and ratepayers, while the losers are miners of high-sulfur coal.**

a policy change. The magnitude of compensation that is viewed as justified is likely to reflect the degree to which the policy change could be anticipated. For example, society might feel that greater compensation would be justified if there was a sudden change in policy. However, the legitimacy of a claim might be diminished if ample warning of a change had been given. For example, with regard to the 1990 Clean Air Act Amendments, many people seem to feel that the claim to compensation by miners of high-sulfur coal has been diminished by the fact that tougher acid rain controls have been debated for nearly fifteen years. Indeed, legislation on acid rain that was offered just a few years ago would have contained a sizable compensation package for coal miners, but was stymied by legislators from the affected regions.

When a switch to an IB policy is being contemplated, another factor that affects the amount of compensation is the fact that IB policies already embody elements of compensation. Unlike CAC policies, IB policies provide implicit compensation to the extent that they lessen the burden on individuals who would be negatively affected. For instance, given that society has decided to do something

about acid rain, cost burdens are minimized through the use of IB policies (even though some groups would benefit if forced scrubbing or some other mandated technological approach were required). Thus less compensation may be justified when IB policies replace more costly CAC policies.

Incentive-based policies can also embody an element of explicit compensation. In the case of emissions permits and emissions taxes, the initial allocation of permits and the dispensation of tax revenues constitute transfers of wealth that explicitly compensate some of the agents who must comply with emissions reductions at the expense of other such agents. A well-functioning emissions permit market or system of emissions taxes will achieve an efficient outcome independently of how permits are initially allocated among emitters or tax revenues are dispensed. However, implementation of a permit market or emissions tax system would be incomplete if policymakers failed to prescribe the initial allocation of permits or the dispensation of tax revenues. Thus, unlike CAC policies, IB policies require policymakers to address compensation issues by assigning costs within an industry.

Hence, IB policies may invite less compensation than CAC policies for two reasons. First, the magnitude of the negative effects of a policy change are reduced due to the implicit compensation resulting from the economic efficiency of IB policies. Second, the distribution of the remaining cost burden can be directly remedied, in part, through the explicit apportioning of costs.

### **What form should compensation take?**

When motivated purely by altruism, a monetary transfer is often thought to be the most efficient form of compensation because it maximizes the well-being of the recipient while minimizing the cost to the donor. Unfortunately, the presumed superiority of monetary compensation breaks down in a wide assortment of circumstances.

One disadvantage of monetary compensation is the difficulty individuals have in placing a fair dollar figure on harm. This is because compensable harm virtually always takes multiple forms. For example, harm due to the operation of an industrial facility may take the form of decreased property values, increased traf-

fic congestion, and negative health effects that occur over time and are of an uncertain nature. Subjective monetary valuation of such harm can lead to inconsistent decisions on compensation. Some individuals simply do not want to calculate a monetary value for harm, perhaps because they find it offensive to do so. Even if economists could consistently assign a monetary value to harm, individuals might not be able to reconcile that valuation to their own satisfaction.

One alternative to monetary transfers that avoids the problem of monetary valuation is linked compensation, wherein the form of compensation directly addresses the form of harm. To take the example of harm from operation of an industrial facility again, linked compensation could call for the dedication of money or land for local amenities such as open space to bolster property values, road improvements to remedy congestion problems, and community programs to improve public health. The benefits of these amenities would persist over time, thereby partly averting the perplexing tradeoffs between the present and the future. Most important, the tradeoffs between the benefits of the amenities and the harm posed by the facility are made transparent in a way that is impossible with monetary valuation.

Linked compensation is likely to meet with greater acceptance than monetary compensation because subjective comparisons between similar objects are easier to make than comparisons between dissimilar objects, such as those required in monetary valuations of compensable harm. In psychology, this phenomenon is known as the comparability hypothesis. This hypothesis suggests that calculation of and consistent judgment about fair tradeoffs are facilitated when individuals are asked to consider compensation that responds to the nature of harm.

Linked compensation also appears superior to monetary compensation for political reasons. For example, when compensation in the form of a monetary transfer is being considered, community concerns can be characterized as "extortion" and offers of compensation as "bribes." These characterizations are less tenable when linked compensation is being offered. In fact, the offer of such compensation validates community con-

cerns, indicating to the public that its concerns are being taken seriously and that policymakers are willing to compromise. Moreover, linked compensation avoids political issues that arise in monetary transfers, such as how money is to be divided. In general, linked compensation promotes a perception of fairness, which is particularly important in the absence of precedents for monetary valuations. This perception can instill a sense of procedural equity that is important to reaching an agreement on the compensation to be provided.

The superiority of linked compensation is also supportable on grounds of efficiency. First, whenever government has imprecise information about the distribution of compensable harm among the population (a prevalent circumstance), the offer of monetary transfers invites individuals to misrepresent their qualifications to claim compensation intended

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**L**inked compensation facilitates consistent judgments about fair tradeoffs, promotes a perception of fairness, and encourages economic efficiency.

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for others, a phenomenon known as adverse selection. In this circumstance, linked compensation is more efficient than monetary compensation—as long as the compensable goods or services cannot easily be transferred or exchanged among individuals—because individuals have less incentive to unjustly misrepresent their claim to resources.

Second, the anticipation of monetary compensation tends to discourage potentially injured parties from pursuing appropriate behavior to avoid or minimize harm, creating a situation referred to as moral hazard. Indeed, the potential for such a situation has been a prevalent argument against ever providing compensation. However, linked compensation reduces moral hazard and leads to more efficient avoidance behavior.

Third, linked compensation is frequently less expensive than a monetary

transfer. When harm affects a public good—by depressing property values, for example—a compensating investment in a public good—say, dedication of land for open space—creates benefits for the donor as well as the public. These benefits to the donor partially offset the dollar cost of the investment. On the other hand, when the compensable harm is privately experienced—as in the case of a potential threat to the health of some individuals—a compensating investment in a health service or a health monitoring system may allow the donor to extend its own existing employee health programs, thus spreading out the fixed costs of its health programs.

Finally, linked compensation can be superior to monetary compensation when compensation is motivated by paternalism rather than by altruism. When the party providing compensation is interested in improving the overall welfare of the recipient, this interest is usually regarded as altruism. When the party providing compensation is interested in improving a particular aspect of the recipient's welfare, this interest is regarded as paternalism. Linkage between the nature of the harm and the nature of the compensation can help to satisfy paternalistic interests while facilitating the provision of compensation.

Compensation motivated by paternalism may play an important role in negotiations concerning international environmental problems such as global warming or the depletion of the ozone layer. The enormous potential cost of abating these problems requires that negotiators place a premium on finding cost-effective approaches. Since the less developed countries—which are experiencing the most rapid increase in population, energy use, and pollution—typically have less efficient technologies than the industrialized countries, a cost-effective approach would require large investments to improve technological efficiency in the economies of less developed countries. Most observers agree that the industrialized countries have to be willing to make large transfers of resources to less developed countries for this purpose. But in the United States, at least, the political climate is not conducive to dedicating additional resources to interna-

tional aid. However, transfers of resources that are specifically targeted for technological investments to reduce pollution in developing countries may serve the paternalistic self-interest of developed countries seeking cost-effective solutions to international environmental problems.

Some have suggested that IB approaches, such as an international system for trading emissions permits or for taxing pollutant emissions, could provide cost-effective mechanisms for reducing global pollution. The transfer of revenues that would occur would be targeted for improving technological efficiency in less developed countries.

Linked compensation inherently complements incentive-based approaches to environmental problems in domestic situations as well. For example, a CAC approach to air pollution typically requires a new industrial facility to con-

form with specific performance standards. This approach may not be cost-effective, and often does not compensate those who are harmed by the additional air pollution from the new facility. One less costly approach, which effectively compensates those who would be harmed by additional sources of pollution, is the automobile "death certificate" program initiated in southern California by the Unocal Oil Company. Under this program, Unocal bought and scrapped highly polluting pre-1977 automobiles to offset its own new sources of pollution. This approach is both cost-effective and widely perceived by the community as fair.

In summary, the role of compensation is an area of research in which one can reach few general conclusions. Every person has an individual sense of justice and an equally valid opinion about the merits of compensation in specific circumstances.

However, linked compensation is one principle that has broad applicability. It makes the connection between harm and compensation explicit, thereby promoting a sense of allocative equity. It also serves to validate individual concerns, helping to promote a sense of procedural equity. Moreover, it encourages economic efficiency in the delivery of compensation. For all these reasons, linked compensation can be a useful principle for implementing new approaches to cost-effective environmental regulation. ■

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*Dallas Burtraw is a fellow in the Quality of the Environment Division at RFF. This article is based on research conducted by Burtraw and RFF vice president Paul R. Portney.*

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## The role of biological and economic analyses in the listing of endangered species

Jeffrey B. Hyman and Kris Wernstedt

*Application of the Endangered Species Act is typified by intense and sometimes acrimonious debate among parties with divergent ecological and economic viewpoints. Unfortunately, formal biological and economic input to the process of protecting species under the act is often underappreciated. Faced with the proposed listing of several salmon stocks in the Columbia River basin as endangered, the Pacific Northwest region has the opportunity to bring biological and economic analyses, such as those developed at Resources for the Future, to a more prominent position. Critical as they are, such analyses must reflect the enormous uncertainty about threatened and endangered populations.*

**A**nadromous salmon (salmon that ascend rivers from the sea for breeding) are considered by many to be a critical component of the legacy and identity of the Pacific Northwest region of the United States. During the last 100 years, however, the annual runs of adult salmon in the Columbia River basin have declined by an estimated 75 to 85 percent, according to the Northwest Power Planning Council. Some runs are already extinct, while others (such as the run of sockeye salmon in the Snake River) have dwindled to a small fraction of their original size. Dams built throughout the region for power generation and flood control are thought to be the largest factor behind the declines. Other contributing factors are fishing, withdrawals of water for irri-

gation, and land-use practices that affect the stream habitat where adult fish spawn and the young spend their early lives.

On April 2, 1990, the Shoshone-Bannock Native American Tribe of Idaho petitioned the National Marine Fisheries Service (NMFS) of the U.S. Department of Commerce to list sockeye salmon in the Snake River as an endangered species. Following the tribe's lead, a coalition of environmental groups petitioned the NMFS to list coho salmon in the lower Columbia River, as well as the spring, summer, and fall runs of Chinook salmon in the Snake River, as endangered.

As required by the Endangered Species Act (ESA), the secretary of commerce had one year from the date of petitioning to decide whether to propose

listing for any of the runs. In April 1991, the secretary proposed that the Snake River sockeye be added to the endangered species list, and in June the secretary proposed that the spring, summer, and fall runs of Chinook be listed as threatened, as opposed to endangered. (A threatened species is one which is deemed likely to become endangered within the foreseeable future.) The secretary must make a final decision on the sockeye run by April 1992 and on the Chinook runs by June 1992. For any stocks listed as threatened or endangered, the NMFS must designate the critical habitat of the stocks and produce explicit plans for their recovery.

The part of the listing process that still remains (final listing decisions, critical habitat designations, and production of recovery plans) will not be easy. The process is complicated by the importance to the regional economy of human activities that have contributed to the decline in salmon populations. Numerous and often divergent ecological and economic viewpoints must be considered in the process if it is to be perceived as politically legitimate. Unfortunately, some of the interest groups representing these view-

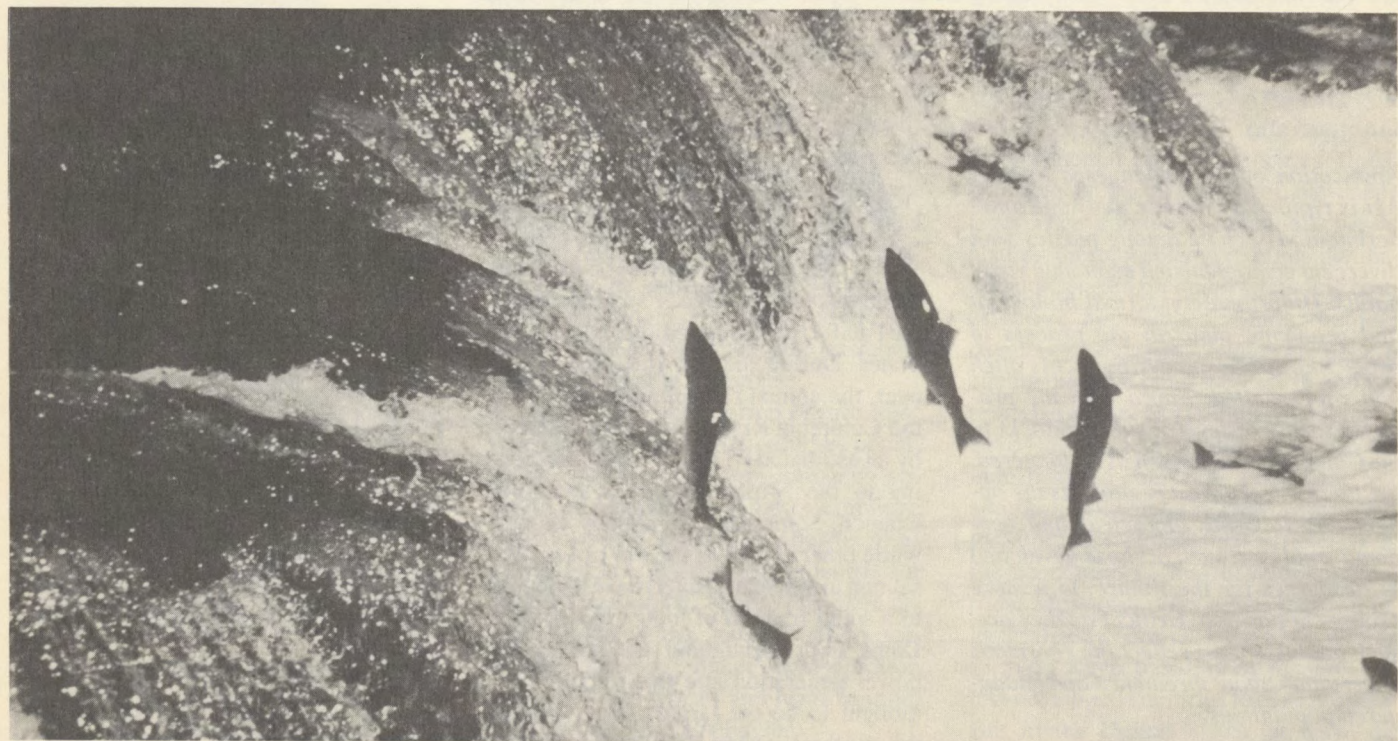
points—electric utilities, environmental advocates, the barge industry, recreational boaters, agricultural irrigators, logging and mining interests, the aluminum industry, government agencies, and commercial, sports, and tribal fishing interests—often have different values and assumptions, and common ground is difficult to find. For example, many fish advocates believe strongly that the Columbia and Snake rivers' salmon stocks should be preserved at all costs. Other groups, representing such interests as farming and commercial fishing, believe that the decision to list a stock as endangered must take into account the economic livelihood of humans.

Political forces will ultimately decide what to protect and how to protect it. Nonetheless, diverse values and viewpoints need to be integrated in the decision-making process through rational application of biological and economic analyses. Even in a rational atmosphere, however, the obstacles to clear analyses under the ESA are formidable. Questions about viable population sizes, what populations are covered, and the relevance and scope of economic analyses complicate the picture.

## Minimum viable populations

A fundamental question in the ESA listing process is how small a population can be without being in serious danger of extinction. Small populations tend to lose their genetic variation, a phenomenon that is thought to compromise their evolutionary ability to adapt to variable conditions such as exposure to new diseases or climatic change. The viability and fecundity of these populations may also be reduced as a result of inbreeding among related individuals. In addition, small populations are more vulnerable than large populations to short-term environmental events (such as weather extremes and disease outbreaks) and to random failures of individuals to survive and reproduce. These factors create a feedback cycle known as an extinction vortex: the smaller the population, the greater the effects of these factors, which further reduce the population size, and so on.

As part of the listing process, scientists try to determine the minimum number of individuals needed to maintain a viable population. Typically, one of two criteria is used to define the minimum viable population (MVP): (1) the popu-



*Some interest groups say salmon stocks in the Columbia River basin should be preserved at all costs; other groups assert that protection of endangered stocks must not be allowed to threaten the region's economic livelihood.*

Photo courtesy of the U.S. Fish and Wildlife Service

lation size necessary to ensure a given probability that a population will persist for a given duration (for example, a 95 percent probability of persistence for 100 years), or (2) the size necessary to ensure that a population will continue to have the capacity to evolve. It is likely that the second criterion will give MVP sizes much larger than the first, but the actual population size necessary to satisfy either criterion is difficult to determine and likely varies for each population being considered.

### What populations are covered by the ESA?

Interpretation of the Endangered Species Act itself presents difficulties to those involved in the ESA listing process. One recurrent issue is how to apply the act—which affords protection to species, subspecies, and populations—to populations within a species. In the case of the Columbia River basin salmon, it is not biologically designated species that have been proposed for listing, but rather stocks—that is, populations that to some extent are isolated in time or space from other populations of the same species during breeding. Given that the American Fisheries Society has recently identified 76 native stocks of Pacific salmon and steelhead trout in the Columbia River basin that are at risk of extinction or are of special concern, a question arises about which stocks qualify for ESA coverage.

The NMFS has recently concluded that distinct stocks may be considered a species for the purposes of the ESA if two criteria apply. First, the stocks must be substantially isolated reproductively from other stocks of the same species. Second, they must represent an important component in the evolutionary legacy of the species—that is, they must contribute to the ecological and genetic diversity of the species as a whole. Stocks that would qualify most easily are those from large tributary systems and those with unique traits that reflect adaptation to local conditions. Preserving several geographically separate and distinct populations of a species is thought to be integral to the preservation of the species as a whole by protecting genetic variation and sources of recolonization.

Determination of reproductive and genetic isolation is complicated by several factors. Although adult salmon theoretically return to their natal stream to spawn, homing is not perfect, and there may be substantial straying among some stocks. Moreover, hatchery operations have been a major cause of stock mixing. Even if there is physical mixing of stocks, however, this need not imply that a large amount of genetic mixing has taken place or that population gene frequencies will be substantially altered. A combination of genetic analysis, geographic analysis, and physical tagging of fish would be required to provide evidence for or against reproductive and genetic isolation.

### Relevance of economic concerns

Biological analysis is clearly important in the ESA listing process, but is economic analysis also relevant? The different values of various interest groups involved in the process, and misunderstandings about how the process works, often fuel debate concerning how large a role economics should play. The ESA stipulates that economics cannot play a role in the decision to list a species as endangered or threatened. This requirement reflects a belief that the preservation of animal and plant species takes priority over human economic activities. In other words, the benefits, however

interest groups weigh the costs and benefits of a proposed listing and management actions associated with the listing, and decide to support or oppose a listing petition based partly on that assessment. This takes place outside the formal listing decision process, but obviously influences the deliberations in some qualitative sense since these groups submit scientific data to the secretary of the Interior or Commerce departments, who makes the listing decision. Furthermore, since the ESA requires the secretary to take into account existing efforts at preservation in the decision on whether to list a species, economic analysis is indirectly incorporated if it entered into the design of those existing preservation efforts.

A second use of economic analysis in the ESA listing process is supported by Section 4 of the Endangered Species Act. This section stipulates that the secretary of the Interior or Commerce department designate habitat critical for the survival of the endangered or threatened species after taking into consideration the economic impact, and any other relevant impact, of specifying a particular area as critical habitat. Thus, while the likelihood of economic impacts cannot formally influence the decision on whether to list a species as threatened or endangered, economic impacts can be used as criteria for developing critical habitat guidelines.

A third clear role for economic analysis lies in evaluating recovery plans that must follow designation of a species as endangered or threatened. A recovery plan must provide estimates of the costs associated with the measures proposed to achieve recovery. In the case of the ESA listing process for salmon, an economic analysis would attempt to explore the costs of recovery actions that produce fish or enhance their survival. These costs include the direct capital and operation and maintenance costs of actions, as well as the opportunity costs of removing resources from existing uses. An obvious example of the latter is the value of the hydropower losses that result from attempts to manage the hydrosystem to benefit fish rather than maximize power revenues. The annual opportunity cost to the Bonneville Power Administration (BPA), the federal agency that markets the hydroelectricity produced at federal

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**G**uidelines that limit the scope of formal economic assessments may be difficult for decision makers to implement in practice.

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measured, of preserving a species and preventing an irreversible ecological change exceed the costs of preservation. Most would agree, however, that there are several informal as well as formal applications of economic analysis during both the pre- and post-listing process.

Informal economic assessments often take place de facto, whereby special in-

dams on the Columbia-Snake river system, reaches \$50 million.

The implementation of these guidelines for economic analysis is often difficult in practice. For example, even though the ESA clearly limits the scope of formal economic analysis, decision makers are subject to political pressures and thus understandably may have trouble keeping such analysis out of the decision on whether to list. Moreover, decision makers must be aware of the influence of informal economic analysis on the level, timing, and objectives of participation by special interest groups in the ESA process.

### Biological and economic uncertainty

A high degree of uncertainty characterizes any biological or economic analysis. Therefore, analysts must explicitly address the issue of uncertainty in all ESA deliberations. On the biological side, there will always be limitations in our knowledge of the characteristics and functions of ecosystems, populations, and or-

ganisms. There is a general lack of accurate estimates of demographic parameters and population sizes, especially for populations threatened with extinction. Even those parameters that are relatively easy to measure often exhibit pronounced yearly fluctuations and are difficult to predict. In addition, the projected effects of actions to preserve populations are often based on theoretical rather than empirical considerations.

Most of the economic uncertainty is associated with post-listing recovery plans. Analysts probably can make reasonably accurate predictions of the direct costs of recovery actions—for example, the costs of bypass systems that divert fish from dam turbines. However, analysts are on less stable ground when they try to account for the adjustments that economic interests in the region may make in response to the indirect effects of recovery actions—for example, the decreased availability of irrigation water. Economic theory clearly indicates that adjustments in resource use and prices can occur. However, the extent of these

adjustments is controlled by both rational and nonrational human behavior, and is thus difficult to predict.

In the context of traditional decision making, biological and economic uncertainty simply weakens arguments, and thus often becomes the basis for delaying action. Yet, to prevent the possible

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**D**ecision makers must accept the fact of biological and economic uncertainty and incorporate it in the decision-making process.

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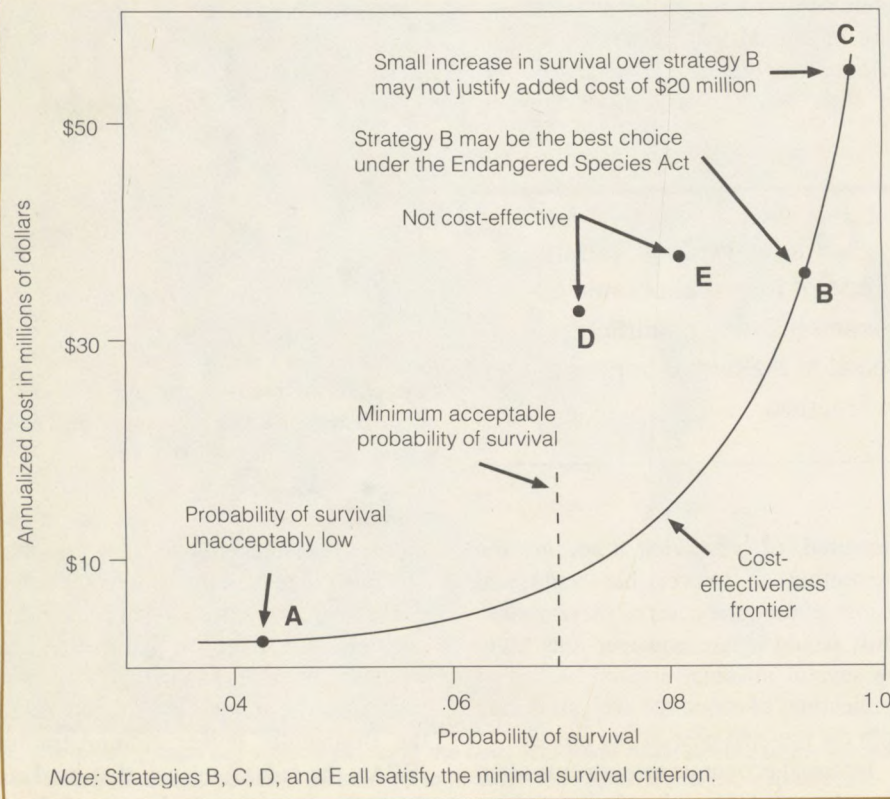
extinction of a species or population, biological and economic analyses must proceed as quickly as possible. Decision makers must accept the fact of uncertainty and incorporate it into the decision-making process. Any statement concerning the expected fate of a species or population, its response to mitigation, or the economic implications of mitigation, should be stated in terms of the probability that any one of a range of future states will occur. The acceptability of the probabilistic outcomes can then be evaluated on the basis of criteria established a priori.

### A modeling approach

Faced with the need for a methodological approach that can deal with the inevitable uncertainties and time constraints encountered in every ESA listing process, reliance must be placed on mathematical models. These models address the need for an explicit, objective, and relatively quick method for evaluating the present and future danger to a species or population, as well as the economic costs associated with reducing that danger.

Mathematical models that depict biological processes have already contributed greatly to the assessment of several small populations threatened with extinction, such as the grizzly bear, the Florida panther, and the northern spotted owl. For modeling such populations, some type of stochastic model is generally used so that

**Relationship Between Costs of Species Protection and the Probability of Species Survival for Five Hypothetical Protection Strategies**





uncertainties about the future states of nature can be explicitly incorporated. The output of such models consists of probability distributions for summary measures such as the predicted number of years until extinction of the population.

On the economic side, one of the most common evaluative approaches is to use some form of cost-benefit analysis. This is inappropriate for the task, however, since species survival is given overriding importance and thus is perceived as having infinite benefits. A cost-effectiveness modeling approach avoids the issue of evaluating benefits by setting desired objectives a priori and searching for the lowest-cost ways of achieving these. It thus facilitates comparison among alternative recovery management plans. It does not provide a metric to decide how many fish to produce and at what cost, but it can allow elimination of those actions that cost more than equally or more effective alternatives or those that cost the same as more effective options. Such an approach also allows decision makers to build a "frontier" of cost-effective actions that highlights the higher marginal costs associated with producing additional plants and animals or ensuring greater survivability (see figure, p. 8). At some point, the small increase in the probability of survival may not justify the tremendous increase in costs.

Before the 1991 decisions by the Commerce Department on the proposal to list the sockeye and Chinook stocks, researchers at Resources for the Future (RFF) and BPA applied a stochastic simulation model developed at RFF to examine the likelihood that the petitioned stocks would survive under various scenarios. The RFF biological model covers the entire life cycle of anadromous fish in the Columbia River basin, and incorporates various sources of parameter variability. In addition to the biological model, RFF researchers have been developing an integer programming model for evaluating the cost-effectiveness of management actions aimed at mitigating the damage done to salmon populations. The model allows quick evaluation of the costs and effects of a number of management actions by assessing all the possible combinations of these actions and screening out all those that do not lie near the cost-effec-

tiveness frontier. Actions that lie on or near the cost-effectiveness frontier can be explored more fully with the more detailed biological model.

The RFF models can contribute to the listing process in several ways. First, they provide information during the listing decision. For example, the results of the biological model suggest that if current conditions continue, Snake River fall Chinook will almost certainly become extinct in the next forty years. Snake River spring and summer Chinook have less than a 10 percent chance of becoming extinct in that time. Second, both the biological and economic models can play a role in the planning of recovery strategies by further refining predictions of the effects and costs

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### **B**iological and economic models can play a role in the planning of recovery strategies and help identify the extent and cost of an effective program to monitor such strategies.

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of alternative actions, thus aiding the selection of management actions. Third, the models can help identify the necessary extent and probable cost of an effective monitoring program once a recovery plan is adopted. The ability to detect an increase in the abundance of salmon resulting from management actions (statistical power) is directly proportional to both the magnitude of the increase in numbers of salmon and the number of years that data are collected, but is inversely proportional to the amount of random variation in abundance. The RFF models can be used to examine the tradeoffs among statistical power, monitoring costs, the necessary effectiveness of mitigation, and the number of monitoring years.

### **Future scientific input to the ESA**

The Endangered Species Act by itself does not adequately protect biodiversity, or ecosystems, or even species in many cases. However, because the ESA can be

brought to bear in a crisis, it is a useful and critical component of any conservation program. The scientific community therefore must continue to improve the quality of the information that it provides to the ESA during the listing process.

On the biological side, more basic research is needed on quantifying genetic change and variation and the interactions among environmental, demographic, and genetic factors. Also, the ability to build models that reflect these interactions must be improved.

On the economic side, more attention needs to be focused on economic changes that may result from measures taken to protect endangered species, and a better understanding is needed of the implications of such changes for regional economic activities. However, analysts must also be aware of ongoing structural changes in the regional economy that, while not themselves driven by the ESA, may interact with ESA-driven changes.

Over the last several years, application of the Endangered Species Act has highlighted the need to consider broad-scale biological and economic issues. The current widespread threat to Columbia and Snake river salmon populations raises serious questions about the ecological integrity of the river system. Moreover, long-term economic sustainability in the Pacific Northwest region also is in question because current patterns of resource use may conflict with the value that the region places on the preservation of salmon populations. The region has begun to address these issues through its approach to the ESA process. Further efforts to integrate species preservation, ecosystem integrity, and sustainability will provide a much needed example of a progressive approach to regional ecological conservation. ■

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*Jeffrey B. Hyman and Kris Wernstedt are fellows in the Quality of the Environment Division at RFF. This discussion draws on ongoing RFF research on evaluating fish and wildlife enhancement strategies in the Columbia River basin. This research is being conducted by the authors, senior fellows Allen V. Kneese and Walter O. Spofford, Jr., and fellows Danny C. Lee and Charles M. Paulsen.*

# New perspectives on transporting nuclear wastes in dedicated trains

Theodore S. Glickman and Dominic Golding

*For years radioactive waste in the United States has been transported in regular freight trains at the behest of the nuclear industry and regulatory agencies. Since 1975, however, the railroads have advocated the use of dedicated trains, believing public safety would be enhanced. It now appears that the decision to use regular freight trains was based on incomplete cost and risk estimates and that social and institutional factors were neglected. New information reveals that the additional cost of dedicated service is lower than previously thought and a small price to pay for reduced public opposition and increased levels of public trust.*

**S**hould spent nuclear fuel and other radioactive waste be transported in regular freight trains or dedicated trains? This question has been at the heart of a fifteen-year debate and is now the subject of a study mandated by the U.S. Congress in the Hazardous Materials Transportation Uniform Safety Act of 1990. The nuclear industry and its regulatory agencies would like to consider the case closed, but this new legislation gives the railroads and other proponents of dedicated trains another chance to present their case. It is a propitious time, therefore, to ask whether earlier conclusions favoring regular trains over dedicated trains are still valid.

In the context of high-level nuclear waste transportation, a "dedicated train" is made up of a locomotive, caboose, buffer cars, and one or more flatcars carrying casks of radioactive materials. No other freight is carried. Following conventional practice, dedicated trains may not exceed 35 miles per hour (mph), and when a dedicated train passes a regular train on a parallel track, one of the trains must stop.

At one time, the railroad industry transported all radioactive materials in regu-

lar train service. In 1975, however, the Association of American Railroads (AAR) advocated that spent fuel and large-quantity radioactive waste should be shipped only in dedicated trains. Growing doubts among the railroads about issues of liability and public safety encouraged this shift in attitude. The railroads have emphasized that dedicated trains may reduce the risks of transporting high-level nuclear waste because passing is restricted, speeds are limited, time and activity in switching yards are minimized, and other hazardous freight is prohibited. The use of dedicated trains also facilitates monitoring, and may enhance public acceptance.

Under current Nuclear Regulatory Commission (NRC) regulations, rail casks for the shipment of high-level nuclear waste must be able to withstand both normal and accident conditions without the loss of shielding or any release of

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**The railroad industry believes the use of dedicated trains will enhance public safety, but the nuclear industry and the agencies that regulate it argue that these trains do little to reduce negligible risks.**

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radioactive materials, and without "going critical"—that is, achieving a self-sustaining nuclear chain reaction. Normal conditions are defined as those that a cask might be expected to endure during routine transportation and handling. The ability of a cask to withstand accident conditions is evaluated by a sequence of tests on the same cask, including: a free drop of 30 feet onto an unyielding surface; a

free drop of 40 inches onto a blunt spike; exposure to a temperature of 1,475° F for 30 minutes; and immersion in 3 feet of water for 8 hours.

The railroad industry has argued that these performance criteria may be inadequate. Fires lasting longer than 30 minutes at temperatures higher than 1,475° F are possible, given the variety of flammable chemicals often carried on regular freight trains. Prohibiting other freight from dedicated trains reduces the likelihood of accidents. Similarly, the railroads recommend restricting dedicated trains to 35 mph, since this is the speed attained during the drop tests. The railroads are also skeptical of the crash tests conducted by the nuclear industry in Great Britain and by national laboratories in the United States. These dramatic demonstrations have included running locomotives into casks at high speeds and crashing cask-carrying trucks into concrete barriers. The railroads have criticized these tests as spectacular exercises in public relations that fail to demonstrate the invulnerability of casks.

The railroads also have continuing concerns about liability. In 1959 they pushed for federal indemnity protection under the 1957 Price-Anderson Act, fearing that the losses arising from a major transportation accident involving the release of radioactive materials could be catastrophic. While the likelihood of such an accident was thought to be remote, the total bill for the claims could be enormous. No insurance company would offer adequate insurance, and the railroad companies could not afford self-insurance of this magnitude. By limiting the liability of operating utilities in the event of a reactor accident, the Price-Anderson Act was intended to encourage the development of commercial nuclear power. The railroads wanted similar protection, and within the year federal indemnity was extended up to \$500 million.

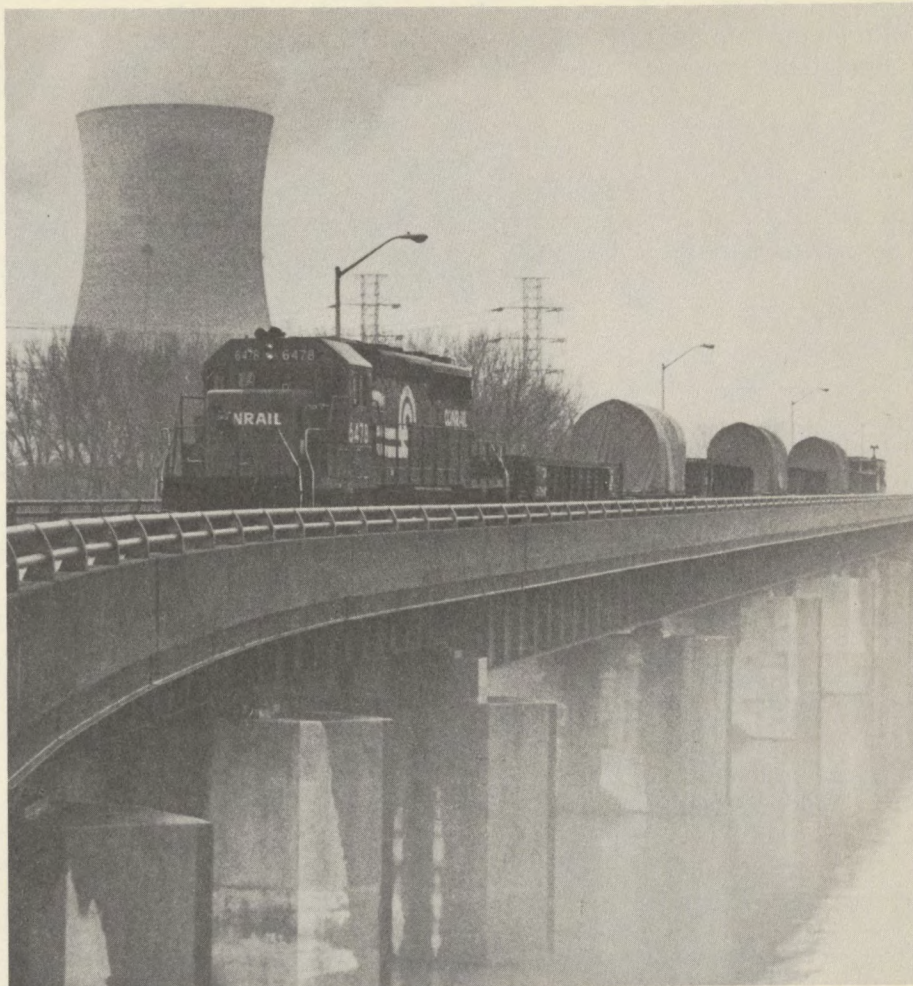
Even in the absence of a release, however, an accident involving a shipment of spent fuel could be very costly in terms of business disruption if it were to result in the prolonged closure of rail lines. It remains unclear whether the Price-Anderson Act would cover such losses.

In contrast, the nuclear industry and the agencies that regulate it have argued that dedicated trains are not only expensive, but do little to reduce already negligible risks. They assert that dedicated trains are unnecessary and uneconomical. In support of this position, the Interstate Commerce Commission (ICC) has repeatedly concluded that the railroads have a common carrier duty to ship spent fuel and high-level nuclear waste, that dedicated trains are unnecessary and wasteful given compliance with federal regulations, and that any surcharges for such shipments are unreasonable.

One particular case was especially influential in setting the terms of the debate. In 1976, a group of eastern railroads proposed to offer commercial rates for the shipment of spent fuel and large-quantity radioactive waste only if these shipments were restricted to dedicated trains. The Energy Research and Development Agency (ERDA), the NRC, the Tennessee Valley Authority, and various utilities objected. Presuming such transportation would comply with NRC and Department of Transportation regulations, the presiding administrative law judge concluded that dedicated trains would provide little additional safety. He found that the risks were already so small that dedicated trains were unnecessary and that additional costs would pose an uneconomical burden on shippers and the public. The ICC concurred.

### The Three Mile Island shipping campaign

In spite of repeated setbacks with the ICC, the railroads were notably successful in negotiating the use of dedicated trains for the shipment of radioactive materials from the damaged reactor at Three Mile Island (TMI). One hundred and fifty tons of highly radioactive fuel and debris were moved in 30 rail shipments from the reactor site near Harrisburg, Pennsylvania, to the Idaho National



*Conrail argued that using dedicated trains to transport radioactive materials from the damaged reactor at Three Mile Island would dramatically reduce transit time.*

Engineering Laboratory (INEL) between July 1986 and April 1990. The route selected by the Department of Energy (DOE) involved two railroads: Conrail from Harrisburg to East St. Louis and the Union Pacific from East St. Louis to Idaho.

While the major controversy revolved around the choice of route, there was also considerable debate about the use of regular versus dedicated trains. DOE wanted to use regular trains but Conrail disagreed, arguing that dedicated trains offer several distinct advantages. Routes could be planned to use the best-quality track and to avoid population centers, and the movement of other trains along the selected routes could be controlled. Such planning and control would facilitate emergency response in the event of an accident. The speed of the train could be restricted and the train could be scheduled to avoid other rail traffic to mini-

mize the likelihood and severity of accidents. Escorts could be provided and trains could be monitored more easily en route, thus minimizing the potential for terrorist intervention. Finally, Conrail believed the use of dedicated trains would enhance public confidence in the safety of rail transport of radioactive waste.

DOE did not accept Conrail's argument, but agreed to the use of dedicated trains because local freight service was the only alternative. (This would have taken eight days rather than two days to reach Union Pacific at East St. Louis, and the rail cars would have spent most of the time idle in sidings under reduced surveillance.) On learning of Conrail's position, Union Pacific, which had originally agreed to ship by regular trains, negotiated to move the first three shipments by dedicated train, with one cask per train. In a subsequent review of DOE's performance, Union Pacific concluded

### Projected Number of Fatalities from Rail Transport of Spent Nuclear Fuel to the Proposed Yucca Mountain Repository Over 25 Years

	Without an MRS		With an MRS	
	Regular trains	Dedicated trains	Regular trains	Dedicated trains
Radiological fatalities	0.10	0.04	0.10	0.07
Nonradiological fatalities	0.73	6.70	8.70	11.00
Total fatalities	0.83	6.74	8.80	11.07

Source: Basinger, K. L., P. L. Hofmann, and L. A. Smith. 1990. *Comparative Analysis of Regular and Dedicated Train Service for the Transport of Spent Nuclear Fuel: Costs and Risks*. OTSP/TM-09. Columbus, Ohio: Battelle Energy Systems Group, Office of Transportation Systems and Planning.

that the agency had failed to educate the public adequately on the safety of the shipments and that public insistence on dedicated trains had increased. General Public Utilities, the owner/operator of the TMI facility, then agreed to cover the additional cost of using dedicated trains for the remaining shipments in order to accelerate the de-fueling process.

Even though dedicated trains were used throughout the campaign, a series of mishaps occurred that led to a temporary suspension of shipments in March 1988. On March 24, 1987, a TMI train hit an automobile in St. Louis, and on December 22, 1987, a TMI train arrived in St. Louis during rush hour. On January 26, 1988, a regular Union Pacific train derailed at the Meramec River on the Missouri portion of the TMI shipment route. Finally, on February 9, 1988, a buffer car erroneously marked with a flammable materials placard was placed in a TMI train that later passed through St. Louis in the morning rush hour, reportedly at excessive speed. The ensuing media attention and public furor prompted Senator John Danforth of Missouri to call for the suspension of further shipments pending a review by the Federal Railroad Administration (FRA). He also called for additional safety measures to be put in place on resumption of shipping. These included the avoidance of rush hours by TMI trains, the requirement that an FRA official and a health physicist accompany all TMI trains, and the placement of three casks on each train to reduce the number of shipments.

Continuing his commitment to this issue, Senator Danforth later pressed for an amendment to the Hazardous Materials Transportation Act that would require the use of dedicated trains in shipping spent fuel and other high-level nuclear waste. In the final Hazardous Materials Transportation Uniform Safety Act of 1990, a compromise provision calls for a study on the advisability of dedicated trains to be completed by the fall of 1991. However, this deadline is unlikely to be met.

#### Cost and risk estimates

The comparative costs and risks of dedicated and regular trains have been estimated in a number of government studies. The costs were addressed most recently by the Battelle Memorial Institute in a report prepared for the DOE

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**The cost of dedicated train service is greater than that of regular train service, but the difference may be overestimated.**

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Office of Civilian Radioactive Waste Management. This report estimated the total cost of transporting high-level nuclear waste from reactors to the proposed waste repository at Yucca Mountain, Nevada, with the possibility of interim storage at a monitored retriev-

able storage (MRS) facility in the eastern United States. With no MRS, the Battelle report estimated this cost to be \$247 million with regular trains and \$373 million with dedicated trains, a relative increase of about 50 percent. These estimates changed to \$539 million and \$583 million, respectively, with an MRS in the system. In this case, the relative increase in cost is only about 10 percent. The costs are smaller with an MRS primarily because DOE assumes that dedicated train service would be used from the MRS to the repository even if regular trains were used between reactors in the eastern United States and the MRS and between reactors in the western United States and the repository.

Included in these estimates are the costs of acquiring and maintaining casks, hauling, security escorts, and inspection. Owing to the surcharge on the basic freight rates and the increase in the total number of train-miles if dedicated trains are added to the existing system, the hauling costs account for most of the additional expense. Assuming a surcharge of \$48 per train-mile, these costs amount to roughly half of the total cost of using dedicated trains without an MRS, and about two-thirds with an MRS. However, the surcharge may be much less than Battelle assumed. For example, in the case of the TMI shipping campaign, the shipper and the carrier negotiated a surcharge of only \$24 per mile.

Battelle's approach to estimating costs is illuminating since it accounts for all of the important costs, not just the hauling costs. By contrast, in the case of *Commonwealth Edison Co. et al. v. Aberdeen & Rockfish Railroad Co.*, the Interstate Commerce Commission limited its attention to hauling costs. In this case, in which the utility was seeking reimbursement for past surcharges on the ground that they were unwarranted, the ICC found only that the railroad's special train charges were "several times" the charges for regular train service. Thus, the ICC apparently did not recognize the savings in any of the other costs. Some advocates of regular trains have overstated the difference in hauling costs even more, estimating the rate charged for dedicated train services at more than twelve times the regular freight rate.

As regards risks, one of the most widely-referenced research efforts is the so-called modal study conducted by the Lawrence Livermore National Laboratory for the NRC. This study estimated the annual expected number of spent fuel casks involved in accidents in regular train service to be 0.82 per year ( $1.7 \times 10^{-6}$  accidents per car-mile times 735 miles per trip, times 652 shipments per year). Of these, the fraction involving a release of radioactive materials would be 0.6 percent due to mechanical forces and less than 0.1 percent due to the thermal effects of a fire. The probability of a release due to either cause is thus  $8.8 \times 10^{-6}$  per year (0.82 divided by 652, times 0.7 percent). This risk is small but not negligible. It is about the same as the annual individual risk of death from accidental gas or vapor poisoning in the United States.

The Battelle study for DOE also compared the expected number of fatalities resulting from the shipment of 63,000 metric tons of uranium with the proposed Yucca Mountain repository over the course of 25 years (see table, p. 12). Radiological fatalities result from exposure to radiation during normal operating and accident conditions. Nonradiological fatalities result from accidents and exposure to nonradiological pollutants (such as diesel fumes from locomotives). With regular trains, the expected number of radiological fatalities is very small whether there is an MRS or not; the expected number of nonradiological fatalities is substantially higher in each case. With dedicated trains, the expected number of radiological fatalities is somewhat lower whether or not there is an MRS. However, this advantage is swamped by the increase in the expected number of nonradiological fatalities in each case. This increase is directly related to the greater number of trains needed for a dedicated service and is almost entirely due to the associated rise in grade-crossing accidents and accidents in which trespassers are hit.

The ICC's ruling in favor of regular trains in the Commonwealth Edison case and the cases preceding it assumes that the expected number of fatalities increases with dedicated trains since the total number of train-miles increases. This assump-

tion may not be valid or may be exaggerated given that the operational advantages of dedicated trains—such as shorter train length, lower train speed, better track quality, and increased yard avoidance—received little or no attention in the supporting analyses. Even if valid, this assumption does not address the major public concern: catastrophic accidents involving large releases of radiation. None of the analyses to date has estimated the risk of such accidents. In other words, better estimates of the probabilities of high-fatality accidents resulting from radioactive releases are needed, rather than estimates of the average number of fatalities resulting from accidents in general.

### Public confidence and support

Institutional factors are as important to resolving the debate as are the estimates of costs and risks. Public trust in

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### **D**istrust of the agencies that regulate the nuclear industry fuels public concerns about the risks of nuclear waste transportation.

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the institutional arrangements for transporting nuclear waste is a paramount consideration.

The first major lesson to be learned from the experience of past shipping campaigns is that shipments of nuclear waste are impossible without some measure of public confidence and support. This is illustrated by the public opposition that led to the interruption of the TMI shipping campaign in 1988. Even relatively minor mishaps are often seen by the public as indicative of larger, more pernicious and systemic management problems. This underscores the railroad industry's contention that major losses can result even from relatively minor nonradiological events.

Large volumes of shipments to a repository from multiple origins over an extended time will create a situation that is immensely more complicated than any

past shipping campaigns. Smooth and successful shipping will require the support of multiple state and local jurisdictions and, to the extent possible, of various public interest groups. Since opposition at any point could threaten the functioning of the entire program, it is prudent to foster as much public support as possible.

Evidence on public attitudes toward dedicated trains is limited but persuasive. State and local officials generally favor dedicated trains, in part because they enhance monitoring capabilities and are more acceptable to the public. Environmental and public interest groups strongly favor the use of dedicated trains for their perceived safety and environmental benefits. Public insistence was one of the major reasons why Union Pacific argued for the continuation of dedicated services in the TMI campaign. The railroads are sensitive to the fact that public protests over spent fuel shipments can delay and disrupt their entire operations, even in the absence of an accident.

The other major lesson to be learned is that the creation and maintenance of public confidence and support is an institutional and social problem, not a technical one. Confidence and support depend on the development of trust. Unfortunately, the public is very distrustful of the agencies responsible for regulating the nuclear industry, particularly DOE. Public concerns over the risks of nuclear waste transportation are fueled by and exacerbate this lack of social trust, and provoke intense public opposition.

Once trust has been lost, recovering it is likely to be a long and difficult process. This process is as yet poorly understood. Certainly, improved risk communication efforts play a part, but redoubled programs of public education and information are not by themselves likely to bring the public's perception of the risks into line with experts' assessments.

Five key dimensions of trust can be identified: openness, commitment, caring, competence, and predictability. The use of dedicated trains would build on each of these dimensions, and would offer DOE a relatively low-cost way to demonstrate its commitment to regaining public trust.

Opting for dedicated trains necessarily demonstrates a willingness by the nuclear industry and its regulatory agencies to be open about their activities. Dedicated train service avoids the impression that the industry and the agencies are trying to sneak the waste through by night or disguised among other freight. Openness can be enhanced by engaging in extensive information and notification programs, which are easier to conduct with a dedicated service incorporating regularly scheduled shipments. The overwhelming number of requests for information from DOE during the TMI campaign demonstrates the need for extensive prenotification activities that satisfy public demands for information.

The decision to use dedicated train service would also demonstrate the commitment of the nuclear industry and the regulatory agencies to public safety, regardless of the additional cost. Public officials favor dedicated trains, and the available evidence indicates that the public perceives dedicated trains to be safer than regular freight services. This commitment to public safety is synonymous with a caring attitude.

In addition, the selection of dedicated trains is likely to enhance public perceptions of competence. Any minor mishaps will be perceived as indicators of more general incompetence, so extra efforts (such as the use of dedicated trains) should be taken to avoid them. The logistics of dedicated services are much more simple, and inspection, monitoring, and emergency preparedness are likely to be improved. Competence in the transport sector, however, will be of little use if it is not matched by similar competence in other sectors of radioactive waste management.

Finally, the use of dedicated trains is likely to enhance the public's perceptions of predictability. Schedules would be known ahead of time. Adherence to schedules would be more likely if dedicated trains were to be given priority in passing and were to avoid sidings and switching yards. The resulting services would be both faster and more routine.

The nuclear industry and the regulatory agencies would like to consider the subject of dedicated trains closed. With the recent reauthorization of the Hazardous Materials Transportation Act, how-

ever, the railroads have another chance to present their case for the use of dedicated trains. Improved cost analyses will likely demonstrate that the true costs of a dedicated service are only marginally greater than those of a regular freight service. Improved risk analyses will likely confirm that the risk of a catastrophe with either alternative is low, but not negligible, since the number of shipments will be high.

While such analyses necessarily inform the debate, they also serve to obscure the major issue—namely, that the benefit perceived by the public outweighs the additional cost of a dedicated system. This cost is a small price to pay for increased public acceptance or, at least, for reduced public opposition. Contrary to

widely held beliefs, the public does not expect zero risk. It does expect industry and government to demonstrate a sincere concern for and commitment to public safety. Opting for dedicated trains would neither eliminate the risks nor completely restore the credibility of the nuclear industry and the agencies that regulate it, but it would help demonstrate that they are more deserving of public trust. ■

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*Theodore S. Glickman is a senior fellow in the Center for Risk Management at RFF. Dominic Golding is a fellow in the center. Research on which this article is based is expanded on in RFF discussion paper CRM91-04.*

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## Inadequacy of scientific and economic data in pesticide benefits analyses

Leonard P. Gianessi and Cynthia A. Puffer

*Scrutiny of the risks that pesticides pose to human health and the environment is putting pressure on the U.S. Environmental Protection Agency to cancel registered uses of some pesticides. Some agricultural scientists fear that regulatory decisions will be made without sufficient knowledge of how they will affect crop production; some economists question whether analysis of the costs likely to result from cancellation of such registrations would adequately capture the complexity of crop production. Appropriate scientific experimentation and correction of shortcomings in economic analysis might affect decisions to cancel or not to cancel pesticide registrations.*

**T**he use of pesticides in agricultural production can increase crop yields, improve crop quality, and expand the range of farm management options—for example, the ability to use minimum or no tillage or to grow a crop earlier or later in the

season. However, pesticide use can also pose risks to human health and the environment. In some cases, the risks may be great enough to warrant cancellation of a pesticide's registration for use on a particular crop or crops. But in other cases a pesticide's benefits, which are measured as the gain to growers and consumers from its use, may outweigh any risks use of the pesticide poses.

While extensive testing and research are conducted to provide data for estimating the risks posed by the use of a pesticide, scientific and economic data to support claims of the benefits of pesticide use are often not available. Current benefits analyses lack the sophistication and rigor required of risk assessments. Given the greater abundance of research regarding risks, many agricultural scientists fear that decisions to cancel registered uses of pesticides will be made relatively quickly over the next few years. Without the development of adequate

benefits analyses, the consequences of such decisions would only become apparent as farmers sought ways to make do with fewer pesticides.

Of particular concern is the effect of cancelling the registration of pesticides for use on minor crops (such as snap beans, carrots, and strawberries), which often require complex pest control strategies, and crops grown in regions of the country that tend to have more severe pest problems (such as the Southeast). Losses in yield and quality could result if the available substitute pesticides prove less effective. Yet these losses are difficult to document in the absence of appropriate experimentation. Moreover, the substantial costs that some farmers would incur from these losses cannot be ascertained without more up-to-date economic data, which are necessary for more sophisticated economic analysis.

### Benefits analysis

Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the U.S. Environmental Protection Agency (EPA) is charged with the reregistration of all pesticides currently in use. It is during the reregistration process that the registration of a pesticide for use on a crop or crops may be cancelled. Amendments to FIFRA, which were approved in 1988, have expedited the process by requiring manufacturers of agricultural chemicals to supply data from scientific studies to demonstrate that currently registered pesticides do not pose an unreasonable risk to human health or the environment. Manufacturers have voluntarily withdrawn the registrations of many

older pesticides whose patents have expired because those pesticides bring in profits too small to offset the cost of such testing. The effect that the unavailability of these pesticides would have on crop production may never be considered.

When studies identify no new evidence of risk, the reregistration process is completed. However, when a study identifies a hazard or risk, the EPA must determine whether or not the risk is unreasonable. This determination is based

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**T**he benefits side of pesticide risk-benefit analysis suffers from a lack of scientific and economic data.

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on risk-benefit analysis. Using such analysis, the EPA can estimate the costs of changes in agriculture that will accompany a decision to cancel the use of a pesticide and thus act to minimize any unintended consequences of pesticide regulation. Unfortunately, the benefits side of pesticide risk-benefit analyses suffers from a lack of scientific and economic data.

Benefits analyses at the EPA are conducted by the Biological and Economic Analysis Division within the Office of Pesticide Programs. Typically, the task is divided between a lead biologist in the Biological Analysis Branch and a lead economist in the Economic Analysis Branch. The EPA also utilizes benefits analyses prepared by the National Agri-

cultural Pesticide Impact Assessment Program in the U.S. Department of Agriculture (USDA). In addition, the agency examines information submitted by chemical manufacturers as part of its benefits analyses.

Benefits are computed as the cost of switching to substitute pesticides, plus the value of any yield losses that occur when substitutes are used. The key pieces of agronomic information the EPA needs to compute pesticide benefits are pesticide usage patterns, including amounts applied and number of acres treated; the efficacy of a pesticide for controlling pest(s) that affect a particular crop as compared with other pesticides that are available; the costs of substitute pesticides or alternative pest control strategies; and the yield losses that would occur if a pesticide is banned for use on a crop or crops. To value yield losses, economists must derive the demand and supply schedules for an affected crop—that is, they must determine how such losses will affect the supply of the crop and how an increase in the crop's price will affect demand for the crop.

### Weaknesses in scientific data

Detailed information on the extent of pesticide use in the United States has been spotty in past decades. With the National Agricultural Statistics Service, the USDA's Economic Research Service has conducted periodic surveys of pesticide usage on large-acreage commodities—such as field corn, wheat, soybeans, and potatoes—in the states where the majority of these commodities are produced. However, pesticide usage data for



*In one field-plot experiment conducted by the Rutgers Research and Development Center, the currently used pesticide pronamide was more effective as a weed killer in lettuce fields than the potential substitute pesticide bensulide.*

Photos courtesy of Brad Majek

other crops grown in other states are rarely collected. (For example, surveys of pesticide use on fruits, which have a high economic value per acre, have not been conducted since the 1970s.) For pesticide usage data on these other crops, the EPA has had to rely on the best guesses of agricultural scientists, on estimates gleaned from private marketing reports, and on whatever state reports were available. However, the USDA has renewed efforts to obtain pesticide-use estimates for these crops. In 1991 it is expected to release the results of a survey of pesticide use on vegetables in the five major vegetable-producing states. A survey of pesticide use on fruits and nuts is expected to follow in 1992. Many state governments are also conducting their own pesticide-use surveys in response to information needs in formulating policy on issues such as water quality.

Much less progress has been made in obtaining data on the efficacy of individual pesticides for controlling pests. Currently, the EPA's strategy is to solicit

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**E**fforts to collect pesticide usage data are increasing, but less progress has been made in obtaining data on the efficacy of individual pesticides.

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the opinions of experts, usually crop protection scientists with states' cooperative extension services or land grant universities. Even when studies of differences in efficacy among pesticides are available, it is difficult to predict how these differences will affect crop yields.

Furthermore, the use of expert opinion is often difficult to defend. A recent economic analysis of the proposed cancellation of the pesticide maneb submitted by the Pennwalt Corporation was not accepted by the EPA, partly because the comparative efficacy data, gathered by extensive communication with extension scientists, was judged to be inadequately documented. Problems with reliance on expert opinion extend to in-house analyses at the EPA. The agency is currently

reevaluating how expert opinion is handled by its analysts after an administrative law judge gave little or no weight to expert predictions of the impact of cancelling the registrations of all pesticides containing arsenic. In an effort to make expert opinions defensible in administrative and judicial proceedings, the EPA policy now requires that such opinions be substantiated by experimental data or other credible information.

The need to solicit opinions regarding the comparative efficacies of various pesticides seems surprising when so much of the work of crop protection scientists involves the testing of pesticides. For example, hundreds of papers involving herbicide efficacy experiments are published annually in journals such as *Weed Science* and are presented at national and regional meetings. The Entomological Society of America annually publishes a volume entitled *Insecticide and Acaricide Tests*. In some cases, this research is used in the regulatory process. For example, experimental results from *Insecticide and Acaricide Tests* were used to determine comparative efficacy in the benefits analysis of diazinon use on turf.

However, much experimental work is not useful in benefits analyses during the reregistration process. Many tests are for newly registered or experimental products. Other tests compare pesticide-treated plots with untreated ones instead of plots treated with other pesticides. In some tests, pesticides are applied at higher or lower rates than the rate recommended by the manufacturer. Some experiments that do test the comparative efficacy of pesticides do not go on to measure the effects on yield of differences in pesticide performance. And in other cases a particular pest of concern in the experiment is not the pest of concern in the benefits analysis.

Experiments can be designed to provide information needed for the reregistration process, but the time required to plan and carry out the work can be a barrier. Reregistration is a risk-driven process. Once the EPA has compelling data regarding health hazards to pesticide applicators or consumers, it has a responsibility to act quickly in response to the risk. Generally, this leaves one year or less to prepare the benefits portion of the risk-

benefit analysis. Thus, if experimental work is to be conducted for the benefits analysis, agricultural scientists must anticipate the pesticides and the crops for which information will be most needed. Given the possible combinations of pests, pesticides, crops, and regional growing conditions for which experiments could be designed, deciding which experiments will be most essential to the reregistration process is difficult at best.

Some field-plot experiments have been conducted in response to regulatory concerns. A few years ago there was evidence that the herbicide alachlor was contaminating groundwater in the state of Florida. In response to a probable ban

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**D**espite weaknesses in field-plot experimentation, it is better to rely on experimental data than on expert judgment alone.

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on its use on peanuts in Florida, Daniel Colvin, an extension weed scientist with the University of Florida, obtained funding to conduct field-plot experiments to determine the differences in the efficacy and yield effects of alachlor and a number of alternative herbicides. His field experiments indicated that metolachlor performed as well as alachlor in controlling weeds. This was somewhat surprising since experience had indicated that metolachlor would not control certain weed species as well as alachlor, and expert opinion had predicted peanut yield losses of 13.2 percent in Alabama, Florida, and Georgia if metolachlor was substituted for alachlor. In 1990 the registrant of alachlor decided to withdraw the registration of that herbicide for use on peanuts in Florida on the basis of the state of Florida's concerns about groundwater contamination. Although Colvin's experiment did not play a role in deciding the fate of alachlor in Florida, it did provide extension weed scientists with information on how to advise farmers with regard to substitutes for alachlor. Some farmers have reported some problems since substituting metolachlor for



alachlor. Colvin states that the reasons for these problems are not yet clear.

Does this mean that scientific field-plot data are not helpful in providing reliable estimates of yield losses needed in benefits analyses? There are some weaknesses in field-plot experimentation. Because of the small number of test plots and the natural variation in plot yields, large differences in yields must be observed between each pesticide treatment if these differences are to be considered statistically significant. In addition, field-plot tests do not reflect the full range of conditions under which a crop is grown. Yet experiments like Colvin's allow new combinations of herbicides to be tested that had not been tried before. Moreover, regulators at the EPA would agree that it is better to rely on experimental data than on expert judgment alone. However, plot experiments are not an adequate substitute for extensive knowledge of growers' experiences in the field.

### Weaknesses in economic data

Economists working on benefits analyses are hampered by the inadequacy of available data on the revenues and costs of crop production. To value yield losses that may result when a substitute pesticide is used, economists must know what the demand for the affected crop is, as well as how the supply of that crop would shift if the pesticide currently used on it is banned. However, the number of USDA marketing studies on minor crops has decreased over the last several years. Moreover, economic models that can be used to examine the interaction between supply and demand are lacking for fruit and vegetable crops. In response to this situation, the EPA's Office of Policy Planning and Evaluation is funding the development of commodity models of the apple and processed tomato industries. These models will provide estimates of supply and demand functions for use in benefits analyses.

Some economists argue that pesticide usage should be evaluated with an entire crop production system in mind, rather than on a chemical-by-chemical basis, to more fully capture the complexities of crop production. Issues like managing or preventing resistance of pests to available pesticides have been mentioned in

current analyses but not quantified as part of the benefits estimate. A commodity modeling approach would require substantial input from the agricultural scientific community. Complex relationships within the production system would have to be defined in such a way that the data input required for the analysis would not be an insurmountable barrier.

### Is filling data gaps necessary?

The cry for more funding of research is heard in any situation in which information is lacking and important decisions must be made. But are the efforts needed to fill gaps in scientific and economic data really justified? Past benefits analyses have estimated that the costs to farmers of cancelling a pesticide registration are relatively small. Although these costs range from several million dollars to several hundred million dollars for more widely used pesticides, they are still small compared with the costs of other governmental regulations. For example, the total annual cost of complying with all federal air pollution laws in the United States is estimated to be \$27 billion. Moreover, experience indicates that increased data input and more sophisticated analysis tend to drive the estimated benefits figure down, not up, for a given pesticide. Considering that much uncertainty exists in estimates of costs in terms of risk, is it necessary to be so precise in calculating costs to farmers?

Many think the effort would be worthwhile. They argue that if shortcomings in benefits analyses were corrected, the high cost to some farmers of some pesticide registration cancellations would be revealed. As a result, the EPA might not cancel some pesticide registrations that it normally would under current benefits analysis.

One shortcoming is the failure to separate the costs to users and nonusers of pesticides that would no longer be available. The net benefit from the use of a pesticide does not account for distributional effects in the costs of cancellation. A small subset of growers could conceivably incur the majority of the costs of cancellation since pest problems are not uniformly distributed through the entire producer population. A few pesticide us-

ers might suffer a substantial loss of income due to yield losses while others might benefit from the increased price of a commodity due to a decrease in the overall supply of that commodity. Thus cancellation of a pesticide registration may have a positive, if small, effect on nonusers, but a negative, often large, effect on some users. In some cases, regional inequities might result from cancellation of pesticides. Growers in certain regions of the country might not be able to compete with growers in other areas due to rising costs or increased yield losses from uncontrolled pests. Yet their losses could mean gains to growers in other regions as supply decreases and price increases.

The net effect of pesticide cancellation on agricultural producers can be very

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**C**urrent benefits analyses do not separate the costs to users and nonusers of pesticides that would no longer be available; thus they cannot account for distributional effects in the costs of pesticide cancellation.

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small, as gains by some growers from an increase in price cancel out losses on the part of others. The impact on consumers also may be small—a price increase of a few cents for a certain commodity. But the removal of a pesticide could have drastic consequences for certain producers. In light of this outcome, efforts to supply scientific and economic data lacking in current benefits analyses appear warranted. It may be that the most appropriate funders for this type of analysis are regional commodity organizations that represent fruit and vegetable growers. ■

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*Leonard P. Gianessi is a fellow in the Quality of the Environment Division at RFF. Cynthia A. Puffer is a research assistant in the division. Since 1986, Gianessi and Puffer have been developing a national pesticide use database that is widely used by federal agencies in assessments of pesticide policies.*

## RFF awards \$100,000 in grants

Resources for the Future has awarded \$100,000 in research grants to individuals at four universities and one college. The awards were made through the RFF Small Grants Program, which provides financial support to researchers at universities and other nonprofit institutions in the United States and abroad to study issues related to the environment, natural resources, and energy.

This year RFF awarded grants to the following individuals for research on the subjects indicated:

- Dennis Coates and Michael Munger, departments of Economics and Political Science, University of North Carolina: Voting for the Southeast Interstate Low-Level Waste Management Compact: A Comparative Micro-Level Analysis of Eight State Legislatures.

- Hugh Ellis and Nancy Kete, Department of Geography and Environmental Engineering, Johns Hopkins University: Acid Rain, Emissions Trading, and Regulatory Reform: The Politics of Markets in the 1990s.

- Douglas Larson and John Loomis, departments of Agricultural Economics and Environmental Studies, University of California-Davis: Measuring Existence Values from Incomplete Market Demand Systems.

- Robert Weiner, Department of Economics, Brandeis University: Origins and Development of Natural Resource Markets: The Petroleum Exchanges in the 19th Century. ■

## NCFAP resident fellowship awarded

The National Center for Food and Agricultural Policy at RFF has appointed Roy R. Carriker as its resident fellow for 1991–1992. He is a professor of food and resource economics in the Institute of Food and Agricultural Sciences (IFAS) at the University of Florida and associate director of the IFAS Center for Natural Resources. At RFF he will explore potential institutional change to resolve disputes over the adverse environmental consequences of agricultural irrigation and drainage at two national wildlife refuges—Loxahatchee in Florida and Kesterson in California. Each year, the National Center offers resident fellowships of up to twelve months to scholars from universities, government, and the private sector for the pursuit of innovative policy analyses. ■

## New book

*America's Renewable Resources: Historical Trends and Current Challenges*, edited by Kenneth D. Frederick and Roger A. Sedjo

Much can be learned about the current status and likely future problems of renewable resources in the United States through a better understanding of past changes in the condition, use, and management of those resources. This belief underlies the book's examination of long-term historical trends in the condition and capabilities of the nation's water, forest, rangeland, cropland and soil, and wildlife resources, and its evaluation of the effects of outdoor recreation on these resources.

Specialists in their fields, the six authors are B. Delworth Gardner of Brigham Young University (rangeland resources) and five senior researchers at Resources for the Future: Kenneth D. Frederick (water), Roger A. Sedjo (forests), Pierre R. Crosson (cropland and soils), Winston Harrington (wildlife and recreation), and Marion Clawson (recreation).

The authors trace the use and condition of the nation's renewable re-

sources over some 200 years, assessing the influences of changing demands, technologies, management systems, government policies, and institutions. They conclude that the long-term productive potential of these resources is vulnerable, and that this potential is renewable only within limits and under wise management. They also find that over time resource uses have changed as the nation has become less dependent on the conversion of renewable resource stocks to consumptive purposes. Yet they find too that the availability and quality of renewable resources are increasingly perceived as important to the quality of life. This perception poses new problems for allocating the resources, for balancing competitive and changing demands, and for attempting to ensure that these resources are managed on a long-term, sustainable basis.

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## 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 the Publications Office, Resources for the Future, 1616 P Street N.W., Washington, D.C. 20036-1400.

The following papers have recently been released.

### Center for Risk Management

- "The EPA at 'Thirtysomething,'" by Paul R. Portney, Katherine N. Probst, and Adam M. Finkel. (CRM91-03) Free
- "For a Few Dollars More: Public Trust and the Case for Transporting Nuclear Waste in Dedicated Trains," by Theodore S. Glickman and Dominic Golding. (CRM91-04) Free

### Energy and Natural Resources Division

- "Domestic Earmarks as Trade Policy: An Application to U.S. Log Exports," by A. Clark Wiseman, Kenneth S. Lyon, and Roger A. Sedjo. (ENR91-09) \$5.00
- "U.S. Energy and Environmental Policies: Problems of Federalism and Conflicting Goals," by Margaret A. Walls. (ENR91-10) \$5.00
- "Economic Considerations in Supplying Earth Observation Data from Space," by Molly K. Macauley and Michael A. Toman. (ENR91-11) \$5.00
- "Assessing the Impacts of Climate Change on Water Scarcity," by Kenneth D. Frederick. (ENR91-12) \$5.00
- "The Economics of Energy Security: Theory, Evidence, Policy," by Michael A. Toman. (ENR91-13) \$5.00

### National Center for Food and Agricultural Policy

- "Revisiting Surplus Food Programs After Surpluses: The Temporary Emer-

gency Food Assistance Program and Its Role in the District of Columbia," by Nicole S. Ballenger and Courtney Harold. (FAP91-01) \$3.00

### Quality of the Environment Division

- "Natural Resource Damage Assessments and the Mineral Sector: Valuation in the Courts," by V. Kerry Smith. (QE91-09) \$2.25
- "On Separating Defensible Benefits Transfers from 'Smoke and Mirrors,'" by V. Kerry Smith. (QE91-10) \$2.25
- "Evaluating the Relative Effectiveness of Economic Incentives and Direct Regulation for Environmental Protection: Impacts on the Diffusion of Technology," by A. B. Jaffe and R. N. Stavins. (QE91-11) \$2.25
- "Who Bears the Burden of Energy Taxes?" by Diane E. DeWitt, Hadi Dowlatabadi, and Raymond J. Kopp. (QE91-12) \$2.25
- "Implementing Environmental Costing in the Electric Utility Industry," by Karen Palmer and Hadi Dowlatabadi. (QE91-13) \$2.25

## Recent corporate contributions, grants

Resources for the Future has recently received corporate contributions from the following corporations and corporate foundations: Agway Foundation; American Cyanamid Company; American Petroleum Institute; ARCO Foundation; ASARCO Incorporated; Ashland Oil, Inc.; AT&T Foundation; The Brooklyn Union Gas Company; CF Industries, Inc.; Chevron Corporation; Consolidated Edison Company of New York, Inc.; Consumers Power Company; EG&G, Inc.; E. I. du Pont de Nemours & Company; Electric Power Research Institute; Exxon Corporation; FMC Foundation; Georgia-Pacific Corporation; Hershey Foods Corporation; ICI Americas, Inc.; Johnson & Johnson Family of Companies; Mitchell Energy & Development Corp.; National Agricultural Chemicals Association; New England Electric System; Nippon Oil Company, Ltd.; Ocean

Spray Cranberries, Inc.; Pacific Gas and Electric Company; Potlatch Corporation; Stone & Webster Engineering Corporation; Syntex Corporation; TECO Energy; Texaco Foundation; Unilever United States, Inc.; Union Camp Corporation; Union Carbide Corporation; Uniroyal Chemical; Unocal; USX Corporation; Waste Management, Inc.; and Westvaco Corporation.

In addition, The Esther A. and Joseph Klingenstein Fund, Inc. awarded \$50,000 to the Center for Risk Management. The John D. and Catherine T. MacArthur Foundation approved a \$90,000 grant to the National Center for Food and Agricultural Policy. The G. Unger Vetlesen Foundation awarded \$50,000 to the Climate Resources Program of the Energy and Natural Resources Division. ■

## RFF documentary wins Golden Eagle Award

RFF's first documentary videotape, "Future Conditional: Global Climate Change" has received the Golden Eagle Award from the Council on International Nontheatrical Events (CINE). Selected as an excellent production in the category of environment, it is eligible to represent the United States in future international film festivals. "Future Conditional" was also selected as a finalist in the environment and ecology category for the American Film Festival sponsored by the American Film and Video Association, and was a finalist in a film festival at the Second International Conference on Environmental Management held in Rotterdam, the Netherlands.

The videotape, which focuses on the uncertainties surrounding the likely effects of global warming and on potential mitigation and adaptation strategies, is currently airing on Public Broadcasting Service stations nationwide. A VHS cassette of "Future Conditional" can be purchased for \$95.00. Checks should be made out to Documentaries and mailed to Resources for the Future, 1616 P Street, N.W., Washington, D.C. 20036. ■

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*Managing editor*, Samuel Allen  
*Staff writer*, Melissa Edeburn  
*Production manager*, Brigitte Coulton

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