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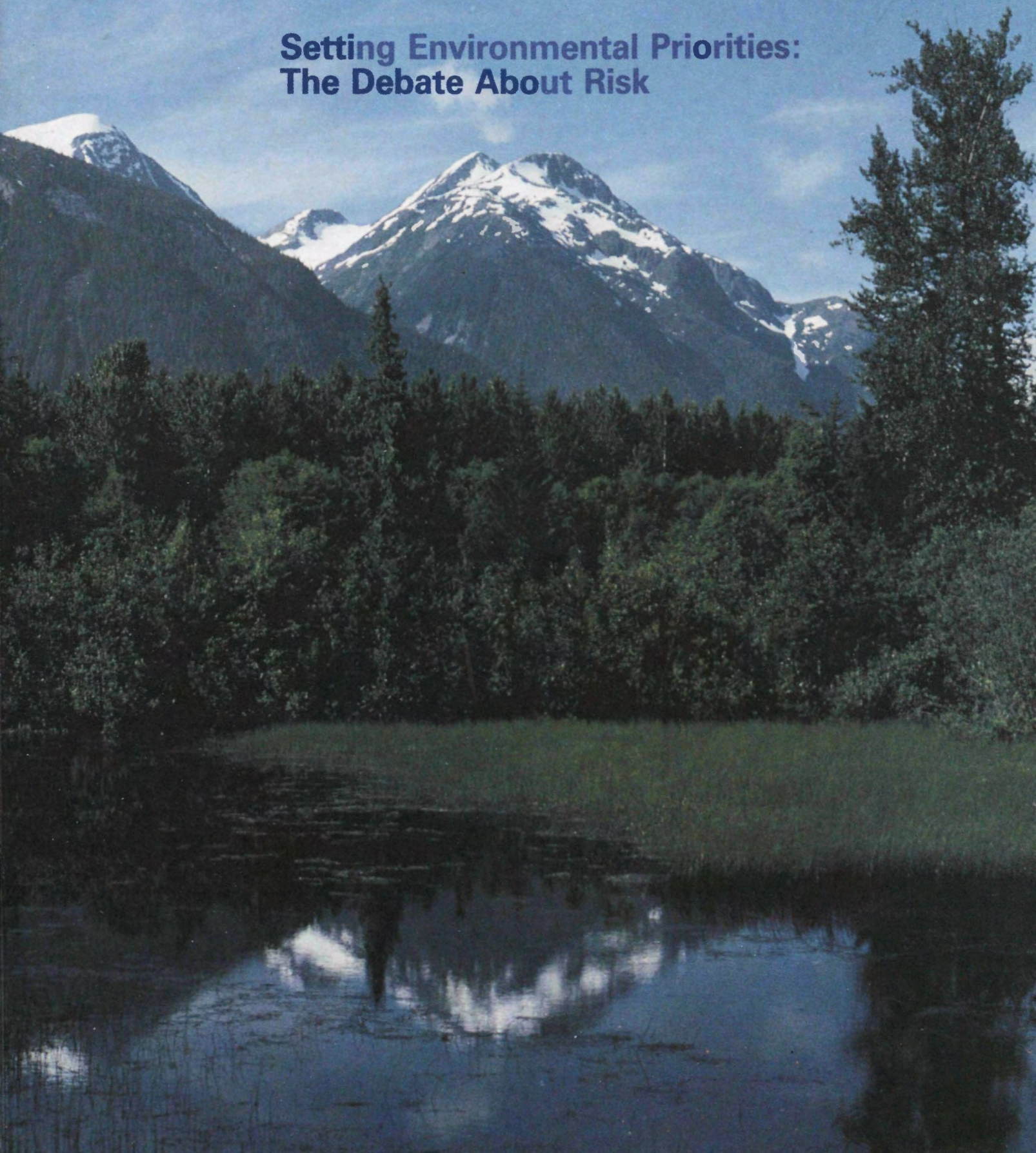
Setting Environmental Priorities: The Debate About Risk



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Front Cover: Environmental inspiration.
Photo by David Falconer for Folio, Inc.

From the Editor

Should Congress and EPA rely more on science in setting the nation's environmental priorities? Specifically, should they use comparative risk analysis, assessing and comparing the risks between different problems, as the yardstick? And, do we know enough? Is the science adequate?

Last fall, EPA Administrator William K. Reilly used the occasion of the public release of an important and provocative report to launch a national debate on these questions. The report was prepared at Reilly's request by EPA's Science Advisory Board. Among other things, the report recommended applying comparative risk analysis to sort out environmental problems and reevaluate their importance relative to each other.

The editors have prepared this issue of *EPA Journal* to extend the debate. We invited contributions from some senators and congressmen who have authority over environmental legislation and appropriations; we asked scientists from universities and from government; and we solicited the views of knowledgeable representatives from industry and from environmental organizations. We were impressed by the thoughtfulness and variety in the answers we received, whether they were skeptical or supportive of risk-based decision making.

To provide a historical context for the debate, we asked Al Alm, who has been involved with the Agency from the beginning, to do a piece, and we asked EPA Deputy Administrator Henry Habicht to explain what the Agency is doing now to strengthen its ability to make sounder, science-based environmental decisions. Other articles spell out the Science Advisory Board's recommendations regarding a risk-based environmental action philosophy and describe how the public's environmental agenda is expanding, as new problems are added to old.

You, the reader, may notice something else: *EPA Journal* is changing. This issue includes a book review. A new section *Habitat*, will feature sometimes poetic, sometimes humorous segments from the works of great environmental writers. *Featuring EPA* contains (in this issue) an article on how Russian and EPA scientists worked together to measure Chernobyl's effects in the Baltic Sea. Last issue we introduced Newsline, which gives you glimpses of EPA actions. The issue before, we redesigned the table of contents to make it more inviting and narrowed the outer margins to provide more "white space" on the pages. You can expect more changes in future issues, such as an occasional profile of a famous conservationist and a *Focus* section which will explain key environmental problems for students and their teachers. We are excited about the idea of fashioning a better, more interesting, more approachable magazine, and we welcome your comments as the process unfolds.

John Heritage

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Why I Propose a National Debate on Risk

by William K. Reilly

In Shakespeare's *Troilus and Cressida*, the Greek hero Ulysses is heard to muse:

> The heavens themselves, the planets, and this center,
> Observe degree, priority, and place,
> Insisture, course, proportion, season, form,
> Office, and custom, in all line of order.

Ulysses would find it hard to work at EPA—or, indeed, anywhere in the United States—during the final decade of the 20th century. Today, setting priorities is difficult under the best of circumstances, even at the relatively coherent level of the individual household or local community. At EPA, the speed of change and the complexity of issues generates such severe turbulence that simply keeping a day's schedule "in all line of order" is something of a triumph.

Setting environmental priorities for the whole nation and bringing our Agency's resources into alignment with those priorities are supremely daunting tasks. It is only a slight exaggeration to say they demand the rigorous thinking of a mathematician, the resolute discipline of a Zen master, and the extended vision of an astrophysicist.

In 1991, EPA has a budget of more than $6 billion and employs about 17,000 scientists, lawyers, and other professionals and administrative personnel—a 310 percent increase from the 5,500-person workforce that formed the Agency in 1970. These employees, located in the Agency's Washington headquarters, 10 regional offices, and 56 research laboratories, work under the authority of a dozen major environmental laws and some 100 other statutes, all of them enacted since 1970. EPA employees, moreover, are responsible for writing, refining, and enforcing 9,000 regulations and for responding to an annual flood of tens of thousands of letters from Members of Congress, other government officials, and taxpayers. Imposing rules of logic, efficiency, and effectiveness on this incipient chaos requires a keen sense of priorities.

This lesson was reinforced in my mind shortly after my EPA appointment was announced, when I made a memorable courtesy call on a leading member of the Senate Environment and Public Works Committee, which would soon be considering my confirmation. "Above all," insisted New York's Senator Daniel Patrick Moynihan, "above all . . . do not allow your agency to become transported by middle-class enthusiasms." His meaning, of course, was unmistakable: "Pay attention to science; don't be swayed by the passions of the moment."

The Senator's advice meshed nicely with my own thinking and that of my immediate predecessor. Thanks in part to Lee Thomas' pioneering work, I came to EPA convinced that we need to change our approach to environmental problems. Although we have achieved important victories over the past two decades, we have developed our environmental policies piecemeal, with each problem addressed separately and without sufficient reference to other problems or to overall effects, risks, and costs.

Each time a new issue appeared on the radar screen of public concern, we would unleash an arsenal of control measures in a style reminiscent of the old "space invaders" video game. In the late 1960s, for example, we saw air pollution and we enacted ambitious legislation designed to scrub the air. At the same time, we also became aware of water problems, so we tried to solve them with an equally ambitious water act. Next, we saw toxic chemicals endangering health, and we passed a sweeping law to control toxic substances. And so it went through the 1970s and 1980s, with drinking water, radiation, hazardous waste, pesticides, indoor pollution, medical wastes, and many other problems. Each deserved attention, to be sure, but each was dealt with separately, in isolation from all the others.

The consequence of this approach is obvious to all our employees: For 20 years we have established goals on a pollutant-by-pollutant and medium-by-medium basis without adequately considering broader environmental quality objectives. Rarely have we evaluated the relative importance of pollutants or environmental media—air, land, and water. Nor did we assess the combined impacts on whole

Fatal smog: In 1948, industrial smoke from the Donora, Pennsylvania, zinc works of the American Steel and Wire Company killed more than 20 people. This early incident focused the nation's attention on the hazards of air pollution—beginning a pattern in which environmental priorities have been set in response to disasters.

(Reilly is Administrator of EPA.)

Wide World photo.

ecosystems and human health. Given the scatter-shot evolution of the Agency and its missions, we were seldom encouraged to look at the total loadings of pollutants deposited through different media from separate routes of exposure at various locations. We have seldom if ever been directed by law to seek out the best opportunities to reduce environmental risks, *in toto*, or to employ the most efficient, cost-effective procedures.

Such fragmentation has a cost. EPA is simultaneously pulled in many directions by Congress, other federal agencies, other levels of government, the regulated community, constituency groups, the courts, the public, and the press. We answer to many taskmasters. To take just one example of the complexity of our work, approximately 100 congressional committees and subcommittees lay claim to a piece of the environmental policy pie. Many problems, such as local land-use decisions, are not in our jurisdiction, yet we often find citizens hold us responsible for solving them. When the press zeroes in on a "pollutant of the week," it rarely considers the pollutant's importance relative to other environmental problems—or to any of a number of competing social issues, for that matter.

Crisis management is certainly not unique to the environmental arena.

We have seldom if ever been directed by law to seek out the best opportunities to reduce environmental risks, in toto, or to employ the most efficient, cost-effective procedures.

Nevertheless, since we deal with the public's health and safety every day, I believe it is necessary to step back occasionally and take a broader view. Looking ahead to the environmental problems already looming in the 21st century, I think the time has come to find a better way of setting environmental priorities. In short, we need to find a way of bringing Senator Moynihan's advice about the critical importance of sound science into the center of our decision-making processes.

To the extent allowed by law, sound science can help us establish priorities and allocate resources on the basis of risk. Obviously, many factors go into shaping priorities—the values and perceptions of the American people, the constraints of the economy, the culture of governance—but hard science remains our most reliable compass in a turbulent sea of environmental concerns. Science can lend a measure of coherence, predictability, authority, order, and integrity to the often costly and controversial decisions that must be made.

Using risk as a common denominator creates a measurement that lets us distinguish the environmental equivalents of heart attacks from indigestion, the broken bones from bruises. Despite uncertainties and controversies hovering around the evaluation of hazards, comparative risk assessment already serves as an excellent guidepost for indicating the most

For 20 years we have established goals on a pollutant-by-pollutant and medium-by-medium basis without adequately considering broader environmental quality objectives.

promising road to follow, for targeting our limited resources, and for mobilizing and deploying expertise in an efficient and rational way.

Five years ago, Lee Thomas first officially recognized the problem of setting priorities by instructing EPA's scientists and managers to examine our assignments and then try to rank environmental problems on the basis of risk. The result of this exercise was a brave and visionary report published in 1987 under the title: *Unfinished Business: A Comparative Assessment of Environmental Problems.*

After ranking environmental problems on the basis of risk, the report revealed that expert and public opinions about the seriousness of many environmental problems diverge markedly. As *Unfinished Business* put it, "EPA's priorities appear more closely aligned with public opinion than with estimated risk." Not surprisingly, our laws are a better reflection of constituent opinion than of scientific judgment. The inescapable conclusion: We need to improve the translation of scientific knowledge into the vernacular of politics and public opinion, to make rational risk assessment a part of every citizen's common sense.

In one of my first actions as EPA Administrator, I asked the Agency's Science Advisory Board (SAB)—a distinguished panel of independent scientists, engineers, and other technical experts—to review *Unfinished Business*, assess its rankings by applying the best technical and scientific knowledge available, and suggest ways to improve the process of identifying, assessing, and comparing risks. I also asked the board to find strategies that would be particularly effective for attacking specific problems or for mitigating many problems at the same time.

The fruits of the SAB study—chaired by Dr. Ray Loehr of the University of Texas and Jonathan Lash, former Secretary of Vermont's Natural Resources Agency and now director of the Environmental Law Center at Vermont Law School—were published in September 1990. The board's report, *Reducing Risk: Setting Priorities and Strategies for Environmental Protection*, significantly advances the environmental debate by comparing disparate environmental problems according to degree of risk and spelling out the fundamental principles for developing broader, more integrated, and more carefully crafted environmental policies.

The most essential recommendation in *Reducing Risk* proclaims, in no uncertain terms, that EPA and the nation must locate and target the most promising opportunities for reducing the most serious risks to human health and welfare and to the environment. I believe that our response to this recommendation is pivotal to the success of all our efforts at environmental protection.

Chosen primarily on the basis of the overall degree of public exposure to known toxic agents, the human health risks highlighted in the report are: ambient air pollution; exposure of industrial and agricultural workers to dangerous chemicals; indoor air pollution, including radon; and contamination of drinking water, particularly by lead. The recent reauthorization and strengthening of the Clean Air Act reflects this ordering of priorities. Also compatible with the underlying principle of this listing is EPA's Pollution Prevention Strategy, which presents a blueprint for a comprehensive, voluntary program of pollution prevention across the country. One important goal of this strategy is the reduction of emissions of 17 especially troublesome toxic chemicals by 33 percent by the end of 1992 and 50 percent by the end of 1995.

Reducing Risk also identifies high-risk ecological problems, chosen chiefly on the basis of their geographic scope and the time necessary to reverse negative impacts: alteration and destruction of habitat; extinction of species and loss of genetic diversity; depletion of stratospheric ozone; and changes in the global climate. The report further recommends that we address ecological risks with the same level of effort that we have devoted in the past to human health risks. This recommendation recognizes the intimate relationship between vital and productive natural ecosystems and the ultimate well-being of people and their only habitat.

In April of this year, two different reports underscored the SAB's focus on ecological relationship. First, a NASA study showed that ozone loss over the United States since 1978 has amounted to almost 5 percent, nearly twice what we thought just a few months ago when the community of nations negotiated amendments to the Montreal Protocol. EPA estimates this could result in an additional 200,000 American deaths from skin cancer over the next 50 years—a fatality estimate 21 times higher than previously forecast. (These are estimates based on models and could vary plus or minus 25 percent.) Second, in an EPA-funded study of global climate change, the National Academy of Sciences said the possibility of global warming (by as much as nine degrees Fahrenheit) "poses a potential threat sufficient to merit prompt responses," including U.S. participation in international programs to slow population growth, development of safer and more efficient transportation and energy systems, reforestation, elimination of chlorofluorocarbons (which are also

the prime culprit in ozone depletion), and public education for conservation and recycling programs.

Meanwhile, it is important to remember that both *Unfinished Business* and *Reducing Risk* assume that currently mandated programs will continue far into the future. EPA has no intention of relaxing the vigor with which we are enforcing environmental laws already on the books. In fact, in 1989, we set records in virtually every category of enforcement—and then we broke them in 1990. So we've established our *bona fides*.

Nevertheless, the time has come to pay as much attention to *how* we spend our resources as to *what* we spend them on. The traditional approach to environmental protection—command-and-control regulations oriented toward specific technologies—as much as it has achieved, is no longer sufficient.

The great complexity of our environmental problems requires an equivalent complexity in our responses. Among the responses already suggested in the SAB report are increased research, public education and information dissemination, technical assistance, market incentives, and, above all, a national mobilization to prevent the creation of pollution in the first place.

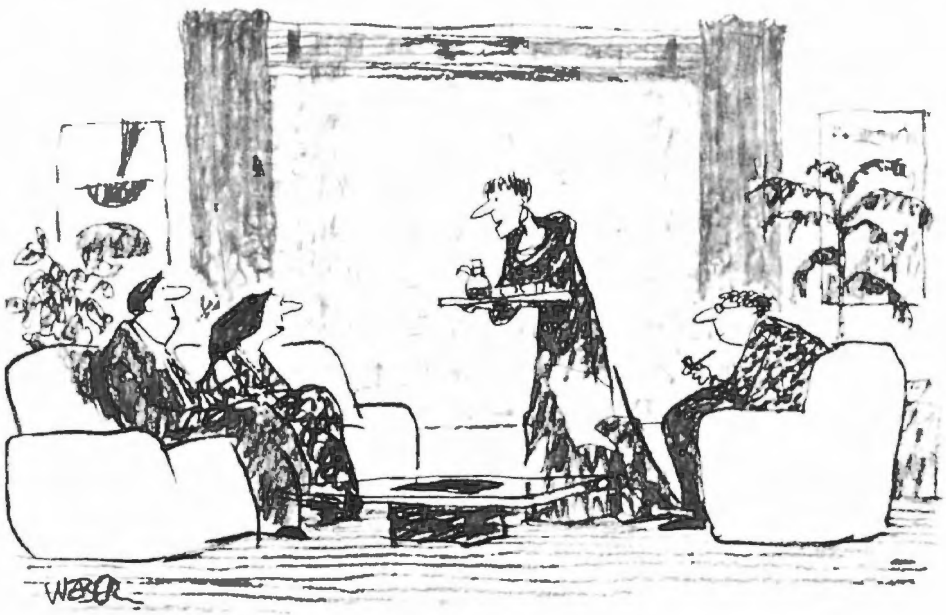
Our budget decisions already are being guided by the risk-reduction principles of EPA's long-term planning process. New programs, such as our strategy for cleaning up the Great Lakes region, involve innovative efforts that cross jurisdictional lines, wipe out the artificial boundaries that compartmentalize the various media of contamination, and integrate enforcement mechanisms affecting entire ecosystems.

Changing the way EPA does business means moving science and information processing to the very center of our enterprise. To emphasize the importance I place on this task, I try not to let a week pass without discussing the implications of the SAB report in one forum or another. I speak to gatherings of citizens and students, and the press. I ask for hearings before Congress, I enter into "constructive dialogues" with environmental and industry groups, and I consult with scientists across the country.

This issue of *EPA Journal* is yet another contribution to EPA's efforts to extend the dialogue and to provide an airing of all points of view; it includes two forums, representing a wide range of opinion from key observers, on two of the central issues raised by the SAB report.

I understand fully that any effort to establish environmental priorities on the basis of relative risk—in effect, to rethink the environmental agenda for the next century—is fraught with contentiousness and difficulty. It demands a tolerance for uncertainty, a willingness to confront error and learn from mistakes, a capacity to adapt quickly to new information and changing circumstances.

But the potential results more than justify our efforts. If the long-term course of environmental policy is to gain currency, if it is to be persuasive in an enduring way, we at EPA must ensure that our commitment to the environment is matched by the scientific rigor that goes into the choices we make and the decisions we enforce. That, in a nutshell, is the challenge the Science Advisory Board has laid at our—and the nation's—doorstep. □



"We've decided to express our concern for the environment by redecorating."

What Raised the Issue?

by Raymond Loehr

Early in 1989, Administrator Reilly asked the Science Advisory Board to review EPA's 1987 report, *Unfinished Business: A Comparative Assessment of Environmental Problems*, and to assess and compare different risks to human health and the environment in light of the most recent scientific data. He also asked that the board examine strategies for reducing major risks and recommend improved methodologies for assessing and comparing risks and risk reduction options in the future. The board delivered a report to Administrator Reilly on September 25, 1990; excerpts follow.

The Concept Of Risk

The fragmentary nature of U.S. environmental policy has been evident in three ways:

- *In Laws.* As different environmental problems were identified, usually because the adverse effects were readily apparent, new laws were passed to address each new problem. However, the tactics and goals of the different laws were neither consistent nor coordinated, even if the pollutants to be controlled were the same.
- *In Programs.* EPA evolved an administrative structure wherein each

EPA's Science Advisory Board

The Congress, in 1978, established the Science Advisory Board to provide independent scientific and engineering advice to EPA and to those committees of Congress having responsibility for environmental matters. The EPA Administrator appoints members—currently, there are 60 who serve two-year terms. Additionally, more than 250 scientists and engineers serve the board as consultants. The eight committees of the board conduct about 50 public meetings and release 30 to 40 reports each year. A 16-member staff supports the activities of the board.

Shortly after he took office, Administrator Reilly asked the board to evaluate the findings of *Unfinished Business*, EPA's 1987 report on environmental risk and to suggest innovative strategies for reducing sources of high environmental risk.

In response, the board formed a Relative Risk Reduction Strategies Committee which, in turn, was divided into three subcommittees: one each on human health, ecology and welfare, and strategic options. The 39 members of the committee were nationally recognized scientists, engineers, and managers with broad experience in environmental and health issues. In the course of their work, they held 12 public meetings.

(Loehr is Chair of the Science Advisory Board and Professor of Civil Engineering at the University of Texas.)

When wetlands are altered or destroyed, so is critical wildlife habitat. Wetland loss is rated a high-risk problem in the Science Advisory Board report.

program was primarily responsible for implementing specific laws. Consequently, the efforts of the different programs rarely were coordinated, even if they were attempting to control different aspects of the same problem.

- *In Tools.* The primary tools used to protect the environment have been controls designed to capture pollutants before they escape from smokestacks, tailpipes, or sewer outfalls, and technologies designed to clean up or destroy pollutants after they have been discharged into the environment. These "end-of-pipe" controls and remediation technologies almost always have been applied because of federal, state, or local legal requirements.

This fragmented approach to protecting the environment will not be as successful in the future as it has been in the past. The most obvious controls already have been applied to the most obvious problems. Yet complex and less obvious environmental problems remain, and the aggregate cost of controlling those problems, one-by-one, is rising.

Moreover, this country—and the rest of the world—is facing emerging environmental problems of unprecedented scope. Population growth and industrial expansion worldwide are straining global ecosystems.

The environment is an interrelated whole, and society's environmental protection efforts should be integrated as well. Integration means that government agencies should assess the range of environmental problems, then target protective efforts at the problems that seem to be the most serious. It means that society should use all the tools—regulatory and non-regulatory alike—that are available to protect the environment. It means that controlling the end of the pipe where pollutants enter the environment, or remediating problems caused by pollutants after they have entered the environment, is not sufficient. Rather, waste-generating activities have to be modified to minimize the waste or to prevent the waste from being generated at all. Most of all, integration is critically important because significant sources of environmental degradation are embedded in typical day-to-day personal and professional activities, the cumulative effects of which can become serious problems.

One tool that can help foster the evolution of an integrated and targeted national environmental policy is the concept of environmental risk. Each environmental problem poses some possibility of harm to human health, the ecology, the economic system, or the quality of human life. That is, each problem poses some environmental risk. Risk assessment is the process by which the form, dimension, and characteristics of that risk are estimated, and risk management is the process by which the risk is reduced.

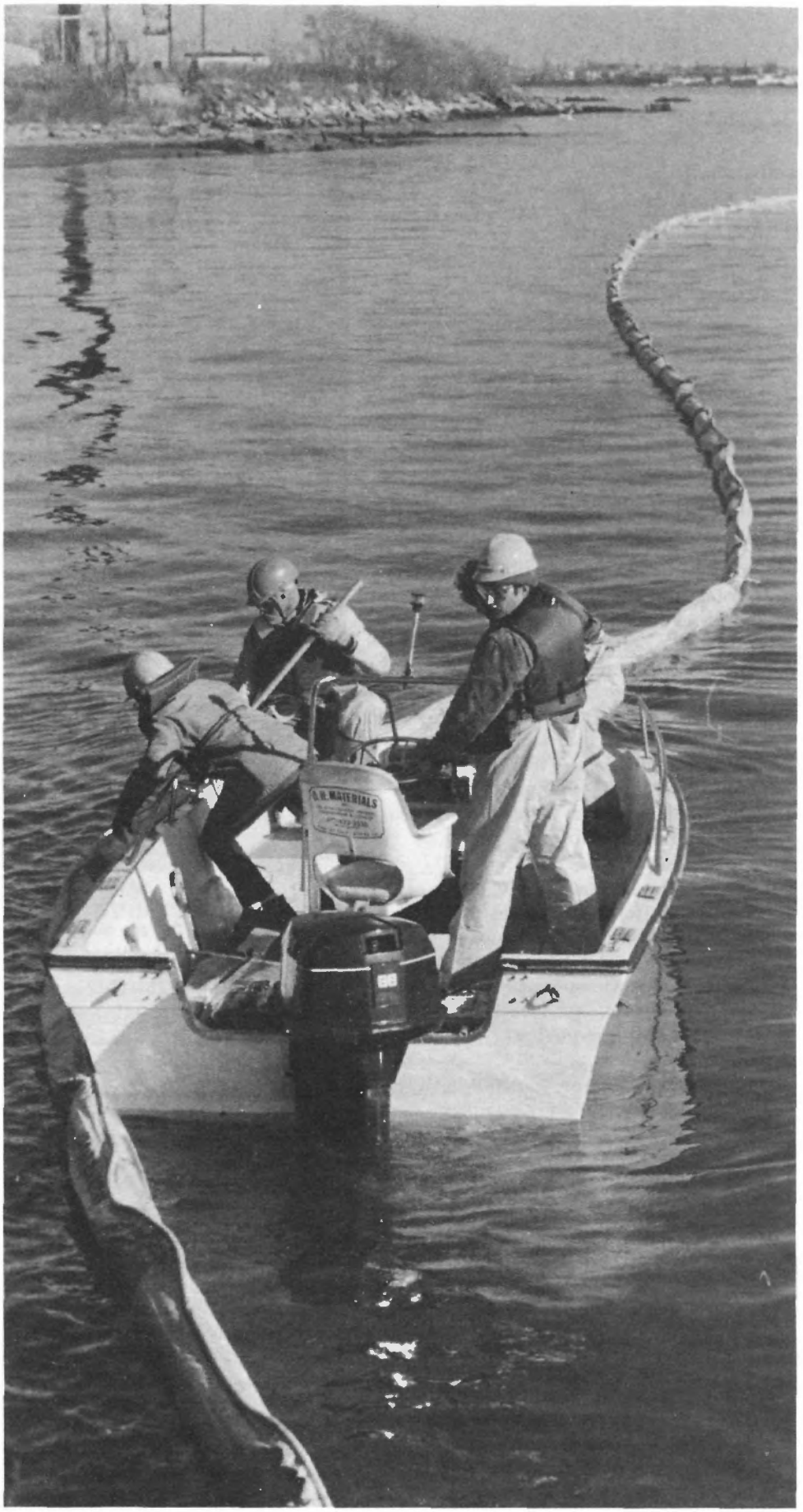
The concept of environmental risk, together with its related terminology and analytical methodologies, helps people discuss disparate environmental problems with a common language. It allows many environmental problems to be measured and compared in common

terms, and it allows different risk reduction options to be evaluated from a common basis.

Scientists have made some progress in developing quantitative measures for use in comparing different risks to human health. Although current ability to assess and quantify ecological risks is not as well developed, an increased capacity for comparing different kinds of risks more systematically would help determine which problems are most serious and deserving of the most urgent attention.

An improved ability to compare risks in common terms would have another value as well: It would help society choose more wisely among the range of policy options available for reducing risks.

There are heavy costs involved if society fails to set environmental priorities based on risk. If finite resources are expended on lower-priority problems at the expense of higher-priority risks, then society will face needlessly high risks. If priorities are established based on the greatest opportunities to reduce risk, total risk will be reduced in a more efficient way, lessening threats to both public health and local and global ecosystems.



Workers adjust boom lines to protect the coastline between New Jersey and Staten Island, New York, from a recent oil spill. Scientists ranked oil spills among relatively low-risk environmental problems, primarily because resulting ecological damages are usually reversible. The public, however, sees such spills as more alarming.

Wide World photo.

Problems In Ranking Risks

As long as there are large gaps in key data sets, efforts to evaluate risk on a consistent, rigorous basis or to define optimum risk reduction strategies necessarily will be incomplete, and the results will be uncertain. For example, data on human exposure and on the toxicity of many pollutants are seriously deficient.

Moreover, great uncertainty often is associated with the data that do exist. Exposure and toxic-response models, the numbers used to quantify risks, and variations in individual susceptibility to risks are often highly uncertain. Without more and better data, conclusions about relative risk will be tenuous and will depend in large measure on professional judgment.

In addition to the lack of data, methodological inadequacies also impede the assessment and comparison of risk. In particular, the methodologies currently used to estimate the benefits of risk reduction activities are inadequate and inappropriate.

An additional difficulty entailed in any attempt to compare and rank environmental risks is the inevitable value judgments that must be made. For example, are health risks posed to the aged more or less serious than health risks posed to infants? Comparing the risks posed to human populations with the risks posed to ecosystems may be even more difficult. It seems clear that subjective values always will—and should—influence the ranking of relative environmental risks, no matter how sophisticated the technical and analytical tools become.

The Extraordinary Value Of Natural Ecosystems

Natural ecosystems like forests, wetlands, and oceans are extraordinarily valuable. They contain economically valuable natural resources that feed, clothe, and house the human race. They act as sinks that, to a certain extent, absorb and neutralize the pollutants generated by human activity. Although natural ecosystems—and the linkages among them—are not completely understood, there is no doubt that over time the quality of human life declines as the quality of natural ecosystems declines. Further, they have an intrinsic, moral value that must be measured in its own terms and protected for its own sake.

There are heavy costs involved if society fails to set environmental priorities based on risk.

However, over the past 20 years and especially over the past decade, EPA has considered the protection of public health to be its primary mission, and it has been less concerned about risks posed to ecosystems. The Agency's relative lack of concern reflects society's views as expressed in environmental legislation.

Over the long term, ecological degradation either directly or indirectly degrades human health and the economy. For example, as the extent and quality of saltwater estuaries decline, both human health and local economies can suffer. As soils erode, forests, farmlands, and waterways can become less productive. And while the loss of species may not be noticed immediately, over time the decline in genetic diversity has implications for the future health of the human race. National efforts should recognize that human health and welfare ultimately rely on the life support systems and natural resources provided by healthy ecosystems.

Time, Space, and Risk

Two aspects of potential environmental problems—i.e., their temporal and spatial dimensions—must be given considerable weight.

The temporal dimension is the length of time over which the problem is caused, recognized, and mitigated. For some environmental problems it can be long. It may take decades of human activity to begin to change the global climate, and more decades may pass before the effects of human activity on the global climate are clearly understood. Some pollutants can persist in the environment—and thus pose environmental risks—indefinitely. And it may take decades or even centuries before depleted species of wildlife recover from the loss of habitat.

The spatial dimension of an environmental problem is the extent of the geographical area that is affected by it. Some, like elevated levels of radon, may be limited to the basements of some homes, while stratospheric ozone depletion can affect the entire globe. And some global problems, like the loss of genetic diversity, can be caused by

human activities in relatively limited geographical areas.

Ecosystems are generally resilient to short-term insults. For example, oil spills and water pollution usually cause only temporary ecological changes; nature has a substantial capacity for healing itself. However, some changes are either permanent or semi-permanent.

In fact, some long-term and widespread environmental problems should be considered relatively high-risk even if the data on which the risk assessment is based are somewhat incomplete and uncertain. Some risks are potentially so serious, and the time for recovery so long, that risk reduction actions should be viewed as a kind of insurance premium.

Steve Delaney photo.

Risks to the Natural Ecology and to Human Welfare

The following are ecological risks the Science Advisory Board felt were of considerable importance and should receive attention in any discussions about current and future environmental risks and methods to control such risks. The order of problems listed within each of the three different risk groups is not meant to imply a ranking.

Relatively High-Risk Problems

- *Habitat Alteration and Destruction*

Humans are altering and destroying natural habitats in many places worldwide, e.g., by the draining and degradation of wetlands, soil erosion, and the deforestation of tropical and temperate rain forests.

- Species Extinction and *Overall Loss of Biological Diversity*

Many human activities are causing species extinction and depletion and the overall loss of biological diversity, including the genetic diversity of surviving species.

- *Stratospheric Ozone Depletion*

Because releases of chlorofluorocarbons and other ozone-depleting gases are thinning the Earth's stratospheric ozone layer, more ultraviolet radiation is reaching the Earth's surface, thus stressing many kinds of organisms.

- *Global Climate Change*

Emissions of carbon dioxide, methane, and other greenhouse gases are altering the chemistry of the atmosphere, threatening to change the global climate.

Global warming and stratospheric ozone depletion are big-picture problems on which scientists and the public don't see eye to eye. The Science Advisory Board sees these as high-risk problems. In public opinion polls, they have received medium- to low-risk rankings.

Relatively Medium-Risk Problems

- *Herbicides/Pesticides*
- *Toxics, Nutrients, Biochemical Oxygen Demand, and Turbidity in Surface Waters*
- *Acid Deposition*
- *Airborne Toxics*

Relatively Low-Risk Problems

- *Oil Spills*
- *Ground-Water Pollution*
- *Radionuclides*
- *Acid Runoff to Surface Waters*
- *Thermal Pollution*

The Links Between Risk and Choice

The sources of risk often are to be found in the day-to-day choices made by individuals, communities, and businesses. And many kinds of environmental risk will not be reduced substantially, especially over the long term, if past patterns of individual, community, and business choices do not change in light of the relative risks posed by those choices.

Individuals either increase or lessen environmental risk depending on which consumer products they buy, how they design their homes, and whether they walk or drive to work. Society affects environmental risk at the local level through building codes and zoning laws and at the national level through tax, energy, and agricultural policies.

Choice is influenced by a number of factors, including education and ethics. Some people may choose to purchase certain consumer products because of a genuine concern about the environmental effects of their personal buying patterns. Similarly, some businesses may redesign production processes to eliminate pollution because of a desire to be perceived as corporate "good citizens."

Economic incentives are also important tools for inducing particular kinds of choices. When the price of energy rises, consumers are likely to buy more fuel-efficient vehicles and weatherize their homes, while plant managers have an added incentive to purchase more energy-efficient equipment. Full pricing of municipal services can give people an incentive to recycle their household wastes and conserve water.

Laws and regulations are effective at shaping individual and social choices. Local zoning laws can change the pattern of economic development in a community and limit where homes can be built. Local, state, and federal procurement regulations can have a substantial effect on the development of markets for recycled products.

Projected future growth in population and economic activity could add enormously to the environmental risks faced in this country and around the world. But growth and reductions in environmental risk are not necessarily incompatible, if past patterns of individual, community, and business choice can change.

Public Perceptions Of Risk

Public opinion polls taken over the past several years confirm that people are more worried about environmental problems now than they were 20 years ago when the first wave of environmental concern led to major changes in national policy. But the remaining and emerging environmental risks considered most serious by the general public today are different from those considered most serious by the technical professionals charged with reducing environmental risk.

This dichotomy presents an enormous challenge to a pluralistic,

democratic country. Since public concerns tend to drive national legislation, federal environmental laws are reflective of public perceptions. Consequently, EPA's budget and staff resources tend to be directed at those environmental problems perceived to be most serious by the general public.

One way to bridge the dichotomy would be to improve the public's understanding of the scientific and technical aspects of environmental risk while improving scientists' understanding of the basis of public concern. Since environmental policy necessarily embodies subjective values, scientific understanding should not be the sole determinant of environmental policy.

Relatively High Risks To Human Health

The following are human health risks that the Science Advisory Board felt were of considerable importance and should receive attention in any discussions about current and future environmental risks and methods to control such risks. Available data support high-risk rankings for four areas. Other areas also involve potentially significant exposure of large populations to toxic chemicals; e.g., pesticide residues on food and toxic chemicals in consumer products. However, the data bases to support those concerns are less robust.

- *Ambient Air Pollutants*

Stationary and mobile sources emit a range of different air pollutants to which large populations are exposed. Some have toxic and/or carcinogenic effects following direct inhalation exposure (e.g., carbon monoxide and benzene). Other pollutants, such as lead and arsenic, reach humans by a variety of pathways including direct inhalation, inhalation of re-suspended dust, and ingestion of dust deposited on food products. Still others are important precursors that can lead to compounds such as ozone, acid aerosols, and carcinogenic hydrocarbons that form in the atmosphere over large areas of North America.

- *Worker Exposure to Chemicals in Industry and Agriculture*

Industrial and agricultural workers are exposed to many toxic substances in the workplace. Such exposures can cause cancer and a wide range of non-cancer health effects. Due to the large population of workers directly exposed to a range of highly toxic chemicals, this problem poses relatively high human health risks.

- *Pollution Indoors*

Building occupants may be exposed to radon and its decay products as well as to many airborne combustion products, including nitrogen dioxide and environmental tobacco smoke. Indoor exposures to toxic agents in consumer products (e.g., solvents, pesticides, formaldehyde) also can cause cancer and a range of non-cancer health effects. Due to the large population directly exposed to a number of agents, some of which are highly toxic, this problem poses relatively high human health risks.

- *Pollutants in Drinking Water*

Drinking water, as delivered at the tap, may contain agents such as lead, chloroform, and disease-causing microorganisms. Exposures to such pollutants in drinking water can cause cancer and a range of non-cancer health effects. This problem poses relatively high human health risks because large populations are exposed directly to various agents, some of which are highly toxic.

Recommendations for Reducing Environmental Risk

Here are the 10 major recommendations of the SAB's report, *Reducing Risk*.

- EPA should target its environmental protection efforts on the basis of opportunities for the greatest risk reduction.
- EPA should attach as much importance to reducing ecological risk as it does to reducing human health risk.
- EPA should improve the data and analytical methodologies that support the assessment, comparison, and reduction of different environmental risks.
- EPA should reflect risk-based priorities in its strategic planning processes.
- EPA should reflect risk-based priorities in its budget process.
- EPA—and the nation as a whole—should make greater use of all the tools available to reduce risk.
- EPA should emphasize pollution prevention as the preferred option for reducing risk.
- EPA should increase its efforts to integrate environmental considerations into broader aspects of public policy in as fundamental a manner as are economic concerns.
- EPA should work to improve public understanding of environmental risks and train a professional workforce to help reduce them.
- EPA should develop improved analytical methods to value natural resources and to account for long-term environmental effects in its economic analyses. □

Why We Didn't Use "Risk" Before

by Al Alm

William C. Reilly's strong advocacy of the Science Advisory Board's (SAB) recent report on *Reducing Risk* has, as the EPA Administrator intended, opened up a debate on whether risk-based priority setting is feasible, desirable, and morally proper. The conclusions of the report—in short, that risk-based priority setting is indeed necessary—are anchored in 20 years' experience with both risk-based decision making and priority-setting at SAB. These two distinct concerns were linked initially with EPA's 1987 internal report *Unfinished Business* and embellished in the SAB report. Their linkage could have profound implications for the future of environmental programs.

The term "risk" was rarely used during EPA's formative years. In the early 1970s, the public, Congress, and EPA were primarily focused on curbing the *damages* from gross air and water pollution. The early symbols of environmental degradation included a burning Cuyahoga River, a dying Lake Erie, and a smog-choked Los Angeles.

With these problems so firmly etched in public consciousness, the Agency declared a holy war against pollution of all forms. These absolutist concepts were applied mainly to air and water pollution but were also carried over into control of hazardous chemicals. Although EPA's pesticide legislation balances risk versus value (economic and social benefits) of pesticides, much of the early legal reasoning behind the Agency's actions on cancellations and suspensions was based on the premise that any threat of cancer was unacceptable.

(Alm, a former Deputy Administrator of EPA, is now Director and Senior Vice President of the Science Applications International Corporation in McLean, Virginia.)

Setting priorities was not a problem during EPA's early years.

However, as the Agency began to deal with an onslaught of chemical contamination problems—Kepone in the James River, mercury in the Great Lakes, and PCBs almost everywhere—it became clear that a new decision-making process was necessary. It was simply going to be impossible to ban all potentially harmful chemicals.

The threat of cancer provoked the first steps toward the formal process of risk assessment. After being briefed on the range of carcinogens in the environment—including to his dismay, liquor—the Administrator Russell E. Train directed me, as Assistant Administrator of Planning and Management, to develop a "cancer policy." Working with excellent EPA staff—Betty Anderson, Walt Barber, and Tony Cortese—we concluded a "policy" was both unworkable and potentially politically divisive. On the other hand, we concluded that there was no analytical framework for making decisions relating to cancer and for comparing one cancer risk against another.

The working group recommended to the Administrator the creation of a Carcinogen Advisory Group (CAG)—a small staff that would analyze the cancer risk of individual decisions. The CAG was the forerunner of the Office of Health and Environmental Assessment (OHEA), created in 1980 within the Office of Research and Development. Betty Anderson moved from heading up the CAG to the leadership of the newly created OHEA. In addition, a risk assessment staff had been created in the Office of Pesticides and Toxic Substances to help support the Toxic Substances Control Act, which was enacted in 1976.

Laboratory research can identify specific risks, such as the cancer-causing potential of certain compounds, but professional judgment necessarily plays a significant role in comparative risk assessment, which entails the ranking of diverse health and ecological problems.

EPA photo.

During the last half of the 1970s, EPA had developed the capability to evaluate the risk of harmful chemicals—primarily carcinogens—in quantitative terms. By evaluating both the potency (toxicity) and exposure, EPA could estimate the quantitative risk from emissions or use of a chemical. For example, EPA could estimate that Chemical X poses a risk to society of 10 additional cancer deaths per thousand people. This practice, which is currently

By the end of the 1970s, EPA's statutory authorities had ballooned.

commonplace, was relatively new in the mid-1970s. Many EPA professionals no longer used bi-modal terms such as safe or unsafe, but rather began to think and talk in probabilistic terms.

The term risk assessment did not gain widespread popular currency until the second term of William D. Ruckelshaus as Administrator. Ruckelshaus took over the helm of EPA at a time of turbulence. As never before in its history, Congress was pushing EPA to make a major onslaught on hazardous chemicals. The public was demanding absolute safety from toxic contamination, and no one was arguing the impossibility of such a goal.

Ruckelshaus viewed public education as one of the chief responsibilities of the EPA Administrator. Educated himself by participation on a National Academy of Sciences panel on risk assessment and risk management, Ruckelshaus set out to educate the public on risk. In a landmark speech to the National Academy of Sciences, Ruckelshaus argued that zero risk was impossible: that society had to accept some risks in return for economic and social benefits that were expected. In that speech, he also articulated a decision-making process that separated risk assessment from risk management.

Almost like a judge, Ruckelshaus used individual decisions to illustrate the need for statutory flexibility in dealing with risk. For example, in presenting the draft National Ambient Air Quality Standard for PM10 (particulates of respirable size), he argued that the health test in the Clean Air Act was unreasonable. The public forum he created to deal with arsenic emissions at the ASARCO Tacoma Smelter illustrated trade-offs between environmental risk and jobs in a local economy.

Ruckelshaus neither invented the techniques of risk assessment nor was he successful in gaining statutory flexibility from Congress. He was successful, however, in embedding risk assessment more deeply in the Agency's decision-making process and in changing the perception of senior EPA staff.

Ruckelshaus did not deal explicitly with comparing the relative risk between environmental problems, although the genesis of this idea took form during his tenure. Nor did he really explicitly focus on ecological risk. These issues were to be faced later during the Thomas and Reilly periods.

Setting priorities was not a problem during EPA's early years. During the early 1970s, the public, Congress, EPA, and the experts pretty much agreed about the severity of environmental problems the country was facing and what needed to be done to correct them. Public outrage was focused on ecological threats from water pollution and health and aesthetic threats from air pollution. With agreement on the problems among EPA, Congress, the public, and most experts, EPA was able to focus its efforts and resources on massive clean-up programs.

Over time, however, EPA's authorities began to strain resources, and the Agency, not surprisingly, lost focus. In 1974, the Safe Drinking Water Act (SDWA) was passed—the first major new authority since the creation of the Agency. On the heels of the SDWA, the Toxic Substances Control Act (TSCA) and the Resource Conservation and Recovery Act (RCRA) were enacted in 1976. In 1980, the Comprehensive Environmental Recovery and Compensation Liability Act (CERCLA)—popularly known as Superfund—was enacted.

By the end of the 1970s, EPA's statutory authorities had ballooned. The SDWA and TSCA were being implemented as full-scale programs, but RCRA implementation was at an early stage, and CERCLA implementation was just beginning. During that time, budgets had increased substantially to meet the

EPA photo.

Asbestos and other potential indoor air pollutants are relatively new environmental concerns. The agenda of unfinished business has grown, not diminished, since EPA's 1970 creation.

What is Comparative Risk Analysis?

Setting environmental priorities will never be easy. Many problems beg for attention. While a variety of factors must be considered, the priority-setting process must take into account some estimate of the relative seriousness of the problems.

Comparative risk projects are simply a formal way of gathering together available information and professional judgments to produce estimates of relative seriousness. The 1987 *Unfinished Business* project, the 1990 *Reducing Risk* project, and the various other comparative risk projects mentioned in this issue of *EPA Journal* have shared several characteristics:

- Teams of 20 to 75 experts from different fields list the problems to be analyzed. The list typically includes criteria air pollutants, radon, active hazardous waste sites, pesticides, and so forth. There are different ways of dividing up the problems, and teams have listed from as few as 18 to as many as 31.
- Participants define different types of risks by which the problems will be compared. Typically, they include cancer, non-cancer health effects, ecological effects, and welfare effects, such as materials damage and economic losses. Because there is no commonly accepted way of "adding" these risk types, all teams have kept the comparisons separate. The participants also agree on ground rules, such as looking only at risks that remain after current controls are applied.
- Participants assemble data on each problem and compare the relative seriousness by risk type. Because there are gaps in data, and because data are often not strictly comparable, there is no way of making the comparisons precise. Thus, each team has had to use considerable judgment to produce rankings. It is rarely possible to accompany rankings with good quantitative estimates of total impacts. In fact, each team has stressed that its comparative rankings are only rough judgments. Nevertheless, they have all had confidence that their higher ranked problems are more serious than their lower ranked problems.

The results of comparative risk projects are being used as one type of aid to inform the debates on environmental priorities. Other factors that must be considered include statutory mandates, public concern (which may vary substantially from the comparative risk project rankings), the status of existing programs, the economic or technical controllability of the risks, the benefits to society of the activities that cause the environmental problems, and the qualitative aspects of the risks that people find important, such as equity. Comparative risk analyses can also yield insights on individual problems concerning sources, pathways and exposures that are useful in identifying opportunities to reduce risks.

needs of new programs, as well as to beef up existing ones.

The Gorsuch regime attempted to reverse the two driving forces at the end of the Costle period—expanding the environmental agenda and expanding resources devoted to EPA programs. The new Administrator, Ann Gorsuch, believed EPA could "do more with less" by better management and a clearer sense of the federal role. In a sense, priorities were established by substantial cuts in most EPA programs to make room for the new hazardous waste programs.

The Ruckelshaus team faced serious budget problems when it took over management of the Agency in 1983. The traditional EPA programs had been reduced substantially from the Costle budget. Congress was about to make dramatic changes to RCRA, and CERCLA reauthorization was on the horizon.

The 1984 amendments to RCRA brought the issue of priorities to a head. The 1984 RCRA reauthorization, with its massive shift of emphasis, was going to require substantial increases in personnel and dollar resources. As Deputy Administrator, I had to make room for large RCRA increases and at the same time provide some relief to traditional EPA programs. But how? No machinery existed to make such choices. Reacting to this unsatisfactory state of affairs, I directed the Agency's Office of Policy, Planning, and Evaluation (OPPE) to study how risk-based priorities could be developed. The immediate budgetary decisions were made with minimal analytical back-up.

The subsequent OPPE staff study pointed out a wide disparity between the risk associated with many EPA programs and the level of resources devoted to them. Because only OPPE participated in the study, however, Office Directors and other line managers were not committed to the study's results and were at least mildly apprehensive about them. If risk-based priorities were to have any chance of becoming a serious part of EPA decision making, wider participation in the priority-setting process was imperative.

OPPE staff, to their great credit, did broaden participation to include many of the Agency's most respected senior managers. The "best and brightest" of EPA's senior staff participated in ranking risks in four different categories: cancer health risk, non-cancer health risk, ecological risk, and welfare risk. In February 1987, the report of this internal task force, entitled *Unfinished Business*, was released. While *Unfinished Business* was a

critical success among senior EPA staff and thoughtful outsiders, it had limited impact on Agency priorities and on internal operations.

The report did, however, catch the eye of William Reilly, then President of World Wildlife Fund and The Conservation Foundation. When Reilly became EPA Administrator two years later, he decided to appoint an outside group to go through a similar exercise in developing risk-based priorities. After reviewing several options for outside participation, he finally chose the EPA Science Advisory Board (SAB) as the instrument for conducting the study.

The final SAB report, *Reducing Risk*, strongly argued that risk-based priorities were critical to protecting the public and the ecosystem. The report also suggested that ecological risk should be given equal billing to health concerns; that a greater range of tools should be employed toward reducing risk, such as market incentives and information; and that other national policies, such as energy and agricultural policy, needed to reflect environmental concerns. While calling for upgrading analytical tools, the report also recognized that informed judgment would play a role in the development of risk-based priorities.

The timing of the SAB's report, released in September 1990, was perfect. Almost 20 years after EPA's creation, the need for coming to grips with priorities had never been greater. Old problems, such as nonpoint-source water pollution or smog, had defied solution. The implementation of RCRA and CERCLA was still in the early stages. New problems reached political prominence, such as radon, asbestos, and other forms of indoor air pollution; ozone depletion; species diversity; and global warming. The backlog of unfinished business had grown, not diminished, over time.

Second, it was clear that resource constraints were going to be a reality in the foreseeable future. EPA's budget over recent years has been relatively flat. It increased only about 10 percent between 1990 and 1991, and the Administration's proposal for fiscal year 1992 was an even smaller percentage increase. Beside the general limitations on federal spending, EPA is also faced with extreme competition within its appropriations subcommittee. The Independent Offices Appropriation subcommittee must weigh EPA resource needs against those of the National Aeronautics and Space Administration (NASA), which has a politically sophisticated constituency; the Department of Veterans Affairs, recently upgraded to Cabinet status; and the National Science Foundation, which funds basic R&D, an Administration priority. The paucity of funds for discretionary federal programs, coupled with this institutional rigidity, almost guarantees the EPA's budget will lag behind legislative expectations by a large amount.

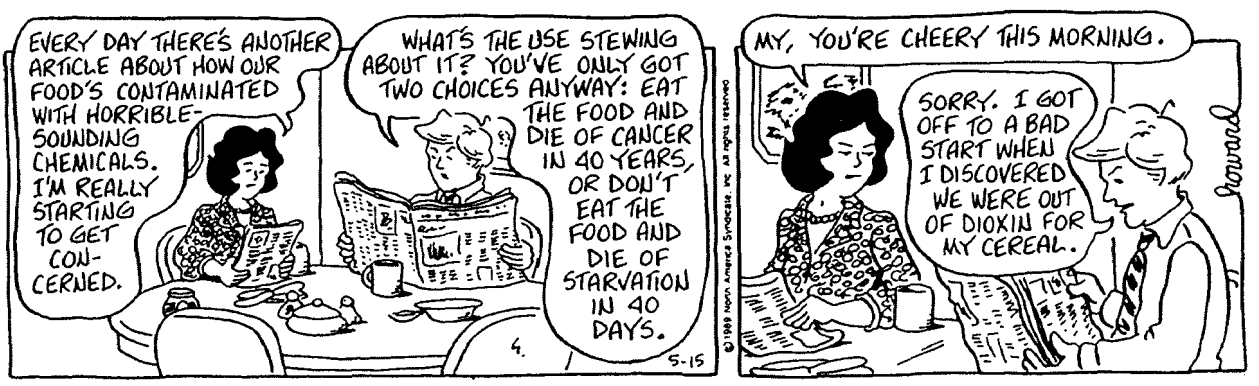
Almost 20 years after EPA's creation, the need for coming to grips with priorities had never been greater.

The SAB report solidified the coalescence of risk and priority-setting into the concept of relative risk. As a concept, risk could not only be used to guide individual decisions, it could also be used to rank risks against each other. In some cases, such as cancer risk, the risks could be compared quantititatively. In most cases, however, professional judgment must be used to rank risk, backed up by the best analytical data possible. For example, judgments are necessary to compare suffering by asthmatics from air pollution to premature deaths from human exposure to a carcinogen. And judgments are necessary to compare the potential risks from global warming to oil spills. Answers to these questions require judgment, experience, and adherence to criteria; no analytical "silver bullet" can make these decisions for us.

Establishing relative risk rankings does not necessarily translate to budgetary and programmatic priorities. Managers must ultimately rank relative risk reduction potential. That is, a moderately high risk may be amenable to a great deal of risk reduction at low cost, while addressing a higher risk might be less feasible and much more expensive.

The SAB report does not reveal any blinding new insights or divine revelations. In fact, it is no more than a synthesis of policy and analytical ideas and processes that have developed over the last 20 years—particularly those relating to risk assessment and priority setting that were embodied in *Unfinished Business*. It is nevertheless a very influential document. Never before has such a distinguished group of scientists reached such a strong consensus of the need for new directions, and equally important, never has an Administrator embraced changes with such gusto. □

SALLY FORTH



Greg Howard

Two Forums—The Policy and the Science

Mike Boylan photo.

The Debate

In a recent report, EPA's Science Advisory Board argued that we should make certain our spending on the environment achieves the maximum reduction in risk. The board recommended that we use scientific analysis of the relative risk of environmental threats as the basic yardstick for assigning priorities to programs.

Few would dispute the desirability of getting the biggest bang for our buck, but there is a variety of opinion on the rest of the argument. To provide our readers with a comprehensive roundup of views on this issue, *EPA Journal* organized two forums.

In the first, leaders in the environmental field were asked:

Should Congress, and by implication EPA, revise the current ordering of the nation's environmental program priorities to better match scientific assessment of the relative risk of the various threats to the environment?

In the second forum, a number of scientists were asked:

Is the science of estimating risk sufficently advanced so that we can rely on it to help order our priorities and allocate resources for environmental programs?

The two forums follow:

Should We Set Priorities Based on Risk Analysis?

Senator
Daniel Patrick
Moynihan

(Moynihan (D-New York) serves on the Senate Environment and Public Works Committee.)

If it can be said that we have a "national environmental policy," it can only be the sum total of the environmental laws Congress has enacted over the past two decades. In studying the nature of this "national policy," EPA's own Science Advisory Board has come upon an interesting pattern. The priorities reflected in our laws have much more in common with the public's perception of environmental risks than they do with a rigorous scientific assessment of these risks. This is not surprising. The question we must confront is whether it is desirable—and what to do if we decide it is not.

Reducing risk is not about any particular environmental problem, or any particular environmental bill. It is about a set of ideas—matters of environmental philosophy—the fundamental principles we should use in setting priorities. Which risks are greater and which are lesser? If we can come to a consensus on what these principles are to be, future environmental debates will be more rational (and more peaceable) than those to date.

Of course, it should not be assumed that reduction of the overall risk is the only factor to consider in making environmental policy. Matters of social equity, for example, must be considered. Coal miners in Appalachia will be paying a much higher price for reductions in acid rain than an average citizen, and it is also argued that the poor are exposed to pollution much more than the affluent. Nonetheless, as a principle of government, the prioritization of environmental problems is a sound starting point. It is, as Mr. Reilly has said, "common sense."

I call special attention to two of the report's recommendations:

- EPA should improve the data and analytical methodologies that support the assessment, comparison, and reduction of different environmental risks.
- EPA should develop improved methods to value natural resources and to account for long-term environmental effects in its economic analysis.

Taken together, these recommendations make a compelling case for a topic that I have been interested in for some time, which is the commencement of rigorous benefit/cost analysis for environmental laws. As a start, Section 812 of the Clean Air Act Amendments of 1990 will require EPA to perform benefit/cost analysis for its clean air regulations.

Of course, we know that answers do not come quickly in these matters. Almost three decades ago, I became an Assistant Secretary of Labor in the administration of John F. Kennedy, with a nominal responsibility for the work of the Bureau of Labor Statistics, founded in 1884. If there is one thing those brilliant mathematicians and public servants taught me, it is that fashioning economic indicators takes time. It had taken them a half century to learn to measure unemployment. But they were patient and meticulous, and in the end they succeeded. With this success they changed the way we think about an industrial (or post-industrial) society. I have no doubt that it will take quite a long time to develop reliable methodology to assess the costs, and even more difficult, the benefits of environmental regulation. But this is no reason not to begin.

Jonathan Lash

(Lash was co-chair of the EPA Science Advisory Board committee which prepared the Reducing Risk *report.)*

Chicken Little, it turns out, has occasionally been right. From hairspray to Hanford, the dire warnings of lonely voices have proven to be accurate, and conventional wisdom—often dispensed with condescension or even hostility—has turned out to be wrong. But Chicken Little has sometimes been wrong too, or at least overwrought. Some risks are not worse, but less serious than we feared. The public is skeptical and confused. One recent poll revealed that 80 percent agreed with the statement, "There are so many contradictory things said about the environment that it is sometimes confusing to know what to do."

Both *Unfinished Business* and *Reducing Risk* express the judgment of scientists and environmental officials that some risks, such as global climate change and indoor air pollution that have received little attention in national policy, are far more significant than others, such as inactive hazardous waste sites, which have received a great deal of attention. To date, our problem-by-problem political response to environmental policy has caused us to look at the world and time in pieces, breaking apart the complexity of environmental degradation in order to simplify the attempt to regulate its causes. For regulatory purposes, we separate air pollution from water pollution from hazardous wastes. We issue permits plant by plant and pollutant by pollutant but seem to lack a coherent understanding of the interrelationship of environmental effects and their causes.

Public policy in the United States reflects public perceptions. Public perceptions about the environment are based on a haphazard combination of good and bad information, well learned fear, outrage, and skepticism about official assurances minimizing risks. Over the past 20 years, we have responded to new discoveries about the nature and extent of environmental risks with a patchwork of laws that better reflect our political history than ecologists' understanding of the Earth. We have mitigated or postponed some environmental problems, but there is much that we have not addressed, and some of our solutions have created new problems.

Risk assessment by itself offers no escape from the quandary. Risk assessors look at the narrowest of questions: What is the risk of cancer to a hypothetical population exposed to an assumed level of a specific substance? In most cases, the answer to even that narrow hypothetical question is only an estimate. It is far more difficult to calculate actual risks to real people or to ecosystems.

Even if we knew enough to calculate risks with certainty, there is another problem with risk as a tool for making policy. The concept of risk is meaningless until we decide what risk of what harm to what values we wish to consider. Do we consider only the risk of death, or also the risk of illness? Are all lives the same, or are future lives less important than current lives? How do we compare risks to human beings and risks to ecosystems? Even if we could precisely calculate the risks created by human activities that affect the environment, that would provide only a piece of information to use in making environmental policy. We would still have to decide what values are important enough to us to protect from risk, and how much risk is too much.

The comparative risk assessment process described in Reducing Risk offers a framework for the use of risk information in shaping environmental policy. It requires an explicit and thoughtful decision about what sources of risk and what values at risk to consider, and about how to recognize uncertainty. Environmental policy has both scientific and moral content. Comparative risk assessment provides a structure for a debate which considers both.

Representative J. Roy Rowland

(Rowland (D-Georgia) is a member of the House Committee on Energy and Commerce.)

Those who advocate the use of "risk assessment" to evaluate environmental dangers appear to be gaining ground in Congress.

It's about time. For more than 20 years the federal government's efforts to achieve a cleaner environment have often been influenced more by fears than by scientific findings. The resulting patchwork of laws has made it all but impossible to address problems rationally and consistently.

Four years ago, when the House Science, Space, and Technology Committee called on EPA to use "scientifically sound methodologies" to assess the risk of ground-water contaminants, they conceded that risk assessment was not a perfect science. Scientists sometimes interpreted data differently, or they had to make decisions on the basis of data that was incomplete. However, the committee pointed out, risk assessment was a highly useful tool for policy makers.

In my view, risk assessment is more than a useful tool; it is unavoidable. Even those who argue that toxic chemicals should be banned without regard to cost have to rely on science to identify the chemicals that are toxic.

Nevertheless, there continues to be substantial opposition to any deliberate effort to use risk assessment in designing regulatory programs. We faced this opposition in trying to incorporate risk assessment in the Clean Air Act.

Opponents argued that risk analysis could not substitute for moral values, and that scientific knowledge was too uncertain to provide a reliable foundation for decisions. These views missed the point.

Risk analysis cannot replace moral values, but the information provided by risk analysis can guide us in making choices that respond to moral values. And, since perfect information will never be available, these choices must be based on the best information we have. When we are sick, we consult physicians knowing they sometimes disagree; we are aware that they may not know all there is to know about a disease. To behave differently when environmental protection is concerned would not be responsible.

I was pleased to have Congress endorse the concept of risk assessment last year by enacting provisions in the new Clean Air Act that require a detailed study of both the scientific and policy questions surrounding the regulation of hazardous pollutants. I was a co-author of these provisions.

Risk assessments had seemed almost irrelevant in previous deliberations over the act, even though it had been part of the overall environmental debate for many years. The act's grounding in absolute protection of health had precluded modification by a risk assessment process.

The environmental community, which was in the forefront of the phenomenal progress made over the past two decades, has been prominent among the doubters of risk assessment. I believe they strike a poor bargain when they resist risk analysis to preserve yesterday's victories. Without the support of risk analysis, problems that are important, but that are also politically unrewarding to address, may be ignored by the system.

If our environmental laws were already based on risk assessment, the regulatory system, itself, would advance our knowledge of environmental problems and their relative importance. The new risk assessment provisions of the Clean Air Act hopefully will point Congress in the right direction. By insisting on the application of these findings to other environmental laws, Congress can help move the country toward a new era of environmental progress by assuring that our limited resources are used in the most effective way possible.

Lawrie Mott

(Mott is a senior scientist at the Natural Resources Defense Council.)

The notion of using science to revise priorities for environmental programs is tempting but ultimately will result in reduced protection of public health and the environment. Setting environmental priorities on the basis of scientific comparisons of risk is unrealistic and ignores the intricate complexities of environmental problems. Setting priorities this way also assumes that we must choose which hazards to address and cannot seek to solve all environmental problems.

The very nature of scientific research is to raise as many questions as it answers. Debates in any scientific forum are just as heated as in the courts or Congress. To assume that science will be able to determine, empirically and without disagreement, which environmental problems are the worst is naive.

Certainly science can provide valuable information, but it cannot be the ultimate arbiter for fundamental questions about how society can best protect the environment. Important issues intrinsic to environmental hazards do not lend themselves to incorporation in scientific risk assessment. For instance, certain environmentally hazardous activities can provide benefits to one segment of society but present risks to another group. How can science indicate that the actions of some individuals will necessarily harm others? Similarly, how does a scientific risk assessment take into account when a risk is entirely avoidable or preventable through a technological innovation? Likewise, involuntary risks are more objectionable than voluntary ones. Yet science is ill-equipped to convey that fundamental belief. And consider children who may already be inadequately protected by scientific risk-assessment procedures. What if, as a society, we deem—and we should—children our most important resource? Analytical risk comparison cannot reflect that choice.

The environmental problems we know about today are very complex, with limited scientific knowledge about these issues. Mechanisms of toxicity are minimally understood for carcinogens. For others, such as reproductive toxicants and neurotoxins, we know even less. Data on exposure to toxins are scarce. Then consider endangered-species loss, wetlands degradation, and global warming. These very different problems cannot be reduced to one dimension for comparative analysis.

This quest towards relative risk priorities signals a basic failure in our efforts to protect public health and the environment. Basing environmental priorities on relative risk will quickly lapse into environmental triage. The top three or five or even ten issues will receive attention, resources, and perhaps some progress will be made in these areas. Other risks not on the short list will languish, or worse yet, be ignored. Triage serves a useful function in the emergency crisis on the battlefield. But environmental protection cannot become management through triage. If current resources are inadequate for addressing environmental problems, we should seek additional means. Pitting Superfund against pesticides against air pollution is counterproductive. We should strive to solve all, not just some, environmental problems. To admit that we can do anything less, as comparative risk assessment necessarily does, indicates our ultimate failure to protect public health and the environment.

Senator
Joseph I.
Lieberman

(Lieberman (D-Connecticut) is on the Senate Environment and Public Works Committee.)

Administrator William Reilly should be commended for his foresight and guts in commissioning the landmark report of the Science Advisory Board: *Reducing Risk: Setting Priorities and Strategies for Environmental Protection*. The report contains enormous challenges for EPA, Congress, industry, scientists, and the public.

One of the report's principal recommendations is that EPA must stop being a "reactive" agency in which problems are addressed in a piecemeal fashion as they arise; instead, EPA should be "proactive" and set priorities for reducing environmental risks that are based on opportunities for the most cost-effective options for risk reduction. I agree with this recommendation. It is critical for EPA to look ahead and make the best use of its limited resources to obtain the broadest reductions in risk to human health and our natural ecosystems.

In setting priorities to achieve the greatest risk reduction, I believe that EPA must rely on the latest scientific information available and address environmental problems in an integrated manner. For example, the health and environmental risks of a chemical should not be evaluated only in the context of a specific statutory scheme. Instead, the goal should be to apply the most sophisticated tools to develop an approach which reduces the risk of the chemical across all media and sources.

EPA's *Strategy for Reducing Lead Exposures* (February 1991) begins to focus on ways to identify and address the most serious existing exposures to lead. The health risks are not unique to just a single exposure medium, but come from multiple sources—lead-based paint, urban soil and dust, and drinking water. While I have concerns about the adequacy of aspects of EPA's strategy, I believe the coordinated effort to address the most significant environmental risk to America's children could serve as a model for addressing other environmental risks.

At the same time, the lead strategy highlights major concerns I have regarding the implementation of an effective risk reduction program. Any effective program must be backed by a budget that reflects the importance of these priorities. The SAB report acknowledged the need for EPA to shift its budget priorities toward those problems posing the greatest risks. Unfortunately, EPA's budget proposed only $4 million for the implementation of the lead strategy in 1992. This completely inadequate budget proposal undermines the credibility of EPA's entire effort.

As recommended by the SAB, EPA needs to establish itself as the leader on the nation's decisions on environmental risk. If Congress and the public are to have confidence in decisions based on risk, we must be convinced that those experts entrusted with the responsibility to guard human health and the environment are actually making the risk decisions.

Yet we are confronted regularly with intervention by other agencies, such as the Office of Management and Budget (OMB), the Domestic Policy Council, or the Vice President's Council on Competitiveness, which dictate environmental decisions to EPA. For example, OMB, in its 1991 introduction to the "Regulatory Program of the United States," lashed out at EPA's risk assessment methods, decrying conservatism in risk assessment because it "distorts the regulatory priorities of the federal government." At the Environment Committee's hearing on the risk reduction report, I congratulated Administrator Reilly for his defense of EPA's conservative approach and noted that, contrary to OMB's position, some experts believe that EPA is not conservative enough since its risk assessments have focused on cancer and have not taken into consideration other health effects such as neurological and reproductive risks.

The bottom line is that EPA should be the nation's chief spokesman on *all* environmental issues, including issues that arise in the context of transportation, energy, housing, and agriculture. The distinguished scientists involved in the SAB report highlighted the importance of this role for EPA.

The SAB report also contains other innovative recommendations. Most important, it urges that pollution prevention be our first line of environmental defense. Pollution prevention is a cost effective approach to environmental protection. A pollution prevention strategy can result in savings to American industry as well as help industry compete in the global market by encouraging the efficient use of energy and raw material and stimulating the development of new technologies and "safer" chemicals. In March, I introduced legislation which would require industries to prepare plans setting forth goals for pollution prevention. The goal of this legislation is to assist industries in understanding the benefits of pollution prevention —that it is a "win-win" situation for both a clean environment and a business bottom line.

I look forward to working with EPA as it strives to integrate the SAB's recommendations into its mission.

Bernard D. Goldstein

(Professor Goldstein is chair of the National Academy of Sciences Committee on Risk Assessment Methodology and Director of the Environmental and Occupational Health Sciences Institute.)

For a risk scientist to oppose the use of risk assessment in ordering EPA's priorities is as unexpected as the "man bites dog" story favored by news editors. However, this risk scientist would like to bite the dog of risk assessment being used as the primary driving force in EPA's prioritization process. Most certainly, I do strongly support the use of science to determine the relative risk of environmental hazards. And most certainly, I fully agree that the protection of health from environmental threats is best served by applying the greatest resources to the biggest threats. However, there is a disconnect between what is measurable by the science of risk assessment and what are the greatest threats to environmental health.

Perhaps the best way to describe this limitation in the ability of risk assessment to fully define EPA's priorities is to consider the basic concepts of prevention. In public health we usually speak of three modes of prevention: primary prevention, the most effective, consists of actions which prevent the problem or threat from ever developing; secondary prevention deals with this threat in its early stages; while tertiary prevention, in essence, deals with the treatment of the adverse effect once it has occurred.

Reducing risks measured through the risk assessment process is a form of secondary prevention. Setting priorities for pollution prevention is performed through a quantitative risk assessment which depends upon correctly interpreting the potential impacts of pollutants whose presence is quantifiable. While it is important to use risk assessment to set priorities among the various existing problems which require mitigation and cleanup, it is even more important to prevent future problems of potentially far greater magnitude.

How is primary prevention applied to environmental health? A simplistic approach would be to remove any possibility for any exposure in any situation. This is not possible, nor is it desirable to focus equally on all agents, regardless of their risk. The best approach is to understand the mechanisms by which chemical and physical agents produce biological effects in humans or in ecosystems. This understanding permits appropriate choices to be made in a cost effective manner that translates itself into primary prevention. Today, a manufacturer searching for a new chemical product has a number of short-term predictive tests which quickly guide whether to develop the chemical for market. For example, a positive Ames Test for bacterial mutagenicity will lead to this chemical being put back on the shelf and a redirection of R&D effort elsewhere. The Ames Test, and other short-term assays, are the outgrowth of a long series of basic research studies aimed at understanding the underlying mechanisms by which disease processes occur. For the Ames Test, it was first necessary to understand the mutagenic basis of carcinogenicity, the role of changes in the genetic code as a basis for mutation, the metabolic basis for the conversion of certain chemicals to carcinogens, and the means by which mutations can be expressed in bacteria.

A budget process that focusses on those problems that already exist because their risk can be quantified may well do so at the expense of support of primary prevention approaches. For example, the provisions of TSCA (the Toxic Substances Control Act) that are related to the clearance of new compounds require a strong knowledge base and a highly expert staff for what is a classic primary prevention approach. In addition, the research budget is likely to be further torqued in the direction of existing problems rather than the longer term anticipatory approach that leads to effective primary prevention.

In my view, the most important contribution of EPA has been the prevention of what has not happened at all. Scientific understanding has permitted us to develop tests which now greatly reduce the likelihood that new chemical or physical agents will result in deformed babies or dead fish.

While continuing to emphasize risk assessment as a means to prioritize the approach to existing problems, EPA needs to assign a high level of priority to the much more cost-effective approach of anticipating and preventing new environmental problems. It is difficult to know what would have happened but did not. There have been numerous attempts to use quantitative methods to determine the value of primary prevention, often resulting in complex mathematical formulas. In my judgment, the most accurate quantitative expression of the relative value of primary prevention, as expressed in standard risk assessment terminology, is $.016 \times 10^3/1.0$. This is equivalent to 16:1 and is based on the well-known folk statement that an ounce of prevention is worth a pound of cure.

Representative
Bob Traxler

(Traxler (D-Michigan) is Chairman of the House Appropriations Subcommittee on VA, HUD, and Independent Agencies.)

In recent years, the scientific community has focused attention on the haunting possibility that humankind is threatened by changes in the global environment. As the world population continues to multiply, and as agrarian societies continue to industrialize and develop a preference for the lifestyles of the industrialized world, there is the strong possibility that humanity's actions may be putting our global habitat at risk.

This threat to human survival is evolving gradually, and it isn't always apparent to citizens. The U.S. Congress must respond to the will of the people it represents. However, if the people don't perceive the threat, Congress may face conflicting priorities. The differing demands for action by U.S. citizens and the scientific community could cause a legislative stalemate.

In addition, there are financial and budgetary concerns. For instance, policy options that limit the amount of carbon in the atmosphere could easily exceed the financial resources and the economic capabilities of the nation and the industrial world.

EPA's Science Advisory Board has identified a mismatch between the priorities of the scientific community and the priorities of the public and has rightfully expressed alarm. This gap in comprehension of the risks involved in global environmental change is a rising challenge that can be met only through national leadership.

The very existence of a gap in the United States, the most advanced communications society in the world, underscores the seriousness of the gap in comprehension that exists in the developing and newly industrialized countries. We can hardly expect that the economically deprived peoples of these societies will be motivated to curtail slash-and-burn agricultural practices or the release of pollutants from emerging industries.

Given the global interlocking nature of the new threats to human survival, an unprecedented worldwide consensus may be required to address them effectively. Institutionalizing relative risk assessment as an integral part of policy making would contribute importantly to worldwide decision making.

I believe it is of utmost importance that we establish institutions and mechanisms for informing policy makers and the public of the scientific consensus on the risks, the priorities, and the rationale for proposed responses to global change. I believe our nation not only has the technological capability of achieving this goal, but has the moral responsibility to do so.

As Chairman of a congressional committee which has funding responsibility for science and environment, I have proposed, and my colleagues have accepted in the fiscal year 1990 appropriations bill, the initiation of a process to develop options for creating a mechanism to share global change information. This effort is being conducted by the Consortium for International Earth Science Information Network (CIESIN), a private non-profit organization of the leading university, corporate, and private non-profit institutions with strong capabilities in information and environmental sciences.

As a nation, we have invested billions of dollars in scientific study of earth sciences, yet this information in many instances remains locked away in archives. And additional data on the human dimensions of global change are just starting to be identified.

These current practices represent a waste of national wealth that can be ill afforded. We are depriving the world of an opportunity to build upon what we have already learned. Moreover, in the information age, many of the technologies related to disseminating information are directly related to the ability of the United States to compete in the international marketplace.

We can ill afford the waste of national wealth. We are depriving the world of an opportunity to build upon what we have learned. Moreover, many of the technologies related to disseminating information are directly related to the ability of the United States to compete in the international marketplace.

Opening these archives to the world could enhance scientific investigation, public education, and economic growth in the United States. As our nation, and the international community, continues to collect more and more data, the challenges associated with global change suggest that we have a vested interest in developing methods for disseminating information on the state of our planet and the forces causing change.

Peter F. Guerrero

(Guerrero is Associate Director for Environmental Protection Issues at the U.S. General Accounting Office.)

In order to answer the question of whether Congress and EPA should reorder the nation's environmental priorities, it is important to understand the three major forces shaping contemporary environmental policy.

First, despite high public expectations for environmental protection, the federal government is sharply constrained in its abilities to address environmental problems. The federal budget deficit is estimated to approach $300 billion in 1991. Under the Omnibus Budget Reconciliation Act of 1990, the deficit will be reduced essentially through caps on discretionary spending, which includes EPA funding; revenue increases will come with economic growth.

While this means that EPA is not likely to get much additional funding, the fact is that for the last decade EPA's budget has been essentially level. Even the apparent gains under the President's 1992 budget request disappear once inflation is taken into account.

Second, there is clearly a disparity between what the public sees as environmental risks and what scientific assessments tell us. As illustrated by the recent report of the Science Advisory Board, the problems judged by scientists to pose the most serious risks were not necessarily the ones that Congress and EPA had targeted for the most aggressive action.

Finally, environmental legislation and regulation have grown increasingly complex: The 1990 Clean Air Act, for example, is over 700 pages long. As a result, EPA is subject to hundreds of legislative deadlines, litigation, and congressional oversight that give the Agency little flexibility to set priorities and allocate its resources accordingly.

How is EPA to reconcile limited resources with unlimited public expectations, narrow the gap between perceived and actual risk, and meet legislative mandates yet increase its ability to respond flexibly to environmental problems? While there may be no simple answers here, one thing is apparent: EPA cannot do it alone. It must educate both the public and the Congress on the difficulty of the task ahead. To do so, it must rebuild the public education and information programs that were largely dismantled in the 1980s. And it must work closely with Congress in helping to set environmental priorities. While EPA has the ability and, arguably, the responsibility to assess the relative risks posed by environmental problems and to educate the public about them, it nevertheless remains the responsibility of Congress to translate that information into legislation. Over the next few years, EPA and Congress will have an important opportunity for change as a number of major environmental statutes become due for reauthorization.

To set rational environmental priorities for the resource-constrained 1990s, EPA will also need to continue to do a better job of assessing how well its programs are improving the quality of the environment. In the past, instead of judging how well it's doing by how clean the environment is, EPA has generally counted the numbers of regulations it has issued or the enforcement actions it has taken as measures of progress.

EPA's problems in this regard are partly the result of funding constraints that have prevented it from fully monitoring environmental conditions. Moreover, developing good ways to measure environmental conditions is difficult. Although EPA has tried to develop better information on environmental conditions, Congress may need to let EPA know, through its appropriations and oversight activities, that continued progress in this area is important.

It will take time to develop the consensus needed to reorder the nation's environmental priorities. EPA's efforts to put these important issues before Congress and the American public are encouraging. By so doing, EPA has set the stage for the important discussions that must take place if we are to have a more rational, cost-effective environmental protection program in the future.

Senator
Steve Symms

(Symms (R-Idaho) is a member of the Environment and Public Works Committee.)

When EPA's Science Advisory Board (SAB) recently recommended that the Agency tackle public health and environmental problems in the order of "highest risk first," they were merely stating the obvious. To do otherwise is to throw away human lives needlessly.

The use of risk-based priorities is necessitated by the fact that we live in a world where resources are limited. If resources (i.e., labor, time, money, etc.) were unlimited, we could task the EPA with full and immediate response to every health and environmental problem, no matter how small or insignificant. But since resources are not boundless, we must carefully pick where to focus Agency efforts to achieve the maximum environmental protection possible within our limited capabilities.

It is like having a portfolio containing loans of varying interest rates. In order to pay off those loans as inexpensively and quickly as possible, you pay first on the highest rate loans. The benefit of this approach is a savings of dollars that would otherwise be needlessly paid if high rate loans persisted on the books for a longer period of time. Likewise, addressing the highest risk environmental problem first will also yield dividends, but the savings is not dollars: It is in human lives and the health of the environment in which we live.

The use of risk assessment as a policy tool yields a number of side benefits besides this essential prioritizing function. Often, the assessment itself will produce critical information on the best risk reduction measure. By breaking down the variables that lead to a particular risk, one can target the factor that is most efficiently and effectively addressed. For example, the relative dose, the duration of exposure, or the toxicity of the agent itself may all contribute to an unacceptably high environmental risk. Risk assessments should enable the Agency to identify which of these actors represents the best opportunity in terms of policy options for reducing the risk.

Furthermore, once a risk assessment has been made, it is possible to more accurately contrast that risk with benefits and alternatives. The Agency's recent suggestion to ban the use of phosphate slag in road-building is a good example of why this is important. When the risks of alternative road-building materials and the benefits (in increased road safety) of phosphate slag are evaluated, they far outweigh the risk posed by use of slag itself. By comparing these risks, the Agency can choose the policy course that truly saves lives. Ignoring such comparisons may cause more deaths than the policy is intended to save.

The SAB report goes beyond merely recommending that EPA's priorities be based on their "potential for risk reduction." The report also urges that the Agency's budget should "more directly reflect risk-based priorities." To a limited extent, that may be accomplished within Agency budgeting procedures. To truly achieve the necessary degree of budget re-allocation, however, action on the part of Congress is required. In fact, Congress should be basing ALL of its efforts on sound scientific risk. As the SAB report states, "To the extent that EPA has discretion to emphasize one environmental protection program over another, it should emphasize the program that reduces the most environmental risk at the lowest overall cost to society. *The Congress should also be encouraged to observe this principle in writing and revising legislation*" (italics added).

Again, the SAB is only stating the obvious: that Congress ought to be advancing policies that save the most lives possible, rather than aiming wildly at whatever environmental issue happens to be politically popular at the time, at the cost of needless loss of life and unnecessary degradation of the environment.

Nicholas L. Reding

(Reding is Executive Vice President of Monsanto Company, with responsibility for environmental, safety, health, and manufacturing operations.)

When asked if we could set our priorities for environmental programs based on scientific assessment of relative risks, the answer in an ideal world would be a resounding "yes."

In an ideal world, EPA would apply the talents and intelligence of its people to pursue the most effective means of environmental control at the least cost. The Agency would have greater flexibility in such a world to set environmental priorities based on scientific risk assessment. And Congress would be able to come to some sensible policy conclusions based on real threats to the environment and how they should be addressed.

In the real world, however, the only answer can be "yes, but . . . ."

Yes, health and environmental threats should be assessed based on sound scientific facts, not on public perceptions. But do we really have the ability to scientifically assess relative risk? And, assuming the capability is there, where does that leave the public in this process?

Over and over again, we've seen that the public does not assess environmental risk on a scientific basis. Risk is assessed on an emotional basis, on how well the threat is understood, and on whether there is a choice in terms of exposure. When environmental concerns hit close to home, the public responds out of fear. We saw this with Alar, and the same response pattern is reflected in the evolution of the Superfund program.

The public fears toxic air pollution and strongly feels that it must be cleaned up, whether or not there is a real health risk. That is one of the reasons Monsanto voluntarily pledged to reduce toxic air emissions, worldwide, by 90 percent by the end of 1992. The program is in place even though the best scientific and medical data indicate that Monsanto's emissions do not pose a health risk in our plants or communities.

If we rely solely on scientific assessment of relative risk to set environmental priorities, the public is left out of the equation. We must be mindful of the public's interest. Obviously, at the same time, we must be mindful of what the real risks are and try to mesh these divergent views when establishing priorities.

We need to better inform the public, allowing people to be part of the debate. Scientific assessment of relative risk can be viewed as a tool to help form public opinion based on real threats, not perceived threats.

All those involved—the regulatory agencies, Congress, the Administration, the regulated industries, and, most of all, the public—must work toward taking care of the biggest risks first.

As America began to industrialize in the 19th century, many assumed that natural resources—like air and water—were limitless and free. Society made many decisions based on that assumption, decisions which have resulted in many of the environmental problems we have today.

Similarly, many assume today that America has unlimited financial resources which can be applied to any and all environmental problems, regardless of real risks or threats. That assumption could lead to a misuse of resources and a worsening of real problems. If EPA could align its priorities to account for the relative risk of environmental threats as judged by "good science," we could begin to better protect our planet.

Lee M. Thomas

(Thomas, Administrator of EPA from 1985 to 1989, is Chief Executive Officer of Law Environmental, an environmental consulting firm.)

Today's engineers, scientists, and environmental professionals have access to extensive databanks and other information resources. These represent a whole new body of knowledge describing the character of pollution, its effects on the environment, and the relationship between environmental quality and human health. This information offers some significant new insight into pollution, also into the subtle range of potential environmental risk associated with it.

Although the data are neither whole nor perfect, they nonetheless provide the ability, for the first time, to scientifically assess and compare the relative risks of several major air, water, and land-based pollution problems. Comparative risk assessments performed to date clearly show discrepancies between real environmental problems and how people perceive environmental risks. Despite these findings, the institutional response towards focusing on the most severe environmental problems so far has been limited.

Although complete information is not available to assess comparative risk, should Congress apply relative risk and call for a reordering of the nation's priorities for its environmental programs? Would such an approach contradict the will of the people? And do scientific uncertainties alone pose a substantial enough risk to discourage Congress from taking such action?

Consider first whether the public will or welfare would be contradicted by revising the nation's environmental priorities through a risk-based approach.

It's notable that despite a proliferation of environmental laws and regulations—and evidence of improvements in environmental quality over the last 20 years—public concern over the damaging effects of pollution continues to mount. Opinion polls repeatedly indicate that a majority of the public feels that environmental quality is declining and that health and ecological risks from pollution are on the increase.

Obviously, the public is not happy with the status quo. While the public appears to be growing increasingly disenchanted, environmental expenses, now estimated at $100 billion yearly or approximately two percent of the nation's GNP, continue to escalate. Although a reordering of the environmental agenda is unlikely to reduce environmental costs significantly in the short term, I would point out that these increasing costs are drawing the public into a growing national debate over the government's effectiveness in protecting the environment.

Despite differences of opinion between the public and environmental experts over the allocation of resources, I'd also emphasize that the United States already has in place several important environmental statutes of high caliber. A big problem with these statutes is that they have never been prioritized in any systematic manner. Rather they have been enacted, one after another, more or less in response to crisis situations.

Using comparative risk analysis as a mechanism to prioritize the nation's agenda would not necessarily result in a major restructuring of our existing environmental laws and programs. Nor would it diminish the public's strong environmental commitment. It would require the public to become much more knowledgeable about the relative seriousness of the nation's problems. And comparative risk analysis would enable legislators and regulators to fine tune existing environmental laws and programs so that they function more effectively.

Concerning the scientific uncertainties associated with risk management, I would point out that risk management, as distinguished from risk assessment, is not, nor does it make any claims to be, a science. Rather it entails the use of science as a factor in making subjective policy and budgetary decisions. For the purposes of setting basic environmental priorities, absolute scientific precision generally is not attainable. Reliable, accurate information to allow for a general comparative ranking is all that is needed.

Setting environmental and other policies involves reviewing choices, setting priorities, and making hard decisions. When everything is a priority, nothing is a priority. In a time when the world's natural and economic resources are under growing strain, it is my belief that Congress, and by implication the EPA, will continue their progress toward finding improved solutions to the nation's environmental problems. Risk management should, and will, play an increasingly important role in these efforts.

Representative Don Ritter

(Ritter (R-Pennsylvania) is ranking Republican member of the House Subcommittee on Environment.)

Last fall, the EPA's independent Science Advisory Board (SAB) issued the *Reducing Risk* report, which recommended that EPA deal with environmental hazards based on the severity of risks to human health and the environment. Administrator Reilly has stated that EPA should pursue a "worst first" policy. This makes sense, but how can the Agency make it work in practice?

Think of EPA as a company attempting to change its business plan in response to reports that say times have changed. The research department's director says the company should rely more on new products his department is testing. He warns, however, that tests to assess these products aren't foolproof. Unfortunately, the researchers spend most of their time and resources fixing problems with current products. There's another problem: The company is almost broke. There's no choice for the foreseeable future but to service and sell the current product line.

This is an approximation of EPA's current dilemma. In 1970, the new Agency tackled traditional smokestack and end-of-pipe controls. Twenty years later, it must address more complex situations, such as pollution-source reduction and disparate non-point or "area" sources. EPA must adapt to the changing needs of environmental protection, or serious problems will go unsolved. The Agency should decide which hazards to address first, based on scientific justification.

As in the corporate world, there are scientific and financial issues. *Risk assessment*, the science of modeling risks to the environment, is still relatively new. EPA scientists spend the bulk of their time providing technical support for activities under major environmental statutes, such as the Clean Air Act. For this reason it's difficult for the Agency to consider research, let alone new regulatory programs, in other fields where risks to the population may be higher. Of course, in the current federal budget climate, funds are scarce for all research activities.

Some risk assessment models are well developed, and the magnitude of certain hazards is established. EPA's program offices, however, do an inadequate job of understanding risk assessment methods and integrating them into regulatory decisions. The Agency must do a better job of meshing science and policy.

Here are three specific recommendations to help the current situation by moving the Agency toward a risk reduction strategy:

- *Develop stronger risk assessment criteria.* EPA should improve the accuracy and consistency of risk assessment methodologies. At the March 12 hearing of the Subcommittee on Environment on the FY 92 budget request for EPA's Office of Research and Development (ORD), Dr. Robert Huggett of the Science Advisory Board (SAB) testified that data gaps remain in key areas, including adequate evaluation of impact on ecosystems and human exposure to pollutants. ORD's research activities could narrow these gaps.

- *Improve cooperation between researchers and program offices.* Too often, the program offices view science as a mere input into the regulatory process. There should be more feedback between scientists and regulators, with regulatory decisions made in tandem with scientific advances. ORD should upgrade its efforts, through its Risk Assessment Forum, to apprise the program offices of significant developments in risk assessment practices. Finally, enhanced training for program office scientists will bolster their understanding of proper risk assessment protocols.

- *Modify the budgetary process.* At the March 12 hearing, ORD Assistant Administrator Bretthauer described a pilot program to incorporate risk-based concerns in the budgetary process. Of course, Congress continues to mandate actions based on considerations other than a "worst first" approach. That is the current reality of environmental protection. Still, EPA will have considerable latitude to implement a "worst first" approach.

Risk-based budgeting is an idea whose time has come. I support this activity and hope it spreads through the entire Agency. The upcoming debate over reauthorization of the Resource Conservation and Recovery Act (RCRA) affords a good opportunity to incorporate concepts of risk-based budgeting. As the SAB has demonstrated, solid waste issues present a relatively low risk to human health and the environment compared to other environmental hazards. Yet the public is avidly interested in these issues. The challenge for Congress will be to address legitimate public concerns, while optimizing the limited resources available to EPA and the private sector.

In an era of relatively static fiscal budgets, the environment is not well served by forcing cleanups and management standards for solid waste far beyond the point of diminishing returns. A risk-based, "worst first" policy of setting priorities, with greater consideration of costs to the public and private sectors, will yield substantial benefit to public health and the environment.

When good science forms the basis for good regulatory policy, EPA will have come a long way toward fulfilling its mandate to promote a healthy environment.

Mark Sagoff

(Sagoff is Director of the Institute for Philosophy and Public Policy at the University of Maryland at College Park.)

In the United States during 1987, 1988, and 1989—the most recent years for which the FBI has published statistics—no one was killed or injured as a result of a terrorist attack. In the same period, lightning killed more than 200 Americans.

We worry more about terrorism, however, than about lightning. We accept the risk of being struck by a lightning bolt in a way we never could accept the risk of being hit by a terrorist bullet. This is because terrorism, besides endangering individuals, violates our moral intuitions and expresses contempt for the principles on which civil life is based.

In the regulation of risk, safety is not our only goal, and it may not even be our principal concern. We are also concerned about man's inhumanity to man. We rightly spend more to reduce comparatively small risks that outrage us than to reduce larger risks that occasion no such resentment. The acceptability of a risk may depend less on its *magnitude* than on its *meaning*.

Oil spills, hazardous wastes, leaking underground storage tanks, ground-water contamination, and the release of radioactive materials: Each of these may pose less danger to public safety and health than, for example, radon; nevertheless they occasion more resentment. A naturally occurring danger in no way violates our intuitions about how we should treat each other. By contrast, negligent handling of hazardous waste outrages us even if the damage it does is comparatively small.

The Scientific Advisory Board (SAB) report urges EPA to "target its environmental efforts on the basis of opportunities for the greatest risk reduction." This reasonable suggestion may lead EPA to spend more, for example, on indoor air pollution and less on hazardous waste.

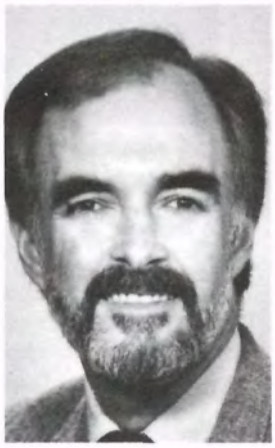
While applauding this suggestion, one might point out that the laws EPA enforces express many of the same moral and social principles we find embodied in criminal and in common law. The purpose of punishing criminals is not simply to deter crime; it is also to enforce the rule that we should not harm each other without justification. Likewise, the common law of tort—as we see in the recent Supreme Court decision to uphold punitive damages—vindicates community standards concerning the care a reasonable person should exert to protect the interests of others.

The SAB aptly observes that "EPA should attach as much importance to reducing ecological risk as it does to reducing human health risk," in part because "natural ecosystems ... are intrinsically valuable." If EPA may vindicate the public's perception that ecosystems are intrinsically good, the Agency may also vindicate the public's perception that certain kinds of pollution are intrinsically bad. The Agency has statutory authority to penalize instances of environmental irresponsibility which criminal and common law have yet to reach.

The SAB sensibly instructs EPA to improve the scientific methodologies "that support the assessment, comparison, and reduction of different environmental risks." The Agency should also analyze the moral principles that allow us to understand the meanings of different risks—to comprehend why we resent lightning, for example, so much less than we resent terrorism.

Do We Know Enough to Take a Risk-Based Approach?

D. Warner North



(North is Director of Decision Focus, Inc., a consulting firm in Los Altos, California. He is president-elect of the Society for Risk Analysis.)

Estimating risk is a process for summarizing science to support decision making. Protecting the environment involves managing risks, and it requires judgment about what we want to protect and how important it is to protect it. What the risk manager wants from the scientist is an assessment of the level of harm and how likely the harm is to occur. So making risk estimates is a way to have clear and concise communication from scientist to decision makers, and to those who are interested in and affected by environmental protection decisions. Quantification of risk facilitates comparisons among action alternatives and between problem areas. Even qualitative judgments about risk may be useful as a means of summarizing scientific judgment.

Labeling of risk estimates is critical. For example, EPA's cancer risk numbers are described in the Agency's 1986 Guidelines as . . . "a plausible upper limit to risk consistent with some proposed mechanisms of carcinogenesis . . . . The true value of the risk is unknown, and may be as low as zero." Without this clarification, EPA's cancer risk numbers might be mistaken for relatively precise estimates of cancer deaths resulting from exposure to toxic substances, similar to the risk estimates for deaths from highway accidents. The two sets of risk numbers are of a different character. Risk estimates for highway deaths are based on extensive statistical data. For most chemical carcinogens such statistical data do not exist; EPA's cancer risk numbers are extrapolations from high-dose animal experiments, made using a standard procedure in order to project the highest plausible level of human cancer risk. Most cancer risk numbers reflect risks that are highly uncertain and which could be zero, whereas the highway risk estimates reflect risks that are, unfortunately, predictable with high precision.

Even if properly labeled, a single risk estimate may not be adequate. For important decisions, the responsible decision makers will want to know more. They will want to have a narrative that describes the most important scientific information, the methodology used to estimate the risk, a description of important uncertainties, and answers to "what-if" questions to ascertain how risk estimates would change if different methods or assumptions were used.

Risk estimates should be critically reviewed for the methodologies employed, the scientific data used, and judgment of experts used in preparing the estimates. Scientists often disagree. Risk estimates can illustrate the extent of a disagreement and help decision makers to assess its importance.

Estimates of risk can sharpen debate about how to manage our environment. They help communicate what science can tell us about the possible harm to the environment of various activities. Estimates of magnitude and likelihood help us comprehend the possibility for harm. Further, they can help to clarify areas of uncertainty and to evaluate the importance of scientific disagreements. They can help EPA and other regulatory organizations to be more consistent and more efficient in using finite resources to implement environmental protection policy. However, they cannot resolve controversies over how much should be spent to protect the environment or which aspects of the environment are most in need of protection.

Paul Deisler

(Dr. Deisler is a retired official of the Shell Oil Company.)

To this question, the two-handed scientist—that bane of the manager who dearly wants the one right answer—will stand up and say: "On the one hand, yes; on the other hand, no." And I have bad news for that manager: The scientist can be right, either way.

Which way the answer goes depends a lot on the willingness of both managers and scientists to understand and accept the current limitations of knowledge, the gaps and uncertainties in it, and the fact that new knowledge often changes what we thought we knew. They must realize that any risk-based ranking of environmental programs is provisional. If they do, and if they are willing to accept not only factual data but scientific best judgment and opinion as part of the ranking process, the answer comes up "yes."

Ranking is useful to a risk manager even if it is uncertain, provisional, and temporary, even if it is cast into doubt the next time a research paper is published or a new thought is expressed. Both managers and scientists must learn to live with change, to cope with uncertainty and, at the same time, to encourage and help bring about the increase in knowledge and understanding. They must be flexible, ready to revise today's best thinking. I know this from my own experience, and I've always been happy to accept the best current scientific opinion as an ingredient in my thinking, to use it carefully in light of the cautions I've been given.

After all, if the best, current scientific opinion is not the best guidance about a deeply scientific matter, what is?

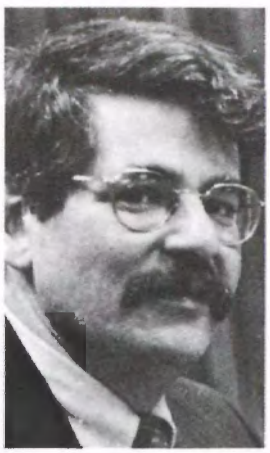
Managers and scientists alike also need to understand that a risk-ranked program list is not a priority list. Other considerations than risk help form a priority list. They include timing; technical and economic feasibility; the urgency of action for each program; and the fact that, in any one year, there is a limit to how much money and effort is available.

It is very important for managers to reassure scientists that their rankings will be accepted and used in the proper spirit, and that their concerns about uncertainty and incomplete hard information will not be disregarded. Scientists, in turn, must assure managers that they have done their best to arrive at the best answer, that they have followed a logical process of assembling, assessing, and considering all available information, judgments, and opinion, and that they have defined and used reasonable criteria.

Also, even with the best will and understanding in the world, there may exist so little basis to support opinion or judgment in some cases that particular programs can't be ranked against others. Here, the unrankable programs stand as signs pointing to the need for information, and they should be given a priority ranking, as opposed to a risk-ranking, based on other factors I've already mentioned. The whole risk ranking exercise serves to point out just where more knowledge is critically needed to do the job better.

So my answer to the question is "yes," if the ranking is done and used with the understanding that, like the weather report, it is a form of interim guidance and not a guarantee. Don't wait for the millennium. Start now, get better as you learn what you need to know, and get on with the job of managing risk.

Frank Mirer



(Dr. Mirer, a toxicologist and industrial hygienist, is Director of the United Auto Worker's Health and Safety Department.)

The question of whether science should be used for setting priorities and allocating resources for environmental programs implies that currently it is not, and that efforts are disordered. In fact, scientific knowledge is incorporated into existing legislation and regulation. However, the ultimate authority must remain with the public, and policy makers must represent the public's view.

The recommendations of the Science Advisory Board (SAB) that EPA should do more about ecological endpoints, such as global warming, habitat destruction, loss of biological diversity, and acid rain, have merit. So do their recommendations that the Agency pay more attention to the health effects of ambient air pollutants and worker exposure to chemicals. However, this doesn't mean that EPA should do less about hazardous waste, pesticide residues in food, and problems related to exposure to toxic chemicals.

The board's claim that reordering priorities on the basis of risk analysis will result in more cost-effective use of resources is highly suspect. Not only does the science of risk assessment, itself, have a way to go, the practice of estimating costs of

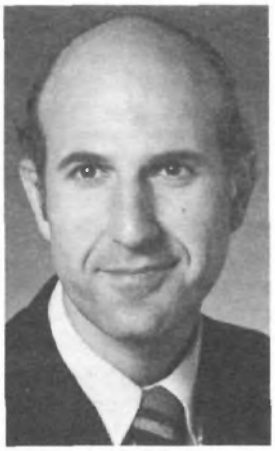
environmental and occupational health protection, thus far, at least, has proven to be an abject failure. Most often it has been advocated by ideologically conservative economists who have never worked at the "bench" of financial analysis or subjected their methods to systematic review.

The present framework of laws and regulations is the result of a collision between current scientific knowledge, industry resistance, and public health agency inaction. Where action is taken, it is limited to areas where there is apparent precision in expressing risk. Issues such as the stench of some factories or the clear-cutting of forests, where the outcome can't be expressed as a number, are neglected.

Science won't be helpful in at least two areas of priority setting. Science can't compare risks that have ecological endpoints with those that have health endpoints, and ecological concerns are often denigrated by limiting public intervention to those matters which cause disease and death. Even within the health sphere, scientists can't always help. How are they to decide between high risks to small groups (pesticide applicators) and smaller risks to large groups (pesticide residues)? How are they to evaluate low probability/high impact catastrophes (nuclear power plants) against exposures that are deferred and therefore less predictable (buried toxic waste)?

New science confirms the wisdom of past legislation, but it also demonstrates the need to reemphasize previous concerns for both health and the environment. We should not allow claims of reordering priorities to camouflage the dropping of existing protection programs.

Gilbert S. Omenn



(Professor Omenn (M.D., Ph.D.) is Dean of the School of Public Health and Community Medicine at the University of Washington in Seattle.)

Formal risk assessment by the major regulatory agencies emerged only in the past 15 to 20 years. In my opinion, the framework that has evolved is very helpful in organizing both the scientific gathering and the scientific interpretation of information as part of the decision making process. The actual decisions rest upon statutory requirements and political, economic, and social judgments.

The recent effort by EPA and its Scientific Advisory Board (SAB) to use estimates of risk to order priorities is a bold and logical step forward from that of assessing individual chemicals. There is no doubt that such an approach could be applied to a set of pesticides with similar desirable and similar adverse effects. Similarly, a combination of quantitative risk estimates and weighting for severity of effects would help inform the priority setting among criteria air pollutants and air toxics, both indoors and outdoors.

The SAB effort to embrace ecological as well as health risks was just a start, exposing the need for "rules of thumb" or "equivalences" across such disparate effects. It was an important affirmation that we want to protect *both* health and environment, that reduction of emissions will have benefits in both spheres.

If this effort at relative risk assessment can help ecologists and environmental health specialists communicate with each other, perhaps we can break down the barriers between them. These scientists earn their degrees in different colleges, attend different meetings, publish in different journals, speak and write in different jargon, and know rather little about each other's problems. Priority-setting exercises can bring them together within EPA and the counterpart agencies in the states and in universities and industrial and environmental organizations as well. Priorities are set all the time on political and budgetary grounds; the new approach explicitly asks what science can bring to the table. I am confident that scientific data and, equally, the scientific method can bring a lot to these decisions and can help bridge the gulf between scientists and the public at large.

Administrator Reilly's testimony in January 1991 before the Senate Committee on Environment and Public Works set just the right tone. We need to make existing laws workable. We need to find convergences of our environmental, economic, and energy goals. And we need to convince a skeptical public not only that we are attacking the worst problems first, but that we know how to move on to other serious problems, when risks identified earlier have been reduced.

Paul J. Lioy

(Professor Lioy is Director, Exposure Measurement and Assessment Division, University of Medicine and Dentistry of New Jersey.)

Estimating the risk of an environmental pollutant depends on our ability to measure both the human exposure to the pollutant and the hazard. My experience has focused primarily on exposure; it illustrates some of the problems encountered when attempting to set environmental priorities on the basis of risk.

The fundamental problem in assessing exposure is the paucity of baseline data on human contact. For many pollutants, the data are weak or incomplete with respect to personal contact, measurements for different routes (for example, inhalation or ingestion), and identification of the activities which affect contact.

The lack of such data should be of no surprise, since there is no national research program on human exposure with funds dedicated to basic and applied research. In the current EPA Office of Research and Development budget, only $6.7 million is dedicated to exposure, which represents 18 percent of the total EPA research budget on human effects.

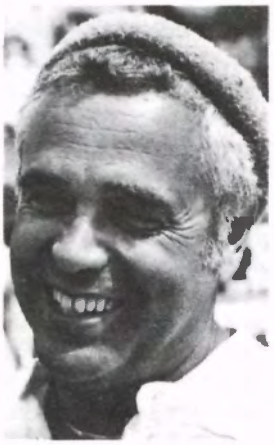
This level of effort contrasts with the ones in toxicology that form a major part of the data bases used in hazard assessment. For example, within the National Institute for Environmental Health Sciences, the contribution to the National Toxicology Program is $72 million, and funds are committed for 4,000 to 6,000 extramural environmental health research projects per year. Few, if any, are devoted to human exposure. Obviously, there is a need for concerted efforts to substantially increase the funds available for applied and basic research on exposure. The results will provide the data bases necessary to "truly" prioritize national risk problems.

The data currently available for use in an assessment are frequently derived from measurements made in air, water, soil, or food. Normally, the measurements were not made for the purpose of defining actual human exposures. These data are only useful for identifying the range of exposure, since measurements in multiple media are not usually made at the same time and place. Further, the places for which data are available may not be representative of the locations where the high exposures actually occur. Unfortunately, these data have been used to identify a Theoretical Maximum Exposed Individual, a poor soul who, it is assumed, spends his or her 70 years of life in direct contact with the pollutant all day long. These types of estimates can lead to an over estimation or under estimation of the actual exposure. If, eventually, we are able to greatly improve our databases on those human activities likely to cause exposures, and quantify the actual contact with a contaminant for one or more routes of entry to the body, we will be able to prioritize many environmental risks.

There are encouraging signs that opportunities for exposure assessment to play a critical role in establishing a scientific basis for prioritizing environmental risk will improve. Included are the EPA Exposure Assessment Guidelines, which convey the idea of prioritizing problems by multimedia pathways and routes of contact, and the National Research Council's report on Air Pollution Exposure Assessment, which provides a scientific framework for conducting basic and applied research on total human exposure.

Finally, there is another factor to be considered. All environmental risks cannot have the same level of societal response. Some are long-term problems; others are short term. The overall impact of some long-term problems can be devasting to mankind (stratospheric ozone, for example), but their solution requires a major international commitment. Other problems may be more immediate, or of smaller scale, and still require high priority for risk reduction (tropospheric ozone or environmental lead). We can affect the latter using the strategies developed within our country. Consideration of this factor might lead to the identification of categories of national environmental risk.

William Cooper



(Dr. Cooper is a professor in the Department of Zoology and the Institute for Environmental Toxicology at Michigan State University.)

Like all models, risk assessment models are abstractions of reality. Are current risk assessment models sufficiently developed to aid in environmental decision making? Pragmatically speaking, the answer

depends in large part on what are the alternatives.

My response to this question will focus specifically on ecological risk assessment. Ecological models have been tested empirically, in the real world, for decades. Pest management, watershed management, farm pond aquaculture, and game and landscape management are all examples of the practical applications of ecological models.

The best examples of ecological risk assessment, using models that forecast future events, are found in Environmental Impact Statements required under the National Environmental Policy Act (NEPA). For the purpose of Environmental Impact Statements, NEPA requires that we anticipate positive and negative environmental impacts years into the future. At the same time, these requirements are sufficiently flexible to allow the integration of the "best professional judgments" of scientists from many diverse disciplines. Thus, it is a mistake to think that the only risk assessment methodologies available are those employed by toxicologists in assessing the impacts of carcinogens in humans.

Existing ecological models are not precise, but they are logical, they integrate findings from various disciplines, and they are prospective. Our society cannot wait until the models are perfect before committing monies, energies, and human resources toward mitigating potential threats to the environment. Most of us won't live long enough to observe if we over- or under-react to environmental problems. We have to make commitments today, and our grandchildren will perform a post mortem on our logic.

The need for proactive decision making is clear when you consider what is at stake. Moreover, I would rather gamble on the instincts of field scientists who manage landscapes than those of lawyers, statisticians, and economists. At least the projections of the former are regularly tested against the natural laws of thermodynamics and evolution.

Stanley Auerbach

(Auerbach is Director Emeritus for the Environmental Sciences Division of the Oak Ridge National Laboratory.)

The science of risk analysis is a quantitative method of generating a probability of the occurrence of some undesirable event. Risk estimation is a judgment based on experience, perception, or similar intuitive approach. Combining the two poses a dilemma. Current "estimates" of many environmental risks may embody too much variability or uncertainty for them to be relied on in setting priorities or allocating resources.

To define risks scientifically, whether they be environmental or health risks, we must first define the endpoint: in other words, what is at risk? Society generally accepts cancer, injury, or death as endpoints for human health risk analysis. However, we do not as yet agree on ecological endpoints that can be used in quantitative risk analysis.

Currently, we spend billions of dollars cleaning up environments that have been contaminated by accidents or by the disposal of wastes. Municipal landfills, hazardous waste disposal sites, formerly used industrial facilities, and defense installations are undergoing massive and unprecedentedly expensive clean-up efforts. Oil spills and chemical releases, whose impacts are immediate and more dramatic, also call for large outlays of funds. Further, such accidents may have long-term consequences for ecosystems.

For many, if not most, of these clean-up efforts, the presumed risks to health and the environment are based on limited scientific data and analysis. There is definite lack of knowledge as to the degree of uncertainty surrounding the assessment of risk. Here is where science is needed. Science can incorporate the degree of uncertainty that may become evident during the risk assessment process, whether it be short- or long-term risk. Priorities can then be set to direct needed research programs.

My answer to the question posed in this forum, then, is yes, provided we combine quantitative risk assessment with a formal uncertainty analysis, which is a mathematical measure of the degree of confidence in the prediction of risk. Uncertainty analysis becomes a powerful tool because, in addition to measuring this degree of confidence, it can identify the sources that contribute to the uncertainty. It can, therefore, guide us in allocating resources to bring perceived risks closer to actual risks in dealing with environmental issues. Lastly, it can help improve the public's understanding of risk in an absolute and relative sense.

Mark A. Harwell

(Harwell is Associate Professor at the Rosenstiel School of Marine and Atmospheric Science at the University of Miami.)

Clearly, we know that the health of our environment is being significantly affected by a host of human activities. But there are substantial uncertainties in our present understanding of how ecosystems work. What is natural ecological variability over time and space? What is the nature of human stresses on ecosystems? How do ecosystems respond to stress? There are many other areas.

The environment, and human impacts on it, are so complex that there will *always* be uncertainties, but that does not mean we know nothing about the environment. We can and must make environmental decisions in the presence of uncertainties. Research and experience over time will increase our ability to predict ecological effects of human activities and thus assign risk more accurately. However, prioritizing major environmental problems, to show where efforts would be most effective in protecting the environment, only requires assessing *relative* risks, not calculating precisely the absolute values of risk. This makes the task much easier and well within the present state of scientific understanding of ecology.

Through the EPA Science Advisory Board's relative risk project, we developed ways to assign relative risks for a broad diversity of environmental problems by first listing categories of ecosystems and dividing environmental problems comprehensively into categories of stresses. Then we systematically estimated how widespread each environmental stress is, how much and what kind of ecological damage it may cause for each ecosystem type, and how long it would take for the ecosystem to recover. By looking across ecosystem types and across scales of space and time, we were able to collapse all that information into an organized listing of what environmental problems are of greatest risk (e.g., global climate change, habitat alteration, species extinction and loss of biodiversity, and stratospheric ozone depletion) as distinct from those problems of much more limited concern (e.g., radionuclides in the environment, or thermal pollution). That is not to say that radionuclides are of no concern, or that thermal pollution may not be important in some locations, just that their overall ecological risk is much lower than the risk from climate change or tropical deforestation.

Yes, there are uncertainties. No one, for example, can yet say defensibly just where climate change will cause the greatest impacts or precisely what level of species diversity is necessary for ecosystems to be healthy. It is very important that ecological research address these and many other environmental questions so that we may continually reexamine and improve our estimates of risk and anticipate new threats to the environment. Nevertheless, our scientific understanding of ecology today is sufficient to begin the relative risk-ranking process, sufficient to set priorities across major categories of human activities, and thus sufficient to allocate resources in a way that is in concert with real ecological risks. In other words, we know enough that we don't have to just respond to the latest environmental crises or to popular perceptions of risk.

John D. Graham

(Graham is Director of the Center for Risk Analysis of the Harvard School of Public Health.)

In order to recognize the virtue of comparative risk analysis for environmental policy, it is instructive to consider the politics of resource allocation. Additional resources are needed to address numerous problem areas: toxic air pollution, endangered species, carcinogenic pesticides, smog in the cities, hazardous wastes, global warming, nonpoint-source water pollution, wetlands protection, and so forth.

Each problem area has a political constituency which exists inside EPA, in various congressional committees, in the mass media, in the consulting and research communities, in private industry, and among environmental advocacy groups. Without comparative risk analysis, the claims of these constituencies for expanded resources are made independently, often without adequate review of their plausibility.

If the American people are willing to write a blank check to pay for the cost of environmental policy, then there is no resource allocation problem. But there is no blank check. As my colleague Paul Portney has argued, environmental expenditures should be scrutinized because our nation has numerous other needs that require expanded resources. They include deserving causes such as education, AIDS research, health care insurance, traffic safety, family violence, space exploration, and the military capabilities that were

recently demonstrated in the Persian Gulf. Congress limits EPA's budget precisely because the American people and interest groups pressure their elected representatives to meet a wide range of compelling needs.

Faced with conflicting claims for access to limited resources, EPA has recently turned to its Science Advisory Board for help in the priority setting process. Rather than rely solely on political negotiation to establish budgetary priorities, EPA has sought some advice from independent scientists about which environmental risks are the most serious and which can be reduced most efficiently.

SAB's message, which has generated celebration and alarm among political constituencies, is that relatively more attention should be focused on global and ecological risks while relatively less attention should be given to speculative health threats such as the current and future risks of hazardous waste. It is refreshing that EPA and Congress are open to the views of scientists about the allocation of scarce national resources.

The only danger in this process is that some citizens may be deluded into thinking that comparative risk analysis is a purely scientific undertaking. It is not. Risk assessments, while useful, cannot usually offer policy makers a high degree of precision. The more fundamental point is that judgments must be made about tradeoffs between cherished values, such as protection of public health and preservation of ecosystems. Even within the domain of human health, value judgments must be made about the relative importance of cancer and noncancer health effects (e.g., neurological effects).

When the EPA Science Advisory Board offers advice about comparative risk, it must be—either implicitly or explicitly—making sensitive value judgments. The board should articulate the limits of its scientific knowledge and the nature of the value judgments that it is making. IF EPA and/or Congress disagree with the SAB's comparative findings, they can ignore them.

Nancy Kim

(Dr. Kim is Director of the Division of Environmental Health Assessment at the New York State Department of Health.)

Despite many uncertainties, the science of estimating risk can be used to help order priorities and allocate resources for environmental programs. The best science available should be used for these purposes. However, the limitations of risk assessment need to be understood when using it for decision making of any kind. In particular, it is important to consider the assumptions that underlie risk assessments and the frequent data limitations in such areas as toxicology and exposure.

Broadly speaking, human health risk assessments are based on two major components: toxicology, which evaluates the inherent toxicity of a chemical substance; and exposure assessment, which estimates the extent to which people may actually be exposed to the substance. In many cases, our knowledge about the toxicology of a chemical, its potential adverse health effects, is incomplete or lacking.

The Chemical Abstract Service has assigned registry numbers to some 10 million chemicals. Roughly 70,000 chemicals are used in commerce; fewer than 10,000 have some health effects data; and about 100 have some direct human data. Certainly these data limitations are formidable. Moreover, it is important to set priorities for testing chemicals for adverse effects by considering available information on use patterns, potential exposure patterns, and similarities among chemicals.

Exposure data gaps may be even more problematic than gaps in toxicology data. Historically, much more emphasis has been placed on obtaining toxicology information than on acquiring exposure data. This situation is beginning to change and more attention is being paid to exposure considerations. For example, emissions data now being compiled under the Toxic Chemical Release inventory required under the Superfund Amendments and Reauthorization Act of 1986 can be used to identify potential exposure problems. Monitoring studies may then be conducted to obtain necessary exposure data.

Efforts to gather monitoring data are increasing, but they are still sporadic. EPA is establishing additional monitoring requirements for drinking water, which will help characterize exposures through drinking water. The Food and Drug Administration routinely monitors foods for pesticide residues, but food is not normally monitored for the presence of common industrial chemicals. Our understanding of exposure to chemicals through incidental ingestion of dust and dirt has greatly increased, but is still limited. In short, we have a long way to go in exposure assessment.

In addition to data limitations, there are uncertainties inherent in standard risk assessment procedures, which typically involve extrapolating from test animal data to human exposure scenarios. The science of risk assessment is imperfect; however, we should use as much science as possible in setting priorities and allocating resources. Otherwise, our options are to rely on what people believe, intuitively, is important, on the public's worst fears, or on political interests. These other aspects and technology should be considered in decision making, along with risk assessment.

Adam M. Finkel

(Finkel is a fellow at the Center for Risk Management at Resources for the Future.)

Risk-based environmental policy has its pitfalls, to be sure, but to a large extent the faults "lie not in the stars, but in ourselves."

I am optimistic that risk assessment could provide a far more helpful and less divisive instrument than it now does. Ironically, we are asking too much of risk assessment, while at the same time failing to exploit all that the existing science has to offer. If I had to choose one improvement (requiring no new scientific breakthroughs) that would make risk assessment more useful while revealing its limitations, I would require risk assessors to quantify and communicate the uncertainties inherent in their risk estimates.

Let me illustrate this point with a simple example of priority-setting. Suppose that (before EPA prohibited the spraying of Alar on apples) you were a consumer trying to decide whether apple juice or peanut butter contaminated with aflatoxin, a natural carcinogen, was more dangerous to you personally, or more worthy of federal regulatory intervention. Perhaps you had read about the comparative risk assessment Dr. Bruce Ames performed on a variety of natural versus synthetic carcinogens, from which he concluded that the aflatoxin in a daily ration of peanut better is 18 times as risky as the Alar in a daily ration of apple juice.

The degree of false confidence implicit in that kind of "point estimate" of risk is simply staggering. By comparison, using widely accepted methods to account for at least some of the major uncertainties in the toxicology of those two chemicals and in human exposures to them, I estimate that a randomly chosen consumer could be only 90 percent sure that peanut butter is between 300 times *more* and 30 times *less* of a cancer risk than apple juice is. The number 18 is not "wrong" as a relative risk estimate, but the number alone tells about as much of the story as "In the beginning" tells you about the Old Testament.

Fortunately, comparative risk assessment *could* help EPA tell the whole story, as long as it tackles the problems of uncertainty and public preferences head-on rather than obscuring them behind "cookbook" risk assessment procedures and generic assumptions about values. Despite what people say, you *can* compare apples and oranges. We do so all the time, both literally and figuratively, by deciding what characteristics matter to us, how we value them, and how much of each quality each choice is likely to offer. When comparing things (like risks of uncertain magnitude), additional dimensions of uncertainty intervene: An orange may taste better to you than an apple, but, all in all, an orange the size of a pea would be less satisfying than an apple as big as a basketball. So, in fact, comparative risk assessment is even *harder* to do well than the one-thing-at-a-time risk analysis EPA has used up to now. But using only one number for each risk makes a hard task virtually impossible to perform systematically and confidently.

The sensible way for a person to decide whether to consume peanut butter or apple juice—or for EPA to decide whether to transfer resources from, say, the Superfund program to a radon reduction effort—is to recognize and weigh *all* the possible consequences of making the wrong choice. In any decision scenario, the possibility that the seemingly smaller risk might in fact be more dangerous than the "larger" risk should lead the decision maker to scrutinize very carefully the component factors that go into the decision, particularly the uncertainties and variabilities associated with them. (In the example above, I estimate there is a one in three chance that apple juice is in fact riskier than peanut butter.) This would mean carefully examining, for example, such considerations as variations in risk to different population groups (e.g., for *whom* is apple juice or hazardous waste more dangerous than peanut butter or radon?), the nature of the benefits that accompany the risks, and the degree to which exposure and risk may be voluntary or unavoidable.

As the other forum in this issue of *EPA Journal* makes clear, even the most honest and complete risk assessment is a sterile tool without commensurate attention to the non-quantifiable social values that supplement or transcend the mere risk numbers. Moreover, comparative risk management faces empirical and quantitative problems not only in the area of health science, but in two other pillars of environmental policy as well: cost assessment and risk reduction solutions. The widespread false precision in estimating the costs of environmental regulation will continue to impede the adoption of effective policies. And the most sophisticated ranking of risks and benefits will be a vain exercise unless EPA is committed to controlling even the small risks when the solution is cheap or economically beneficial and dedicated to searching for new ways to ameliorate what seem to be large but intractable risks.

Thomas A. Burke

(Dr. Burke is with the Johns Hopkins University's School of Hygiene and Public Health.)

From Love Canal to Bhopal, Prince William Sound to the Jersey Shore, environmental disasters have galvanized public opinion and shaped the country's environmental laws. Historically, the policies of EPA and state environmental agencies have been reactive in nature. Many priorities have been established in response to the crisis of the day, with budgets driven by public opinion rather than public health. It is no surprise that the recent report from the EPA Science Advisory Board, *Reducing Risk: Setting Priorities and Strategies for Environmental Protection*, concluded that the amount of money spent on environmental problems at EPA had little relationship to the level of risk posed by those problems.

Properly applied, risk assessment can play an important role in improving the public-health basis for setting our priorities and targeting the efforts of EPA to reduce health and environmental risks. Over the past decade, risk assessment has evolved to the extent that it can offer scientists a common method to utilize information from the fields of toxicology and epidemiology, to better understand potentially harmful environmental pollutants, to identify previously unrecognized hazards, and to estimate the degree of risk to public health posed by many pollutants. On both federal and state levels, risk assessment has become a pivotal component of the regulatory process. Risk assessments have been successfully used in establishing drinking water standards and in providing guidance for many of the clean-up and pollution prevention programs.

To use risk assessment effectively in setting priorities, policy makers must recognize its limitations. There are many assumptions that have to be made in measuring risk that introduce uncertainty. For instance, a very basic assumption is that adverse effects observed in laboratory animals represent potential risks to humans. For this reason, risk assessments represent a range of potential impacts rather than a precise measure of actual effects.

Risk assessment is also limited by our lack of information regarding the potential health effects of pollutants. Only a small fraction of the chemicals in our environment have been adequately studied for adverse effects. This has led to the regulatory equivalent of "looking for the keys under the lamppost." The result has been strict regulation of a small number of cancer-causing substances, such as asbestos and PCB's, but little or no control of other substances common in our environment which may have other effects on health. For example, despite widespread concern, little has been done to control exposures which may cause reproductive or developmental effects or harm to the nervous or immune system. To be successful in reducing risks, EPA must commit itself to filling the information gaps and continually broadening our knowledge of the health effects of environmental pollutants.

Another serious limitation to the use of risk assessments has been the inability of the scientific community to communicate results to the public. Confusing numbers, like parts per trillion or one in a million, compounded by press reports of disagreement among the experts, have undermined trust in science and the regulatory process. A commitment to improve risk communication is essential to the success of risk-based priority setting.

Despite the many limitations and uncertainties, the science of measuring risk offers a powerful tool for priority setting. However, even a flawless risk measurement cannot define "acceptable" risk. Putting risks in perspective and bridging the gap between science and public policy may be the most difficult challenge facing EPA. Successful priority setting will ultimately depend on the ability of policy makers to balance risk measurements with public values.

What the Public Thinks

by Thomas A. W. Miller
and Edward B. Keller

Changing public attitudes have been the driving force behind this country's environmental commitment.

Americans' attitudes concerning most environmental issues are in a state of rapid and profound change. Whether we look at worries about pollution in general, or perceptions of the risks posed by specific problems, the recent shifts in public opinion have been little short of extraordinary.

At the broadest level, the message being sent out by the American people is a clear one: We are increasingly nervous about the environmental problems around us—virtually any kind of environmental problem. Although the recession has somewhat dampened environmental concerns in the short term, as it has for education and drug abuse, the long-term trend toward heightened public sensitivity about environmental matters will continue.

When examined in detail, however, the recent shifts in public opinion tell a much more complex and, at times, ambiguous story. This article will discuss current perceptions of specific environmental risks, changes in those perceptions in recent years, and the underlying attitudes driving public concerns. From the perspective of our public opinion research, we will also suggest some implications for public policy and for educational initiatives.

(Miller is Senior Vice President and Keller Executive Vice President of The Roper Organization, the public opinion research firm.)

How Americans View Environmental Risks

In 1987, working with EPA, The Roper Organization developed a comprehensive list of 29 environmental problems. The purpose was to rate the perceived seriousness of these problems from the public's point of view. These ratings would then be compared to scientific assessments of the risks attached to these problems, as determined by EPA's staff. A benchmark measure was taken early in 1988, and an update in early 1990. Each time, the measure was taken of nationally representative samples of adult Americans, interviewed in person in their homes.

At the broadest level, these studies illustrate vividly how the concern spreads to virtually all types of environmental problems. Majorities of Americans consider 28 of the 29 problems to be at least "somewhat serious." They also call 17 of the 29 "very serious." Further, for 18 problems, more people called them "very serious" in 1990 than did so in 1988. This is a clear illustration of the general growth of environmental concerns.

Topping the list of most worrisome problems, according to the public, are hazardous waste sites, whether still in use or already abandoned. Nearly two-thirds mention these as "very serious." Also high on the list are water pollution from industrial waste, worker exposure to toxic chemicals, accidental oil spills, depletion of the ozone layer, and radiation from nuclear power plants.

At the opposite end of the spectrum—the problems *least* likely to be associated with high risk—are radiation from microwaves and X-rays, and indoor air pollution.

Several points about how Americans perceive the risks of environmental problems are worthy of note.

First, they do perceive different levels of risk, whether or not their perceptions coincide with those of the experts. There is a significant "spread" from the 67 percent who consider active hazardous-waste sites to be "very serious" to the 13 percent who assign this rating to radiation from microwave ovens. At the very least, this spread suggests that the capacity for public discrimination is real—albeit sometimes, perhaps, misinformed.

Second, and more important, the effect of *language*—*how* problems are described to people—is clearly evident. It comes as little surprise that the two most serious problems concern "hazardous" waste sites. To say that a problem is "hazardous" almost automatically raises a red flag in front of the public.

The potency of terminology is clearly illustrated by a test Roper conducted in its 1990 study of

Ken Kerbs photo.

specific risks. We used two different descriptions of the same problem and obtained different responses from the public. One nationally representative sample was asked about the seriousness of "solid waste created by people's litter and trash"; a different sample was questioned about "non-hazardous waste sites such as trash from households and industry" (the terminology we developed along with EPA for our 1988 benchmark measure). The first problem was considered "very serious" by 51 percent, the second by only 31 percent—an extremely large difference.

Even though both questions addressed the same issue, solid waste, the inclusion of the phrase "non-hazardous" in the second description allayed the concerns of a very large number of people. If an environmental problem is called not hazardous, it is much less likely to be considered serious. Conversely, the use of words like "hazardous" or "toxic" will almost certainly increase public anxieties.

Another interpretation is that "solid waste" is a familiar term, and the problem hits close to home. In fact, in late 1990 nearly half the public said "consumer solid waste" was "very serious" *in their own community*—double the level of concern only two years earlier. The proximity of the issue, as well as the use of common—not technical—language to describe it, helps explain the public's reaction.

Finally, the public's ranking of environmental problems differs in major respects from the views of experts. As discussed above, hazardous-waste sites are considered to be the most serious problems by the public; the risks ascribed to them by most knowledgeable authorities

The effect of language—how problems are described to people—is clearly evident.

are much lower. Similarly, small—and declining—numbers of Americans express concern about indoor air pollution or radon; experts consider these to pose relatively significant risks to human health.

In some areas, public perceptions are moving closer to expert assessment. For example, the proportion of Americans calling destruction of the ozone layer a "very serious" problem jumped from 47 percent in 1988 to 60 percent in 1990. The concern about the greenhouse effect also rose strongly over this period: from 33 percent to 48 percent. In EPA's Science Advisory Board report, *Reducing Risk*, these are two of four high-risk problems.

Other changes in public opinion, however, suggest that perspectives are shaped more by media attention to problems than by greater public knowledge of their risks. Perhaps the most dramatic illustration of this phenomenon is the changing attitudes about accidental oil spills. In 1988, prior to the *Exxon Valdez* spill, only 38 percent thought oil spills were a "very serious" environmental problem. By 1990, after the accident, the proportion shot up to 60 percent. Oil spills are now thought to be the fifth most serious of the 29 environmental problems Roper asked about, despite expert agreement that they pose relatively low risks to the environment and human health.

As memories of the *Valdez* incident fade, and media attention falls off, it is possible that public worries about oil spills may also decline. Indeed, previous spills were typically accompanied by upswings in public concerns that eventually subsided. However, the *Valdez* spill was so massive that it may leave an indelible imprint on public perceptions.

Continued on next page

Risk Communication

Unfinished Business, the EPA report predating the Science Advisory Board work, observed that the attention the Agency paid to problems didn't always correlate well with the risks posed by the problems. Not all, but several problems posing high risks received minimal attention. Conversely, high levels of funding were directed at several low-risk problems. The disparity was explained by the fact that EPA's funding priorities were determined largely by Congress, which reflected public opinion as to the severity of environmental problems.

The board agreed, and asked itself a question: "What should be done about a problem posing high residual risks (as evaluated by EPA staff or SAB committees) that the public perceives as not very serious? Or vice versa? Such problems present challenges in risk communication. It is not clear if the 'experts' know things about these problems that the public does not and public opinion about them would change if the public were better educated. Alternatively, the public may be reacting rationally to a qualitative aspect of the risk posed by the problem that the 'experts' have failed to take into account in their analysis."

The board gave the answer in one of its formal recommendations to EPA; the recommendation is repeated, in part, here.

"In a democracy the support of individual citizens is important to the success of any national endeavor. In the national effort to reduce environmental risk, such understanding and support is essential, because both the causes of and solutions to environmental problems are often linked to individual and societal choice. Consequently, EPA must expand its efforts to educate the public in general and the professional workforce in particular, both in terms of what causes environmental risks and what reduces them.

"For example, EPA should work to reduce the gap between public perceptions of risk and the scientific understanding of risk. In many cases, public perception and scientific understanding are quite different, if only because scientists have ready access to information that the public does not. It is important that EPA increase its efforts to share risk information with the public, because in the long run the public will have to approve EPA's risk-based action agenda. Better public awareness of relative environmental risks will help the nation allocate its resources to maximize risk reduction.

"At the same time the Agency must be attuned to the concerns of people who are closest to the real-world health, ecological, and welfare risks posed by different environmental problems. An engaged public often can be helpful in gathering information that supports the technical analysis of risk. Moreover, because they experience those risks first-hand, the public should have a substantial voice in establishing risk-reduction priorities.

"Thus EPA should include broad public participation in its efforts to rank environmental risks. Such participation will help educate the public about the technical aspects of environmental risks, and it will help educate the government about the subjective values that the public attaches to such risks. The result should be broader national support for risk-reduction policies that necessarily must be predicated on imperfect and evolving scientific understanding and subjective public opinion."

Health Concerns, Not Ecology, Are Base of Public Risk Assessment

Knowing that EPA's report, *Reducing Risk*, was coming out, we felt it would be useful to discover what forces lay behind the public's environmental agenda. We asked Americans whether the primary concern behind protecting the environment was human health or natural resources. The results are clear. Worries about personal health and safety are the prime mover behind Americans' growing environmentalism. Far less important is preserving the environment for the environment's sake.

In a Roper survey conducted in August 1990, more than 6 in 10 Americans said that protecting human health from pollution is one of the most important reasons for protecting the environment. About 4 in 10 believed that protecting natural resources for future generations is one of the best reasons, while a third thought a key objective is to ensure the existence of natural places and wildlife. Substantially fewer cited the need to protect natural resources for economic or recreational purposes.

In that same survey, we asked Americans to weigh a direct trade-off between human health and ecology: Which one is the major reason for protecting the environment? Nearly three-quarters said it was to protect people's health; just a fifth thought it was to preserve natural places and things.

However, the public does not distinguish between health and ecological concerns when it comes to individual problems. For instance,

Other changes in public opinion, however, suggest that perspectives are shaped more by media attention to problems than by greater public knowledge of their risks.

radon in people's homes is as much concern to the public for its impact on nature and wildlife as it is for its effect on human health. Similarly, destruction of wetlands is considered to be as much a human health problem as an ecological one.

This suggests, perhaps, the need for more and better education. However, in its defense, it is probably not the public's job to determine *why* individual problems need to be addressed. Rather, its role is to be convinced that specific problems are indeed serious enough to be considered environmental priorities.

The basic standards, then, by which expert judgments are made have to be popularly understood. And that has tremendous implications for EPA as it tries to broaden the focus of national policy to include ecological risk. For the moment, at least, such an effort runs against the tide of public opinion.

Implications For the Future

Although popular anxieties about specific risks have risen in recent years, the rise suggests not so much a more sophisticated approach to establishing priorities, but rather a broadening of the public's environmental agenda. More problems are being added to those that need to be resolved; relatively few are being deleted. Americans do not feel that our environmental problems are under control, and they are inclined to look at most of them as increasingly serious.

This is good news for our country's continuing effort to improve the quality of environment. There is a definite mandate from the public to proceed.

A change in policy orientation from human health risks to larger ecological risks, however, challenges the current perspective of most Americans. The underlying rationale for this change needs to be communicated convincingly. The focus, at least initially, should probably be to explain the value of natural ecosystems and to draw a clear connection between them and human health and welfare. Once this message has been received, the public will be in a better position to understand the types of risks posed by specific problems.

Another key issue, especially when it comes to specific risk assessment, centers around language—the language used by scientists, government officials, and other experts to communicate to the public, as well as the language employed by opinion researchers such as ourselves to elicit public opinion. Using words such as "toxic" or "hazardous" to describe a problem can have a dramatic impact on the public's evaluation of the problem.

Finally, gaps between expert and public assessments of risks, while narrower perhaps than in the past, still exist. In all likelihood they will continue to exist. However, in our opinion, we should not attempt to bring public perceptions precisely into line with those of experts. Such an attempt would require a massive educational effort and a lot of time, time that most Americans, and the environment, simply do not have. Instead, the basic objective should be to cultivate public confidence in the *general* goals of our scientific and environmental leadership, so that Americans willingly "delegate" responsibility for specific risk assessments to those most capable of making them. Once this is accomplished, the resources and funds needed to address our most pressing environmental problems should follow. □

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The Road to Innovation

by F. Henry Habicht

In September 1990, nearly two years into the Bush Administration, EPA's Science Advisory Board (SAB) released a compelling new report entitled *Reducing Risk*. This document made 10 major recommendations that, taken together, called for fundamental changes in the way EPA carried out its responsibilities. One recommendation has drawn particular attention, and generated extensive debate, both inside and outside the Agency. The SAB recommended that EPA's agenda be shaped by considerations of relative risk. That is, EPA should set priorities for future action based on the comparative risks posed by different environmental problems and on the opportunities available for reducing those risks.

The SAB report on *Reducing Risk* was not the first document to examine relative environmental risk. In fact, the SAB report was explicitly intended to reevaluate and update the findings of EPA's landmark study, *Unfinished Business*, completed in 1987. But *Reducing Risk* went beyond that; it also outlined the main aspects of a risk reduction strategy that "takes advantage of the best opportunities for reducing the most serious remaining risks."

Reducing Risk thus gave a powerful impetus to several initiatives already under way at the Agency. Like the SAB report, our initiatives are about recognizing and realizing opportunities to integrate, to be more effective, and to enlist a broader base of public supporters in the cause of environmental protection. These ideas and initiatives have caused readily apparent changes in EPA's strategic management and daily operations. Risk-based planning and budgeting are not philosophical concepts that might be applied usefully in tomorrow's EPA. As far as EPA's use of comparative risk is concerned, the future is now.

The concept of relative risk reduction also has an important role to play when changes in the Agency's legislative authorities are debated by Congress.

Since being named EPA Administrator in January 1989, Bill Reilly has worked to bring new flexibility, creativity, and a sharpened focus to the Agency's extraordinarily complex legal and moral duties. Setting management priorities on the basis of comparative risk assessment has been one of the most important ingredients of the Reilly philosophy of environmental protection. In fact, risk-based decisionmaking, Total Quality Management, and pollution prevention have been three "pillars" of EPA strategic thinking since 1989.

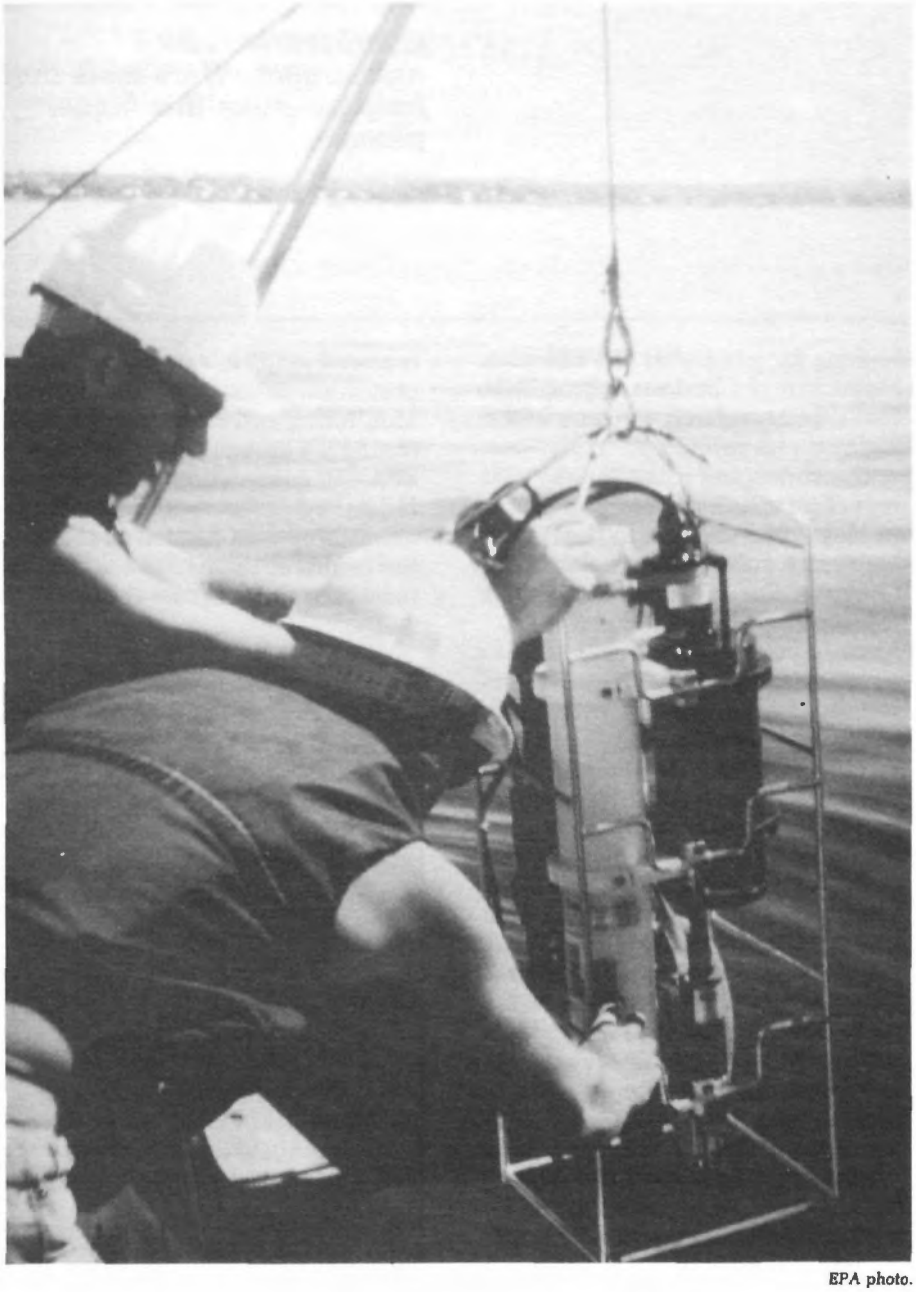
Despite the Administrator's commitment to risk-based decision making and the SAB's strong recommendation, the concept is sometimes criticized as impractical and unrealistic. Admittedly, despite substantial improvements in recent years, environmental data bases remain incomplete, and risk assessment tools remain imprecise. How then, critics ask, can comparative risk assessment be a reliable guide to environmental policy?

It is important to remember that the SAB recognized the scientific uncertainty that underlies—and to some extent will *always* underlie—comparative risk assessments. SAB members understood that subjective value judgments will always play a role in environmental policy; they believed that such a role is perfectly appropriate, no matter how sophisticated the technical and analytical tools become. Nevertheless, they strongly supported the increased use of risk comparisons at EPA. In the words of the SAB report, "EPA programs should be shaped and guided by the principle of relative risk reduction, and all available risk data and the most advanced risk assessment and comparison methodologies should be incorporated explicitly into the Agency's decision-making process."

The value of comparative risk assessment is the pervasive theme underlying the first five recommendations in *Reducing Risk*. They are: EPA should target its environmental protection efforts on the basis of opportunities for the greatest risk reduction; EPA should attach as much importance to reducing ecological risk as it does to reducing human health risk; EPA should improve the data and analytical methodologies that support the assessment, comparison, and reduction of different environmental risks; EPA should reflect risk-based priorities in its strategic planning processes; and EPA should reflect risk-based priorities in its budget process.

In the months since the SAB released its report, EPA has

(Habicht is Deputy Administrator of EPA.)



EPA photo.

EPA's Science Advisory Board recommended initiatives to systematically identify and characterize ecological problems and trends. EPA's new Environmental Monitoring and Assessment Program (EMAP) is one such step. This near-coastal EMAP survey team is measuring dissolved oxygen in the water.

accelerated some ongoing activities—and launched several new initiatives—aimed at carrying out the central thrust of those five recommendations. We are committed to a more precise and scientifically valid targeting *and* integrating of the Agency's efforts to protect both human health and natural ecosystems—local, national, and global.

The SAB's first recommendation—risk-based targeting of EPA resources—is inextricably bound up with the use of risk-based priorities in EPA's strategic planning and budgeting processes—the SAB's fourth and fifth recommendations. Progress toward the fulfillment of all three goals began in 1989 when Administrator Reilly launched a strategic planning initiative that focused on risk and the potential for reducing it. At that time, each EPA office was called on to use *Unfinished Business* and other analyses of comparative risks as the basis for setting program priorities.

This past year, program offices have developed four-year strategic plans that directly address high-risk problems and strive to maximize the risk-reduction potential of their activities. These strategic plans will be updated annually, and new information related to risk will play an important role in those updates.

Turning strategic plans into effective, real-world programs—and then into measurable environmental results—is a major challenge faced by every EPA employee. To help meet that challenge, last February EPA's top managers convened in Baltimore to begin planning the FY 1993 budget. At that time the Administrator strongly emphasized that cross-media, cross-program initiatives will be an essential part of EPA's future agenda. As the artificial walls that have separated EPA programs in the past begin to crumble, I believe that the Agency as a whole will be better prepared to compare different, cross-program environmental risks and target Agency resources accordingly.

The development of a new risk-based agenda has particular impact on EPA's in-house repository of scientific expertise, the Office of Research and Development (ORD). ORD is now readjusting its long-range research planning process, both to reflect priorities dictated by comparative risk and to refine the accuracy of risk assessment.

The Agency's new thinking is not restricted to headquarters. Two years ago, EPA Regions 1, 3, and 10 completed comparative risk analyses based on *Unfinished Business*. Now the other seven regions are following suit. In addition, a growing number of state governments are now benefiting from direct EPA guidance in this complicated new area of environmental management.

EPA is working hard to ensure that priorities set in strategic plans are reflected in program budgets. In a number of important ways, risk-based strategic planning guided the Agency's FY 1992 budget submission, completed early this year. A special EPA task force of senior managers is

Comparative risk assessment offers tools that help us grasp this bigger picture.

looking for additional ways to restructure the budgetary process so that it better reflects program and regional risk priorities.

The concept of relative risk reduction also has an important role to play when changes in the Agency's legislative authorities are debated by Congress. For instance, relative risk information is now being used to identify priorities during reauthorization of the Clean Water Act.

The SAB's second recommendation—increased emphasis on ecological risk—is particularly important to Administrator Reilly. Before he came to EPA, Reilly was President of World Wildlife Fund and The Conservation Foundation. While EPA has developed sophisticated methods for assessing significant risks to human health, we have not developed similar tools for ecological risk assessment. Thus our ability to identify and address the most serious ecological risks has been hampered.

In attempting to steer the Agency back to its roots, when attention to ecological risks and human health risks were better balanced, we have launched a major effort to develop ecological risk assessment guidelines. To provide a firmer foundation for implementing those guidelines, EPA has funded the National Research Council, through its Committee on Risk Assessment Methodology, to examine the underlying scientific issues associated with ecological risk assessment.

Another manifestation of EPA's renewed emphasis on ecosystem protection is our new Environmental Monitoring and Assessment Program (EMAP). Through this program, EPA—in cooperation with other federal agencies—will develop monitoring data needed to evaluate the health of the nation's ecological resources and measure the effectiveness of our nation's efforts to protect them.

Over the past year EPA has begun working with the Department of the Treasury to design debt-for-environment swaps that typically reduce a developing country's international debt while protecting valuable natural

EPA's Use of Scientific Data

—N. Phillip Ross and Suzanne Harris

Several kinds of sources provide the data that go into decision making at EPA.

Ambient Monitoring Programs. Measurements of contaminants in environmental media are taken at regular intervals, usually over long periods: for example, measurements of ozone in air.

Laboratory Analyses of Field Samples. The analyses assess conditions at locations of concern, such as abandoned hazardous waste sites.

Special National or Regional Studies. The National Pesticide Survey, for example, was undertaken to determine the frequency and concentration of pesticide contamination in drinking-water wells and to better understand the causes of contamination.

Animal Bioassay Studies. For example, suspected carcinogens are tested by administering controlled doses to laboratory animals and observing the responses.

Epidemiological Studies. They measure the effects on human health from exposure to environmental contaminants. An illustration would be a study documenting the effects of prolonged exposure of workers to materials containing asbestos.

Studies of "Biomarkers." They measure amounts of environmentally transmitted contaminants present in the body: for example, lead levels in the bloodstream.

Reports by Industry. The Toxic Substances Control Act (TSCA), by way of example, and the Emergency Planning and Community Right-to-Know Act require reports on chemical production, usage, and releases.

Reports by Emergency Response Organizations. For example, they report releases of environmentally harmful substances.

Data collection at EPA now requires over 120 million hours and half a billion dollars per year. Some data are collected to support congressionally mandated enforcement programs. New environmental concerns, such as global climate change, drive other data collection. EPA's routine regulatory responsibilities require extensive data on the production, use, and disposal of increasing numbers of industrial chemicals and on their potential health and environmental effects.

The Agency's decision makers also draw upon data collected by other federal agencies, including the

. . . EPA's employees must be prepared to move forward in demanding new directions.

ecosystems. Under President Bush's "Enterprise for the Americas" initiative, public debt owed to the U.S. government by Latin American countries will be applied to conservation projects in those countries.

SAB's third recommendation—improved data and analytical methodologies—is discussed in the accompanying box by N. Phillip Ross and Suzanne Harris. The EMAP program also advances this goal through its collection and integration of ecological data.

In addition, EPA's Risk Assessment Council is updating and improving its human health risk assessment guidelines to reflect current science. New guidelines on developmental toxicity, exposure assessment, and non-cancer effects will be completed this year. We also are updating our cancer risk-assessment guidelines. The National Academy of Sciences is providing technical advice in these efforts.

Needless to say, the development of sound, comprehensible environmental indicators which cut across media programs is enormously important. We must develop a common scientific currency and nomenclature which we can use consistently in all the key phases of EPA management: planning, budgeting, annual operations, and measuring progress for accountability. This is a foundation which we are committed to build.

To implement the initiatives described above, EPA's employees must be prepared to move forward in demanding new directions. Thus training programs must be improved to incorporate the tools and techniques of comparative risk assessment. Training is the work of the EPA Institute, which now is providing advanced courses in comparative risk assessment and risk management both to Agency employees and to experts from state government. We are also working with the SAB to improve our analysis of the true economic effects of pollution and controls to ensure the soundest possible strategies.

Much of the motivation for these changes is coming from our new philosophy of Total Quality Management (TQM), which encourages ideas for improvement to be developed by *all* EPA employees. In a very real sense, TQM is to risk-based management what the SAB report is to environmental protection as a whole—an integral, empowering

National Oceanographic and Atmospheric Administration and the Fish and Wildlife Service, as well as by state agencies and nonprofit organizations.

To make existing data accessible to a broader audience, many EPA offices publish inventories that outline the nature of their data bases and the purpose and potential uses of the data. EPA and the World Resources Institute published a document earlier this year to improve public access to environmental statistics. The *Guide to Key Environmental Statistics in the U.S. Government* lists some 80 sources of statistics. EPA is updating and expanding the guide to include sources from public and private sectors.

EPA plans to establish a national center for environmental statistics that will provide services comparable to those of other federal programs, such as those at the Bureau of Justice Statistics, the Bureau of Labor Statistics, and the National Center for Health Statistics. Its primary function will be to publish regular reports on the quality of the environment. It will also develop new methodologies to integrate data from different sources into a more complete picture of environmental change.

As long as EPA must rely not only on statistical analysis of data but on models, which contain assumptions that cannot be proven by existing data, some controversy over its decisions will be inevitable. For example, the highly complex models of global warming must employ many assumptions, because scientists do not have complete data on changes in the Earth's temperature and the factors contributing to such changes. Further, scientists do not know exactly how the process of carcinogenesis works in humans. We assume that the effects in animals receiving high doses of a chemical can be related to the long-term effects of low doses in humans. In both examples, varying the assumptions of the model can change the outcomes.

Decision makers ultimately must rely on judgment: Does the weight of the scientific evidence justify a regulatory decision or not? Where risks are grave, it may be ill advised to defer decision until complete information is available. EPA has been in the forefront in developing guidelines for interpreting toxicity-study results. These guidelines provide a framework for decision making in the face of scientific uncertainties.

(Dr. Ross is Chief of the Statistical Policy Branch in EPA's Office of Policy, Planning, and Evaluation. Harris is affiliated with Stretton Associates, Inc.)

Mike Brisson photo.

Improved risk communication and dialogue on comparative risks and priorities can help EPA build a better base of public support. Understanding the causes and consequences of an environmental problem can be the first step toward its solution.

component of our overall approach.

TQM will be the engine of EPA's progress into the future because it will help our employees rise above the program-specific and medium-specific concerns that have characterized EPA's work in the past. Institutional rigidity is an obstacle to innovation. To break down these barriers, cross-media thinking and interaction are being encouraged at every opportunity, and the Agency is embracing this approach not only in its own work but also in its dealings with other federal agencies and state and local governments.

Finally, the SAB report is far more than a technical management document of interest only within EPA. In fact, the spirit of the report's other recommendations is daringly outward-reaching and forward-looking. In essence, the SAB has defined our nation's long-range environmental challenge: involving all the different parts of our society—citizens, business, and all levels of government—and using all the tools at our disposal—regulatory and non-regulatory—to reduce environmental risk.

To meet this challenge, EPA has a responsibility to inform and motivate people so that they practice environmental stewardship in their daily lives. And, as part of a TQM approach to our work, we must also listen closely to experts and affected persons *early* in our decision making process. This responsibility to *communicate* is a new dimension to our work, and a daunting one. The vast majority of America's 250 million citizens are not likely to take the time to understand comparative risk assessment. So EPA is taking several steps to help the public gain a better understanding of the risks they face and what they can do to reduce them.

Rather than publicizing arcane statistics about parts per million of suspended solids, we are using the new techniques of risk communication to raise public awareness of different kinds of environmental risks and win support for national activities —public and private—that reduce those risks. We are trying to focus public attention on specific natural resources or geographically identifiable systems—like the Great Lakes or the Grand Canyon—because, as Jacques Cousteau once said, "People protect only what they love."

Through the recently created EPA Office of Environmental Education, we are also taking steps to educate the voters of the future. Students already are benefiting from grants authorized by Congress in the 1990 statute creating the office. Recycling is a key theme of environmental courses now being offered in our schools.

In all these ways, EPA is moving forward with confidence into the brave new world of risk-based environmental protection. Even though existing environmental data are incomplete, and existing technical and analytical tools are flawed, comparative risk assessment can help us put all the different kinds of environmental problems we face into an integrated perspective. The job we do here at EPA is bigger than the sum of its parts, and EPA is bigger than the sum of all the program offices into which it is divided. Comparative risk assessment offers tools that help us grasp this bigger picture. These tools can open up vast new opportunities for EPA in improving environmental protection and build a deeper base of public support. I am proud of the hard work already underway to realize these opportunities. □

A Dissenting Voice

by Senator David Durenberger

Some cautions I will raise are also stated in the SAB report, but they have been swept aside in the enthusiasm with which the report has been embraced.

The report of the Science Advisory Board, *Reducing Risk: Setting Priorities and Strategies for Environmental Protection*, makes an important contribution to the national debate on environmental protection.

The board's endorsement of pollution prevention and market incentives as public policy tools is appreciated. The Congress has made a start in these areas with the acid rain provisions of the Clean Air Act Amendments and the Pollution Prevention Act, both passed in the waning days of last year. We can do more in these areas, and the report provides many useful examples which deserve to make their way into EPA programs.

But I cannot wholeheartedly endorse the fundamental theme in *Reducing Risk*. That theme is woven from three propositions.

First, health and environmental threats may be measured along a unidimensional yardstick. To quote from the report,

> The concept of *environmental risk*, together with its related terminology and analytical methodologies, helps people discuss disparate environmental problems with a common language . . . .

The second proposition is that an expert assessment of environmental risk can help prioritize society's investment in environmental protection:

> There are heavy costs involved if society fails to set environmental priorities based on risk. If finite resources are expended on lower-priority problems at the expense of higher-priority risks, then society will face needlessly high risks. If priorities are established based on the greatest opportunities to reduce risk, total risk will be reduced in the most efficient way . . . .

And the third proposition is that public opinion, reflected in the environmental laws enacted by Congress, is not a reliable guide when it comes to setting priorities:

> Because most of EPA's program offices have been responsible for implementing specific laws, they have tended to view environmental programs separately ... and questions of relative seriousness or urgency have remained unasked. Consequently, at EPA there has been little correlation between the relative resources dedicated to different environmental problems and the relative risks posed by those problems . . . .

There are many flaws in these arguments. Some cautions I will raise are also stated in the SAB report, but they have been swept aside in the enthusiasm with which the report has been embraced. The counter-intuitive notion, first stated in *Unfinished Business*, that we may be spending scarce resources on the wrong problems is intoxicating for some, so much so that the practical realities of science and politics are no longer recognized as important constraints.

My first set of cautions might be described as methodological. These are problems, theoretical and practical, with comparative risk assessment. The most obvious are the gaps of information. We don't know enough to make comparisons among risks. Our models for cancer risk assessment are in their infancy. We know much less about the mechanisms for other effects, like birth defects and neurotoxicity. Data

(Durenberger (R-Minnesota) serves on the Senate Committee on Environment and Public Works.)

How does one compare a case of lung cancer in a retired petrochemical worker to the loss of cognitive function experienced by an urban child with lead poisoning?

on human exposure to these hazards are limited.

The methodological problems go deeper. There is no objective yardstick along which risks can reasonably be compared. How does one compare a case of lung cancer in a retired petrochemical worker to the loss of cognitive function experienced by an urban child with lead poisoning? How do we make choices between habitat and health?

Suppose that EPA had two programs, one to prevent cancer caused by radon, and the other to protect wetlands for the use of migratory waterfowl. How much should the Agency spend on each? Which presents the greater "environmental risk"?

The SAB report proposes that we spend as much protecting the ecosystem as we do protecting public health. In the long run, according to SAB, human health depends on the health of the environment. But equal funding is a stab in the dark, no more expert a guess on the relative value of these two "environmental risks" than you could get from your spouse, your neighbor, or your congressman.

The proper balance in the EPA budget between habitat and health cannot be found in comparative risk assessment. It's a question that can only be answered by an appeal to public opinion. We must do our best to inform public opinion about the consequences of various choices. Public health and environmental science is critical in that role. But in a democratic society, it is a mistake in method to think these questions can be answered without asking the public about its priorities.

The problem of ground-water pollution illustrates the point. Comparative risk studies suggest we assign low priority to ground-water protection programs like Superfund. Agency professionals compare ground water to other human health problems and rank it low. There is little evidence of health-threatening contaminants in the ground water used for drinking water supplies.

Why, then, is so much money spent on Superfund? It may be that the public measures ground water differently than do the experts. The public may see it as a natural resource, like waterfowl habitat, that is valued for reasons other than its current public health impact. This is a methodological flaw. One cannot substitute quasi-scientific comparisons along a single dimension, like cancer risk, for judgments made by the public that reflect a bundle of different values.

My second caution is about equity. That's what it is called in the SAB report. The public has more on its mind than body counts. Its evaluation of risk is not like the simple calculus of the health service professional. The public will accept relatively small risks spread evenly to many, especially if they are voluntary risks, more readily than it will accept large, involuntary risks imposed on the few. Superfund is, in part, about fairness; it is not just about public health.

Equity value extends to future generations. It is intergenerational. Again, ground water is a case in point. The average glass of ground water poured in the United States fell as rain water 200 years ago. It has taken generations to percolate to the

St. Joseph Gazette. December 14, 1983.

Wide World photo.

Superfund, the author argues, is about fairness as well as public health, an issue brought home when involuntary risks affect people's families and residences. In 1978, kids joined adults in demanding relocation from Love Canal—a Superfund site which became famous for its chemical contamination.

well. As a guide to environmental priorities, mortality and morbidity from ground-water pollution is not much of a factor today. It will be generations before today's pollution shows up in the glass of drinking water.

Most Americans don't embrace the environmental ethic out of a concern for public health statistics. The public's fundamental concern is, perhaps, best expressed in the bumper sticker, "Save the Planet." Their highest value is intergenerational, passing on a world at least as good as the one they received. They don't believe that the future can be carefully engineered. They know that science isn't that good. So they choose their own inheritance as a guidepost and hope to leave as much as they found. Ground-water contamination is a violation of that value system, whatever its current public health impacts. The comparative risk reports, both *Unfinished Business* and *Reducing Risk*, have been blind to the environmental ethic which motivates most Americans.

My final caution is strategic. There is an explicit assumption in these reports that the resources we can devote to environmental problems are limited. It is a matter of priorities, of properly dividing the pie.

I don't buy that assumption. It doesn't reflect the way we make resource-allocation decisions in our government. Seen over the long run, the resource-allocation process is not a zero-sum game. Superfund doesn't compete with indoor air pollution, or worker health and safety, or mallard sloughs.

When Superfund was enacted, Congress did not close down existing environmental programs to provide the financing. The program was paid for with a new tax on chemicals. Comparing Superfund (judged by the experts to present low risks) with ozone depletion (judged to present high risks) will not produce any additional dollars to keep chlorine out of the stratosphere.

In the short term, and at the margin, there are some tradeoffs among EPA programs in preparing an annual budget. But seen from a longer perspective, spending on the environment is only a small part of the very large federal budget. Our commitment to the environmental portion of the budget has grown consistently as new risks have been recognized and addressed.

This point extends to the regulatory side, as well. Some question the large costs that are being imposed on the private sector in cleaning up hazardous wastes and leaking underground storage tanks. Are those the most serious risks, they ask. Well, if we repealed RCRA, would there suddenly be more money to abate indoor air pollution or control runoff from farm fields and city streets? And how can a comparative reference to the risks of indoor air and nonpoint pollution be used to justify unabated contamination of our ground-water resources by waste dumps and leaking tanks?

So, those are my cautions. Our methods aren't suited to making these comparisons. The public holds and expresses values not reflected in the comparative risk calculus. We must not cripple our vision of what's possible by insisting that new problems only be solved by abandoning some part of our current commitment to protecting public health and the environment. The insights produced by risk assessment can make a valuable contribution to the public debate on environmental priorities. But it is no substitute for careful attention to the public's values. □

ENFORCEMENT ACTIONS

"EPA's 800-Pound Gorilla"

Former Administrator Bill Ruckelshaus once referred to the Agency's enforcement function as EPA's 800-pound gorilla in the closet, a strong deterrent to those who would violate the environmental laws protecting the nation's air, water, and land resources.

Today, at headquarters and regional offices the Agency's enforcement staff numbers more than 4,250. As Administrator Reilly pointed out in his article in this issue of the *Journal*, over the past two years this gorilla has been setting records in virtually every category.

Gerald Martineau photo. The Washington Post.

- Polluters in Fiscal Year 1990 paid the highest amount in penalty dollars in EPA history, with $61.3 million in civil penalties. This represents a 74 percent increase over FY 1989.
- During Reilly's tenure (FY 1989-1991), EPA has obtained more than $96 million in civil penalties from some 3,115 cases. This represents almost 40 percent of all civil penalty dollars obtained throughout the Agency's history.
- EPA referred a record 375 civil cases to the Justice Department in FY 1990, and a record 65 criminal cases.
- Eight programs established new records for high individual penalties within their programs in either administrative or judicial cases.
- More than half the individuals convicted for environmental crimes in FY 1990 were given prison sentences; about 85 percent of those serve their time. Prison time is averaging in excess of one year.

The following reports provide a sampling of what EPA and the Justice Department are doing to discourage violators.

Texas Plastics Maker Assessed $3.4 Million For RCRA Violations

Formosa Plastics Corporation of Point Comfort, Texas, will pay a $3,375,000 penalty, the largest ever collected by EPA, for violations of the Resource Conservation and Recovery Act, the nation's hazardous waste and solid waste law.

In addition to the civil penalty, payable within 21 days to the U.S. Treasury, Formosa officials also agreed to set up a $1 million trust fund for environmental education in the surrounding area, including donation of property for nature sanctuaries and other ecological uses. The legal settlement also calls for the company to clean up 6 million gallons of process waste in holding ponds and pump and treat up to 4 million gallons a year of local ground water for as long as 20 years.

The company makes polyvinyl chloride (PVC) powder. A production byproduct, ethylene dichloride or EDC, was found to be contaminating ground water under the company's holding ponds. EDC is highly toxic and a known carcinogen. In an administrative legal action, EPA charged Formosa with improperly handling and disposing of hazardous and solid waste and operating a hazardous waste facility without a permit, among other complaints.

The Texas Water Commission, an environmental agency for the state, documented the chemical contamination at the plant and played a major role in EPA's legal action against the plastics company.

The land disposal restrictions of RCRA require treatment of most hazardous waste, allowing only adequately treated waste and residue from treatment to be disposed on land. The restrictions apply to all persons who generate or transport hazardous waste or who own or operate facilities that treat, store, or dispose of waste. Agency officials stress that RCRA, and its enforcement, actively encourages advanced treatment, recycling, waste minimization, and alternative hazardous waste control technologies in lieu of land disposal.

28 More RCRA Actions By Justice and EPA

In what has been called a nationwide crackdown to enforce the Resource Conservation and Recovery Act ban on land disposal of hazardous waste, the Justice Department has filed eight judicial actions in federal courts, and EPA has taken administrative enforcement actions against 20 facilities, assessing over $3.5 million in penalties.

The combined actions include a penalty of $1.85 million against Du Pont in a judicial settlement involving its Chambers Works facility in New Jersey. As part of the settlement, Du Pont agreed to perform pollution prevention activities to identify and assess opportunities for reducing the generation of hazardous waste.

EPA's administrative enforcement actions include a facility owned by Ciba-Geigy Corporation in McIntosh, Ala.; a facility of B.F. Goodrich in Spencer, W.Va.; and a Boeing Company facility in Everett, Wash.

Community-Right-to-Know Violations Cost Two Companies $98,000

Two New Jersey firms agreed to pay $98,600 in fines for failing to file toxic release inventory forms for 1987 and to meet reporting requirements in the future.

The Emergency Planning and Community Right-to-Know Act requires facilities with 10 or more employees that manufacture, process, or use more than "threshold" amounts of certain chemicals to report chemical emissions to EPA and state agencies.

The two New Jersey companies involved, Alford Packaging in Ridgefield Park and Hoeganaes Corporation in Riverton, signed consent decrees to pay $12,750 and $85,000 respectively for their violations.

Texas Company Cited For TSCA Violations

EPA has issued an administrative civil complaint against Champion Technologies, Inc., (formerly Champion Chemicals) of Houston, Texas, citing the company for violations of the Toxic Substances Control Act (TSCA). That law says no person may manufacture, import, process, or otherwise use a chemical substance not listed in EPA's Chemical Substance Inventory. Champion is charged with manufacture and commercial use of an unlisted chemical and with failure to abide by inventory rules at two of its facilities. EPA is asking a $162,000 penalty from the company.

Hoboken Fined $225,000 For Waste Violations

The city of Hoboken, N.J., has agreed to pay a penalty of $225,000 for discharging polluted waste water into the Hudson River in violation of the city's discharge permit and the Clean Water Act. Under an agreement with EPA, the city will upgrade its sewage system to provide secondary treatment by 1993 and, meanwhile, take steps to improve operations at existing facilities. Sixty percent of the penalty goes to the federal government and 40 percent to the tri-state environmental agency that joined EPA as a plaintiff in the case.

USX Charged With Clean Air Act Violations

EPA has filed a civil suit against USX Corporation (formerly U.S. Steel) for violations of the Clean Air Act at the company's Clairton, Pa., plant, charging USX with using contaminated water to cool coke and with releasing raw coke-oven gas. The Agency seeks an injunction requiring USX to install pollution control equipment and otherwise bring the facility into compliance with state and federal clean air rules. The suit also seeks penalties of up to $25,000 per day per violation, plus litigation costs.

Rate of Ozone Depletion Double Earlier Estimate

New data from NASA suggest the protective ozone layer over the United States has been depleted by four to five percent since 1978, approximately double earlier estimates. As a result of this higher level of depletion, EPA estimates there could be 200,000 more deaths from skin cancer in the United States over the next 50 years.

The ozone layer limits penetration of high-energy ultraviolet radiation to the Earth's surface. Exposure to the radiation may cause skin cancer and damage plants and aquatic life.

Responding to the new NASA data, EPA Administrator Reilly said he was intensifying Agency efforts to reduce the use of ozone-depleting chemicals, among them CFCs, widely used in air conditioning and refrigeration. Other ozone depleters include halons, a fire suppressant; carbon tetrachloride, a commonly used solvent; and methyl chloroform, another widely used commercial solvent.

Worldwide efforts to limit the use of ozone-depleting substances have progressed rapidly over the past several years. A landmark international treaty, the Montreal Protocol, has now been signed by almost 70 nations and was significantly strengthened at a meeting last June. The amended Protocol calls for a phase-out of CFCs, halons, and carbon tetrachloride by 2000 and methyl chloroform by 2005. It also establishes a fund to assist developing countries in meeting their obligation to limit use of ozone depleting chemicals.

"The United States—government and industry—has long played a leadership role in efforts to protect the ozone layer," Administrator Reilly said. "The new information from NASA suggests we may need to do still more. We are exploring the full range of options, including intensifying efforts to assist developing countries and accelerating efforts to bring ozone-safe substitutes on line."

New Report Shows Progress in Air Quality

EPA's 17th annual report on urban air quality, released March 5, 1991, shows progress for six major pollutants over the period from 1980 through 1989.

The report, "National Air Quality and Emissions Trends, 1989" is based on data from some 4,000 air pollution monitoring stations nationwide and deals with the pollutants for which EPA issues national standards. During the 10-year period 1980-1989, the report shows the following changes in average ambient amounts of the pollutants:

- Smog levels decreased 14 percent.
- Lead in the atmosphere decreased 87 percent.
- Sulfur dioxide fell 24 percent.
- Carbon monoxide decreased 25 percent.
- Particulates (dirt, dust, soot) decreased 1 percent in the years 1982-1989.
- Nitrogen dioxide decreased 5 percent.

"The report shows substantial progress in reducing atmospheric levels of our most pervasive pollutants during a period of considerable economic growth," said EPA Administrator Reilly. "This means our country's

significant investments in air quality are paying off.

"The report also shows the magnitude of the problem still remaining: Over 84 million Americans are breathing air that violates at least one federal standard; 67 million are living in counties exceeding the smog standard; while almost 34 million are in counties exceeding the carbon monoxide standard; and over 27 million live in areas violating the particulate standard."

Reilly went on to say the Clean Air Act Amendments of 1990 incorporate proposals by President Bush to bring most American cities into compliance with the smog, carbon monoxide, and particulate standards by the year 2000, without hindering economic growth. [The Act, as well as EPA control measures in other fields, will also reduce sulfur dioxide, lead, and nitrogen dioxide.]

For copies of the report (118 pages) or additional information, contact:

Dr. Thomas C. Curran
Technical Support Staff
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Agency Sets New Standards for Lead in Drinking Water

As part of a continuing nationwide program to reduce human exposure to lead in the environment, EPA has set tighter new standards to lower greatly the level of lead in drinking water.

In a press conference held in Washington May 7, 1991, Deputy Administrator F. Henry Habicht said the new rule will give the United States the most stringent drinking water standards for lead in the world: "EPA is putting in place a program that will significantly reduce lead exposures to 130 million Americans within a period of six years and will bring the blood lead levels of an additional 560,000 children below 10 micrograms per deciliter of blood, which is the level of concern—the safety line."

Over a period of 10 years, the phase-down of lead in gasoline removed 90 percent of lead from the air and reduced children's blood lead levels about 70 percent. According to public health findings, drinking water accounts for 10 to 20 percent of children's total exposure to lead. Lead-based paint and urban soil and dust are other sources. The present average blood lead level is approximately 6 micrograms per deciliter of blood. However, there are significant pockets of population where levels are higher.

One element of the new drinking water strategy requires 79,000 public water suppliers to monitor for lead at household taps. Large water systems, those serving more than 50,000 people, are required to begin monitoring by Jan. 1, 1992. Medium-size and small systems start later.

Another element of the plan focuses on reducing corrosion of lead from pipes, solder, and fixtures between the water treatment plant and the consumer's tap. The more corrosive the water leaving the treatment plant, the greater the chance of leaching lead from plumbing and carrying the lead to the consumer.

Under the EPA plan, all 800 large water systems, those serving 60 percent of the nation's population, will have to begin optimizing their corrosion control by 1993. Many large systems are already doing so, in anticipation of the new standards.

"I want to emphasize that 95 percent of the benefits of this rule will be achieved within six years, and many of the benefits will begin to be realized within two years. For example, corrosion control will begin in earnest in two years in many cities," Habicht said.

The goal of the new standards is to reduce lead levels to 15 parts per billion (ppb) or less at the "first draw" in the morning for at least 90 percent of monitored household drinking water taps. Tap water is likely to have its highest lead content of the day after standing overnight in household plumbing. Prior to the new standards, allowable lead levels were 50 ppb, measured anywhere in the water distribution system.

Hundreds of thousands of homes across the country will be monitored to determine lead levels. The findings in each community will determine the actions a local water supplier will be required to take to achieve the 15 ppb target within the time specified.

Steve Delaney photo.

After monitoring begins, water supply systems that exceed the new action level for lead will be required to install or improve corrosion control and must inform customers how to minimize exposure to drinking-water lead through an EPA-developed public education program.

More information about reducing exposure to lead is in a free booklet entitled *Lead and Your Drinking Water*, available from EPA's Public Information Center; 401 M Street, SW; Washington, DC 20460; (202) 475-7751.

EPA Introduces New Awards Program

In recent ceremonies held in Washington, DC, EPA honored 10 national winners of the Agency's new awards program for environmental achievements, the Administrator's Awards Program.

Winners in this, the first year of the program, were honored for innovations in municipal waste recycling. A special award was made for achievements in environmental education.

Awards categories and the winners are:

Citizen: Bob Kerlinger, Poquoson Recycling Center, Poquoson, Virginia, for founding and coordinating a volunteer recycling center, the success of which has exceeded expectations and is turning a profit for participating civic groups.

Community, Civic, and Non-Profit: Seattle Tilth's Community Composting Education Program, Seattle, Washington, for extensive community training and education in composting that is diverting 5,300 tons of yard waste from the local waste stream.

Educational Institutions (Kindergarten-12th Grade): Aurora Public School, Aurora, Colorado, for developing a teacher's guide. The curriculum educates and helps students make responsible decisions affecting solid waste management.

Colleges and Universities: University of Wisconsin, Stevens Point, Wisconsin, for a comprehensive recycling program that involves the student body, faculty, and university management. It includes the use of pellets from the paper industry to fire a coal boiler, displacing 313 tons of coal, reducing emissions of sulfur dioxide, and saving nearly $3,500.

Large Business: Fort Howard Corporation, Green Bay, Wisconsin, for establishing a "recycling advocacy program" which is evident in all facets of the paper manufacturer's operation. It involves recycling relationships within the corporation, with businesses, local communities, civic groups, and others.

Small Business: eegee's Inc., Tucson, Arizona, for introducing a recycling program for polystyrene foam food containers and other wastes, and for getting other Tucson businesses involved in the recycling program. Proceeds from the sale of recyclables go to local charities.

Local Government: City of Newark, New Jersey, for maintaining one of the highest recycling rates in the nation, including an innovative program for recycling ozone-depleting compounds, and has instituted purchasing of recycled and recyclable goods. The city also deputizes youth as "Recycling Ranger" to involve young people in recycling.

State Agencies: State of Rhode Island, for implementing the nation's first comprehensive and mandatory recycling law (in 1986). Fourteen percent of residential waste is now recycled. Commercial waste at landfills has decreased 24 percent since 1989.

Federal Agencies: U.S. Navy, Naval Submarine Base, Bangor, Silverdale, Washington, for introducing a base-wide collection and recycling program that has spread to local communities and been adopted by other military facilities.

Environmental Education: HDR Engineering, Inc., White Plains, New York, for sponsoring, together with the TV show "Mr. Rogers' Neighborhood," the first major recycling and conservation education program aimed at preschoolers. Audience for the program is estimated at 40 million.

In saluting the winners, Administrator Reilly said their projects are "national role models" that can be replicated in other communities. "We were delighted with the tremendous response to our first awards program and with the high quality of the projects."

Awards for 1991 will be made for achievements in pollution prevention. For more information, contact any regional office of EPA (in late summer).

Mike Brisson photo.

Nicole Miceli, a University of Wisconsin-Stevens Point employee, loads a compactor that can bail as well as compact cardboard. In EPA's first Administrator's Awards Program, the university's recycling project won first place in its category.

How Does Your Garden Grow?

A Book Review by Douglass Lea

Although his day job, helping to edit *Harper's Magazine*, sparkles with sophistication, Michael Pollan is still folksy enough to see the humble American gardener as a true heir of the mythological Sisyphus, the ancient king condemned in Hades to an eternal struggle against the forces of nature. The unpretentious editor grounds his epic vision of the gardener's fate in personal experience: He are one.

He is also a compelling writer. Urbane scholarship, practical advice, and perceptive description are combined irresistibly in his new book *Second Nature*, the sadder-but-wiser story of Pollan's coming to terms with the intractable demands of "his" plot of land.

(Lea, a writer and editor, grows mostly metaphors in his garden in Waterford, Virginia. He also teaches government and politics in The American University's Washington Semester Program. He will be a contributing editor of EPA Journal, producing this feature.)

In the final analysis, Pollan learns, the garden only partly belongs to him. Other creatures, both animal and vegetable, also have strong claims to his domain. And they have been waiting patiently for someone just like him—someone overly clever and absurdly energetic—to appear and bring forth a newly disturbed patch of ground.

His garden, Pollan inevitably discovers, harbors a powerful array of biological and geophysical imperatives that insist on manifesting their own destiny. They resist the geometric overlays of human design. Their chaotic patterns and turbulent cycles defy the logic of human control. The garden seems to possess a mind of its own.

At almost every turn, Pollan meets existential dilemmas and ponders epistemological questions. This intellectual nomad tethers himself loosely to his gardens and then roams widely: from the humor that pervades early memories of family gardens to the subversion of Emerson's sophistry on the glory of weeds and Thoreau's banality on the romance of nature; from a long, discursive essay on the lawn, which has served "to unify the American landscape," to the details of planting a tree; and from the moral drama of compost, "our outward sign of horticultural grace," to an argument for caution in intervening into the immense complexity of natural processes. These and other matters are organized in chapters that follow the seasonal march of the calendar.

Second Nature artfully dodges the snares that typically plague books on gardening and nature. Loaded with how-to information, it nevertheless avoids becoming an arid recitation of familiar facts and data. Committed to a high standard of environmental citizenship, it avoids preaching a message of Manichaean divisiveness. And, written by a real writer, it avoids rhapsodizing about nature.

As a current example of "environmental" writing, *Second Nature* performs a useful pedagogical function: It rescues the language of the genre from the rather perfunctory and dispirited state into which it has fallen. Protecting the environment has become a rather abstract enterprise. And its language has begun to reflect great distance from ordinary human experience: parts per billion; CFCs; no net loss; SDWA; mutagens; VOCs. And on and on through reams of testimony, hundreds of dockets, vast libraries of technical reports.

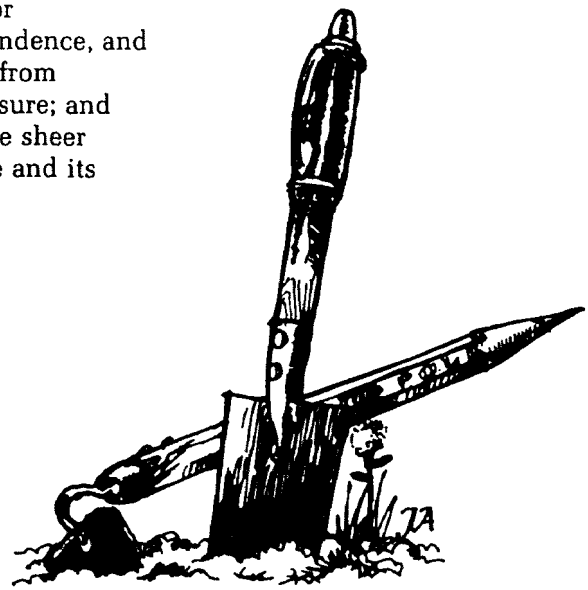
It is the language of professionalism, of lawyers, scientists, and policy makers. Almost immediately after the rhetorical flights of Earth Day, professional jargon began to infiltrate the public discourse of conservation and environmental protection. While convenient for efficient communication of esoteric information, the new language leaves the average citizen unmoved, uninformed, unexcited.

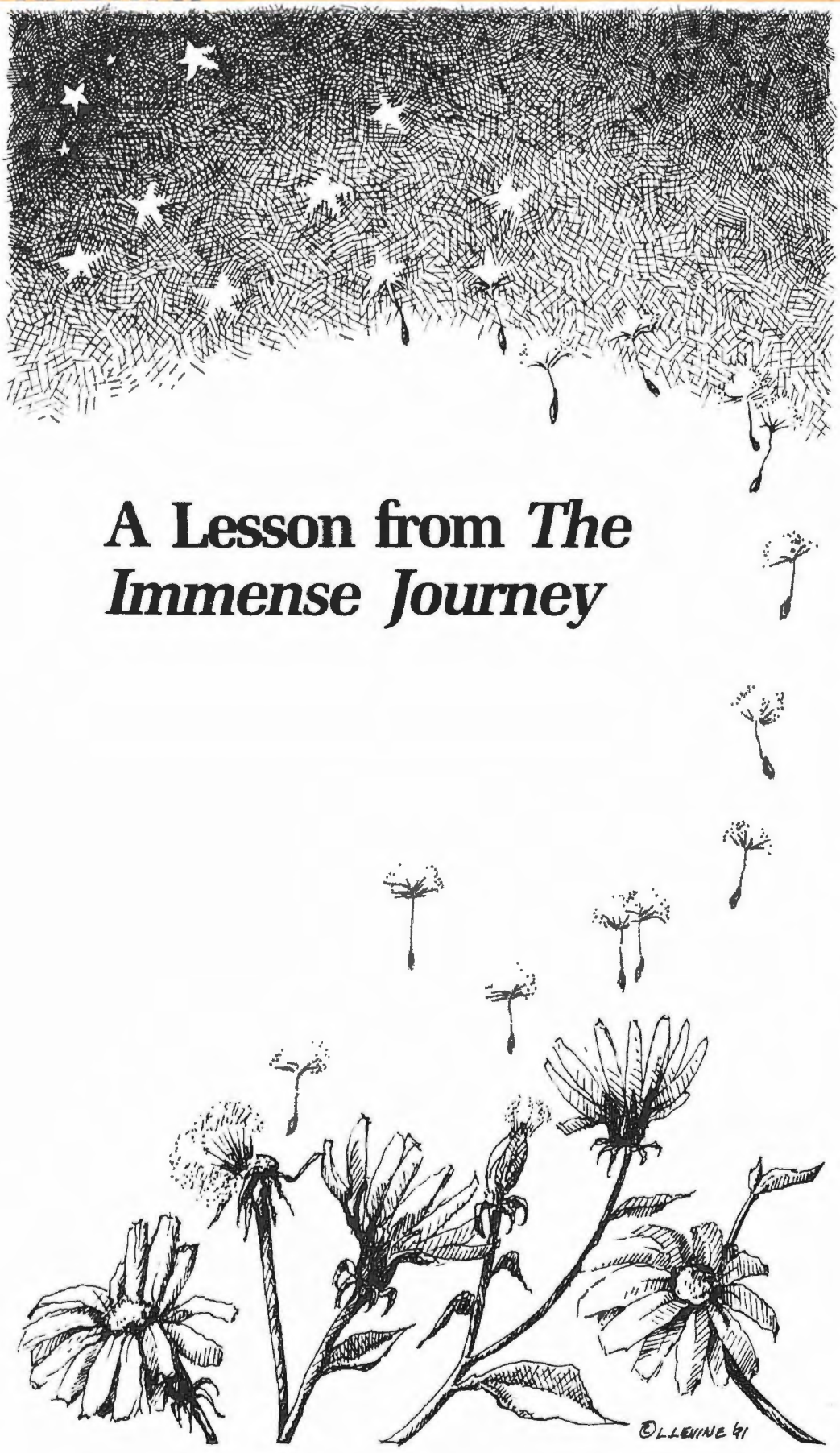
To his everlasting credit, Pollan uses the deceptively simple device of a garden book to re-invigorate conversations about our environment, about our places and our surroundings. "Much of gardening is a return," he writes, "an effort at recovering remembered landscapes." Pollan's audacity is subtle. With thick description and layered nuance, he ties down-to-earth gardening to larger, more global concerns. In the end, he succeeds magnificently, and his book is likely to be passed from hand to hand for generations to come.

From a variety of angles and perspectives, Pollan is essentially saying that to make a garden is to manage in the middle. A garden manifests the dry principles of compromise. It mediates between nature and culture. Every garden has its own special conditions, its own unique combination of vectors. Climate, weather, soil, water, light, and ecological factors influence its design and set its parameters. Since figuring all this out is more art than science, Pollan learns to "design with nature," the title of Ian McHarg's seminal treatise on harmonizing human occupation with natural processes.

Public opinion polls now say that gardening is America's most popular leisure activity. Some do it for creativity and a sense of craftsmanship; some, for self-sufficiency, independence, and health; some, for relief from modern stress and pressure; and others, of course, for the sheer beauty of the enterprise and its results. Whatever the ostensible motivation, virtually all modern gardeners share a powerful urge to forge a new partnership with nature—that is, to accept the local givens and limits of nature, to preserve it as much as possible, to restore it wherever possible, to enhance it, work with it, honor it.

These same sensibilities are also broadly at work in the environmental movement of the past two decades, particularly in its emphasis on ecological interrelationships. *Second Nature*, published by the Atlantic Monthly Press, is Michael Pollan's demonstration of how the worlds of the garden and the environmentalist are inextricably linked. Gardening is a large portal into environmentalism. □





A Lesson from *The Immense Journey*

A little while ago—about one hundred million years, as the geologist estimates time in the history of our four-billion-year-old planet—flowers were not to be found anywhere on the five continents. Wherever one might have looked, from the poles to the equator, one would have seen only the cold dark monotonous green of a world whose plant life possessed no other color.

Somewhere, just a short time before the close of the Age of Reptiles, there occurred a soundless, violent explosion. It lasted millions of years, but it was an explosion, nevertheless. It marked the emergence of the angiosperms—the flowering plants. Even the great evolutionist, Charles Darwin, called them "an abominable mystery," because they appeared so suddenly and spread so fast.

Flowers changed the face of the planet. Without them, the world we know—even man himself—would never have existed. Francis Thompson, the English poet, once wrote that one could not pluck a flower without troubling a star. Intuitively he had sensed like a naturalist the enormous interlinked complexity of life. Today we know that the appearance of the flowers contained also the equally mystifying emergence of man . . . .

Slowly, toward the dawn of the Age of Reptiles, something over two hundred and fifty million years ago, the little naked sperm cells wriggling their way through dew and raindrops had given way to a kind of pollen carried by the wind . . . . Instead of spores (a single cell fertilized in the

beginning by a swimming sperm) simple primitive seeds carrying some nourishment for the young plant had developed, but true flowers were still scores of millions of years away. After a long period of hesitant evolutionary groping, they exploded upon the world with truly revolutionary violence.

The event occurred in Cretaceous times in the close of the Age of Reptiles. Before the coming of the flowering plants our own ancestral stock, the warm-blooded mammals, consisted of a few mousy little creatures hidden in trees and underbrush. A few lizard-like birds with carnivorous teeth flapped awkwardly on ill-aimed flights among archaic shrubbery. None of these insignificant creatures gave evidence of any remarkable talents. The mammals in particular had been around for some millions of years, but had remained well lost in the shadow of the mighty reptiles. Truth to tell, man was still, like the genie in the bottle, encased in the body of a creature about the size of a rat . . . .

Neither the birds nor the mammals, however, were quite what they seemed. They were waiting for the Age of Flowers. They were waiting for what flowers, and with them the true encased seed, would bring . . . .

When the first simple flower bloomed on some raw upland late in the Dinosaur Age, it was wind pollinated, just like its early pine-cone relatives. It was a very inconspicuous flower because it had not yet evolved the idea of using the surer attraction of birds and insects to achieve the transportation of pollen. It sowed its own pollen and received the pollen of other flowers by the simple vagaries of the wind. Many plants in regions where insect life is scant still follow this principle today. Nevertheless, the true flower—and the seed that it produced—was a profound innovation in the world of life . . . .

But the seed, unlike the developing spore, is already a fully equipped *embryonic plant* packed in a little enclosed box stuffed full of nutritious food. Moreover, by featherdown attachments, as in dandelion or milkweed seed, it can be wafted upward on gusts and ride the wind for miles; or with hooks it can cling to a bear's or a rabbit's hide; or like some of the berries, it can be covered with a juicy, attractive fruit to lure birds, pass undigested through their intestinal tracts and be voided miles away.

The ramifications of this biological invention were endless . . . . The well-fed, carefully cherished little embryos raised their heads everywhere. Many of the older plants with more primitive reproductive mechanisms began to fade away under this unequal contest. They contracted their range into secluded environments. Some, like the giant redwoods, lingered on as relics; many vanished entirely.

The world of the giants was a dying world . . . .

On the edge of the forest, a strange, old-fashioned animal still hesitated. His body was the body of a tree dweller, and though tough and knotty by human standards, he was, in terms of that world into which he gazed, a weakling . . . .

He was a ne'er-do-well, an in-betweener. Nature had not done well by him. It was as if she had hesitated and never quite made up her mind. Perhaps as a consequence he had a malicious gleam in his eye, the gleam of an outcast who has been left nothing and knows he is going to have to take what he gets. One day a little band of these odd apes—for apes they were—shambled out upon the grass; the human story had begun.

Apes were to become men, in the inscrutable wisdom of nature, because flowers had produced seeds and fruits in such tremendous quantities that a new and totally different store of energy had become available in concentrated form.

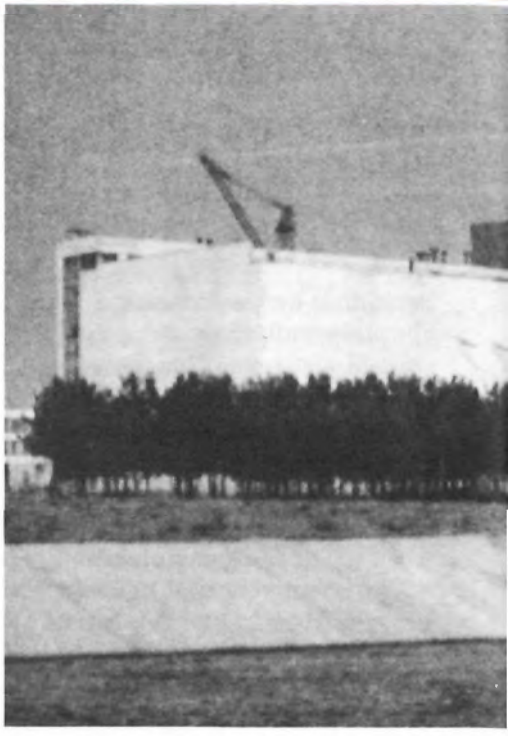
Editor's Note:

The comments of Loren Eiseley's colleagues, who personally knew the famed anthropologist at the University of Pennsylvania before his death in 1977, shed little light on the genius in their midst.

Pleasant . . . a bit shy, they said to EPA Journal *in telephone conversations. Didn't like students button-holing him after lectures . . . . Quite an attractive fellow—tall, brown hair, brown eyes. The* curriculum vitae *on Eiseley explains him no better—born in 1907 in Nebraska, son of a hardware salesman, bookish, liked literature, poetry . . . .* □

On Chernobyl's Trail

by Miles Kahn



Four EPA scientists visited the Soviet Union last summer, where they participated with Soviet scientists in a radiological assessment survey of the Northern Black Sea environment. In addition to samples of sediment, water, and marine life, they brought back an appreciation of the growing environmental movement in the Soviet Union.

The Black Sea survey was carried out under the auspices of the U.S.-U.S.S.R. Joint Committee on Cooperation in the Field of Environmental Protection, established in 1972. The survey, which is the first radiation-related project conducted under the agreement, is also the first environmental project under this cooperative arrangement that is directly related to the 1986 Chernobyl disaster—still a subject of great concern in the Soviet Union.

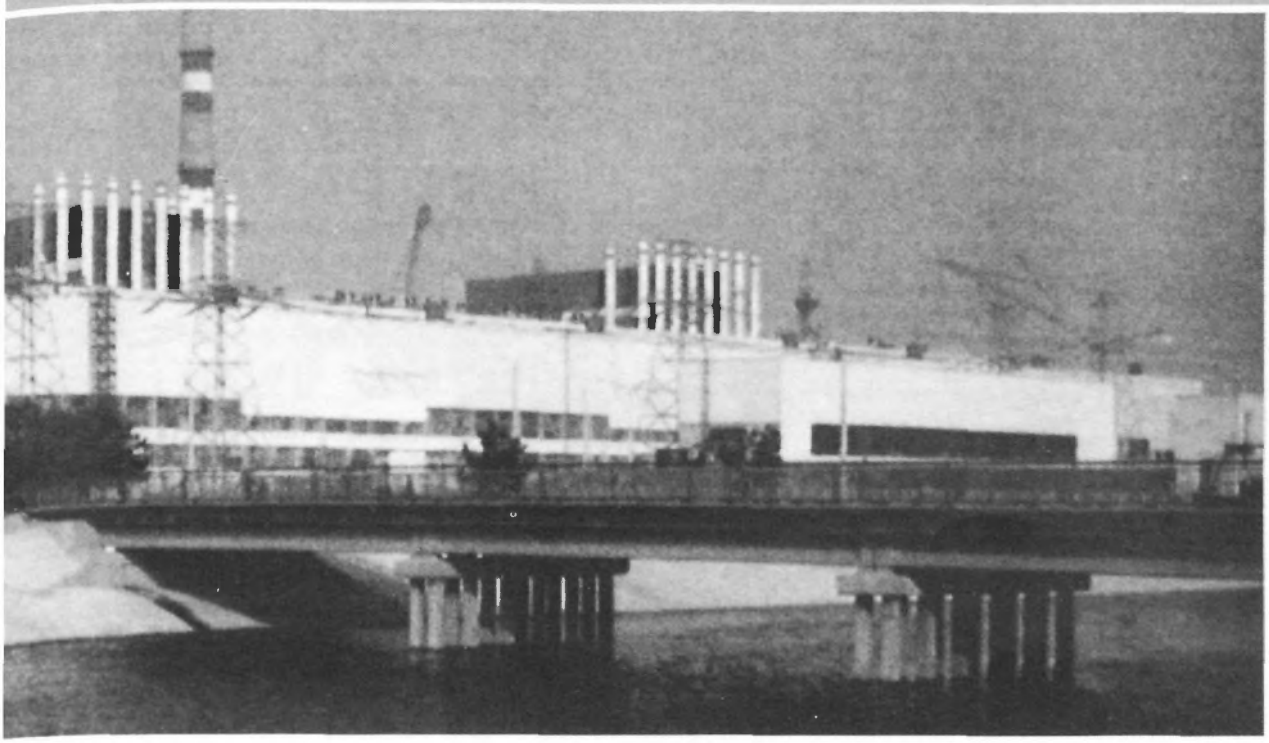
The survey did more than increase the knowledge of the Soviets and others of the long-term environmental and ecological effects of Chernobyl. It has given scientists a unique opportunity to study how a large inventory of radioactive materials from an actual accident at a nuclear-power facility moves through and is ultimately distributed in freshwater and marine ecosystems. The survey is the first part of a program that will eventually provide a more comprehensive understanding of how accident-related radioactive materials move from a source (Kiev) to a final destination (the Black Sea) several hundred miles downstream.

Through this program, scientists will better understand which radioactive materials flow through waterways, which stick to bottom sediments along the way, and which ultimately become deposited in and distributed throughout a distant marine environment. From such information, experts can construct more accurate environmental transport models that predict radionuclide movement and deposition for different accident scenarios. The models, in turn, will help develop long-term monitoring plans to assess radiation releases.

Further, results from the overall program could help develop remediation and clean-up strategies. The strategies, for example, could be used if the sediment in a reservoir or river used as a drinking-water source were disturbed by storms or dredging that dispersed radioactive materials deposited as a result of a nuclear accident.

The initial phase of this ambitious program was conducted from June 12 through June 23, 1990, aboard the Soviet research vessel *Vodyanitskiy*, sailing from Sevastopol on the north central coast of the Black Sea. The *Vodyanitskiy* was made available to EPA by the primary Soviet participating organization, the Ukrainian Academy of

(Kahn is a Public Affairs Specialist with EPA's Office of Radiation Programs.)



The Chernobyl Nuclear Power Station in Kiev, where a 1986 explosion released radioactive materials.

Wide World photo.

Science's Institute of Biology of the Southern Seas (IBSS), headed by Dr. S. M. Konovalov.

Two days prior to sailing, the American contingent—consisting of Bob Dyer, Bill Curtis, Jim Neiheisel, and Jon Broadway from EPA's Office of Radiation Programs—arrived in Sevastopol. There they met with their Soviet counterparts, coordinated survey activities, and prepared the ship. In addition to the four EPA scientists, the group included radiochemist Hugh Livingston and three other scientists from the Woods Hole Oceanographic Institution (WHOI) who participated as co-investigators in this EPA project. Florence Harrison, expert on radiation effects on marine organisms from Lawrence Livermore National Laboratory, completed the American Group.

While in Sevastopol, the Americans stayed aboard the ship since the city had no hotels for foreigners. Because of its naval installations, until recently Sevastopol was closed even to Soviet visitors. And although things are changing there, tourists and foreign visitors still must enter the city through a military checkpoint and are limited to day trips. In contrast to this situation, dramatic evidence of a changing atmosphere was provided in the summer of 1989 by a visit to the city by U.S. Navy ships—the first in over 40 years.

On the morning of June 12, the 215-foot, 1,200-ton *Vodyanitskiy*, with EPA's Curtis, Neiheisel, and Broadway and the WHOI scientists on board, sailed into the Black Sea to begin collecting water, sediment, and marine-life samples. The daily scientific work was conducted to coincide as much as possible with the ongoing studies of the Soviet scientists. Most of the voyage was spent in the northern part of the Black Sea because that is the area into which the Dnepr River system flows. The Dnepr was the major water pathway for radioactive materials from the Chernobyl accident.

The collection of subsurface water samples for cesium and strontium analyses—to determine the levels of radioactive materials still present—required large volumes of water. This was collected by pumping deep water to the surface via hoses and using specialized, cylindrical Bodman-bottle water samplers, each one capable of holding about 25 gallons of water. After the bottles were lowered to a specific depth, seawater from that depth was collected and the bottles were hauled back to the ship's deck. Surface water samples were collected by using floating pumps. All these water samples are being separately analyzed by the IBSS and the WHOI Chemistry Department.

Sediment samples were taken with a box corer, an EPA-furnished piece of equipment. The rectangular-shaped box corer enabled the scientists to collect, in one operation, the number of undisturbed subcores needed to conduct all the required analyses.

The sediment samples are being analyzed to determine overall radioactivity levels, how specific radioactive materials move through the sediment, what the mineralogical makeup is and how this affects radionuclide movement, what the heavy metal content is, and what biological organisms are present that also could redistribute radioactive material. Samples are being analyzed by EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama; the IBSS; WHOI;

Bill Curtis photo.

Biological sampling was part of the work undertaken by the Black Sea survey team.

Brookhaven National Laboratory; the Moscow Academy of Sciences; and the U.S. Army Corps of Engineers.

The third scientific activity, biological sampling, consisted of lowering samplers to obtain mussels and other bottom-dwelling invertebrates and also trawling to collect bottom and near-bottom fish. Because of unique conditions existing in the Black Sea—below 300 to 400 feet the sea cannot support marine life because there is no oxygen in the water—biological sampling for the survey was limited to locations with shallow water. The biological samples are being analyzed by EPA at its Montgomery laboratory, by the IBSS, and by WHOI.

As a follow-up to the analysis of the water, sediment, and biota samples, the results will be shared among the laboratories as part of a program to compare data and methods and establish quality assurance. The initial results of the Black Sea survey are expected by summer 1991.

The shipboard experience could not have been smoother. According to Curtis, EPA scientific team leader and a veteran oceanographer, "The *Vodyanitskiy* is comparable to most U.S. oceanographic research vessels, and the level of cooperation and professional respect among the scientists was exceptional." Also, enough of the Americans spoke Russian, and vice versa, so that there were virtually no communication problems between the U.S. visitors and the onboard Soviet scientists and crew. As a result, the U.S. and Soviet scientists established some strong professional and personal relationships that auger well for successful completion of the proposed second phase of this endeavor.

That second phase of the Chernobyl-related cooperative program involves studying the movement of accident-generated radioactive materials from the Kiev reservoir down the Dnepr River to the Black Sea. The Ukrainian city of Kiev, the Soviet Union's second largest city, is just 65 miles south of Chernobyl. Before the *Vodyanitskiy* set sail, two EPA scientists, Dyer and Broadway, met with officials and scientists in Kiev to discuss plans for a second phase.

At that time, they gained an appreciation of the concern expressed—and actions taken—by local scientists and residents over their continual exposure to radiation from Chernobyl. For example, all Kiev's grass clippings and leaves were collected during the summer and fall following the 1986 accident and buried in a large excavation to isolate the radioactive contamination. The Kiev newspaper still issues weekly reports on radioactivity levels in the vicinity. Last June 2, there was even a television call-in show for Kiev residents to ask questions about radioactivity from Chernobyl. The Director of the Kiev Water Supply and Wastewater Treatment Agency wants Kiev declared a zone of ecological disaster. From what Dyer observed, such activity is part of a very real environmental movement that did not exist in the Soviet Union even two years ago.

The momentum of the Soviet Union's environmental movement is further evidenced by the unprecedented participation of a non-government Soviet environmentalist in the 12th formal meeting of the U.S.-U.S.S.R. Joint Committee hosted by EPA at its Washington, DC, headquarters in 1990. We are looking forward to increased levels of participation by more segments of Soviet society, not only in the study of radiation and its effects, but in all important environmental areas. □

EPA's Water Office has undergone a major restructuring, announced recently by LaJuana Wilcher, Assistant Administrator for Water. The purpose of the reorganization is to put a greater emphasis on pollution prevention and ecological risks, which will include targeting specific geographical regions. The following is a summary of key appointments in the reorganization:

Martha G. Prothro is the new Deputy Assistant Administrator for Water.

Her professional federal government service began in 1965, when she served in a variety of positions in a federally sponsored demonstration program assisting welfare recipients in obtaining work, training, and experience in the District of Columbia. Prothro began her career at EPA as an attorney in the Office of Enforcement and General Counsel in 1973. She worked in the Stationary Source Air Enforcement Program until 1980, serving as a staff attorney, as a section chief, and beginning in 1977, as Chief of the Enforcement Proceedings Branch in the Division of Stationary Source Enforcement.

Prothro joined the Senior Executive Service in 1980, when she became the Director of the Noise and Radiation Enforcement Division. One year later, she was named the Director of the Permits Division, within the water program. She served as Acting Director of the Office of Water Enforcement and Permits in 1982 and became the Director of the Office of Water Regulations and Standards in 1988.

A 1965 graduate of the University of North Carolina, Prothro earned a JD from George Washington University's National Law Center in 1973.

Robert H. Wayland III is the new Director of the Office of Wetlands, Oceans, and Watersheds, which is responsible for policy and management; the Office also provides support to regional and state programs to prevent and control nonpoint source pollution, the assessment and monitoring of the health of the nation's waters, coastal and ocean protection programs, and the wetlands program.

Prior to his current position, Wayland was Deputy Assistant Administrator for Water. Before joining the Office of Water, he was the Deputy Assistant Administrator for EPA's Office of Policy, Planning, and Evaluation from January 1988 to November 1989. Wayland was a Special Assistant to EPA Administrator Lee M. Thomas and Deputy Administrator A. James Barnes and was responsible for providing independent counsel to them on issues involving several EPA programs, including those administered by the Office of Water. He also held positions in EPA's Office of Enforcement and the Office of Solid Waste and Emergency Response; he came to EPA in 1974, when he joined the Agency's Congressional Affairs staff.

Prior to his EPA career, Wayland held positions in the U.S. House of Representatives and Senate as well as the National Transportation Safety Board. He has also served as a Planning Commissioner in the City of Falls Church and was a member of the Architectural Review Board in that community.

Wayland is a graduate of the George Washington University in Washington, DC, and is a recipient of EPA's Gold Medal for Exceptional Service.

Michael B. Cook is the new Director of the Office of Wastewater Enforcement and Compliance, which is responsible for issuing and enforcing permit controls on municipal and industrial wastewater discharges. In addition, it administers federal financial and technical assistance for publicly owned wastewater treatment works.

Cook joined EPA in 1973 and worked in several positions in the Construction Grants Program for municipal wastewater treatment facilities. In 1980 and 1981, Cook managed EPA's emergency response program, including early implementation of the Superfund legislation. From 1981 to 1985 he was the Deputy Director of the Office of Solid Waste. Cook became the Director of the Office of Drinking Water in 1985 and served there until his current position.

Cook served in the counterinsurgency program in Vietnam and as a consul with the Foreign Service in Northeast Thailand. He also worked for HUD in the Model Cities Program.

He received a bachelor of arts degree in political science from Swarthmore College in 1963 and earned a bachelor of philosophy degree in political science from Oxford University in 1966. Cook has received numerous awards, including EPA's gold, silver, and bronze medals. He also received the Distinguished Executive Award from President Reagan in 1987.

The new Director of the Office of Science and Technology is **Tudor Davies.**

Prior to his current position, Davies served as the Office of Water's Director for the Office of Marine and Estuarine Protection for seven years. Within the Office of Water, he has also been the Director of the Office of Program and Management Operations in 1983.

He joined EPA in 1972 and worked in the Office of Research and Development. He was the Deputy Laboratory Director of the Gulf Breeze Environmental Research Laboratory from 1975 to 1979; subsequently, he became the Director of the Narragansett Environmental Research Laboratory from 1979 to 1983. He also served as Director of the Chesapeake Bay Program from 1979 to 1983.

Davies attended the University of Wales in Swansea and earned both a bachelor of science degree and a doctorate in geology. He was a Postdoctoral Fellow at Dalhousir University in Canada. Before joining EPA, he was an Associate Professor of Geology at the University of South Carolina.

He was a recipient of the Presidential Meritorious Executive Award in 1989.

James R. Elder has been named the new Director of the Office of Ground Water and Drinking Water.

Prior to his recent appointment, Elder has held several positions within EPA going back to 1971. Most recently, Elder was the Director of the Office of Water Enforcement and Permits within the Office of Water for five years. Transferring from the Office of Management and Budget, his first position at EPA was as management analyst in the Office of Planning and Management and then as the Assistant to the then Assistant Administrator Al Alm in 1974. From 1975 to 1979 he was the Director of the Management Division for Region 3 in Philadelphia.

As part of the President's Executive Exchange Program, he served for one year as the Executive Assistant to a senior vice president at the Potomac Electric Power Company. Elder returned to EPA to become the Deputy Director of the Office of International Activities. In 1983, he moved to the Water Program to become Deputy Director of the Office of Water Enforcement and Permits. In 1986 he was detailed as the Acting Deputy Regional Administrator for Region 10 in Seattle.

Elder is a 1967 graduate of Johns Hopkins University with a bachelor of arts degree in international relations. He also attended George Washington University in 1969, where he studied international affairs.

ON the MOVE

In the Office of General Counsel, **Charles L. Elkins** is the new Senior Counsel to the General Counsel, specializing in legal policy.

Elkins' environmental career began in 1967 as the budget examiner for Environmental Health in the Office of Management and Budget. In that position he played a principal role in the creation of EPA in 1970. He then joined the Agency as a special assistant to Administrator William Ruckelshaus in 1971. One year later, he became the Principal Deputy to the Assistant Administrator for Categorical Programs, which included pesticides, solid wastes, radiation, toxic substances, and noise. From 1973 to 1974, Elkins was the Acting Assistant Administrator for Hazardous Waste Control. He then served as the Senior Budget Officer for the Office of Water and Hazardous Materials until he became the Director of the Noise Control Program from 1975 to 1981. During that time, he was also the Executive Director of the Commission on Fiscal Accountability of the Nation's Energy Resources for the Department of the Interior.

From 1982 to 1983, Elkins was the Senior Budget Officer for the Office of Air and Radiation (OAR). He served as the Acting Assistant Administrator for Air and Radiation for six months in 1983, then again for one year in 1985. Between those positions, he was OAR's Director of Program Development. Elkins was the Director of the Office of Toxic Substances from 1986 until his current position.

Elkins received a bachelor of arts degree in philosophy from Yale University in 1962 and a JD in 1967 from Yale Law School. He was a recipient of the EPA Gold Medal in 1972 and the Presidential Award for performance in 1986.

The new Deputy Director of the Office of Air Quality Planning and Standards within the Office of Air and Radiation (OAR), Research Triangle Park, North Carolina, is **Lydia N. Wegman**. Wegman began her career with EPA in 1977 as an attorney-advisor to the Office of General Counsel. Four years later, she became an Acting Assistant General Counsel within the same office. She was a special assistant to the Director of Mobile Sources from 1985 to 1987. Her most recent position was as the Senior Legal and Policy Advisor to the Assistant Administrator for the OAR.

Between various EPA positions, Wegman was a legal assistant for the President's Office at the University of Iowa in 1987, where later that same year, she became an Immigration Specialist for the Office of Finance and University Services. She was also an associate at the law firm of Swidler, Berlin and Strelow from 1982 to 1985.

A 1971 graduate of Yale University, she received a bachelor of arts degree in history. She then earned a JD from Columbia Law School in 1976. Wegman has been a recipient of the Group Gold Medal for Exceptional Service in 1989 for outstanding work on the Clean Air Act Amendments and the EPA Group Silver Medal for superior work in developing regulations to prevent significant deterioration of air quality in clean air areas.

Richard D. Morgenstern has been named the new Acting Assistant Administrator for the Office of Policy, Planning, and Evaluation (OPPE). The former OPPE Deputy Assistant Administrator will take the position most recently held by Dan Beardsley. Prior to that, he served as OPPE's Director of the Office of Policy Analysis, a position he has held since 1983. Morgenstern has served as Executive Director of the Agency's Task Force on Global Climate Change and co-chaired the Agency's Economic Incentives Task Force. In 1981 he was the leader of the task force that produced *Unfinished Business*.

Before joining EPA, Morgenstern held a number of positions inside and outside of government. From 1971 to 1976, he was a tenured associate professor of economics at Queens College. He then became the Deputy Assistant Director for Energy, Natural Resources, and the Environment for the Congressional Budget Office in 1976. From 1979 to 1980 he served as a senior legislative assistant for Senator J. Bennett Johnston. In 1980, he became the Director for the Energy Program at the Urban Institute.

A 1966 graduate of Oberlin College, Morgenstern received a bachelor of arts degree in social science. Four years later, he earned a doctorate in economics from the University of Michigan.

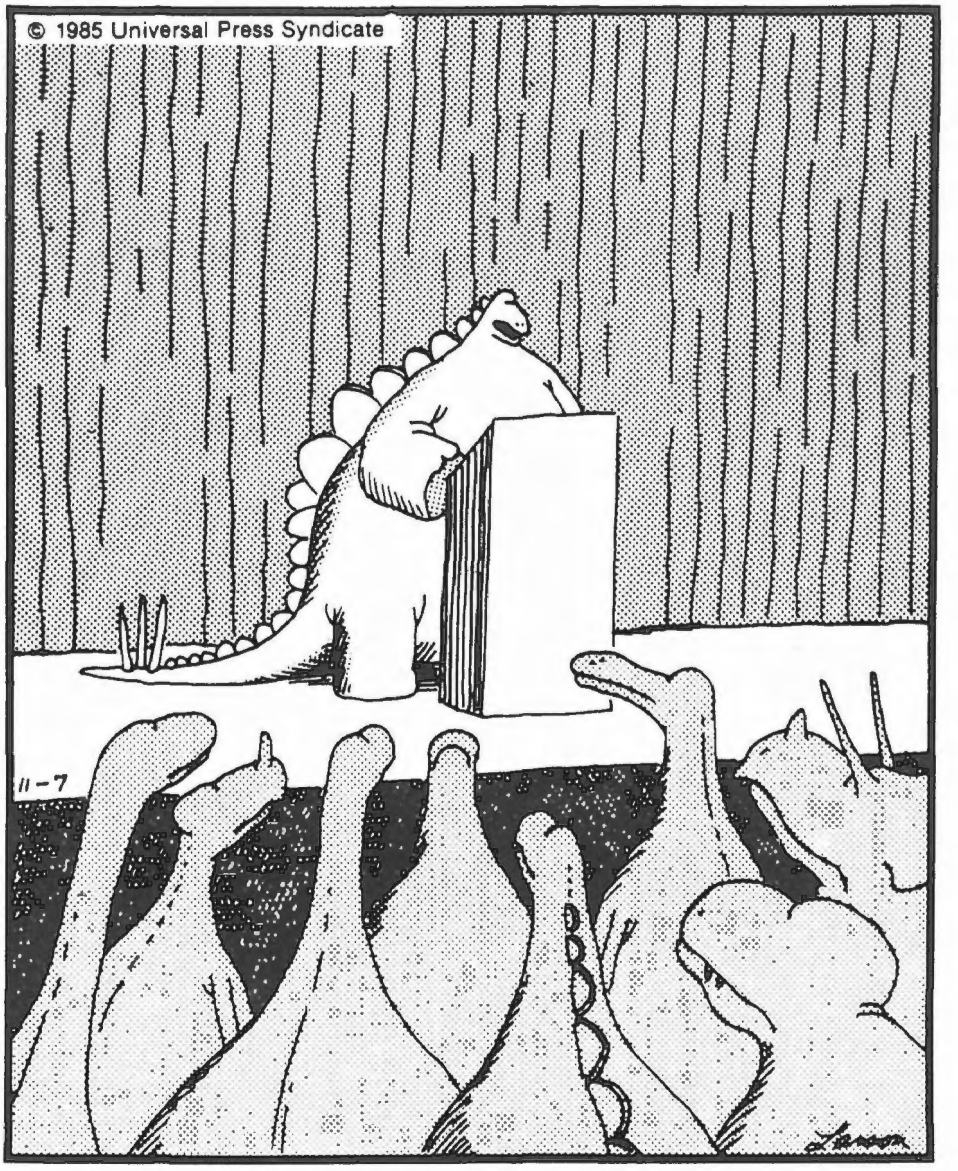
The new Director of Technical Assistance and Soviet and East European Affairs for the Office of International Activities is **Dan Beardsley**.

Beardsley joined EPA in 1980 as a program analyst for the Integrated Environmental Management Division within the Office of Policy, Planning, and Evaluation (OPPE); he became director of that division in 1982. From that position, he became OPPE's Director of the Regulatory Integration Division in 1986. Beardsley was named OPPE's Deputy Assistant Administrator for Policy, Planning, and Evaluation in 1989 and served as Acting Assistant Administrator from March 1, 1991, to his present position.

Beardsley began his career as a chaplain at the University of Florida in 1968. From 1972 to 1977, he managed drug treatment programs for the City of Atlanta and the State of Georgia. He moved to Washington, DC, to become assistant to the Director of the ACTION Agency, which includes VISTA and the Peace Corps.

A 1966 graduate of Kalamazoo College, Beardsley received a bachelor of arts degree in philosophy. In 1972 he earned a master's in divinity from Yale University.

THE FAR SIDE By GARY LARSON



"The picture's pretty bleak, gentlemen. ... The world's climates are changing, the mammals are taking over, and we all have a brain about the size of a walnut."

Back cover: A decent environment, the nation's goal. Photo by Pat Lanza for Folio, Inc.