ESTIMATING BENEFITS OF ENVIRONMENTAL REGULATIONS FOR IMPROVED DECISION MAKING AT EPA

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SUMMARY

Benefit-cost studies are required by Executive Order 12291 and are important for promulgating efficient environmental regulations. As the principal repository of EPA expertise on the economic benefits of pollution control, the Benefits Branch in the Office of Policy, Planning, and Evaluation provides analysis and guidance to the Administrator and program offices for specific regulatory decisions. The Benefits Branch supports and reviews benefit-cost analyses at EPA and often participates directly in benefit-cost studies by providing benefit estimates. Program offices typically provide the cost estimates for these studies. It also administers a research program to develop improved methods and data for estimating the benefits of environmental regulations.

Some recent rule makings that have been evaluated in a benefit-cost framework include revision of the primary ozone standard, new source performance standards, revision of the primary and secondary standards for particulate matter, emission controls on copper smelters, benzene standards, and lead in gasoline. Benefit-cost estimates influenced these decisions in various ways, including organizing the data in a way suited for comparing options, explicitly considering the degree of precision in the data that were analyzed, and identifying more efficient regulatory alternatives or degrees of stringency.

The ability to provide timely, accurate analyses to decision makers depends on the availability of suitable estimating techniques

and data. Although the research program of the Benefits Branch has supported important past developments in benefit valuation, there are numerous remaining conceptual and empirical problems that inhibit analysis, particularly in the pesticides, toxic substances, and hazardous waste programs and in areas of health risks and ecological effects. Nevertheless, these programs are among the fastest-growing of EPA's responsibilities and are often most important for EPA's decisions. The Benefits Branch has developed a research agenda that is sensitive to expected future regulatory demands in these areas.

This report reviews the policy analysis and research functions of the Benefits Branch and the role of benefit-cost analysis in improving regulatory decisions at EPA. Agendas for future activities have been developed and are described.

ROLE OF BENEFIT-COST ANALYSIS AT EPA

Benefit-Cost Analysis and Improved Regulatory Decisions

Executive Order 12291 requires executive branch agencies to estimate the costs and benefits of all major regulatory actions and advocates more careful balancing of benefits and costs, where permitted by law. A recent General Accounting Office report strongly supports efforts to develop improved economic estimates.* It concludes that EPA should make greater use of benefit-cost analysis, despite major data deficiencies that prevent precise estimation of

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* U.S. General Accounting Office, "Cost-Benefit Analysis Can Be Useful in Assessing Environmental Regulations, Despite Limitations," GAO/RCED-84-62, April 6, 1984.

some values. Apart from an economic analysis group in the air program office, the Benefits Branch is the primary office at EPA that currently produces quantitative benefit estimates.

Competent benefit-cost analysis contributes to more efficient regulatory decisions in several ways.

- It organizes scientific and economic information into a consistent framework for evaluating alternatives. This framework emphasizes the importance of the revealed preferences and values of individuals and provides techniques for aggregating values when policies affect large numbers of people.
- It emphasizes use of "best estimates," rather than "worst-case estimates," of regulatory outcomes, while carefully specifying the degree of uncertainty and likely biases in the data.
- It affects regulatory criteria used by decision makers by consistently seeking either to maximize the benefits of a given amount of resources devoted to improving environmental quality, or to minimize the resources necessary to achieve some given amount of environmental benefits.
- It identifies appropriate changes in the stringency of regulations in its search for alternatives that maximize the net benefits of regulatory actions.

The following examples illustrate how benefit-cost studies are affecting EPA's decision making.

Organizing Information Consistently

Since benefit analysis is intrinsically decision oriented, it helps organize available information, whether or not specific quantitative benefit estimates are explicitly weighed against costs. For example, substantially better information is being assembled for revising the primary ozone standard, compared with that used for earlier rule makings for ozone.

The 1979 estimate of risk was based on a probability function derived from expert opinion, whereas the 1985 risk analysis will be based on an ozone dose-response function derived from several published studies, as well as an analysis of data from the 1980 Health Interview Survey. The 1979 estimate of exposure included only sensitive individuals, whereas the 1985 estimate will include the total exposed population. The 1979 estimate of the effects of exposure to ozone qualitatively described adverse health effects, whereas the 1985 study will document such specific health outcomes as the number of restricted activity days. The 1979 analysis did not attempt to monetize the effect estimate, whereas the 1985 analysis will. Finally, the 1979 analysis showed only incremental physical differences among various levels of control, whereas the 1985 analysis will present both physical and monetary changes.

Improving Cost Estimates

Because EPA is now comparing cost estimates with benefit values, program offices are beginning to shift to cost estimates that are more consistent with benefit measures. Concerns about economic feasibility previously caused program offices to develop upper-bound estimates based on worst-case assumptions. An example of this kind of change is the recent analysis of new source performance standards for volatile organic compounds. Because the original cost estimates were based on worst-case assumptions, the air program office is now revising its calculations to reflect "most-likely" assumptions for model plants.

Cost estimates are also being adjusted to conform to the time

period of compliance requirements and associated benefits. For example, the air office revised cost estimates for the recent regulatory impact analysis of the particulate matter standard. The estimates were higher after being corrected to reflect complete compliance with the ambient standard over the appropriate time period.

Influencing Regulatory Criteria

Benefit-cost analysis is gradually affecting the criteria that EPA uses to set standards, as illustrated by the recently-proposed rule for inorganic arsenic emissions from primary copper smelters. The agency used its traditional approach of analyzing only cost effectiveness and economic impact to propose requiring secondary emission controls for existing smelters with an inorganic feed rate greater than 6.5 kg/hr. In the same regulatory package EPA acknowledged that its method for deciding which sources must comply with BAT requirements might result in no additional controls on certain smelters, even though they pose greater estimated health risks than some of the smelters that the Agency is proposing to regulate. Therefore, EPA asked for public comments on two alternatives for setting the standard.

One alternative would be to select sources to control based on population density around the source. This approach introduces a benefit criterion by considering total, rather than individual, exposure. EPA would subdivide sources into high-density sources (10,000 people or more living within 20 kilometers) and low-density sources (fewer than 10,000 people living within 20 kilometers). It

would require controls at smelters in high-density areas with feed rates greater than 25 kg/hr and at smelters in low-density areas with feed rates greater than 35 kg/hr.

The second alternative introduces a more satisfactory benefit criterion. This approach would distinguish between sources by jointly considering maximum individual risk and population risk. Sources with emissions resulting in unacceptable combinations of individual and population risks would be classified as high risks and would be subject to regulation. Conversely, sources with acceptable combinations would be classified as low risks and would not be subject to additional regulation.

Affecting the Stringency of Regulations

The greater emphasis on benefit-cost analysis is influencing the stringency of several regulations. For example, EPA decided in March 1984 to withdraw earlier proposed standards for maleic anhydride plants, ethylbenzene/styrene plants, and benzene storage vessels. Since the Agency proposed the standards for the three source categories in 1980, the emission estimates have declined significantly, resulting in reductions of estimated before-control individual and population health risks associated with each source category. EPA consequently determined that the risks to public health are small and that there is no significant health benefit from controlling these emissions.

A second example is the recently released study of the costs and benefits of reducing lead in gasoline. Although the study is not yet a proposed rule making, its conclusions differ markedly

from the Agency's position in the late 1970s and its initial thinking in 1981 that it might allow increased levels of lead in gasoline.

In the 1970s EPA took several actions that it assumed would restrict and eventually eliminate lead exposure of the general population, especially young children, to airborne lead from mobile sources. These regulations were also expected to reduce undue health and welfare damage from conventional pollutants. However, the growing problem of the misuse of leaded fuels in cars with catalytic converters, the increasing recognition of serious health effects from even low lead levels, and the identification of gasoline as the major source of lead exposure indicated that current policies should be reevaluated. An EPA benefit-cost study of additional reductions of lead in gasoline subsequently concluded that the benefits of both the low-lead option and the all-unleaded option significantly outweigh the costs.

Limitations of Benefit-Cost Analysis

The ability to perform timely and accurate policy analyses is severely constrained by the availability of data and the accuracy of methods of transforming raw data into policy-relevant information. There is an especially serious lack of defensible economic estimates for health and ecological benefits of pollution control. Yet nearly every environmental regulation affects one or both of these benefit categories.

All of the examples in the previous section involve air regulations. Much of the early research on economic benefits

focused on air pollution. Much less research is available in the other program areas of water, hazardous waste, toxics, and pesticides. The air program has allocated substantial resources to benefit-cost studies, and is committed to rigorous analysis of regulatory outcomes. Unfortunately, other program offices have had insufficient resources and trained staff to support such analyses.

A substantial increase in the FY 1983 economic research budget made it possible to support a wider range of projects at more institutions, and to initiate research in the areas of hazardous wastes, pesticides, and toxic substances for the first time. It is reasonable to suppose that a period of sustained research in these areas would be required to develop an analytical infrastructure similar to that available for supporting benefit studies of air regulations.

Benefit analysis is inherently dependent on adequate scientific data on pollution exposure and resulting effects. Where there is reasonable consensus on health effects, as in the study of lead in gasoline, benefit analysis is much more credible and much more likely to be an important factor in decision making. However, where there is much uncertainty about health effects, as in the case of the particulate matter RIA, the analysis is less credible, because it cannot identify a sufficiently narrow range of probable values.

Even when dose-response data are good, available benefit estimation techniques often produce inadequate measures of people's willingness to pay for significant health, welfare, and ecological

outcomes. In some cases substantial agreement among economists has not been sufficient to persuade decision makers to accept research results. There is no consensus at EPA, for example, on how to value morbidity. The Agency's guidelines for valuation recommend using foregone wages, even though this value is not conceptually correct and excludes values for distress and discomfort associated with changes in morbidity. Neither do the guidelines offer any practical guidance on how to measure losses or gains in ecological outcomes.

Perhaps the most difficult analytical problems involve the probabilistic nature of many effects. Health effects especially tend to occur as individual, low-probability catastrophic losses. Although most studies simply convert uncertain events to "equivalent" certain events, this conversion is inadequate if people are averse to risk itself. We know very little about how people process information about environmental hazards, how to value the resulting perception of hazard, and how averting and mitigating actions occur.

Because benefit-cost analysis is based on economic efficiency criteria, such studies usually do not discuss important distributional effects. Some people argue that EPA's mandate requires elimination of high levels of individual risk, regardless of the total number of people affected or the costs. Economic efficiency would indicate that policies that reduce risk to the total population at least cost are preferable. The attempt to include both criteria in setting the inorganic arsenic standard implies that the Agency has not adequately resolved this issue.

POLICY APPLICATIONS OF BENEFIT-COST ANALYSIS

Setting Priorities for Policy Applications

The objectives of the policy analysis program of the Benefits Branch are:

- o to encourage greater use of benefit-cost analysis within EPA,
- o to ensure quality control for EPA's benefit-cost studies,
- o to provide economic advice to EPA's decision makers, and
- o to conduct benefit-cost studies in cooperation with program offices.

These functions are best served by relatively small, short-term contracts or by internal studies by Benefits Branch analysts. Policy studies rely primarily on existing data, "off-the-shelf" research results, and established methodology.

Because regulatory activities change, long-term budget planning is difficult. It is essential that Benefits Branch responses remain flexible and responsive to the concerns of program offices. Managers therefore pay close attention to the semiannual Regulatory Agenda in allocating resources. Four criteria generally determine policy priorities for the Benefits Branch:

- o Is there a pending decision on a regulation requiring a significant investment of social resources? Significance is not limited to regulations with annual costs in excess of $100 million. It includes such major programs as construction grants and new source performance standards.
- o Does the relevant program office lack sufficient expertise and resources to produce an adequate benefit-cost analysis? Program offices are expected to cooperate by providing scientific data, by providing estimates of compliance costs, and by assisting with funding for the benefit analysis.
- o Does the Benefits Branch think the analytical problem is tractable? Both data availability and quality as well as existence of suitable economic methods influence this judgment.

- Is the analysis likely to influence regulatory decisions, given prevailing legal, political, and institutional constraints?

The Current Policy Agenda

The current agenda of the Benefits Branch encompasses a wide array of activities that are both general and program specific. Applications of general interest include supplementary guidance for the Agency's RIA guidelines and estimating aggregate benefits of pollution controls. Studies that are more specific to programs include a national assessment of urban and rural runoff and a multimedia benefit study of the pulp and paper industry. Assistance to program offices varies considerably. Table 1 summarizes current activities by program area. Appendix 1 contains a more detailed list of current projects.

A Future Policy Agenda

Deciding upon a specific future agenda for benefit applications is difficult, given that the Benefits Branch must be responsive to unanticipated requests from management and program offices. However, the branch has a general strategy for the next two years that should significantly improve its ability to improve regulatory decisions.

The most promising new opportunities for benefit estimation are in the hazardous waste and water programs. These programs involve significant resource commitments and entail major environmental effects that are amenable to benefit analysis. Priority areas include proposed bans on land disposal of chemicals, proposed controls on air emissions from hazardous waste disposal sites, proposed regulations on ordinary landfills, controls on rural

Table 1

Current Benefits Branch Policy Program

Air Quality Planning and Standards:

- o Supplementing OAQPS's major commitment to RIAs.
- o Covering some areas not adequately funded, such as new source performance standards.

Mobile Sources:

- o A benefit-cost study of reducing lead in gasoline.
- o A benefit analysis for the heavy-duty truck standard.
- o A study of the benefits of reducing diesel odors.

Water Regulations and Standards:

- o Benefit analysis in support of the effluent guideline for organic plastics and synthetics.
- o Benefit studies on Combined Sewer Overflow (CSO) projects.
- o Participating in the POTW strategy study.

Groundwater:

- o Evaluating the trade-offs among prevention (containment), monitoring, and corrective action (remedial responses).

Solid Waste:

- o Demonstrating the feasibility of risk-benefit assessments for determining which chemicals to ban in landfills.
- o Exploring the applicability of risk assessments to other major RCRA regulatory options.

Acid Deposition Assessment Staff, Office of Research and Development:

- o Benefit studies (aquatic, forestry and materials) in support of the 1985 and 1987 assessments. (With less than two percent of the acid rain research budget assigned to economic benefit studies, the branch thinks that additional economic analysis is necessary for the assessments and for air program support.)

Superfund and Toxic Substances:

- o A demonstration project on cost-effectiveness in setting Superfund priorities.
- o Minor efforts with toxics and pesticides.

nonpoint sources of water pollution, combined-sewer-overflow projects funded by municipal construction grants, and proposed water regulations for best conventional technology.

The branch also assigns high priority to assisting the Acid Deposition Assessment Staff. Improved benefit estimates will result in a more rigorous evaluation of the consequences of reducing SO_2 and NO_x emissions. Among other activities, the branch hopes to continue funding a study of materials damage associated with acid deposition.

RESEARCH ON POLLUTION CONTROL BENEFITS

A Research Program to Improve Benefit-Cost Analysis

As a result of a 1983 agreement with the EPA Office of Research and Development, the Benefits Branch is now responsible for directing the Economic Research Program and for coordinating methods development and data acquisition with policy analysis efforts. The research program has the following objectives:

- o to develop and demonstrate improved methods for determining the economic benefits and, to a more limited extent, the costs of pollution control;
- o to acquire new and improved data efficiently for supporting benefit-cost analyses; and
- o to provide Agency analysts with access to the best and most current economic research, and thus to improve the accuracy and usefulness of benefit-cost studies.

Development of individual research projects reflects several considerations, including:

- o whether the research is relevant to improving EPA's capabilities for carrying out benefit-cost analyses on significant environmental regulations;
- o whether there is expressed interest in the research on the part of EPA management or a program office; and
- o whether there is a reasonable prospect that the reseach will be successful.

The research program has made major contributions to establishing conceptually valid and practical techniques for estimating environmental benefits. EPA has funded development of such innovative methods as contingent valuation and has made significant advances in data acquisition, econometric methods, and hedonic modeling (see Appendix 4).

Because of the technical difficulty of the problems that must be solved, the program makes competitive awards primarily to academic economists, often in cooperation with other relevant disciplines. Researchers pursue a specific research plan under a cooperative agreement between EPA and the host institution.

A Five-Year Research Agenda

The staff has recently developed a five-year research agenda designed to guide resource allocations for the next generation of methodological developments and to acquire data to meet future demands for regulatory analysis. Table 2 lists the current topics and goals of the benefits research agenda, and Appendix 2 is a list of specific projects in the current program.

Table 2 divides research areas into methods development for

TABLE 2

Five-Year Research Goals

RESEARCH AREA	GOAL
Methods Development: Techniques	
Travel cost method	Resolve the value of time, substitute, and multiple destination problems. Estimate a set of regional water recreation models.
Clinical experiments	Develop techniques to ascertain extent to which economic theory accurately predicts behavior in eliciting value estimates.
Health econometrics	Develop improved applications of econometric techniques to distinguish health effects of single pollutants from other pollutants and other factors.
Benefit aggregation	Develop methods of accounting for utility interactions, averting behavior, cross-sample aggregation, and regulatory sequencing in aggregating environmental values.
Hedonic technique	Resolve the identification problem, incorporate disequilibrium and uncertainty, and determine which applications are valid or invalid.
Contingent valuation technique	Develop, validate, and demonstrate CV methods for increasingly less easily defined national benefits of pollution control.
Cross comparison	Determine the degree of consistency, complementarity, and substitutability among valuation methods for the full range of environmental applications.
Net benefit estimates	Evaluate current cost estimation techniques for accuracy and consistency with benefit estimation techniques.

TABLE 2 (continued)

RESEARCH AREA	GOAL
Methods Development: Pollution Effects	
Change in and value of life expectancy	Identify differences in risk values depending on risk characteristics.
Value of morbidity and quality of life	Derive methods for estimating willingness to pay to avoid chronic and acute disabilities associated with pollution exposure. Account for averting or compensating behavior, risk, and voluntary response to improved information.
Materials values	Modify existing damage-function approaches to incorporate human adaptation to and compensation for pollution-induced damages to materials.
Nonuser and general ecosystem values	Develop reliable means of eliciting estimates of option, existence, bequest, and other nonuser values. If feasible, determine how to obtain such values for general ecosystem characteristics for which there is no directly related consumption activity.
Recreation values	Explicitly model choice among alternative leisure activities and locations as affected by environmental quality. Derive accurate estimates of the value of marine fishing, disaggregated by participant characteristics, fishing mode, species, and location.
Agricultural values and pesticide exposure	Modify existing techniques to accommodate averting and compensating behavior on the part of farmers, including crop switching and other protective measures. Estimate values for esthetic effects of vegetative damages from pollution for both users and nonusers.
Visibility values	Incorporate CV refinements in estimating improved visibility values.

TABLE 2 (continued)

RESEARCH AREA	GOAL
Data Aquisition	
Health	Gather micro data sets specifically structured for health econometric analysis.
Materials	Gather data suitable for accounting for adaptive and compensating behavior in estimating damage values.
Recreation	Obtain data on recreation choice and environmental variables suitable for modeling choice and estimating marine benefits.
Agriculture and pesticides	Assemble data sets incorporating appropriate measures of farmer response to crop damage from pollution, restrictions on current pesticide practices, and pesticide damages.
Visibility	Acquire improved data on exposures to impaired visibility to support benefit estimation.
Ecological effects	Obtain data on physical effects of pollution on sensitive ecosystems, including food chain and other indirect effects.

techniques, methods development for environmental effects, and data acquisition. There is considerable overlap and interdependence among these categories. In most cases technique development arises in the context of analyzing some specific environmental problem. On the other hand, it is usually possible to apply more than one technique to a given environmental problem. The information demands of a particular technique generally motivate acquisition of new data for specific environmental exposures, effects, and recipient responses.

The emphasis of EPA's agenda is consistent with the concerns of the larger environmental research community. Several individuals and groups have constructed lists of important issues for benefits research in the last ten years. Although substantial progress has been made in various areas, there is surprisingly little change in the basic issues identified over time.

Despite differences in orientation and emphasis, the agendas share a substantial number of common concerns. Table 3 lists those issues that appear on more than one of the seven agendas. Appendix 3 summarizes the items in each agenda. The two issues mentioned most frequently are improved methods of revealing preferences and more consistent techniques for aggregating values across regions, media, and benefit categories. All of these issues are included in the EPA agenda, with the exception of discounting problems. This area is a general problem in economics and is the subject of well-funded research elsewhere.

The Benefits Branch expects to continue supporting basic

TABLE 3

Issues Mentioned by More Than One Source

Issue	(A)	(B)	(C)	(D)	(E)	(F)	(G)
Better risk estimates	x				x	x	
Methods to reveal preference	x			x		x	x
Methods to aggregate values	x	x			x		x
Discounting problems	x	x			x		
Subjective v. objective risk	x				x		x
General equilibrium models		x		x			
Substitution behavior		x				x	x
Integrate economic and epidemiological studies			x		x		x
Changes in life expectancy			x		x		
Cross comparison of estimation techniques			x			x	
Benefit estimates of past policies			x		x		
Improved agricultural estimates				x		x	
Voluntary v. involuntary risk					x	x	x
Monetization of nonmarket values		x			x		

(A) National Academy of Sciences, Environmental Quality and Social Behavior: Strategies for Research, 1973.

(B) Jordening, David L., and James K. Allwood, "Research Needs and Priorities: Water Pollution Control Benefits and Costs," EPA Office of Research and Development, EPA Report No. 600/5-73-008b, October 1973.

(C) Freeman, A. Myrick III, The Benefits of Environmental Improvement, The Johns Hopkins University Press, 1979, and Freeman, A. Myrick III, "Benefits of Pollution Control," in A. Hershaft editor, Critical Review of Estimating Benefits of Air and Water Pollution Control, EPA Office of Research and Development, EPA Report No. 600/5-78-0Y4, 1978.

(D) Crocker, Thomas D., "Benefits of Air Pollution Control," in A. Hershaft, editor, Critical Review of Estimating Benefits of Air and Water Pollution Control, EPA Office of Research and Development, EPA Report No. 600/5-78-0Y4, 1978.

(E) Vaupel, James W., "Priorities for Research on the Benefits of Health, Safety, and Environmental Regulations," in Allen R. Ferguson, editor, Attacking Regulatory Problems: An Agenda for Research in the 1980's, Ballinger Press, Cambridge, 1981.

(F) Resources for the Future, "A Program of Economic Research on Improving Estimation of Benefits from Reduced Pollution," unpublished report, February 1981.

(G) Environmental Law Institute, "Proposed Economic Agenda: A Working Paper," unpublished report, December 1983.

methods development and data acquisition to support improved benefit-cost analyses of environmental regulations. Although air and water benefits research will be emphasized because of the large number of policy applications expected in these areas, the research program will continue to expand its efforts in pesticides, toxic substances, and hazardous wastes. However, the scale of such new initiatives depends on future budget constraints.

APPENDIX 1

Current Policy Analysis Program

AIR

Diesel Studies
Acid Precipitation
NAAQS for Particulate Matter
NAAQS for Nitrogen Dioxide
NAAQS for Lead and Sulfur Dioxide
Hazardous Air Pollutants
NSPS for Synthetic Organics, Boilers, etc.
General Methodology for Air Quality Benefits

WATER

Groundwater Strategies
Organic Chemicals Effluent Guidelines
Ocean Dumping
Combined Sewer Overflows
Miscellaneous Water Methodologies
POTW Strategy

HAZARDOUS WASTES

Land Disposal Prohibition
Risk Assessment
Risk Valuation
Hazardous Waste Siting
Hazardous Waste and Property Values
Ocean Incineration

SUPERFUND

Decision Framework
Cost-Effectiveness of Remedial Actions

TOXICS

Pesticide Risks
Pesticide Simulation Models
Pesticides Risk-Benefit Overview

AGGREGATE BENEFITS

Multimedia Benefits

GENERAL GUIDANCE

Health Values
Ecological Values
RIA Guidelines
New Source Bias
Fees
Information Dissemination

APPENDIX 2

Current Research Program

Methodology	Current Co-op Agreements
Travel cost method	Maryland, RFF
Clinical experiments	Wyoming
Health econometrics	RAND, Maryland, Pittsburgh/Wyoming, Pittsburgh/NBER
Benefit aggregation	Kentucky, RFF, Berkeley
Cross comparisons	Maryland, RFF, Harvard, Chicago, Kentucky, Vanderbilt
Hedonic technique	Harvard, Maryland, Kentucky, RFF
Contingent valuation technique	Wyoming, Vanderbilt, RFF, Kentucky, Chicago, Duke
Discounting problems	----
Net benefit estimates	Illinois, Berkeley
Effects and Value Estimation	
Change in and value of mortality	Chicago, RAND, Pittsburgh/Wyoming, Pittsburgh/NBER, Maryland, Duke, Vanderbilt, Berkeley
Value of morbidity	Chicago, RAND, Pittsburgh/Wyoming, Pittsburgh/NBER, Maryland, Duke, Vanderbilt, Berkeley
Materials values	Illinois
Nonuser and general ecosystem values	Vanderbilt
Recreation values	RFF, Maryland
Agricultural values and pesticide exposure	Berkeley
Visibility values	Chicago, Wyoming

APPENDIX 2 (continued)

Data Acquisition	Current Co-op Agreement
Pollution exposure and effects	
health	Chicago, RAND, Pittsburgh/Wyoming, Pittsburgh/NBER, Maryland-B, Berkeley
materials	---
recreation	RFF, Maryland
agriculture and pesticides	Berkeley
visibility	Chicago, Wyoming
ecosystems	---

APPENDIX 3

Comparison of Research Agendas

(A) NAS

1. Relations between population values and scientific evidence.
2. Ways of comparing values across different environments.
3. Measures of preferences--intensity, consistency, and tenacity.
4. Processes of formulating goals.
5. Methods of resolving incompatibilities between values and goals.
6. Role of future values (discounting).

(B) Jordening and Allwood

1. Estimating benefits and costs of specific pollutants.
2. General-equilibrium economic and hydrologic models of complex intra- and interbasin relationships.
3. Formulating a value measure to aggregate nonmonetary benefits and costs.
4. Improving measures of uncertainty.
5. Quantifying substitution effects.
6. Developing an aggregation framework to calculate regional and national values.
7. Improving intertemporal comparisons and discounting.

(C) Freeman

1. Large-sample epidemiological studies to establish health dose-response functions.
2. Changes in probability distributions of life expectancy, rather than simple mortality.
3. Regional recreation benefits models.
4. National recreation participation survey linked to supply of opportunities.
5. Cross check CV and travel-cost estimates of same benefits.
6. Expert panel to develop periodic national benefit estimates.
7. Program to gather and analyze data on national value of past regulatory actions.

APPENDIX 3 (continued)

(D) Crocker

1. General-equilibrium property value models.
2. Household production function models of health effects.
3. Labor productivity studies.
4. Construction of economic indices of environmental quality.
5. Experiments to elicit accurate revelation of preferences.
6. More sophisticated econometric techniques.
7. More sophisticated models of agricultural markets.

(E) Vaupel

1. Improved measures of risk for future effects.
2. Estimates of benefits of past programs.
3. Epidemiological studies of risk factors for various subpopulations.
4. Changes in life expectancy.
5. Perceived v. actual risks.
6. Adaptations to risk.
7. Constraints on exposures v. provision of information on risks.
8. Voluntary v. involuntary risks.
9. Criteria for "acceptable risk."
10. Monetization of risks to life and health.
11. Weighting future effects.
12. Weighting effects for vulnerable or disadvantaged groups.
13. Accounting for large uncertainties.

(F) RFF

1. Estimating better dose-response relations.
2. Risk premiums in market data.
3. Comparison of various estimation techniques.
4. CV applications to visibility, existence values, option value, and anxiety.
5. Use of membership and contributions to environmental groups.
6. Agricultural damages from farm-level cost functions.
7. Human health effects from work place exposure data.
8. Materials damage estimation.
9. Voluntary v. involuntary exposure.
10. Methods of aggregating benefits.
11. Refining the hedonic method.
12. Substitution effects from nonuniform environmental changes.

APPENDIX 3 (continued)

(G) ELI

1. Experimental studies on chronic morbidity, uncertain health effects, and value of noncommercial species.
2. Differences in perceived and actual risks for both health and environmental effects.
3. Compatibility between risk assessment and benefit analysis, policy analysis and research, and physical damage functions and economic analysis.
4. Need for increased accuracy, rather than precision of estimates.
5. Better integration of physical science and economics.
6. Avoidance behavior.
7. Aggregation problems.
8. Improvements in cost analysis techniques.
9. Including psychological behavior in economic models of preference relevation.
10. Consistency in treatment of uncertainty, baselines, preference assumptions, time horizons, etc.

APPENDIX 4

Selected Recent Research Reports on the Economic Benefits of Pollution Control Funded by EPA

EPA/230-07-83-004 Methods Development for Environmental Control Benefits Assessments, Volume I, Measuring the Benefits of Clean Air and Water, Allen V. Kneese, Resources for the Future, Washington, DC (forthcoming).

EPA/230-07-83-007 Methods Development for Environmental Control Benefits Assessments, Volume II, Six Studies of Health Benefits from Air Pollution Control, Shaul Ben-David, Reza Pazand, Thomas D. Crocker, Ralph C. d'Arge, Shelby Gerking, William D. Schulze, Curt Anderson, Robert Buechley, Maureen Cropper, Lawrence A. Thibodeau, University of Wyoming, Laramie, WY (forthcoming).

EPA/230-07-83-008 Methods Development for Environmental Control Benefits Assessments, Volume III, Five Studies on Non-Market Valuation Techniques, David S. Brookshire, William D. Schulze, Ralph C. d'Arge, Thomas D. Crocker, Shelby Gerking, Mark A. Thayer, University of Wyoming, Laramie, WY (forthcoming).

EPA/230-07-83-009 Methods Development for Environmental Control Benefits Assessments, Volume IV, Measuring the Benefits of Air Quality Improvements in the San Francisco Bay Area: Property Value and Contingent Valuation Studies, Edna Loehman, David Boldt, and Kathleen Chaikin, SRI International, Menlo Park, CA (forthcoming).

EPA/230-07-83-010 Methods Development for Environmental Control Benefits Assessments, Volume V, Measuring Household Soiling Damages from Suspended Air Particulates: A Methodological Inquiry, R.G. Cummings, H.S. Burness, R.D. Norton, University of New Mexico, Albuquerque, New Mexico (forthcoming).

EPA/230-07-83-011 Methods Development for Environmental Control Benefits Assessments, Volume VI, The Value of Air Pollution Damages to Agricultural Activities in Southern California, Richard Adams, Thomas D. Crocker, Narongsakdi Thanavibulchai, University of Wyoming, Laramie, WY (forthcoming).

APPENDIX 4 (continued)

EPA/230-07-83-012 Methods Development for Environmental Control Benefits Assessment, Volume VII, Methods Development for Assessing Acid Deposition Control Benefits, Thomas D. Crocker, John T. Tschirhart, Richard Adams, Bruce Forster, University of Wyoming, Laramie, WY (forthcoming).

EPA/230-07-83-013 Methods Development for Environmental Control Benefits Assessment, Volume VIII, The Benefits of Preserving Visibility in the National Parklands of the Southwest, William D. Schulze, David S. Brookshire, Eric Walther, Karen Kelly, University of Wyoming, Laramie, WY (forthcoming).

EPA/230-07-83-014 Methods Development for Environmental Control Benefits Assessment, Volume IX, Evaluation of Decision Models for Environmental Assessment, John Sorrentino, Temple University, Philadelphia, PA (forthcoming).

EPA/230-07-83-014 Methods Development for Environmental Control Benefits Assessment, Volume X, Executive Summary, David Brookshire, Thomas Crocker, Ralph d'Arge, William Schulze, Shaul Ben-David, Ronald Cummings, Allen Kneese, Edna Loehman, University of Wyoming, Laramie, WY (forthcoming).

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