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EPA

Reducing Risk:

Setting Priorities And Strategies For Environmental Protection

NOTICE

This report has been written as a part of the activities of the Science Advisory Board, a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Board is structured to provide a balanced expert assessment of scientific matters related to problems facing the Agency; hence the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency or of other Federal agencies.

This particular project was conducted at the request of the EPA Administrator and addresses a broader range of issues and concerns than most SAB reports. Consequently, many of the findings and recommendations in this report have more of a policy orientation than is usually the case.

Cover Photo by Steve Delaney

REDUCING RISK:

SETTING PRIORITIES AND STRATEGIES FOR ENVIRONMENTAL PROTECTION

The Report of The Science Advisory Board:
Relative Risk Reduction Strategies Committee

to

William K. Reilly
Administrator
United States Environmental Protection Agency

September 1990

Science Advisory Board
U.S. Environmental Protection Agency
Washington, DC 20460
September 25, 1990

Mr. William K. Reilly
Administrator
U.S. Environmental Protection Agency
Washington, DC 20640

Dear Mr. Reilly:

Over a year and a half ago, you asked the Science Advisory Board to review EPA's 1987 report, *Unfinished Business: A Comparative Assessment of Environmental Problems*, and then assess and compare different environmental risks in light of the most recent scientific data. You also asked us to examine strategies for reducing major risks and to recommend improved methodologies for assessing and comparing risks and risk reduction options in the future. This report and its three appendices have been prepared in response to your request.

To undertake this project, the Science Advisory Board created a special Relative Risk Reduction Strategies Committee composed of 39 distinguished scientists and other experts from academia, state government, industry, and public interest groups. The Committee carefully considered the reports written by each of its three Subcommittees, and the findings and recommendations contained in Reducing Risk flow from the work of the Subcommittees and reflect study, discussion, and synthesis by the Committee as a whole. This report has been reviewed by the SAB Executive Committee and has been formally approved as an SAB document.

As you are aware, the Science Advisory Board normally reviews scientific reports for the Agency and evaluates them on the basis of scientific and engineering data. However, in this case our review of *Unfinished Business* and our analysis of risk reduction options have led us to make findings and recommendations that are more policy-oriented than is usually the case. We have done this at your request.

This report, together with its three appendices, suggests steps that the Environmental Protection Agency should take to improve its own efforts — and to involve Congress and the rest of the country in a collective effort — to reduce environmental risk. We strongly believe that the Agency should take steps to ensure that this nation uses all the tools at its disposal in an integrated, targeted approach to protecting human health, welfare, and the ecosystem.

This report is only a step along a long road. We encourage you to lead the Agency in taking the necessary further steps as soon as possible.

Sincerely,

Raymond Loehr
Chair, Science Advisory Board, and Co-Chair, Relative Risk Reduction Strategies Committee

Jonathan Lash
Co-Chair, Relative Risk Reduction Strategies Committee

Contents

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Chapter One—Executive Summary

The Concept of Risk

Over the past 20 years this country has put in place extensive and detailed government policies to control a number of environmental problems. Smog in heavily populated areas, the eutrophication of lakes, elevated levels of lead in the blood of millions of children, the threat of cancer from exposure to pesticide residues in food, and abandoned drums of hazardous wastes are a few of the problems that have driven the enactment of more than a dozen major Federal laws and the current public and private expenditure of about $100 billion a year to protect the environment.

Those efforts have led to very real national benefits. The staggering human health and ecological problems apparent throughout eastern Europe suggest the price this country would be paying now had it not invested heavily in pollution controls.

Yet despite the demonstrable success of past national efforts to protect the environment, many national environmental goals still have not been attained. Factors like the growth in automobile use and common agricultural practices have caused national efforts to protect the environment to be less effective than intended.

Furthermore, with hindsight it is clear that in many cases those efforts have been inconsistent, uncoordinated, and thus less effective than they could have been. 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 — smog in major cities, lack of aquatic life in stream segments, declining numbers of bald eagles — 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. Many laws not passed primarily for environmental purposes also had major effects on the environment.

- *In Programs.* The Environmental Protection Agency (EPA) was established as the primary Federal agency responsible for implementing the nation's environmental laws. EPA then evolved an administrative structure wherein each 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 environmental problem. This problem is compounded by the fact that EPA is not the only agency whose activities affect the environment.

- *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 so-called "end-of-pipe" controls and remediation technologies almost always have been applied because of Federal, State, or local legal requirements.

For a number of reasons, this kind of fragmented approach to protecting the environment will not be as successful in the future as it has been in the past. In this country 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 — are facing emerging environmental problems of unprecedented scope. Population growth and industrial expansion worldwide are straining global ecosystems. Never before in history have human activities threatened to change atmospheric chemistry to such an extent that global climate patterns were altered.

Given the diversity, complexity, and scope of the environmental problems of concern today, it is critically important that U.S. environmental policy evolves in several fundamental ways. Essentially, national policy affecting the environment must become more integrated and more focused on opportunities for environmental improvement than it has been in the past.

The environment is an interrelated whole, and society's environmental protection efforts should be integrated as well. Integration in this case means that government agencies should assess the range of environmental problems of concern and 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. Thus protecting the environment effectively in the future will require a more broadly conceived strategic approach, one that involves the cooperative efforts of all segments of society.

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. Thus the concept of environmental risk can help the nation develop environmental policies in a consistent and systematic way.

Scientists have made some progress in developing quantitative measures for use in comparing different risks to human health. Given sufficient data, such comparisons are now possible within limits. 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. That capacity would be even more valuable as the number and seriousness of environmental problems competing for attention and resources increase.

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 a number of ways to reduce the automobile emissions that contribute to urban smog; there are a number of ways to decrease human exposure to lead. The evaluation of relative risks can help identify the relative efficiency and effectiveness of different risk reduction options.

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.

The Traditional Role of the Environmental Protection Agency

For the past 20 years, EPA has been basically a "reactive" agency. As environmental problems were identified, the public conveyed its concern to Congress, and Congress passed laws to try to solve the problems within some, often well-defined, timeframe. EPA then implemented the laws using the resources — budget and staff — allocated by Congress.

Consequently, EPA has seen its mission largely as managing the reduction of pollution and, in particular, only that pollution that is defined in the laws that it administers. EPA's internal programmatic structure mirrors the environmental legislation that it is required to implement. Moreover, the tools EPA traditionally has used to reduce pollution have been limited, in general, to the emissions controls it could force polluters to apply through regulatory action.

This reactive mode, although understandable when seen in its historical context, has limited the efficiency and effectiveness of EPA's environmental protection efforts. Because of EPA's tendency to react to environmental problems defined in specific environmental laws, the Agency has made little effort to compare the relative seriousness of different problems. Moreover, the Agency has made very little effort to anticipate environmental problems or to take preemptive actions that reduce the likelihood of an environmental problem occurring.

Because most of EPA's program offices have been responsible for implementing specific laws, they have tended to view environmental problems separately; each program office has been concerned primarily with those problems that it has been mandated to remediate, and questions of relative seriousness or urgency generally 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.

Unfinished Business

The Environmental Protection Agency squarely faced the question of relative risk for the first time when it established an Agency task force to assess and compare the risks associated with a range of environmental problems. In 1986 and 1987, about 75 senior career managers and staff compared the relative risks posed by 31 environmental problems within four broad categories of risk: 1) human cancer risk, 2) human non-cancer health risk, 3) ecological risk, and 4) welfare risk. The task force limited its comparison to those risks that remain after currently-required controls have been applied (i.e., residual risks). The results of this effort were presented in *Unfinished Business: A Comparative Assessment of Environmental Problems.*

Unfinished Business was a landmark study. For the first time, the many environmental problems of concern to EPA were compared to each other in a non-programmatic context. Moreover, the report explicitly pointed out the disparity between residual risk and resource allocation at EPA. The problems that the authors judged to pose the most serious risks were not necessarily the problems that Congress and EPA had targeted for the most aggressive action.

However, the report did find a correlation between EPA's programmatic priorities and the apparent public perceptions of risk. That is, Congress and the Agency were paying the most attention to environmental problems that the general public believed posed the greatest risks.

The authors of *Unfinished Business* recognized that their risk rankings, while based on the judgments of experienced professionals, were limited, since they were based on incomplete data and novel risk comparison techniques. But the value of the report, then and now, rests not so much on the accuracy of the rankings but on the fact that EPA had begun to see the long-term public policy importance of understanding relative risks. In short, *Unfinished Business* was yet another sign that the nation as a whole, and EPA in particular, could not continue "business-as-usual" in the face of the environmental risks of the 1990s and beyond.

The Relative Risk Reduction Strategies Committee

Shortly after he took office early in 1989, EPA Administrator William K. Reilly asked the Science Advisory Board (SAB) to review EPA's 1987 report on relative environmental risk, *Unfinished Business*, evaluate its findings, and develop strategic options for reducing risk. In response to that request, the SAB formed a special committee, the Relative Risk Reduction Strategies Committee (RRRSC), which in turn was divided into three Subcommittees: the Ecology and Welfare Subcommittee, the Human Health Subcommittee, and the Strategic Options Subcommittee.

The Relative Risk Reduction Strategies Committee was co-chaired by Dr. Raymond C. Loehr, chairman of the SAB and professor at the University of Texas, and Mr. Jonathan Lash, Secretary of the State of Vermont's Agency of Natural Resources. The Ecology and Welfare Subcommittee was chaired by Dr. William Cooper of Michigan State University; the Human Health Subcommittee was chaired by Dr. Arthur Upton of the Institute of Environmental Medicine, New York University Medical Center; and the Strategic Options Subcommittee was chaired by Mr. Alvin Alm of Science Applications International Corporation.

The 39 members of the RRRSC and its Subcommittees were nationally-recognized scientists, engineers, and managers with broad experience in addressing environmental and health issues. Their names and professional affiliations are listed at the front of this overview report.

Through its combined efforts the RRRSC attempted to achieve four objectives:

1. Critically review *Unfinished Business*, reflecting any significant new information that bears on the evaluation of risks associated with specific environmental problems.

2. To the extent possible, merge the evaluations of 1) cancer and non-cancer risks and 2) ecological and welfare risks.

3. Provide optional strategies for reducing the major environmental risks.

4. Develop a long-term strategy for improving the methodology for assessing and ranking environmental risks and for assessing the alternative strategies that can reduce risks.

In particular, the Ecology and Welfare Subcommittee and the Human Health Subcommittee were charged with reviewing and updating the risk findings from *Unfinished Business*. Those two Subcommittees were to provide, to the extent possible, a single aggregate ranking of the risks that each Subcommittee assessed, and recommend a long-term strategy for improving the methodology for assessing such risks. The Strategic Options Subcommittee was charged with 1) identifying strategy options for reducing residual environmental risks, and 2) developing and demonstrating analytical methodologies for identifying and selecting risk reduction options.

The RRRSC began planning its work in the spring of 1989, and it held its first meeting in September 1989. In all, the Committee and its three Subcommittees held twelve public meetings and three working sessions.

The RRRSC has conducted a lengthy review of the data and methodologies that support risk assessment, comparison, and reduction today. This review of environmental risk has led to several conclusions about the need for and value of comparative risk assessments and their implications for the national environmental agenda.

This overview report highlights the most important findings and recommendations from the three Subcommittee reports, along with insights derived from discussions among the Committee members after they reviewed the Subcommittee reports. The full reports of the three Subcommittees are included as appendices to this report (see inside back cover) and should be referred to for important additional information and detailed support for the contents of this overview report.

The RRRSC recognizes that this overview report and its appendices contain policy-oriented findings and recommendations that are outside the normal scope of SAB purview. But in this case the EPA Administrator explicitly asked the SAB to review, from a technical and scientific perspective, the optional strategies available for reducing risk. Thus this report includes recommendations on approaches to risk management and on the future direction of national environmental policy. However, nothing in this report or its appendices should be construed as an SAB recommendation for a specific policy option to be used to reduce a specific environmental risk.

The Ten Recommendations

1. EPA should target its environmental protection efforts on the basis of opportunities for the greatest risk reduction. Since this country already has taken the most obvious actions to address the most obvious environmental problems, EPA needs to set priorities for future actions so the Agency takes advantage of the best opportunities for reducing the most serious remaining risks.

2. EPA should attach as much importance to reducing ecological risk as it does to reducing human health risk. Because productive natural ecosystems are essential to human health and to sustainable, long-term economic growth, and because they are intrinsically valuable in their own right, EPA should be as concerned about protecting ecosystems as it is about protecting human health.

3. EPA should improve the data and analytical methodologies that support the assessment, comparison, and reduction of different environmental risks. Although setting priorities for national environmental protection efforts always will involve subjective judgments and uncertainty, EPA should work continually to improve the scientifc data and analytical methodologies that underpin those judgments and help reduce their uncertainty.

4. EPA should reflect risk-based priorities in its strategic planning processes. The Agency's long-range plans should be driven not so much by past risk reduction efforts or by existing programmatic structures, but by ongoing assessments of remaining environmental risks, the explicit comparison of those risks, and the analysis of opportunities available for reducing risks.

5. EPA should reflect risk-based priorities in its budget process. Although EPA's budget priorities are determined to a large extent by the different environmental laws that the Agency implements, it should use whatever discretion it has to focus budget resources at those environmental problems that pose the most serious risks.

6. EPA — and the nation as a whole — should make greater use of all the tools available to reduce risk. Although the nation has had substantial success in reducing environmental risks through the use of government-mandated end-of-pipe controls, the extent and complexity of future risks will necessitate the use of a much broader array of tools, including market incentives and information.

7. EPA should emphasize pollution prevention as the preferred option for reducing risk. By encouraging actions that prevent pollution from being generated in the first place, EPA will help reduce the costs, intermedia transfers of pollution, and residual risks so often associated with end-of-pipe controls.

8. EPA should increase its efforts to integrate environmental considerations into broader aspects of public policy in as fundamental a manner as are economic concerns. Other Federal agencies often affect the quality of the environment, e.g., through the implementation of tax, energy, agricultural, and international policy, and EPA should work to ensure that environmental considerations are integrated, where appropriate, into the policy deliberations of such agencies.

9. EPA should work to improve public understanding of environmental risks and train a professional workforce to help reduce them. The improved environmental literacy of the general public, together with an expanded and better-trained technical workforce, will be essential to the nation's success at reducing environmental risks in the future.

10. EPA should develop improved analytical methods to value natural resources and to account for long-term environmental effects in its economic analyses. Because traditional methods of economic analysis tend to undervalue ecological resources and fail to treat adequately questions of intergenerational equity, EPA should develop and implement innovative approaches to economic analysis that will address these shortcomings.

Chapter Two—Findings

1. The Importance of *Unfinished Business*

H-3.0; H-6.0 E-3.0; E-5.0 S-4.2

With the publication of *Unfinished Business* early in 1987, EPA took a bold and much-needed step: it compared the relative residual risks posed by a range of different environmental problems, and thus suggested an important shift in national environmental policy. With that report EPA took the first step toward relative risk reduction; that is, a policy that attempts to match Agency and societal resources to risk.

To produce *Unfinished Business* EPA brought together staff from all its program offices for the explicit purpose of comparing the relative risks of different environmental problems, regardless of individual programmatic priorities or responsibilities. To do that, the EPA staff had to assess environmental risk in a context broader than programmatic structure or legislated activities. In short, they had to put aside considerations of bureaucratic "turf" in order to rank the problems they believed most needed society's attention. EPA should be applauded for the courage and foresight to undertake a project like *Unfinished Business*.

Unfinished Business presents useful, preliminary information for comparing environmental problems, although in some cases its rankings are a matter of judgment and cannot be supported fully by existing data. The Ecology and Welfare Subcommittee questioned the welfare rankings, because it disagreed with some of the economic assumptions underlying those rankings and because of a general lack of relevant economic data. The Human Health Subcommittee questioned the accuracy of any ranking of human health risks at this time, given the limited human exposure and chronic toxicity data currently available. Both Subcommittees observed that the 31 problems assessed were not derived from a systematic classification of all environmental problems, and both suggested alternative and more comprehensive approaches to classification that would facilitate a more coherent ranking.

Most of the 31 environmental problems assessed in *Unfinished Business* are so broad, and include so many toxic and non-toxic agents, that its ranking of problems cannot be evaluated with rigor or confidence. Additionally, the authors of *Unfinished Business* intentionally defined environmental problems to correspond to legislation and programmatic organization. As a result, they attempted to compare heterogenous mixtures of pollutants (like air pollutants and drinking water pollutants) to pollutant sources (like oil spills and mining waste) to receptors (like consumers and workers). Yet without a consistent basis for comparison, such comparisons are tenuous at best.

Moreover, because the authors chose to limit the environmental problems they compared, *Unfinished Business* does not address problems like the loss of habitat and the decline in genetic diversity, even though such problems pose very serious risks, and EPA and other agencies may be able to take actions to mitigate them. A meaningful ranking of relative environmental risks must include all such risks, whether or not laws have been passed or programs set up to control them.

A final shortcoming for the authors of *Unfinished Business* was the availability of data. Good data to evaluate risks simply did not — and in many cases still do not — exist. The EPA staff understandably used their professional judgment to fill the data gaps. The Subcommittee reports appended to this overview report document in more detail the members' judgments as to the relative strength and weakness of the data used to support the risk rankings in *Unfinished Business*.

The findings and recommendations described in this overview report have been derived mainly from the reports prepared by the three Subcommittees of the Relative Risk Reduction Strategies Committee. Those reports, which are included as appendices to this report, contain detailed information that support and more fully explain the findings and recommendations. Such information can be found by referring to the sections of the different appendices that are listed at the beginning of each finding and recommendation. In the listed crossreferences:

- **"E" refers to the Report of the Ecology and Welfare Subcommittee;**
- **"H" refers to the Report of the Human Health Subcommittee; and**
- **"S" refers to the Report of the Strategic Options Subcommittee.**

2. Problems in Ranking Risks

E-3.0; E-5.2
H-3.0; H-6.0

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. In particular, the lack of pertinent exposure data makes it extremely difficult to assess human health risks.

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. At this time EPA does not have an effective, consistent way of identifying environmental problems in a manner that neither fragments nor aggregates sources of risk to an extent that renders comparisons untenable. EPA's current framework of statutory mandates and program structure helps to maintain artificial distinctions among environmental problems, and those distinctions are conducive neither to sound evaluation of relative risk nor to selection of the most effective actions to reduce risk.

In particular, the methodologies currently used to estimate the benefits of risk reduction activities are inadequate and inappropriate. For example, a methodology that presumes the future value of an ecological resource necessarily must be less than its present value will not be a useful analytical tool for sustaining economic development over the long term. The standard practice of discounting future resource values is inappropriate, and it results in policies that lead to the depletion of irreplaceable natural resources.

Reliance on "willingness to pay" and similar techniques commonly used in economic analyses has distorted current understanding of the value of natural resources. While some people may not care about wetlands and assign no value to their existence, such areas still provide valuable ecosystem services to this and future generations. While few people are likely to care about and be willing to pay for plankton and fungi, such organisms play a critical role in sustaining economically valuable ecosystems.

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? Are risks of cancer more or less serious than threats to reproductive processes? 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.

3. The Extraordinary Value of Natural Ecosystems

E-5.2 Natural ecosystems like forests, wetlands, and oceans are extraordinarily valuable. Those ecosystems 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.

The value of natural ecosystems is not limited to their immediate utility to humans. They have an intrinsic, moral value that must be measured in its own terms and protected for its own sake.

However, over the past 20 years and especially over the past decade, EPA has paid too little attention to natural ecosystems. The Agency 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; ecological degradation probably is seen as a less serious problem because it is often subtle, long-term, and cumulative. But for whatever reason, this imbalance is a manifest, if inadvertent, part of current national environmental policy.

EPA's response to human health risks as compared to ecological risks is inappropriate, because, in the real world, there is little distinction between the two. 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.

In short, human health and welfare ultimately rely upon the life support systems and natural resources provided by healthy ecosystems. Moreover, human beings are part of an interconnected and interdependent global ecosystem, and past experience has shown that change in one part of the system often affects other parts in unexpected ways. National efforts to evaluate relative environmental risks should recognize the vital links between human life and natural ecosystems. Up to this point, they have not.

4. Time, Space, and Risk

E-4.3; E-7.0
S-2.2

While the data needed to support firm rankings of risk were found to be limited, the RRRSC identified a number of important factors that must be considered in any assessment or ranking of the risk associated with a particular environmental problem. Those factors include the number of people and other organisms exposed to the risk, the likelihood of the environmental problem actually occurring among those exposed, and the severity of the effects, including the economic losses and other damages involved, if it does occur.

In addition, two other aspects of potential environmental problems — i.e., their temporal and spatial dimensions — also must be given considerable weight in any analysis of relative environmental risk. Consideration of time and space can help guide judgments about relative risks in the absence of complete data.

The temporal dimension of an environmental problem is the length of time over which the problem is caused, recognized, and mitigated. For some environmental problems the temporal dimension can be very long. For example, the chronic human health effects of air or water pollution may become apparent only after many years of exposure. 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, if recovery is possible at all.

The spatial dimension of an environmental problem is the extent of the geographical area that is affected by it. Some environmental problems, like elevated levels of radon, may be limited to the basements of some homes, while problems like 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.

The time and space dimensions of environmental problems should weigh heavily in any comparison of relative environmental risks. For example, if long-lived pollutants like DDT and PCBs can become concentrated in the food chain and pose a threat to future as well as present human and ecological health, those future risks should be taken into account when relative risks are compared. Similarly, if global climate change or stratospheric ozone depletion has the potential to affect the health and/or economic well-being of virtually everyone on earth, now and in the future, the extent and duration of the risk should suggest a relatively high-risk ranking.

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 semipermanent. Destroying wetlands, altering natural water flows (as in the Everglades), global warming, and stratospheric ozone depletion can cause irreversible and, in some cases, widespread problems.

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 and initiated in the face of incomplete and uncertain data. The risks entailed in postponing action can be greater than the risks entailed in taking inefficient or unnecessary action. Moreover, preemptive actions are especially justifiable if — like the energy conservation efforts that would slow the accumulation of greenhouse gases — they lead to unrelated but immediate and substantial benefits, such as improved ambient air quality and reduced U.S. dependence on imported oil.

5. The Links Between Risk and Choice

S-2.2

It is sometimes tempting to think simplistically about the sources of environmental risk as being a particular industry, a particular product, or a particular pollutant. Conceptually, smokestacks can be controlled, products modified, and pollutants banned with relative ease.

But the sources of environmental risk are much more diverse and complicated than that. In fact, 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.

In a sense, the very existence of the human race inevitably poses some level of environmental risk. People necessarily generate wastes, both as individuals and through aggregate economic activities. People necessarily destroy or infringe upon some natural habitats when they construct their own. 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.

But all these activities involve choice, and the environmental risks posed by many human activities can be reduced sharply if different choices are made. So one of the most important questions facing society is how to influence and shape individual, community, and business choices so that environmental risks are reduced.

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, of course, are very 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. In national efforts to assess, compare, and control relative risks, the importance of those choices — and the policy options available to influence those choices — should not be overlooked.

6. Public Perceptions of Risk

S-B.4

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 areas of greatest concern to the public today are not necessarily those problems identified in *Unfinished Business*. In other words, 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 between public perceptions and professional understanding of environmental risk presents an enormous challenge to a pluralistic, democratic country. A Federal agency like EPA must be sensitive to public concerns about environmental problems. In fact, since public concerns tend to drive national legislation, Federal environmental laws are more reflective of public perceptions of risk than of scientific understanding of risk. Consequently, EPA's budget and staff resources tend to be directed at those environmental problems perceived to be most serious by the general public.

Yet if national resources are to be used most effectively to promote environmental quality, then such resources must be aimed at those environmental problems that pose the greatest risks. The ability to match resources to risks will measure the success of national policies to protect the environment.

One obvious way to bridge this 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. Public perceptions of environmental risk tend to incorporate deeply-held subjective values, like justice and equity, that, although difficult to quantify, reflect important elements of the quality of life that government is bound to protect. Moreover, since the scientific understanding of any environmental problem is likely to evolve as the science improves, and since environmental policy necessarily embodies subjective values, scientific understanding should not be the sole determinant of environmental policy.

Therefore, EPA must be prepared to listen carefully to the public's perceptions of risk. Moreover, EPA should balance those perceptions with current scientific understanding as the Agency develops long-term risk reduction strategies.

7. Relatively High-Risk Environmental Problems

E-4.0; E-6.0; H-5.0; H-7.0

The RRRSC not only reviewed the risk rankings contained in *Unfinished Business*, but it also identified several environmental problems as relatively high-risk, based on available scientific data and technical understanding. This effort was challenging for a number of reasons. Ecological, health, and welfare risks can be manifested in a number of different endpoints; it is difficult to compare risks with widely different time scales and spatial dimensions; because of data gaps and methodological inadequacies, it is rarely feasible to quantify total risk. In other words, the RRRSC faced many of the same hurdles that faced the authors of *Unfinished Business* when they developed their risk rankings.

Consequently, the RRRSC did not rank risks in the same manner as *Unfinished Business* did. The Ecology and Welfare Subcommittee grouped environmental problems into high-, medium-, and low-risk areas; the Human Health Subcommittee identified environmental problem areas where existing data indicated that risks could be relatively high. Additional data might identify additional high-risk problems. Both Subcommittees developed their assessments in light of the latest scientific and technical knowledge and using their best professional judgment, and both caution that their assessments are based on incomplete and often inadequate knowledge about 1) the extent of human and ecological exposures to pollutants and 2) exposure-response relationships.

Risks To The Natural Ecology And Human Welfare

The Ecology and Welfare Subcommittee identified areas of relatively high, medium, and low risk, despite gaps in the relevant data. The four environmental problems that it considered to be relatively high-risk are likely to be considered high-risk even after data and analytical methodologies are improved, because the geographic scale of all four is very large (regional to global), and because the time that could be required to mitigate all four is very long, and some effects are irreversible.

The Ecology and Welfare Subcommittee did not limit their assessment to the environmental problems listed in *Unfinished Business*. The order of problems listed within each of the three different risk groups shown below 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.

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
- Groundwater Pollution
- Radionuclides
- Acid Runoff to Surface Waters
- Thermal Pollution

Risks To Human Health

The Human Health Subcommittee limited its assessment to those problems addressed by *Unfinished Business*. On reviewing the rankings in *Unfinished Business*, the Subcommittee identified those problems that represented major types of human exposure known to be associated with significant impacts on human health. In four such instances, relatively high-risk rankings were supported more firmly by the available data than they were for other health problems. The Subcommittee also noted that the development of better methodologies and more complete data could lead to a different approach to the assessment of human health risks, and that such an approach would involve the selection of specific environmental toxicants that warranted detailed assessment and major risk reduction efforts.

- 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). Others, such as lead and arsenic, reach humans by a variety of pathways including direct inhalation, inhalation of resuspended 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.

Other problem 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 not as robust as they are for the four areas listed above.

8. Strategy Options for Reducing Environmental Risk

S-4.4 In addition to reviewing the findings of *Unfinished Business*, the RRRSC also reviewed a broad spectrum of policy options available for reducing major environmental risks. The Strategic Options Subcommittee examined a series of environmental problems and identified a range of risk reduction options for each of them. Thirteen problems were included in the analysis, nine of which had been ranked high in *Unfinished Business*.

The Subcommittee identified six generic risk reduction tools that should be considered for any problem area (see box on the following page), and generated 60 specific examples of options that could be applied to 13 environmental problems. The Subcommittee also developed a series of criteria that can be used to select from among the various risk reduction options available. These criteria include the magnitude of risk reduction to be achieved, the likelihood of achieving that risk reduction, the costs involved, the ease and speed of implementation and enforcement, the degree of intermedia transfer of risk, and overall cost-effectiveness.

Optional Tools For Reducing Environmental Risk

- *Scientific and Technical Measures*

Two major sets of scientific and technical measures are: 1) research and development to improve understanding of problems and point to promising solutions; and 2) innovations in pollution prevention approaches and pollution control technology. Examples include additional research to understand the potential for global warming and development of ecologically protective, cost-effective technologies to manage contaminated sediments.

- *Provision of Information*

In many cases risk reduction can be promoted by providing information to producers, consumers, and/or State and local governments. For example, new home buyers could be provided with the results of radon tests, and state and local governments could be provided with technical information to help them address indoor air pollution.

- *Market Incentives*

A key to reducing environmental risk is to ensure that consumers and producers face the full costs of their decisions. Economic incentive systems often can help accomplish this end. The major categories of incentive systems include: 1) pollution charges, 2) marketable permits, 3) deposit-refund systems, 4) removal of market barriers, and 5) revision of legal standards of liability. Examples include using marketable permits to lower costs and spur innovation in reducing acid rain, and creating deposit-refund systems for tires and batteries.

- *Conventional Regulations*

Conventional regulations include performance standards, design standards, use restrictions, and product specifications. For example, the Agency could tighten restrictions on some uses of pesticides and develop new standards for automobile emissions.

- *Enforcement*

In many cases substantial gains can be made in environmental risk reduction by more vigorously enforcing existing statutes and regulations, particularly by employing innovative enforcement methods. Options include using statistical techniques for enforcement to assure that all classes of potential violators will be inspected, and assuring that penalties create an incentive to comply with environmental laws.

- *Cooperation With Other Government Agencies and Nations*

Many types of government policies affect the environmental problems that EPA must address. Due to EPA's limited jurisdiction, cooperation with other agencies and nations often presents the best opportunities to reduce certain kinds of environmental risk. For example, the Agency could seek an international convention on global warming and an agricultural policy that would reduce non-point source pollution.

Chapter Three—Recommendations

1. EPA Should Target Its Environmental Protection Efforts On The Basis Of Opportunities For The Greatest Risk Reduction

S-4.2 Seen in its historical context, the *ad hoc* development of U.S. national environmental policy is understandable. Yet 20 years of experience in developing and implementing environmental policy has demonstrated that not all environmental problems are equally serious, and not all remediation efforts are equally urgent. The nation cannot do everything at once. In national efforts to protect the environment, the most obvious steps have been taken to reduce the most obvious risks. *Now environmental priorities must be set.*

In order to set priorities for reducing environmental risks, EPA must weigh the relative risks posed by different environmental problems, determine if there are cost-effective opportunities for reducing those risks, and then identify the most cost-effective risk reduction options. This effort should build on the analytical process begun in *Unfinished Business* and in this report and its appendices.

However, the SAB recognizes that risk analyses always will be imperfect tools. No matter how much the data and methodologies are improved, EPA's decisions to direct specific actions at specific risks will entail a large measure of subjective judgment. Yet the SAB believes that relative risk data and risk assessment techniques should inform that judgment as much as possible. In short, 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 decisionmaking process.

In order to implement a risk-based action agenda, EPA must take several essential steps. It must articulate to its own employees and to the general public the fact that it intends to set priorities for action based on opportunities for relative risk reduction. Next the Agency must establish an explicit process for incorporating those considerations into its long-term planning and budget processes. Finally, the Agency must act on those priorities.

In practice, of course, EPA's activities are defined by the laws that it is required to administer. EPA also has a responsibility to respond to public concerns about an environmental problem, no matter how limited the risk may seem to be. However,EPA should not limit its risk comparison efforts to those environmental problems it is required by law to mitigate. The risks posed by other problems and potential problems — like the loss of biological diversity — must be compared and ranked as well.

Simply stated, EPA is responsible for protecting the environment, not just for implementing environmental law. Thus the Agency should assess and compare the universe of environmental risks and then take the initiative to address the most serious risks, whether or not Agency action is required specifically by law.

2. EPA Should Attach As Much Importance To Reducing Ecological Risk As It Does To Reducing Human Health Risk

E-4.0 Largely because of the requirements of the laws it administers, EPA has tended to pay far more attention to protecting human health and welfare than to protecting the ecology. Indeed, during the 1980s EPA's agenda was dominated by concerns about the effects of toxic chemicals on human health.

Yet from the perspective of risk there are strong linkages between human health and the health of wetlands, forests, oceans, and estuaries. Most human activities that pose significant ecological risks — for example, the effects of agricultural activities on wetlands — pose direct or indirect human health risks as well. Likewise, actions taken to reduce pollution and thus improve human health usually improve various aspects of ecological quality.

These very close linkages between human health and ecological health should be reflected in national environmental policy. When EPA compares the risks posed by different environmental problems in order to set priorities for Agency action, the risks posed to ecological systems must be an important part of the equation.

This recommendation is not meant to imply the relative value of human life *vis a vis* plant or animal life. Rather, it is meant to reflect in national environmental policy the very strong ties between all forms of life on this planet. Ecological systems like the atmosphere, oceans, and wetlands have a limited capacity for absorbing the environmental degradation caused by human activities. After that capacity is exceeded, it is only a matter of time before those ecosystems begin to deteriorate and human health and welfare begin to suffer.

In short, beyond their importance for protecting plant and animal life and preserving biodiversity, healthy ecosystems are a prerequisite to healthy humans and prosperous economies. Although ecological damage may not become apparent for years, society should not be blind to the fact that damage is occurring and the losses will be felt, sooner or later, by humans. Moreover, when species and habitat are depleted, ecological health may recover only with great difficulty, if recovery is possible at all.

Thus EPA's risk-based priorities for action should reflect an appropriate balance between ecological, human health, and welfare concerns. Furthermore, the Agency should communicate to the general public a clear message that it considers ecological risks to be just as serious as human health and welfare risks, because of the inherent value of ecological systems and their strong links to human health.

3. EPA Should Improve The Data And Analytical Methodologies That Support The Assessment, Comparison, And Reduction Of Different Environmental Risks

E-4.0 H-6.0 S-4.7

The ability to assess environmental risks, compare them, and select strategies to reduce them all depend on the availability and sophistication of the relevant data and analytical tools. The weakness in *Unfinished Business* stems in large part from the weakness of the data and analytical tools used, and those weaknesses still exist. If EPA's efforts to assess, compare, and reduce risks are to improve in the future, the data and analytical tools must improve as well.

For example, in order to generate the exposure-dose data needed to assess human health risks more reliably, EPA should monitor chemicals in the environment and in human tissues much more systematically. Biomarkers and other newly-developed measures of exposure should be used. To this end, EPA should expand its research and data collection efforts in this area, and cooperate with other Federal agencies to facilitate development of the requisite data bases.

EPA's health-related data collection efforts should not be limited to those areas where risks to human health already are recognized. EPA also needs to develop an ability to predict the potential future risks of emerging problems (e.g., low-level exposures to electromagnetic fields). Therefore, EPA should establish a formal risk-anticipation mechanism, including an in-house expert committee, peer oversight, and long-range research on emerging problems.

Improved methodologies for comparing different human health risks also are needed. A new approach to ranking risks, one that uses a matrix of data on sources, exposures, agents, and endpoints, is needed to help identify specific agents and mixtures for quantitative risk assessments. Risk rankings should be based on risk assessments for specific toxic agents, or definable mixtures of agents, and on the total human exposure to such agents. When possible, risks should be assigned to persons in target or more sensitive populations, as well as to the population as a whole.

For assessment of non-cancer human health risks, the Agency should try to establish a risk assessment framework consistent with that used for carcinogens. Furthermore, although a large number of non-cancer health endpoints exist, there is as yet no easy way to combine assessments of cancer and non-cancer risks into a single, overall health evaluation. The Agency should explore procedures to achieve this end.

Improved data bases and methodologies for assessing ecological and welfare risks also are needed. For example, although ecological data are plentiful, they have not been synthesized into formats useful for assessing ecological risk. Moreover, a substantial amount of ecological data are collected and maintained by other Federal government organizations. EPA should aggregate ecological data that are collected government-wide, and systematically synthesize those data into formats useful for ecological risk assessment.

Finally, all three RRRSC Subcommittees took initial steps in developing methodologies that would allow a more rigorous, scientifically defensible comparison and merging of environmental risks and alternative strategies for reducing them. Those methodologies are described in detail in the appendices to this report. EPA should invest in both in-house and extramural research to help improve those methodologies. *Unfinished Business* took the first steps to compare environmental risk; the appendices to this RRRSC report describe more sophisticated approaches. EPA should ensure that these ideas are developed and tested in the years ahead, so that relative risk reduction can be used as an effective, continually evolving tool in the development of national environmental policy.

4. EPA Should Reflect Risk-Based Priorities In Its Strategic Planning Processes

S-4.7

The Agency needs to build on and improve the kinds of analyses carried out by the authors of *Unfinished Business* and by the members of the RRRSC in the preparation of this report and its appendices. Ongoing assessments of different environmental risks and the policy options for reducing them should be carried out within EPA, but the Agency should consider soliciting the input of external groups and individuals with expertise and interest in this effort. The results of such analyses — the identification of relatively high-risk environmental problems and the most promising strategies for reducing them — then need to be incorporated explicitly into the Agency's strategic planning processes.

Recognizing that scientific understanding and public concerns are constantly evolving, EPA should update its risk-based priorities periodically. A major review of remaining and emerging environmental risks facing the nation — and the globe — should be conducted every several years in order to reflect advances in scientific knowledge and progress in mitigating environmental problems over time. Specific strategies for reducing specific environmental risks should be reviewed and updated more often.

Risk reduction strategies always should be driven by the environmental problems to be solved, not by the structure of existing government programs. Thus it is useful to analyze problems from different perspectives — for example, as pollutants (e.g., toxic air pollutants, groundwater pollutants), as sources (e.g., automobiles, powerplants), in terms of their effects (e.g., increased respiratory diseases, habitat destruction), and in terms of the economic activity causing or affecting them (e.g., energy use, transportation systems, residential and commercial development). Looking at environmental problems from different perspectives will suggest different types of strategic solutions, and EPA should develop plans for specific risk reduction programs only after undertaking this kind of comprehensive, multi-faceted analysis.

The Agency should subject individual strategy options to disciplined analysis to determine how much risk reduction each will achieve. Information on cost, timing, degree of certainty of results, and ancillary benefits or risks should be included in such analyses. The decision matrix developed by the Strategic Options Subcommittee of the RRRSC represents one approach for evaluating alternative strategies against a set of defined criteria. After promising risk reduction strategies have been defined, they should be built into EPA's program plans in a coordinated and explicit way.

Since State governments generally implement national environmental protection policies at the local level, State agencies need to incorporate relative risk assessments into their strategic planning, too. EPA should encourage and support State efforts to assess relative risks and the various policy options available to reduce them, especially since local action is the most effective response to many environmental risks. EPA support should include financial resources, technical assistance, and information, and such support should be focused on those problems and geographical areas where particular risks are likely to be reduced the most, and in the most cost-effective ways.

5. EPA Should Reflect Risk-Based Priorities In Its Budget Process

S-4.8 Historically, EPA's budgets have reflected the resources necessary to establish and implement the regulatory programs mandated by Congress, with virtually no focus on relative risk and cost-effective opportunities for reducing relative risks. Accordingly, over time there has been little correlation between the relative risk of a particular environmental problem and the EPA budget resources dedicated to reducing it.

Spending by EPA is not — and should not be — the sole measure of society's response to a particular environmental problem. In fact, other Federal agencies, State and local governments, private companies, and individual families will have to play significant roles in reducing the risks posed by some environmental problems. However, among those environmental problems that clearly necessitate an EPA response, the Agency should shift its budget priorities toward those problems posing the greatest risks.

Although this change in budget priorities is a necessary component of future national environmental policy, such a change need not occur overnight. Small but consistent changes would accomplish the same objectives, and such changes should be made as the Agency's understanding of relative risks improves. Moreover, changes in EPA's budget priorities need not result in allocations exactly proportional to risk and risk reduction goals, since some risks can be reduced at relatively low cost.

The Agency should initiate a specific process for incorporating relative risk considerations into its budgetary deliberations. For example, at the beginning of the budget cycle the Administrator or Deputy Administrator of EPA could provide clear guidance to the program offices regarding relatively high-risk problems that appear to be relatively underfunded. A second review to ensure that relatively high-risk problems are given higher budget priority could be completed just before the budget is sent to the Office of Management and Budget. But whatever kind of process is instituted, it is critically important that a specific EPA administrative process relates budgetary allocations explicitly to risk.

Finally, the Agency should take the lead in ensuring that overall national efforts to reduce risks are driven by cost-effective risk reduction strategies. As activities by organizations outside EPA — at the Federal, State, and local levels — become increasingly important to the nation's risk reduction efforts, EPA should guide, inform, and help coordinate those efforts. As the Federal agency with the most up-to-date, comprehensive understanding of relative environmental risks and the options available for reducing them, EPA needs to play an active role in helping target national efforts to reduce environmental risks.

6. EPA—And The Nation As A Whole—Should Make Greater Use Of All The Tools Available To Reduce Risk

S-4.4 The main tool that this nation has used to reduce environmental risk has been government-mandated end-of-pipe controls and remediation or clean-up technologies. Such "command-and-control" methods for reducing risk have been very effective in controlling some kinds of pollution, especially from large, centralized sources. However, to control the risks posed by widely dispersed sources like naturally-occurring radon and some consumer products, and to control the risks that remain after the imposition of end-of-pipe technologies, command-and-control approaches may not be as effective. Consequently, other kinds of risk reduction tools that appear to have great promise must be used more extensively.

The RRRSC examined a variety of such tools, including research and development, conventional regulations, enforcement, and international cooperative activities. Two general tools that appear to hold particular promise are market incentives and the provision of information.

The forces of the marketplace can be a powerful tool for changing individual and institutional behavior and thus reducing some kinds of environmental risks. Whenever appropriate and feasible, EPA should use and/or support them. Marketable permits, deposit-refund systems, and pollution charges are types of market incentives that could — and should — play much larger roles in this nation's efforts to reduce environmental risk.

EPA is only one of several Federal agencies with authority in these areas, but EPA is the Federal agency primarily responsible for protecting the environment in the broadest sense. Consequently, EPA should take the lead in fostering more widespread use of market forces to reduce environmental risk.

Information also can serve as a way to reduce risk without the use of command-and-control regulations. For example, the information requirements of the Emergency Planning and Community Right-to-Know Act of 1986 have encouraged companies to take voluntary actions to reduce their inventories and emissions of toxic substances. The exchange of information also can facilitate the wider use of cost-effective pollution prevention strategies. Information provided through environmental audits can help companies improve their risk-reduction efforts. EPA should expand its efforts to provide information and to facilitate information-sharing that helps individuals, businesses, and communities reduce environmental risk.

This recommendation is not meant to imply that command-and-control regulations have outlived their usefulness. For some environmental problems, conventional regulatory approaches hold substantial promise for further reductions in risk. Such approaches include end-of-pipe performance standards, design standards, use restrictions, and product specifications. Together with strict enforcement of existing environmental regulations, these approaches give pollution sources a strong incentive to look for cheaper, innovative ways to achieve the same environmental goals. Thus the RRRSC supports the continued use and strict enforcement of existing regulations.

However, the long-term reduction of environmental risks will require EPA, and the nation as a whole, to use a far broader range of tools. EPA should dedicate budget and personnel resources to develop, test, and fairly evaluate all such tools. The Agency also should make more of an effort to inform and encourage other elements of society — businesses, schools, State and local governments, etc.— to use this broad range of tools.

7. EPA Should Emphasize Pollution Prevention As The Preferred Option For Reducing Risk

S-4.3

The costs of cleaning up and disposing of pollutants after they have been generated can be enormous. The costs of the Superfund program, the planned cleanup of the Department of Energy's nuclear weapons plants, and the cancellation and disposal of chemicals already in use are painful examples of that lesson.

Thus end-of-pipe controls and waste disposal should be the last line of environmental defense, not the front line. Preventing pollution at the source — through the redesign of production processes, the substitution of less toxic production materials, the screening of new chemicals and technologies *before* they are introduced into commerce, energy and water conservation, the development of less-polluting transportation systems and farming practices, etc. — is usually a far cheaper, more effective way to reduce environmental risk, especially over the long term.

More widespread use of pollution prevention techniques holds enormous environmental and economic promise for a number of reasons. For one thing, some environmental problems — like global warming — simply cannot be remediated in any practical way using only end-of-pipe controls.

Pollution prevention also minimizes environmental problems that are caused through a variety of exposures. For example, substituting a non-toxic for a toxic agent reduces exposures to workers producing and using the agent at the same time as it reduces exposures through surface water, groundwater, and the air.

Pollution prevention also is preferable to end-of-pipe controls that often cause environmental problems of their own. Air pollutants captured in industrial smokestacks and deposited in landfills can contribute to groundwater pollution; stripping toxic chemicals out of groundwater, and combusting solid and hazardous wastes, can contribute to air pollution. Pollution prevention techniques are especially promising because they do not move pollutants from one environmental medium to another, as is often the case with end-of-pipe controls. Rather, the pollutants are not generated in the first place.

The advantages of pollution prevention also are becoming apparent as the nation tries to address some of the environmental risks that remain after end-of-pipe controls are applied. Ongoing growth in the amount of wastes generated in this country is quickly overcoming the ability of landfills and incinerators to absorb it, especially since landfills are no longer an option for hazardous waste disposal. Society must find more ways to reduce the amount of waste requiring disposal. Similarly, as the nation attempts to reduce the environmental risks still posed by urban smog more than a decade after automobile emissions were reduced sharply by end-of-pipe technology, it is clear that preventing pollution — e.g., through mass transit, car pools, and the combustion of alternative fuels — is a promising long-term option.

In addition, pollution prevention techniques often bring substantial economic benefits to the sources that use them. Businesses can avoid the costs of end-of-pipe controls, waste cleanup and disposal, and liability by preventing pollution instead of controlling it. Moreover, some pollution prevention techniques, like using energy more efficiently and recycling process materials, can pay for themselves quite apart from environmental considerations. One reason that Japan and Western Europe are formidable economic competitors is that they use energy and raw materials so efficiently. To compete in the global marketplace, American businesses also must use them more efficiently.

8. EPA Should Increase Its Efforts To Integrate Environmental Considerations Into Broader Aspects Of Public Policy In As Fundamental A Manner As Are Economic Concerns

S-4.5; S-4.6

For the past 20 years EPA has been the focal point of the Federal government's environmental protection efforts. As such, EPA was largely responsible for defining, implementing, and enforcing the national command-and-control regulations that have been remarkably successful in reducing certain kinds of pollution, especially from large, centralized facilities.

But reducing environmental risk in the future also will entail the control of small, widely dispersed sources of pollution through the use of a wide range of regulatory and non-regulatory techniques. Consequently, EPA must have a broader perspective. In solving environmental problems like habitat destruction, indoor air pollution, non-point source water pollution, and solid waste disposal, EPA will be only one of a number of Federal and state agencies with important roles to play. Thus EPA should do more to foster the cooperation among government entities that will be essential to the national effort to reduce environmental risks in the 1990s and beyond.

EPA should play an important role in ensuring that environmental considerations are a part of the policy framework at other Federal agencies whose activities affect environmental quality directly or indirectly. Changing Federal policies in sectors not traditionally linked with environmental protection could provide cost-effective environmental benefits that equal or exceed those that can be achieved through more traditional means.

Environmental considerations should be an integral part of national policies that affect energy use, agriculture, taxation, transportation, housing, and foreign relations. For example:

- Energy conservation measures, if given high national priority, could improve the U.S. balance of payments, lower future world oil prices, reduce threats to national security, and help reduce environmental risks locally, regionally, and globally.
- Federal agricultural policies and programs could be revised to reduce or eliminate existing incentives for environmentally unsound farming practices, and to directly support efforts by farmers to control soil erosion and chemical runoff and to make greater use of low-input, sustainable farming practices.
- Tax policies could promote investments in new plants and equipment that are less polluting and more energy efficient.
- Housing and commercial development policies could be used to control development in ecologically fragile areas.

Because EPA is not the only Federal agency whose actions affect the environment, it must work to ensure that environmental considerations are incorporated into policy discussions across the Federal government. Environmental considerations should be as fundamental in this context as economic concerns are. In order to facilitate the government-wide integration of environmental policy, the EPA Administrator should encourage the President to create a cross-government forum where such integration would be explicitly considered and carried out.

9. EPA Should Work To Improve Public Understanding Of Environmental Risks And Train A Professional Workforce To Help Reduce Them

S-4.9

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 necesarily must be predicated on imperfect and evolving scientific understanding and subjective public opinion.

EPA also should take several specific steps to develop and sustain the nation's scientific capability and workforce. For example, the Agency should provide technical and financial assistance to universities to help them incorporate environmental subject matter into their curricula and to train the next generation of environmental scientists and engineers.

In this regard, EPA also should support graduate and post-graduate training programs in the relevant scientific disciplines, and nurture the participation of the scientific community in interdisciplinary research. The nation is facing a shortage of environmental scientists and engineers needed to cope with environmental problems today and in the future. Moreover, professionals today need continuing education and training to help them understand the complex control technologies and pollution prevention strategies needed to reduce environmental risks more effectively.

EPA also should expand its support for environmental training programs targeted at Federal, State, and local officials. Most environmental officials have been trained in a subset of environmental problems, such as air pollution, water pollution, or waste disposal. But they have not been trained to assess and respond to environmental problems in an integrated and comprehensive way. Moreover, few have been taught to anticipate and prevent pollution from occurring or to utilize risk reduction tools beyond command-and-control regulations. This narrow focus is not very effective in the face of the intermedia environmental problems that have emerged over the past two decades and that are projected for the future.

10. EPA Should Develop Improved Methods To Value Natural Resources And To Account For Long-Term Environmental Effects In Its Economic Analyses

E-5.2

Traditional forms of economic analysis, as applied to the costs and benefits of economic development and environmental protection, have systematically undervalued natural resources. This practice threatens the world's natural resources — like estuaries and rainforests — without which the lives of future generations will be impoverished. The failure of current analytic techniques to estimate properly either the full benefits of natural ecosystems or the full costs of activities that degrade them too often has allowed the justification of long-term ecological degradation for the sake of present gain.

A private company invests its profits to maintain and increase its capital value. When a company invests to maintain facilities, expand production, buy new equipment, and improve the quality of services provided, it protects its long-term health.

In a similar manner, this planet requires certain investments in order to maintain itself as a healthy ecosystem and to ensure sustainable, long-term economic growth. Future generations depend on those investments, and if they are not made, then civilization will put itself out of business.

It is necessary and appropriate to conduct economic analyses of human activities that affect the environment. But it is essential that such analyses properly value the long-term, sustained productivity of natural ecosystems. For that reason, EPA should undertake a broad national effort to develop analytical techniques that more adequately assess the real long-term value of ecosystems, and that support the identification of the most cost-effective ways to reduce risks that threaten long-term, sustained productivity.

There are a variety of problems with present methods. Many of the problems stem from the fact that public goods, such as clean air, are unpriced in markets and thus are easily — and often — undervalued in economic analyses. National accounting schemes typically characterize revenues generated by activities that deplete or degrade environmental resources as "income" while failing to consider the resulting depletion of society's environmental capital assets.

When economists do try to value ecosystems, they are hobbled by the limitations of the available tools. For instance, the "willingness to pay" method can significantly undervalue aspects of ecosystems with which people are not familiar. Some of the assumptions underlying discounting procedures do not hold when environmental effects occur over long time periods; thus they assign little value to some very important long-term effects. Multipliers that are applied differently to environmental values than they are to more traditionally measured economic values (e.g., employment) may further distort the results of economic analyses.

As a first step EPA should commission a study that surveys the ideas of ecologists, economists, social scientists, and other experts from inside and outside the Agency. The study should attempt to develop a way of incorporating ecological investments into a concept of sustainable growth.

Environmental economics is a controversial, complex, and rapidly-evolving field. EPA should take the lead in developing methods of analysis that will give fair consideration to investments that will protect the natural resource base for future generations.

This overview report has been derived mainly from three detailed reports prepared by the three Subcommittees of the Relative Risk Reduction Strategies Committee. Those reports are:

- Appendix A: *Report of the Ecology and Welfare Subcommittee*(EPA-SAB-EC-90-021A).

  Includes a critique of the ecological and welfare rankings in *Unfinished Business.* Suggests an alternative approach to defining environmental problems, ranking them from an ecological perspective. Identifies a need to more accurately reflect ecological concerns in economic/welfare considerations.

- Appendix B: *Report of the Human Health Subcommittee*(EPA-SAB-EC-90-021B).

  Includes a critique of the cancer and non-cancer rankings in *Unfinished Business.* Provides specific suggestions for methodological improvements for analyzing and evaluating relative risks of environmental problems, including a possible approach for merging cancer and non-cancer concerns.

- Appendix C: *Report of the Strategic Options Subcommittee*(EPA-SAB-EC-90-021C).

  Describes the wide range of "tools" available for addressing environmental problems. Includes 60 examples of such strategic options applied to 13 different environmental problems. Provides a set of criteria for selecting from among the options in any given case.

Copies of the three appendices to this report can be obtained by writing:

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