U.S. Environmental Protection Agency's Approach to Risk Reduction Through the Process of Comparative Risk Assessment

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ABSTRACT

Comparative risk assessment, broadly defined, is the analysis and comparison of a group of chemicals or issues on the basis of a set of defined risk criteria. Most risk assessments, done in context of environmental programs, have important comparative aspects. Because of the large uncertainties inherent in any risk assessment, conducting a risk assessment strictly to characterize the absolute level of risk without a comparative component would not be prudent economically or environmentally. Furthermore, the U.S. Environmental Protection Agency (USEPA) clearly espouses risk assessment as the policy guide for risk reduction.

In 1987, the USEPA published a report titled "Unfinished Business." This report supported comparative risk studies on a broader scale than standard risk assessment underpinnings. The USEPA's independent Science Advisory Board (SAB), in its' September, 1990 seminal report "Reducing Risk," suggested that USEPA target available resources at the greatest risks to human health and the environment. These two reports set the framework for the agency's look at all environmental problems and thereby ranking the risks which pose the greatest harm to human health and the environment. The agency does, however, recognize that other forces play critical roles in directing policy, including statutory mandates, traditional cost-benefit considerations, environmental equity, technological advances, public perceptions and public values.

USEPA and other federal agencies, as well as industry, have been focused, and in some cases mandated, on reducing environmental risks. There are numerous complications and impediments to the reduction process. This paper focuses on how the USEPA approaches risk reduction through the process of comparative risk assessment.

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USEPA Acronyms

This report includes information obtained from interviews with various officials in the following USEPA offices.

Office of Pollution Prevention & Toxics (OPPT)

Office of Policy, Planning & Evaluation (OPPE)

Office of Water (OW)

Office of Solid Waste & Emergency Response (OSW)

Office of Air & Radiation (OA&R)

Office of Prevention, Pesticides & Toxic Substances (OPPTS)

Office of Research & Development (ORD)

Science Advisory Board (SAB)

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I. Introduction

Comparative risk assessment, broadly defined, is the analysis and comparison of a group of chemicals or other issues on the basis of a set of defined risk criteria. Simply described, comparative risk assessment is a procedure for ranking environmental problems by their seriousness (relative risk) for the purpose of assigning priorities (Cothern, 1992). It is useful to adopt specific definitions for several other key terms. "Environmental risk" is defined as the probability of occurrence of a particular adverse effect on human health or the environment as a result of exposure to an environmental hazard. An "environmental hazard" may be a hazardous chemical in the environment, a natural hazard, or a hazardous technology. "Environmental risk assessment" refers to any formal or informal procedure used to produce a quantitative estimate of environmental risk, while "environmental risk analysis" (sometimes referred to as "environmental impact analysis") is defined more broadly to include quantitative or qualitative evaluation of all relevant attributes of environmental hazards, risks, adverse effects, events and conditions that lead to or modify adverse effects, and populations or environments that influence or experience adverse effects.

The USEPA has set a policy goal for reducing human health and ecological risks (USEPA, 1987, 1990, 1993). Broadly stated, the methodology for achieving this goal is comparative risk assessment. Ideally, the goal and the methodology both are what policy-makers

will need to know in setting priorities for risk reduction actions. The reliability of the methodology is the focal point of justifiable opposition to risk-based prioritization. Some proponents (Bromley, 1992) argue that in relative risk ranking, and in making risk comparisons, the uncertainties tend to cancel. That logic, however, does not support the hard science approach to risk decision-making.

USEPA Comparative Risk staff in the Office of Policy, Planning and Evaluation (OPPE) defines risk-based priority-setting (comparative risk) as a public process that helps participants (stakeholders) decide which environmental problems are most serious and how best to reduce risks. OPPE has outlined the identification and analysis of the problems with 3 levels of risk assessment:

- health risks,
- ecological risks, and
- quality of life risks.

Given the above outline, there are several conditions needed for risk assessments. Known, or hypothetical, pathways linking the risk and the potential effects; empirical data to confirm and quantify the nature, probabilities, and related uncertainties with respect to the pathway; and methodologies to integrate data into the pathway. Table 1 lists management options for different toxic chemical problems. The range of choices for action reflect decisions that result from risk assessments. Table 1 also highlights the no action option and the preventative option.

Also pertinent to risk decisions are nuclear, chemical and biological warfare materials and their threat to human life survival. Furthermore, the USEPA does not monitor or regulate the environmental impact of military operations. Though it is beyond the scope of this paper, military environmental decisions impact the budget and priority setting of the federal government. The huge cleanup costs of these operations is considerably larger than the operating budget of the USEPA.

Table 1

Management Options for Different Toxic Chemical Problems

Range of Choices for Action

Problem	**Preventive**	**Reactive**	**Research**	**No Action**
PCB contaminated ecosystem	Ban PCB production	On-site destruction	Health effects; develop substitutes	In cases with low concs. or large areas
Learning Impairments from Lead	Transportation planning; ban leaded gasoline, solders	Catalytic converters; smog alerts	Study effects of lead on biological systems, develop substitutes	Live with problem
Toxic waste dumps	Incentives recycle reclaim reuse reduce	engineering controls	Effects of leachates on humans and ecosystems	Let it leak

Minimata disease	Ban mercury, limit effluents	Don't eat fish, close fishery, compensate victims	Determine causes; levels, metabolic conversions diet	Do nothing

II. Risk Reduction Activities at USEPA

The U.S. Congress (USC, 1992) has sent a clear message to the Executive Branch that environmental decisions have to be prioritized. Congress has suggested that risk ranking and cost-benefit analyses be used as tools to set priorities. The irony in this approach is that Congress believes that some questions are a matter for the legal system and not the scientists and the USEPA is aggressively seeking the "hard science" approach to risk decisions USEPA, 1993). Additionally, State and local governments will hold Congress and the USEPA more accountable about obligating them to spend their resources on Federal requirements Thus, the consensus is that there are three themes that should be addressed by the process of comparative risk assessment.

1) Protect individuals at high risk.
2) Enhance public participation.
3) Address environmental equity.

Conversely, the limitations of risk assessments (Dwyer, 1990) are:

1) In determining the social, cultural, or political acceptability of a hazard.
2) Addressing issues of equity.
3) Indicating the magnitude of a problem if exposure or effects are linked to special subpopulations or specific situations.

4) Comparing highly divergent types of risks.
5) Comparing the relative risks of different hazards, if the level of uncertainty varies considerably, or if the underlying mechanisms are so different as to rest on divergent or contrary assumptions.
6) For risk management uses, if the input data are insufficient or highly controversial.

According to OPPE, of the 13 major laws regulated by the USEPA, environmental problems can be roughly placed into 22 categories of risks. The agency estimates that only 20% of its budget are spent on pollutants that it considers to be of greatest risk to humans and ecological systems. These categories are based on the risk rankings from the Science Advisory Board (SAB) 1990 report.

The disparities between risk and funding in the USEPA budget result from: 1) Congressional statutory mandates prioritize agency programs largely on the basis of public perception; 2) the administration makes funding decisions according to policy, not science and 3) federal court orders force USEPA to allocate funds on the basis of lawsuits successfully brought against the agency.

Table 2 lists USEPA's 1993 funding according to risks. Under the heading of "Other Risks," inactive and abandoned hazardous waste sites spent 28% and point source discharges to surface waters spent 33% in 1992. Management and multimedia research and development spent 12% in 1992 and estimated 15% in 1993. All of the above

risks were either low or unranked by the USEPA experts.

Table 2

USEPA FUNDING ACCORDING TO RISK

High Risk	Health Risk	Ecol. Risk	Public Concern	% 1992 Budget	% 1993 Budget
Air Pollutants	High	Medium	Medium	7.25	8.39
Pesticides	High	Medium	Med./Low	1.75	2.10
Worker Health	High		High	0.15	0.16
Drinking Water	High		Med./Low	1.64	1.91
Indoor Air	High		Low	0.51	0.58
Radon	High		Low	0.45	0.49
Depletion of Ozone Layer		High	High	0.43	0.58
Destruction of Wetlands		High	Med./Low	0.61	0.74
Global Climate Change		High	Med./Low	0.70	0.75

High Risk	Health Risk	Ecol. Risk	Public Concern	% 1992 Budget	% 1993 Budget
Pollution of Estuaries, Oceans, Coastal		Medium	Med./High	1.40	1.60
Nonpoint Surface Water Poll		High/Low	Med./Low	1.35	2.39

Source: Center for Resource Economics, May, 1993

The USEPA's current pollution prevention paradigm, which started about 1990, focuses on reduction. The agency uses and promotes cooperative industry strategies to reduce risks. Two of the more notable projects, within the agency, are the Design for the Environment (DfE) Program's Cleaner Technologies Substitute Assessment and the Environmental Assistance Division's 33/50 Program.

The DfE methodology is to identify use clusters for a product or industry. A "use cluster" is a set of chemicals, processes, and technologies that can substitute for one another in order to perform a specific function. The use cluster is then ranked using a USEPA system that incorporates factors such as human and ecological risks, exposure, regulatory interest, and pollution prevention opportunities. The intent of the scoring system is to help prioritize and direct research into more environmentally beneficial alternatives.

In 1991, the agency produced a Toxic Release Inventory, as required under Superfund legislation (SARA, 1986). The agency then targeted 17 chemicals for reduction by 33 percent by the end of 1992, and at least 50 percent reduction by 1995. The targeted compounds were identified from recommendations submitted by USEPA program offices, taking into account such criteria as health and ecological risk, the likihood of exposure, technical or economic incentives, and limitations of treatment. The 33/50 program essentially allows

flexible and voluntary reduction of the 17 chemicals. The success of the program will be on the retrospective evaluation of how environmentally effective industry reduces these substances.

Other pollution prevention strategies at USEPA include research and development programs in the Waste Minimization Branch and the Risk Reduction Engineering Research Laboratory. The agency also has developed a hazard ranking system for uncontrolled hazardous substance releases (USEPA, 1988).

One of industry's strategies for risk reduction is called life-cycle assessment (LCA). The Society for Environmental Toxicology and Chemistry (SETAC) has developed an objective process to evaluate the environmental burdens associated with a product, process, or activity in the industrial sector. By identifying and quantifying energy and material usage and environmental releases, LCA assesses the impact of those energy and material releases on the environment. The assessment includes the entire life cycle of the product, process, or activity encompassing extracting and processing raw materials; manufacturing, transportation, and distribution; use/reuse/maintenance; recycling; and final disposal.

A complete life-cycle assessment, as developed by SETAC, consists of the following separate, but interrelated components:

- Life-Cycle Inventory
- Life-Cycle Impact Analysis

- Life-Cycle Improvement Analysis

These three components make up an integrated approach that, when combined with other appropriate information, can provide information needed to maximize environment improvements.

III. The Nature of Ranking

There are several ways risk can be ranked, or measured, in quantitative terms. Expression of risk has to demonstrate that the magnitude and probability of adverse conditions will occur in a specific span of time. However, when assessing the overall benefit of a proposed action, all the adverse conditions that may arise throughout the life of the action must be integrated so that the comparative aspect is clearly demonstrated. The lists or rankings usually are based on risk-risk and cross-risk endpoints. The quantifiable endpoints can be tiered. The tiered approach then becomes the basis for the comparative risk analysis.

The most direct way of expressing risk is to put it as the probability of an unacceptable condition arising and some kind of loss being generated. Another way to express risk is in terms of the probability of a release of say, toxic material involving costs at a certain level measured in terms of loss of lives and damage to property. To the general public, however, the central question is whose life or what property is loss.

Large-scale technological systems have presented decisionmakers with difficult problems in terms of justifying the levels of risk that individuals and groups are exposed to during their lives. Probability, and it's inherent uncertainty, sometimes make any level of risk unacceptable. The power of the expert in determining the ranking of a particular variable seems destined to be a cause

for conflict between the various stakeholders in any decision. Given the political climate and continued calls for public participation in planning and evaluation, consensus may be difficult to achieve.

Table 3 lists the composition of groups of ranking factors.

Table 3

Composition of the Main Groups of Ranking Factors

Factor	**Nature of Risk**	**Possible Compositions of Factors**
Technical	Degree of physical harm to people and environment	Structure reliability, Societal risk, Comparison to other risks
Economic	Less than optimal benefit from financial outlay	Supply and demand, Value of life, Cost of Saving a life, Marginal cost of saving a life, Cost/benefit analysis
Socio-Political	Public Opposition	Voluntary v. Involuntary risks, Response to public comments, Political climate, Equity

IV. Legislation

In 1981, President Reagan issued Executive Order 12291, ordering regulatory agencies to prepare regulatory impact analyses (RIAs) on all major regulations. Each RIA was to include the benefits and costs of a proposed regulation's full range of effects and should compare them with those of other regulatory and nonregulatory approaches. The RIA also was to discuss fully the benefits and costs that could not be quantified and assess the importance of those that are quantified or monetized. When many benefits cannot be monetized, or when law requires a specific regulatory objective, cost-effectiveness analysis may be used to evaluate regulatory alternatives. The goal of the executive order was to develop and organize information on benefits, costs, and economic impacts so as to clarify trade-offs among alternative regulatory options. Specifically, the RIA was required to include:

1) showing of the need for the proposed regulatory action;
2) examining alternatives for the proposed action;
3) quantifying benefits and costs and value them in monetary terms (where feasible); and
4) evaluating the findings on benefits, costs, and distributional effects.

Since that time, the Congress and the Executive Branch have sparred on the issue of risk-based budgeting. Currently, there are several bills in Congress that mandate the use of comparative risk

assessment and require USEPA to promulgate and enforce regulations that are effective in reducing risk, that are economically efficient, and that are rational and equitable.

Section 123 of S.B. 171, which elevates the USEPA to cabinet level, mandates economic and risk analysis. The Johnson amendment to the bill requires, whenever a final regulation relating to human health and safety or environment is promulgated, publication in the Federal Register of the following:

- An estimate ... of the risk to health and safety of individual members of the public addressed by the regulation and its effect on human health or the environment and the costs associated with implementation of, and compliance with, the regulation;

- A comparative analysis of the risk addressed by the regulation relative to other risks to which the public is exposed;

- Certification that the risk estimate and analysis are based on scientific evaluation of the risk to health of individuals and to human health and the environment, generally, and are supported by the best available scientific data;

- Certification that the regulation will substantially advance the purpose of protecting human health or the environment against the specified risk; and

- Certification that the regulation will produce benefits to human health or the environment that will justify the costs to the Government and the public.

If the Secretary cannot make these certifications, then the Secretary must report the fact and identify the reasons.

The requirements of section 123 differ somewhat from the requirements of an RIA. The section does not require analysis of regulatory alternatives, for example, although it does require estimation of costs, benefits, and risks for the regulatory strategy of choice. Neither does the section require calculation of net benefits. Nevertheless, the Secretary is required to certify that the costs of regulation are justified by the benefits. The basis for justification is unclear, but it could be interpreted to require at least a positive net benefit. Most significantly, the proposed mandate would apply to all regulations promulgated by USEPA, approximately 150 regulations annually, whereas currently RIAs only are prepared for a handful of "major" rules.

A resolution of the Science Committee of the U.S. House of Representatives, H.R. 1994, for the reauthorization of the USEPA research and development funds states that within six months after the date of enactment, the Administrator shall submit to the Congress a report that identifies at least 10 environmental research issues:

- Corresponding to the environmental hazards which the Administrator estimates to be in the category of highest risk;

- Regarding which there are, as determined by the Administrator, significant scientific uncertainties with respect to the assessment of such environmental risks; and

- Issues with respect to which such uncertainties could be significantly reduced through research.

The report indicated above shall include an assessment of the research to be conducted, an identification of the significant scientific uncertainties, and a list that identifies, in order of priority, how such research should be conducted.

A. The Delaney Clause

Because of the historical and legislative nature of risk at USEPA, zero risk is not usually the goal. Nevertheless, the Delaney Clause would appear to be the exception. Table 4 lists the statutes and the USEPA program offices that regulate acceptable cancer risks from exposure to toxic chemicals. Except for the Delaney Clause, it appears risks greater than 10-4 are regulated and risks less than 10-6 usually are not.

Table 4

Risk Assessment and Management in

USEPA's Program Offices

Program Office	Statute	Classi-fication	Uses CRAVE Potency	Consider Indiv. Scenario	Consider Size of Exp Pop.	Key Risk levels
OPTS	FIFRA	yes	yes	no	yes	10-4 10-5
	Delaney	yes	yes	no	no	0
	TSCA	no	yes	yes	yes*	
OSW	CERCLA	no	yes	yes	no	10-4 10-7
	RCRA	yes	yes	yes	no	10-4 10-6
OA&R	CAA	yes	yes	yes	yes	<10-4 <10-6
ODW	SDWA	yes	yes	no	no	<10-4 <10-6
OW	CWA	no	yes	no	no	10-5 10-7

* refers only to existing chemicals

Source: Rosenthal, A., G.M. Gray & J.D. Graham (1992). Legislating Acceptable Cancer Risk from Exposure to Toxic Chemicals. Ecology Law Quarterly 19(2): 321.

The Federal Food, Drug and Cosmetic Act (FFDCA) is the organic act of the Food and Drug Administration (FDA) and regulates a variety of areas which lie outside the realm of traditional environmental protection. The sole exception is Section 308 of the Act, which gives the USEPA authority to regulate pesticide tolerances.

Section 409 of the Act, the Delaney Clause, prohibits any pesticide residue "if it is found ... to induce cancer when ingested by man or animal, or if it is found, after tests which are appropriate for the evaluation of the safety of food additives, to induce cancer in man or animal." Under this rule, the USEPA has tried to legitimize the use of quantitative risk assessment.

The risk dilemma the agency faces is the fact that older pesticides that were not adequately tested were grandfathered under the standard. Applying the strict mandates of Delaney would prevent replacement of older high risk toxic compounds with less toxic alternatives.

Table 5 shows a comparison of how the agency's provisions for new and existing products are measured.

Table 5

Comparison of TSCA and FIFRA Provisions

New Products	**TSCA**	**FIFRA**
New Chemical Substances	Must be submitted for review 90 days before manufacture*	New active ingredients cannot be sold unless registered by USEPA
New manufacturers of existing products, new product formulations, new use of product	Not covered unless there is significant new use rule	Must receive registration
Test data	No data required before submission	Extensive data required to register a new active ingredient

Exemptions	R&D, test marketing, others by rule if no unreasonable risk is found	Experimental use permits, emergency uses, and state registrations for special local needs allow for partial exemptions from the full registration process
Existing Products		
Data gaps	Can require testing through rulemaking: USEPA must show need for data	Can require data to reregister or maintain registration of existing pesticides, registration can be suspended if data are nor supplied
Control of unreasonable risks	Through rulemaking	Administrative proceeding to cancel or suspend registrations

* Manufacturer can commence production unless USEPA acts within the review period.

V. Quantitative Risk Assessment

Necessarily, one has to review quantitative risk assessment (QRA) to commence the process of comparative risk assessment. The framework for QRA was developed by the National Academy of Sciences (NAS, 1983). That report identified one of the most perplexing areas of QRA, environmental data. The validity of the data, lack of adequate data, use of existing data, and data extrapolation sometimes limit interpretation of findings and subsequent policy formulation. Table 6 lists the availability of toxicity data on chemicals based on a comparison of pesticides and toxic substances.

USEPA risk assessment research is focused on improving the science and the knowledge base necessary for reducing the uncertainty associated with risk assessments. USEPA's Risk Assessment Forum is responsible for the agency-wide coordination of risk assessments. The Forum is responsible for analysis of data, developing consensus, and providing guidance to agency scientists and managers.

One of the most important factors in risk assessments is the comparison of cancer endpoints to noncancer endpoints. These endpoints of concern are human subchronic (i.e., neurological, developmental, etc.), ecologic, and multiple exposures (e.g., mixtures).

Silbergeld (1993) listed some compelling limitations both

conceptual and practical to QRA. The conceptual limitations are:

1) QRA supports an almost exclusive focus on one health outcome, cancer, and by inference one set of environmental hazards, carcinogens;

2) The methods for noncarcinogens follow the same quantitative methodology and are biologically nonspecific for target organ systems;

3) QRA methods have become more inflexible as default assumptions have become inference rules;

4) Data needs are great; to satisfy the models, to reduce uncertainty (decrease variance), and to escape the default assumptions;

5) It has not been possible to validate QRA through epidemiological research. One notable exception has been dioxin, see Goldman (1991);

6) QRA cannot handle complex mixtures; and

7) QRA does not distinguish between preventable (potential) and reducible (actual) risks.

The practical limitations are:

1) The data needs for resolving uncertainty are very great, leaving the decision-maker with a conundrum of choice between making decisions with a high degree of uncertainty or refusing to decide (abdicating decision-making until further scientific research);

2) QRA is not fully accepted as a policy tool by the public; and

3) QRA does not provide a method for comparing risks on a practical basis. The "infinite risk" paradox of such assessments tends to

distort comparisons at the extremes.

Table 6

Availability of Toxicity Data on Chemicals

	Estimated % with prescribed test for:					
Category	**Acute Toxicity**	**Subchronic Toxicity**	**Chronic Toxicity**	**Reproductive or Developmental**	**Mutagenicity**	**% having no toxicity data**
Pesticides & their Formulations	59 49-70	51 41-62	23 15-32	34 25-44	28 20-38	38 28-49
TSCA >1 mil. lb/yr	20 15-25	10 7-14	4 3-7	6 3-9	9 6-13	78 73-84
TSCA <1 mil. lb/yr	22 15-29	8 5-13	3 2-6	4 2-7	10 5-15	76 69-83

Unknown or Inaccessible	15 9-21	7 3-11	3 0-6	7 3-12	8 4-13	82 76-89

Source: National Academy of Sciences, "Toxicity Testing: Strategies to Determine Needs and Priorities," Washington, D.C. (1984).

VI. Conclusions

The USEPA and Congress are grappling with the issue of determining the risk(s) of environmental pollution. The policy trend is toward pollution reduction, rather than pollution prevention. The system of comparative risk assessment, which prioritizes risks, is neither new nor well-defined. Ranking is a critical step that can help to set priorities when selecting chemicals for chronic bioassay or mechanistic studies, for epidemiologic studies, and regulatory policy. Other methods used for risk reduction include quantitative risk assessment, health risk assessment, life cycle assessment, substitute assessment, and other qualitative methods. Ranking systems used by various organizations include; use cluster scoring system, ecological controlling system, critical materials register, enviro-accounting system, chemical candidates for sunsetting, and several other priority systems.

Despite considerable regulatory efforts, the majority of chemicals in commerce have grossly inadequate data to characterize potential chronic hazards (Table 6). There is a lack of appropriate regulatory strategies to determine reasonable risks. The Toxic Substances Control Act, promulgated to address such an issue, has not been adequately enforced. It appears the dilemma the agency faces is to again reorganize its structure. Single-media, single-chemical focus of USEPA regulations and related science has received significant challenge from external environmental

interests, the USEPA Science Advisory Board, special science advisory panels and Congressional leaders. The credibility of USEPA science has been challenged, both the scientific quality and its relationship to program office regulatory decisions. The USEPA wants a "hard science" approach and the Congress virtually demands ambiguous regulatory processes for political reasons. Thus, the absence of valid information on any component seriously impairs the agency's ability to assess accurately public health risk. The absence of data on human exposure and dose has serious implications for regulatory policies designed to protect public health.

Therefore, one of the most perplexing areas of any risk assessment is reliable environmental data. The validity of the data, adequacy of data, use of existing data, and data extrapolation sometime limit interpretation of findings and subsequent policy formulation. From earlier quantitative risk assessments, and in comparative risk estimates, a major point of uncertainty is the comparison of cancer endpoints to noncancer endpoints, such as neurological, developmental, ecologic, and multiple exposures (e.g., mixtures). Even with sufficient data the regulation of existing chemicals will be difficult because of the inevitable uncertainties in characterizing overall risks and the high economic stakes associated with commercially important substances, such as pesticides. The agency will continue to face rather difficult tradeoffs between the need to adequately assess and control risks and the desire to avoid delays in the introduction of beneficial chemicals and technologies.

The independent Science Advisory Board, in its' September, 1990 seminal report "Reducing Risk," suggested USEPA target available resources, within statutory limits, at the greatest risks to human health and the environment. The following items were recommended:

- Target environmental protection efforts to opportunities for the greatest risk reduction,

- Give as much importance to reducing ecological risk as to reducing human health risk,

- Improve data and methodologies that support the assessment, comparison, and reduction of different environmental risks,

- Reflect risk-based priorities in strategic planning and budgeting,

- Along with the nation as a whole, make greater use of all the tools available to reduce risk,

- Emphasize pollution prevention as the preferred option for reducing risk,

- Integrate environmental considerations into the broader aspects of public policy in the same way economic concerns are integrated,

- Improve public understanding of environmental risks and train a

professional workforce to help reduce them,

- Develop improved analytical methods to value natural resources and to account for long-term environmental effects in economic analyses.

Risk communication is also deeply rooted in the complexity of comparing risks. Risk data is summarily described as error or range of uncertainty. The public perceives uncertainty as an unknown phenomenon rather than the statistical level of confidence. Science would surely be enhanced with efforts in the area of communicating risk data. Scientists have an opportunity to better describe the drawbacks of publishing point estimates with their inherent uncertainties.

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