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Science and Environmental Decision Making: The Potential Role of Environmental Impact Assessment in the Pursuit of Appropriate Information

ABSTRACT

The relationship of science to environmental decision making is complex and controversial in public policy. This is particularly true with regard to a set of problems of emergent complexity characterized by multiple authorities and agencies and varying protocols, decision rules, data types, and political incentives. This article reviews alternative explanations of the sometimes troubled relationship between science and environmental decision making. It then inventories constructive avenues for change – including better use of institutions for generating scientific information and integrating it into decisions. These avenues include outcome effects institutes, administrative rulemaking, consensus workshops, and science advisory boards. A particular focus is on environmental impact assessment.

The National Environmental Policy Act, NEPA, and its state forms, SEPAs, are laws that require assessment of impacts associated with government and, in some cases, private projects. By many, they have not been appreciated as major contributors to addressing complex environmental challenges. Rather, they are often viewed as a necessary step, of limited scientific significance, in a project specific context. However, when compared with other strategies for making better government decisions to protect natural resources and the environment while pursuing other goals, the assessment process looks quite strong. It can be made even stronger. We overview and discuss suggested reforms and improvements in the environmental impact assessment process. The context goes beyond changes in NEPA and its progeny and addresses impact assessment as an evolving and still promising tool in environmental decision making generally. We evaluate

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recent far-reaching suggestions on making this strategy more useful and usable, with particular attention to the generation and use of scientific information beyond the project specific case.

INTRODUCTION

There have been few times when the force of science was more important in relation to understanding and protecting the environment. Without science, we would not be able to draw the relationships between the burning of fossil fuel and global climate change, between human activities and the disappearance of plant and animal species, and between the exposure of humans to some chemicals and the adverse consequences to human health. Yet, the relationship of science to environmental decision making is complex and a matter of considerable controversy in public policy.[1] The public has rejected assumptions that scientists are the sole arbiters and protectors of "sound science" and that the word of science should be taken as definitive, objective, and neutral. For instance, notions of risk diverge sharply between scientists and affected communities when it comes to the discussion of exposure of communities to hazardous wastes. Furthermore, scientific risk assessments have no particular privileged status in these discussions.[2] Another example where notions of risk diverge is with the quality of water. While the public is sensitive to taste, smell, and clarity of drinking water and wants assurances that water has no possibility of affecting health, scientists focus on the many constituents of water, many of which are not detectable by ordinary human senses, and recognize that risks can not be completely eliminated, only greatly reduced.

There are many explanations for divisions between science and environmental decision making and a number of suggested ways to bridge the gaps. Parts of the scientific community believe that governmental officials and agency bureaucrats are ignorant and that self-promotion by a few rogue scientists furthers the gap between science and environmental decision making. They recommend better public understanding of science through more education of non-scientists about scientific methods. They also recommend ways to identify scientists

1. Decision making over the years has been a catchall phrase for what government does that influences—even in some remote way—environmental quality. For this article we use the term quite broadly but consistent with what we develop below are the activities addressed by environmental impact assessment law.

2. SYLVIA NOBLE TESH, UNCERTAIN HAZARDS: ENVIRONMENTAL ACTIVISTS AND SCIENTIFIC PROOF 81-82 (2000).

doing poor and/or narrowly interest-driven science.[3] We believe that matters are more complicated. This article reviews some alternative explanations of the troubled relationship between science and environmental decision making and then it inventories constructive avenues for change, including changes that build on already known procedures for integrating scientific information into decision making. We particularly focus on the much known and often maligned environmental impact assessment process.

I. EMERGENT COMPLEXITY

The nature of environmental problems has undergone a fundamental change. Many modern environmental problems have multiple definitions as to their nature as well as multiple and conflicting criteria for their solutions. These problems are characterized as problems of emergent complexity (colloquially known as "wicked problems").[4] No single perspective or point of view can capture the totality of "emergent complexities" problems. They reflect profound differences in societal priorities and values. Solutions for one problem may be problems for others, and there are few rules for determining when the problems are solved.[5]

"Normal" science is no longer adequate to understand problems of "emergent complexities." Normal science is rational knowledge based

3. In October 2002, the Data Quality Act became law. Treasury and General Government Appropriations Act for Fiscal Year 2001, Pub. L. No. 106-554, 515, 114 Stat. 2763 (2000), codified at 44 U.S.C. § 3516 (2000). Passed as a little followed rider to a much larger piece of legislation, it requires government to set standards for the quality of scientific information that it disseminates. It allows citizens to challenge errors in government provided or circulated scientific results. Under the Act, the government must create procedures "ensuring and maximizing the quality, objectivity, utility and integrity" of scientific information. *Id.*

An interesting debate has emerged on whether the Act's prime users will be those who wish to slow down government regulation independent of concerns about science or those whose primary concerns are with quality. *See* Andrew C. Revkin, *Law Revises Standards for Scientific Study*, N.Y. TIMES, Mar. 21, 2002, at A30. An early study of the use of the Act found limited use, including a lawsuit seeking to stop the federal government from disseminating an assessment of global warming's impact; it was dismissed. Andrew C. Revkin, *National Briefing Washington: Suit on Global Warming Report Is Dismissed*, N.Y. TIMES, Nov. 7, 2003, at A20; *see also* James W. Conrad, Jr., *The Information Quality Act: Antiregulatory Costs of Mythic Proportions?*, 12 KAN. J.L. & PUB. POL'Y 521, 521–48 (2003).

4. For a discussion of complexity and wicked problems in water resources, see Helen Ingram et al., *Taming the Waters: Strategies to Domesticate the Wicked Problems of Water Resource Management*, 3 INT'L J. WATER 1 (2000). For use of the term "wicked problems," see C. West Churchman, *Wicked Problems*, 14 MGMT. SCI. B141, B141–42 (1967).

5. Horst W.J. Rittel & Melvin M. Webber, *Dilemmas in a General Theory of Planning*, 4 POL'Y SCI. 155, 160–66 (1973).

on parsimonious theory and empirical observation that is meant to be objective and neutral. Normal science is disciplinary based and usually involves sophisticated modeling and quantitative analysis. It is often done on questions that have been simplified to address causation as between limited sets of phenomena or variables. Even though results from "normal" scientific research are limited, the results can still assist in finding solutions for the problems of emergent complexity. Like all problems, relevant information about their causes will assist in finding their solutions.

Another layer of complexity in addressing these environmental problems of emergent complexity is that it is often done where many agencies are involved and these agencies have different missions. Many times there are differences over assumptions to be made, such as extrapolating data to humans, extrapolating one dose to different doses, or generalizing one animal model to different animal models. Furthermore, rules for decision making may vary.[6] Some of the more recently controversial cases in the environmental sciences relate to the health effects of low-level amounts of chemicals in a medium, such as arsenic in water; genetically engineered DNA; and the extent of "contamination" of "natural" strains of corn.[7] Agencies may emphasize precaution over great certainty about negative effects. Some may be guided by statutes that preclude economic analysis. Others may factor other than health effects information into their conclusions.[8] (See Figure I.)

6. In June 2002, the American Medical Association published an article indicating that published studies, including those undertaken with peer review, are sometimes misleading and often fail to mention weaknesses such as reporting relative reduction in risk rather than absolute reduction in risk and failing to disclose researcher ties to companies that have financed studies. Tom Jefferson et al., *Measuring the Quality of Editorial Peer Review*, 287 J. AM. MED. ASS'N, 2786, 2787 (2002); *see also* Conrad, *supra* note 3, at 521.

7. In April 2002, the journal NATURE announced it should not have published an article on contamination of Mexican native corn with genetically engineered DNA based on conflicting views of the extent to which the experimental technique of polymerase chain reaction had produced acceptable evidence of implantation of foreign genes. Carol Kaesuk Yoon, *Journal Raises Doubts on Biotech Study*, N.Y. TIMES, Apr. 5, 2002, at A21.

8. *See* Adam Babich, *Too Much Science in Environmental Law*, 28 COLUM. J. ENVTL. L. 119, 126-38 (2003); M. Elizabeth Magill, *Agency Choice of Policymaking Form*, 71 U. CHI. L. REV. 1383, 1386-1403 (2004).

Figure I: Characteristics of Complex Contemporary Environmental Problems*

Numerous possible sources of problem

Authorities for defining problems and considering solutions and solution definition are multiple and decentralized

Agencies studying are numerous and foci differ[9]
- Health
- Environment
- General welfare/designated use

Protocols, methodologies differ
- Models Differ
- Varying spatial and time scales of consideration
- Quality control employed varies
  Peer review
  Other

Interpretation principles/decision rules differ
- Precautionary
- Safety valve
- Adequate margin of safety
- Economically viable

End points and/or Subjects differ[10]

Interpretative judgments required across disciplines

Multiple data types involved: epidemiology, toxicology, structure-activity studies, exposure, metabolism, pharmacokinetics

Political incentives to characterize:
- Minimize risks
- Maximize or exaggerate risk

Communication of Risk Challenge

*Contains some or most of the following characteristics

The normal scientific perspective and "sound science"[11] can go only so far in directing decision makers to sound solutions. There is little

9. For example, in the water quality field the following groups are involved: the U.S. Environmental Protection Agency; numerous state agencies, sometimes with conflicting priorities; regional water quality control boards; and local governments.

10. If environmental health outcomes data comes from studies of only certain groups within the population, it is not always safe to conclude that results will be similar for other populations. *See* Associated Press, *EPA Proposes New Cancer Risk Guidelines*, Mar. 4, 2003. Some EPA studies of potential carcinogens had been based on animal studies and data collected in adults where the impacts on children have never been addressed. It is possible that some mutagens cause a "10 times greater risk of a future cancer in children under 2 years old and in fetuses when the mother is exposed" than in adults. *Id.* The EPA and its Science Advisory Board have proposed stringent new guidelines to protect children.

agreement about how to define "natural."[12] There is also little consensus on issues of acceptable risk, serious and lasting environmental danger, and relative contributions of environmental factors to human health. Furthermore, what is desirable is a question at the heart of many disputes. People disagree about what is an acceptable environmental quality when achieving it involves costs of several kinds. Finally, it is difficult to separate humans and their values from the notion of the intrinsic quality of anything natural.

II. THE MIXTURE OF SCIENCE AND POLITICS IN ENVIRONMENTAL POLICY MAKING

Politicians and the public tend to believe that, all else being equal, scientific expert opinion is valuable when discussing policy proposals about environmental improvement. The public considers science as almost universally useful in understanding causal linkages and means/ends relationships underlying the connection of policy to environmental protection. All sides in environmental policy questions seek the endorsement of scientists and professionals. However, the public knows that scientific findings are interpreted differently by different interests. They also know that scientific effort is channeled not only by researchers' interests but also by the availability of funding and other support. Furthermore, there is considerable disagreement among scholars about the circumstances under which science is used as a rationale or justification and the ways that science should be carried out so that it can exercise real influence in shaping policy content. Governmental officials sometimes expropriate the open-ended nature of scientific investigation and scientific uncertainty when it is politically useful.[13]

In the areas of intense environmental conflicts, scientists have only limited influence where policy is the focus of a fierce struggle between contesting coalitions of interest groups. In light of the ties among science, politics, and policy making, it is not surprising that members of the public have become a good deal more critical than they

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11. By "sound science," here we mean investigations that meet generally accepted rules of methodological rigor and objectivity.

12. For example, how should decision makers treat what some scientists consider background levels of toxic substances in ground water?

11. ANNE LARASON SCHNEIDER & HELEN INGRAM, POLICY DESIGN FOR DEMOCRACY 158-59 (1997). The recent official federal position on global climate change is a major significant example, despite unprecedented consensus in many results. *See* Naomi Oreskes, *Beyond the Ivory Tower: The Scientific Consensus on Climate Change*, 306 SCIENCE 1686, 1686 (2004).

once were in discerning the bias embedded in the communications about scientific findings.[14] What the public does not understand, however, is that the types of questions raised in the environmental arena are inherently subject to challenges regarding causation of the problems. Predominant institutions have generally not evolved to address problems of emerging complexity. Even in those situations where bias is minimal and influence is non-existent, the results of scientific research are non-responsive to some of the questions being asked about protection of the air, the seas, the land, and biodiversity.

Science often clashes with citizen understandings of causation. For example, when communities exposed to toxic and hazardous waste are faced with data from environmental epidemiology studies that find the illness profile of their community is not much different from other communities not exposed to toxic and hazardous waste, grass roots mobilizers are often not persuaded.[15] They maintain that the rules for statistical significance are unreasonably strict, that many relevant illnesses have a long latency, and that the consequences have yet to become evident.[16] They may also argue that the study did not focus on particularly sensitive members of the community such as children.[17] Moreover, community members will assert that ordinary, experiential knowledge is discounted, and that they have greater confidence in their own, locally based observations than in an imposed judgment from outside their community.

Other examples where communities or other non-scientific groups discount the scientific studies involve epidemiological studies of exposure to materials and chemicals in media or in the workplace and the use of medical devices or technologies and health outcomes.[18]

Institutions that generate and disseminate scientific data already exist within the environmental community. These institutions could be reformed so that they could consolidate information from different

14. Dennis L. Soden, *At the Nexus: Science Policy, in* AT THE NEXUS: SCIENCE POLICY 1, 1–4 (Dennis L. Soden ed., 1996).

15. The well-known cases of Love Canal and Woburn, Massachusetts, demonstrate the differences between official studies and popular epidemiology. In both cases, local perceptions and data collection on illness forced officials to reconsider initial positions.

16. For a discussion of popular epidemiology, see FRANK FISCHER, CITIZENS, EXPERTS, AND THE ENVIRONMENT 151–55 (2000).

17. TESH, *supra* note 2, at 32.

18. The manufacturers of breast implants paid multi-billion dollar settlements based on the conclusion that implants cause serious diseases. Later, the Institute of Medicine of the National Academy of Sciences said there was not persuasive evidence that serious ailments that some juries blamed on them, lupus among them, were caused by the devices. William Glaberson, *The Courts vs. Scientific Certainty*, N.Y. TIMES, June 27, 1999, § 4, at 5.

studies and place the data of narrow issues within the framework of the problems of emergent complexity.

Criteria for Evaluating Institutional Reforms

No consensus exists among scholars as to the preferred criteria for evaluating suggested institutional modifications to the relationship between science and policy. Different interest groups tend to support modifications that would improve their access to and influence over scientific processes and their applications. We list four of the broad criteria that appear in many proposals for reform.

1. One of the important roles of improved institutions is to place immediate and specific policy issues in the broader scientific context. Complex problems and their uncertainties lead to continual re-framing of problems by different interested parties hoping to influence decisions. For example, urban water runoff may be framed as a public health issue, a land use issue, an example of bureaucratic overreach, or an unfunded mandate. Various political actors marshal and shape scientific evidence to support a favored framing of problems. To overcome this problem, a general repository of scientific information would be available. These repositories would place the narrow issue constructions within the larger context of all the other available scientific evidence on the broader problem. By focusing on the narrow issue, normal science creates new knowledge that has to meet tests and pass review of scientists themselves. However, as stated above, environmental problems are increasingly characterized by emerging complexities, and, therefore, knowledge must be examined for its ability to inform actual pressing problems and to respond to a wide range of social interests.[19]

2. Institutions need to improve communication and networks among scientists in different agency, non-governmental organizational, and academic settings. Too often scientific information is produced in organizational settings where it is accepted but is never successfully

19. Numerous parallel movements in generating policy-relevant scientific information have been recognized. For a discussion on civic science and adaptive learning, see Kai N. Lee, COMPASS AND GYROSCOPE (1993). For a discussion of transcientific studies, see Silvio Funtowicz & Jerome R. Ravetz, *Emergent Complex Systems*, 26 FUTURES 568, 568 (1994). For a discussion of the dialogic model, see BRUCE A. WILLIAMS & ALBERT R. MATHENY, DEMOCRACY, DIALOGUE, AND ENVIRONMENTAL DISPUTES: THE CONTESTED LANGUAGE OF SOCIAL REGULATION (1995). For a discussion of community based science, see COMMUNITY BASED COLLABORATIVES RESEARCH CONSORTIUM, *at* http://www.cbcrc.org (last visited Apr. 11, 2005). These various approaches agree that there needs to be a more plural notion of the contribution of different disciplines and stakeholders.

transmitted outside of the organization.[20] Institutional design should encourage communication and networking among the different institutions.

3. Scientific knowledge must be credible and trustworthy. The public is understandably suspicious of information that appears to come from a prejudiced source or that is produced in a process that does not reflect accepted scientific procedures and protocols.[21] The issue goes beyond simple matters of conflict of interest, bias, and peer review. Trust and credibility adhere to well-established institutions and procedures that have been relied upon by all relevant parties to disputes. Modifying processes and institutions that have some credibility rather than establishing new institutions makes sense.

4. Scientific processes must be open, transparent, and participatory. There may be ways in which ordinary citizens can inject experiential knowledge into the scientific processes. Participatory mechanisms need to allow citizens access to the scientific process from the initiation of studies to the collection of data and the interpretation of results.

In the next section, we inventory several different approaches to the generation, interpretation and dissemination of scientific information. We review the spectrum of approaches from the industry specific to the general project oriented. We argue that elements of each approach can be integrated to make scientific investigation more responsive to contemporary environmental decision making. There are ongoing parallel activities aimed at increasing knowledge of the environmental impacts of societal actions: we should strive to make them synergistic.[22] (See Figure II.)

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20. For example, at the federal level, scientific results that support a rule in one agency (such as Agriculture) may not be made available to agency rulemaking in another (such as Interior).

21. *See* discussion *supra*, in section titled "Mixture of Science and Politics in Environmental Policy Making" and accompanying footnotes.

22. This treatment focuses on U.S. institutions, but the argument generalizes to the global level and in a future paper we hope to be specific about the international institutions and synergies that we identify. *See, e.g.*, Note, *The CITES Fort Lauderdale Criteria: The Uses and Limits of Science in International Conservation Decisionmaking*, 114 HARV. L. REV. 1769, 1769-92 (2001).

FIGURE II: Institutions for the Pursuit of Appropriate Information for Environmental Decisions

Function / Institution	Make Better Scientific Decisions	Generate Regulatory Standards	Undertake New Scientific Investigations	Generate Project Specific Data
Health Effects Institutes	X	X	X	X
Administrative Rulemaking	X	X		
Consensus Workshops	X	X		X
Science Advisory Boards	X	X	X	X
Environmental Impact Analysis	X			X

III. INSTITUTIONAL MODELS AND ALTERNATIVES

A. Health Effects Research Institutes

Increasingly, the public is concerned about the impact of new technologies on their health.[23] Institutions that address these effects in non-biased ways enhance the availability of high quality scientific results. A number of research organizations on health effects exist. For example, the Health Effects Institute (HEI) was created in 1980 to provide impartial and relevant science on the health effects of air pollutants from motor vehicles and from other sources. Air pollution manifests many of the same characteristics as many other modern environmental problems. For example, there are questions about regulation of the automobile industry that touch on the nature, extent, and seriousness of health effects. Furthermore, there is an immense variety and variability of sources of potentially relevant data that can be applied in other contexts.

The U.S. Environmental Protection Agency (EPA) and the automobile industry support HEI jointly. HEI generates research findings on the health effects of carbon monoxide, methanol and aldehydes, nitrogen oxides, diesel exhaust, ozone, particulates, and other air pollutants. The institute reports also on a broad area of scientific investigation, for example on health effects of asbestos. It identifies

23. Recent concerns include those about cell phone use, genetically engineered foodstuffs, and electromagnetic fields associated with transmission lines.

priority areas for research and then funds and oversees the conduct of the research. The institute also provides review of HEI-supported and related research, as well as integrating HEI's research results with those of other institutions into broader evaluations and communicating results to decision makers.[24]

B. Administrative Rulemaking

Many agencies, federal and state, set standards to comply with statutes, such as arsenic levels in drinking water. The standard-setting process in administrative law in the United States and in some states has characteristics of scientific information creation that make results useful for environmental decision making.

In brief, the standard-setting process begins when Congress (or a state) passes statutes that lay out general principles and goals of a regulatory program. Specific standards are often left to development by administrative agencies. When determining a standard, the agency collects the best available scientific information available and formulates a proposed rule.[25] This gathering of information can either be through an informal or a formal process. The proposed rule is then published, for example, at the federal level, in the Federal Register. Comments are then solicited. This process is potentially open to broad participation. Input into the process can be subject to formal rules and can include cross-examination and critique by opposing scientists.

Another version of the standard-setting process is based on cooperative rulemaking and is known as negotiated rulemaking.[26] In negotiated rulemaking, representatives of the regulated industry, representatives from environmental organizations, and others interested are brought together to develop a proposed rule. In most cases, the resulting standards are based on highly respected and well-vetted scientific procedures.

Often, agencies need to make decisions for specific projects. The decisions for specific projects demand high quality scientific information. For these specific project decisions, the agency process is quite different from the processes described above. For example, in Nuclear Regulatory Commission (NRC) adjudicative procedures before a licensing board for

24. Another example is the Lovelace Respiratory Research Institute, which has addressed the generation, monitoring, and study of the toxic effects of airborne noxious agents.

25. See, for example, the role of scientific information in the creation of Total Maximum Daily Load (TMMDL) under The Clean Water Act, 33 U.S.C. §§ 1251-1387 (2000).

26. Magill, *supra* note 8, at 1399.

record making, scientists participate but lawyers are the decision makers. An administrative law judge presides and panels include a scientist with appropriate expertise. Two of the three Licensing Board members must have technical or other qualifications "appropriate to the issues to be decided" in the licensing.[27] A geologist might be on a panel considering licensing a nuclear power facility in a seismically active area or an aquatic biologist might participate if a proposed facility is near an estuary.[28]

C. Consensus Workshops

In consensus workshops, scientists from industry, government, public interest groups, and the academic community attempt to isolate and summarize the best research results on components of a scientific controversy.[29] Workshops bring together experts for an intensive analysis of all available published and unpublished work on a topic. The idea is to develop a consensus after analysis and review of studies that have been conducted worldwide and to offer regulatory useful scientific conclusions.[30] Epidemiology, metabolic and biochemical analyses of suspect materials, exposure, analytical technology, and sensitization may be the topics addressed by panels of experts who have undertaken studies on a subject substance or issue.[31]

The consensus workshop can summarize what is known about health and environmental effects and usefully establish bounds around the nature of uncertainties and information gaps for regulators. The workshop can evaluate the quality of a finite, although large, research effort. It offers scientists opportunities to question and to challenge each other in ways not common in laboratory settings. The workshop

27. Nicholas A. Robinson, *Legal Systems, Decisionmaking and the Science of Earth's Systems: Procedural Missing Links*, 27 ECOLOGY L.Q. 1077, 1140 (2001) (explaining the Atomic Energy Act of 1954, 42 U.S.C. §§ 2011–2281).

28. *Id.*

29. A Google search on Consensus Workshop produced sites for subjects ranging from sudden cardiac death as a major health hazard to the toxic effects of long-term PUVA Therapy.

30. Various organizations employ some version of this approach. At the National Institutes of Health (NIH), the term used is Consensus Development Conference and a major topic example is biomedical technology. NIH consensus statements are prepared by "non advocates" based on presentations during a public session, questions and statements from the conference, and "closed deliberations" by the panel. The statement is an independent report, not a federal policy statement.

31. Joseph F. DiMento, *Der Consensus Workshop: Ein Geeignetes Forum fur Grenzwertsetzung?* (When Rats Die and We Don't Know Why: Institutional Innovations for Improving the Scientific Basis of Environmental Regulations) *in* GRENZWERTE (Gerd Winter ed., 1986).

provides for a type of centralized information gathering resource that is rare in some scientific fields. It also provides a vehicle for scientists to develop a multidisciplinary understanding of future research needs and of regulatory specific research methodologies. The workshop is a place where data can be pooled, and it allows the resources of government to be focused on a single regulatory relevant problem. Challenges to application of results of the consensus workshop exist but these can assist in addressing reforms for incorporating scientific information in decision making.[32]

As with the science court,[33] participants in workshops should be unusually capable[34] scientists having no obvious connections to the disputed issue.[35] Locating scientists who are both well informed about a technological issue and separated from connections to the affected parties remains a challenge.[36] Furthermore, in the scientific community, one can move from having "impeccable credentials" to being considered by prevailing leaders as working outside a realm of expertise. Indeed, the very existence of consensus on who should participate may indicate a weakness in a context where non-paradigmatic positions should be addressed.[37]

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32. Epidemiologists differ over numerous matters—ranging from proper end point definition to ways of combining data in different studies to create a data set. Experts also disagree over how to search for relevant scientific reports, the number of reports that make up a sufficient database, how outlier findings are to be treated, whether a paper is an outlier or a harbinger of a trend, and the characteristics that define an acceptable study. These are concerns about data quality no matter how generated or used and should be considered in filtering data for decision making. Scientists differ on the manner in which research questions should be framed and on what end-points are important. And clinicians may differ dramatically in their interpretations of a subject. These are the kinds of questions that decision makers should address for any information introduced into the decision-making process or they should expect some other level of review to have done so.

33. First proposed in the 1970s, the court would be a forum where factual technical issues are adjudicated and results made available to decision makers. Arthur Kantrowitz, *Controlling Technology Democratically*, 63 AM. SCIENTIST 505, 506–09 (1975).

34. Determining this standard is not simple, but it might be attained by seeking convergence of nominees by the relevant scientific societies and vetting choices with special panels such as those of the National Academies.

35. Task Force of the Presidential Advisory Group on Anticipated Advances in Science and Technology, *The Science Court Experiment: An Interim Report*, 193 SCIENCE 653, 654 (1976).

36. *See* Andrew C. Revkin, *Dispute Arises over a Push to Change Climate Panel*, N.Y. TIMES, Apr. 2, 2002, at A10 (describing the Bush administration's attempts to replace the chairman of the Intergovernmental Panel on Climate Change in the face of industry pressures). The incumbent had been Dr. Robert T. Watson, "an outspoken advocate of the idea that human actions—mainly burning oil and coal—are contributing to global warming and must be changed to avert environmental upheavals." *Id.*

37. Several other issues make true consensus elusive. Among them:

D. Science Advisory Boards

Science advisory boards provide views to governmental agencies on many issues, from general issues, such as how to make better decisions, to project-specific regulatory information and standards. As an example, the EPA administers the Science Advisory Board (SAB). Established by Congress in 1978, it is the SAB's mission to "make available...advice and comments on the adequacy of the scientific and technical basis of the proposed [federal] criteria document, standard, limitation, or regulation."[38] It also functions as a technical peer review panel. Its agenda is developed based on requests from Congress, the EPA Administrator, and the EPA regions, program offices and departments of the agency. The Federal Advisory Committee Act (FACA) requires a "balanced" panel that is seeking "a range of legitimate, technical opinion."[39]

-What is an appropriate exercise of scientific judgment even when there are considerable good data on a topic?
-Which mathematical model to employ in fitting available data especially when there is a small number of points
-Whether data on one species should be exclusively used or whether extrapolations across species should be routinely undertaken in the absence of clear scientific reasons to do so
-Whether a safety factor should be added to risk assessments even if an observed "no effect" level of exposure could be found.

38. Environmental Research, Development, and Demonstration Authorization Act, 42 U.S.C. § 4365 (2000).

39. Attempts are made to balance committees on the basis of geography, ethnicity, gender, and sector. No member of the SAB can be a full-time federal employee. It is the case, however, that, according to the Government Accounting Office (GAO), the SAB has been criticized for having scientists who often have conflicts of interest. *See* Eric Pianin, *Toxic Chemical Review Process Faulted: Scientists on EPA Advisory Panels Often Have Conflicts of Interest, GAO Says*, WASH. POST, July 16, 2001, at A2.

Other entities generating scientific information for policy makers having characteristics that may also be applicable to the types of problems we address in this article include state and regional government science boards. The Chesapeake Bay Program (CBP) is a regional partnership of Maryland, Pennsylvania, Virginia, the District of Columbia, and the EPA. Subcommittees deal with specific scientific issues affecting the Chesapeake Bay such as nutrients, toxics, monitoring, modeling, and living resources. *See* Chesapeake Bay Program, Bay Program Info, *at* ttp://www.chesapeakebay.net/ (last visited Sept. 2, 2005). The Michigan Environmental Science Board is a permanent state-chartered science board. It aims to provide scientific advice to the governor and to state departments "on matters affecting the protection and management of Michigan's environment and natural resource." *See* Michigan.gov, Dep't of Envtl. Quality, Mich. Envtl. Sci. Bd., MESB Mission, *at* http://www.michigan.gov/mesb (last visited Sept. 2, 2005). The California Bay/Delta Estuary Authority has an Independent Science Board (upon which one of the authors has membership) and other subsidiary science boards to review such programs as ecosystems restoration and the use of water markets for acquiring water for endangered species. The specific charge of the Authority is to integrate the best evolving

E. Environmental Impact Analysis Procedures

"The most significant contribution that the field of environmental law has made to jurisprudence has been to fashion legal procedures that effectively integrate scientific knowledge into the governance framework"[40] Environmental impact analysis (or EIA) is the most generic form of an environmental law requirement, which is "the principal medium through which governmental systems have integrated the environmental sciences into political decision-making...."[41] The National Environment Policy Act's (NEPA) generic procedure for environmental impact analysis "is arguably the most important innovation that environmental law has provided."[42]

We have come to this unfashionable conclusion as well after many years of reviewing alternative strategies for collecting and integrating scientific information into environmental policy making. Reviewing the EIA procedure, Robinson underscores characteristics that mirror what is necessary to address environmental problems of emerging complexity:

> EIA obligates decision makers to set forth a careful exposition of a proposed action, assemble a *competent scientific analysis of the possible impacts* on the environment, *open their information and process to participation* by interested parties and the public, *accept comments or additional scientific information* about the proposal and the assessment, and then undertake a *conscious deliberation* about the

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science into water management. *See* Press Release, California Bay-Delta Authority, California Bay-Delta Authority Appoints Independent Science Board (Aug. 20, 2003), *available at* http://calwater.ca.gov/newsroom/newsreleases_2003/final_newsrelease_cbda_appoints_isb_8-20-03.pdf (last visited Sept. 2, 2005).

40. Robinson, *supra* note 27, at 1142.

41. *Id.* at 1124. Robinson elaborated:

> The procedural dimension of environmental law has been to ensure that...scientific analysis is relied upon in decisions about humans and nature. These procedures couple scientific evaluation with the decisionmaker's essential normative judgment to address specific problems in context: how, in light of competing economic and social factors, and in view of alternative possible technologies, should ongoing or proposed human conduct be modified in order to protect public health and to restore and maintain the integrity of natural systems?

Id. at 1125.

42. The approach now has worldwide adoption. For a discussion of the approach in state law, see Joseph F. DiMento, *State Environmental Impact Review*, *in* ARDEN H. RATHKOPF & DAREN A. RATHFOPF, THE LAW OF ZONING AND PLANNING § 7B (1999); and in regional and international law, see generally JOSEPH F.C. DIMENTO, THE GLOBAL ENVIRONMENT AND INTERNATIONAL LAW (2003).

> environmental effects of the proposal and how to avoid or mitigate those effects....This generic EIA process works because it incorporates scientific knowledge at the very point of decision making.[43]

Nonetheless, Robinson acknowledges that procedural innovations are needed to better link scientific research to the EIA process.[44] We add that, beyond the procedural changes, changes are also needed in the use of scientific information. The grandfather of the impact assessment notion, Professor Lynton Caldwell, concluded that, despite its influence, "NEPA has not come near to realizing its full potential either at home or abroad....The research, oversight, and forecasting provisions of NEPA under Title II have yet to be fully implemented."[45, 46] It is our assessment that we can get more out of the environmental impact process by asking more, not less, of it. With certain reforms and trade-offs, the process can improve important local, regional and national environmental decisions. The reforms described are responsive to critics' concerns. More importantly, these reforms respond to larger scale concerns over NEPA's implementation—and indeed its interpretation.

Some critics have cited three key shortcomings in NEPA's implementation: "(1) a lack of engagement with the NEPA process early in the planning process through interdisciplinary collaboration; (2) a lack of rigorous science and the incorporation of ecological principles and techniques as an appropriate mechanism for enriching our understanding of ecological systems and natural resources; and (3) a lack of emphasis on the Act's substantive goals and objectives...."[47] There are many other shortcomings, including some we consider major.

One such shortcoming is that cumulative effects are often not taken into consideration. "Methods for analyzing a proposed action's incremental contributions to cumulative impacts are generally less advanced than those for project-specific impacts."[48] Cumulative impacts, a serious threat to national environmental quality, include the impacts of "past, present and reasonably foreseeable future actions" independent of who takes those actions, according to the Council on Environmental

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43. Robinson, *supra* note 27, at 1143–44 (emphasis added).

44. *Id.* at 1145.

45. L.K. Caldwell, *Future Significance of the National Environmental Policy Act*, 22 HARV. ENVTL. L. REV. 203, 205 (1998).

46. Among NEPA's purposes is "to enrich the understanding of the ecological systems and natural resources important to the Nation." 42 U.S.C. § 4321 (2002).

47. Claudia Goetz Phillips & John Randolph, *The Relationship of Ecosystem Management to NEPA and Its Goals*, 26 ENVTL. MGMT. 1, 1 (2000).

48. Lance N. McCold & James W. Saulsbury, *Including Past and Present Impacts in Cumulative Impact Assessments*, 20 ENVTL. MGMT. 767, 767 (1996).

Quality.[49] When cumulative impacts are ignored, the likelihood of identifying significant impacts is lessened. And most relevant to our suggested reforms: "the inconsistency of methodologies and of reporting on methodologies and results has, among other reasons, seriously hampered the accumulation of one body of relevant experience and knowledge in the prediction of impacts on biodiversity."[50]

Enhanced environmental impact analysis has some of the characteristics of adaptive management and the two can be mutually reinforcing. This approach emphasizes managing according to a plan. Decisions are made and modified as a function of what is known and learned about a system, including information about the effects of previous management actions. Adaptive management emphasizes formal experimentation with replicates, controls, and extensive monitoring. It inquires retrospectively about alternatives considered, those chosen, and attempts to compare approaches as applied in other systems. Adaptive management is a knowledge driven system, and environmental impact statements can be a central supplier of the relevant data. Lack of monitoring data over long periods can thwart the retrospective analysis so important in policy learning and adaptive management. Because environmental impact statements continually revisit the environmental health of particular regions, environmental assessments build up the knowledge base as they accumulate over time. Our concern is more focused on means of improving the quality of the information, which will be managed in different ways depending on policy needs. The two enterprises, improving the quality of information and using it adaptively, are compatible.

Various criteria are used when evaluating reform ideas. Here we employ one: quality of information available. The reforms we discuss fall into two categories: one, those reforms that require new sites of government action and activity (that is, some entity or entities must finance and coordinate efforts)[51] and two, those reforms that require only minor modifications at the existing decision-making level.[52] Accordingly, some entities need only agree to participate by making information available and modestly adjusting their procedures. The reforms derive from the leading academic literature and from interest

49. Protection of Environment, 40 C.F.R. § 1508.7 (2004).

50. Roel Slootweg & Arend Kolhoff, *A Generic Approach to Integrate Biodiversity Considerations in Screening and Scoping for EIA*, 23 ENVTL. IMPACT ASSESSMENT REV. 657, 659 (2003).

51. *See infra* Part III.E, Recommendations 1 and 2.

52. *See infra* Part III.E, Recommendation 3.

groups' published or circulating positions.[53] For each recommendation, the technological feasibility is not a serious concern.

Recommendation 1. Establish clearinghouses/repositories for environmental information and data[54]

The federal government and the states should work together to create regional institutes to collect project and program environmental analyses. The institutes should also be repositories of environmental intelligence on the regions from other data-generating institutions.[55] The relationship between these and the following recommendations is graphically presented in Figure III. This is very close to a recommendation of grounding EIA in a well-structured regional database of environmental quality information. Robinson argues that place-based data needs to be maintained in a sustained way for a period of years in order to understand environmental trends.[56] Furthermore, he would require that in the scoping-process, the environmental review lead entity would correlate the data collection and analysis with ongoing studies in the project's region.[57]

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53. *See generally* S.M. Bartell, *Ecology, Environmental Impact Statements, and Ecological Risk Assessment: A Brief Historical Perspective*, 4 HUM. & ECOLOGICAL RISK ASSESSMENT 843 (1988); Caldwell, *supra* note 45; Bryan Foster, *NEPA in a Knot*, 109 AM. FORESTS 46 (2003); COUNCIL ON ENVTL. QUALITY, THE NATIONAL ENVIRONMENTAL POLICY ACT: A STUDY OF ITS EFFECTIVENESS AFTER TWENTY-FIVE YEARS (1997), *available at* http://ceq.eh.doe.gov/nepa/nepa25fn.pdf (last visited Apr. 9, 2005); Phillips & Randolph, *supra* note 47; Robinson, *supra* note 27; Slootweg & Kolhoff, *supra* note 50; P. Benjamin Underwood & Charles C. Alton, *Could the SEA-Directive Succeed Within the United States?*, 23 ENVTL IMPACT ASSESSMENT REV. 259, 260 (2003); Dinah Bear, *Some Modest Suggestions for Improving Implementation of the National Environmental Policy Act*, 43 NAT. RESOURCES J. 931 (2003).

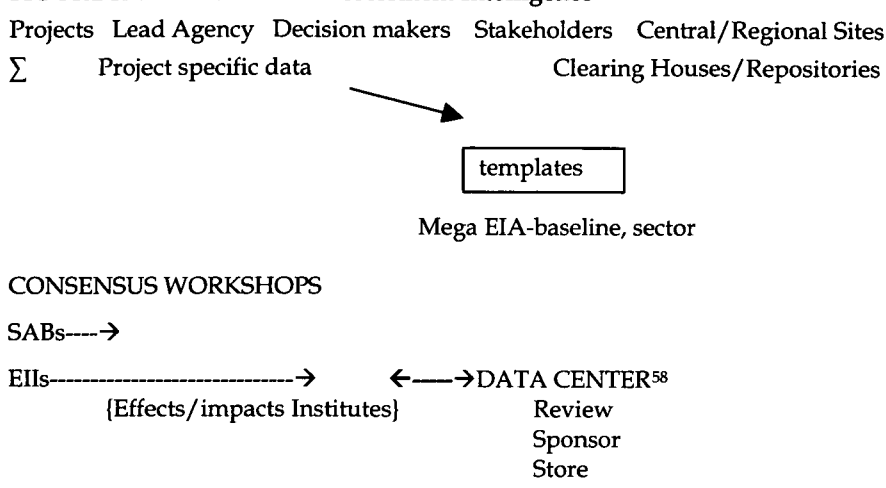
54. Reportedly, at the federal level there exists no single repository of NEPA generated knowledge or even of the raw environmental impact statements themselves. Some states do request that the reports be sent to a state agency office where they are collected as in a library.

55. *See infra* Part III.E.2, Recommendation 2.

56. Robinson, *supra* note 27. A possible start for a model might be the Annual UCLA Institute of the Environment Report on the environmental conditions of Southern California. Whether the clearinghouse or houses should be or should include The Council on Environmental Quality (CEQ) is a policy question. Unless CEQ is radically better funded and made more independent, such as is the Council on Economic Advisors, we think that its links to particular political administrations can taint the perception of its objectivity.

57. *Id.*

FIGURE III: Environmental Assessment Intelligence



There can be several components and contributions to the databases. Consensus workshops, science advisory boards, and criteria documents used in standard setting should contribute to these databases. The data repositories should also incorporate data sets that can be accessed for relevance to project specific analyses. For example, "The Health Effects of Air Emissions from the Transportation Sector" from the HEI[59] or data on the health effects of a particular substance that is used in or produced in facilities that undergo project environmental impact assessment. These clearinghouses can provide invaluable resources to countless challenging environmental decisions. To illustrate, we present two applications.

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58. The Centers could also access data independently of the main participating institutions or of data submitted to the EIA library. Sources could include: the Toxic Release Inventory (TRI) required under the Emergency Planning and Community Right to Know Act; information available under the OSHA Hazard Communication Standard; Clean Air Act section 112 risk management information (now tightly controlled by EPA); Safe Drinking Water Act public data; information from the Beach Bill (following Congress's year 2000 amendment to the Clean Water Act requiring public disclosure about water quality at beaches, testing of recreational beaches for pathogens; and the maintenance by EPA of a national data base of contaminated waters); state right to know act information (Proposition 65 in California for example) and other right to know sources of data. *See* John D. Echeverria & Julie B. Kaplan, *Poisonous Procedural "Reform": In Defense of Environmental Right-to-Know*, 12 KAN. J. L. & PUB. POL'Y 579, (2003).

59. Discussion on the HEI. Scoping refers to choosing and limiting the range of actions, alternatives, and impacts to be considered in an impact assessment. Protection of Environment, 40 C.F.R. § 1508.25 (2004).

Consider the dispute about the health effects of C8,[60] which is used in DuPont plants to make polymers that go into the production of Teflon. C8 emissions historically have not been strictly regulated. The science about its effects has been done and used in a non-centralized manner. A state agency involved in aspects of its regulation issued a report in recent years saying that current levels of exposure to the substance in a plant in West Virginia are not harmful. But lawyers for neighbors of the plant "have complained that the DEP[61] wrongly underestimated the chemical's dangers."[62] Others have alleged that DEP official ignored "existing studies of its toxicity, misapplied formulas for determining safe levels of chemicals, and misled the public about the process."[63] Subsequently the U.S. Environmental Protection Agency's Office of Pollution Prevention and Toxics has begun a new investigation and the agency has asked the Science Advisory Board of EPA to review risks of C8 exposure. These studies can produce results made available for assessment in other regions and for other uses of C8. Critics charge that the available science was accessible by the state agency and that a "perfunctory review of industry documents on file with the agency would have yielded facts and scientific conclusions very much at odds with the 'science behind DEP's work' on C8."[64]

The second situation involves a series of disputes on decisions on the economically significant closure of beaches in southern California.[65] Grant and Kim paint a disturbing picture of the almost completely incorrect warnings about whether water quality is acceptable for recreation uses. These warnings were incorrect in part because information over many reporting periods and trends and sources of data from regional boards, private associations, the surf riders, and other groups are not centrally collected and assessed with methodological rigor.[66]

The amount of quality control and review of the data supplied will depend on the government commitment to these clearinghouses.

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60. The formal name of C8 is perfluorooctanoic acid, a chemical used in many industrial and consumer products. It is a ubiquitous substance that can remain in the body for up to five years.

61. DEP is an acronym for the West Virginia Department of Environmental Protection.

62. Ken Ward Jr., *EPA Gears Up to Study DuPont Chemical: In Use Since 1951, C8 Exposure Now Alleged to Be Dangerous*, CHARLESTON GAZETTE, Nov. 18, 2002, at 1A.

63. *Id.*

64. *Id.*

65. Joon Ha Kim & Stanley B. Grant, *Public Mis-Notification of Coastal Water Quality: A Probabilistic Evaluation of Posting Errors at Huntington Beach, California*, 38 ENVTL. SCI. & TECH. 2497 *passim* (2004).

66. *Id.*

The clearinghouse would at a minimum identify inconsistencies in scientific studies.

Technically, greater use of geographical information systems (GIS) can be useful here and generally can enhance the intelligence that this aggregate body of environmental data represents. GIS can visually represent environmental impact and baseline information in ways that are understandable to the participating public and to decision makers. Just as importantly, it can be a means of cross checking compatibilities and inconsistencies, even contradictions, in space based impact information. Thus, water quality data from a regional water control board can be checked before integrated with data from private labs or other sources. Clusters of health effects impacts associated by some with chemical use can be plotted. Visual representations of air quality in a region and cumulative impacts of various projects can be consolidated. GIS can plot where controversial projects and facilities are sited and where others are being considered.

The evolution of the Internet makes finding and consolidating scientific studies and results much more feasible. The benefits of Internet access are well known: the power of retrieval, the access to immense amounts of information, the ability to categorize and to benefit from the categorization of others—these are a few of the changes we have witnessed in recent years. But Internet use must be undertaken with knowledge of the need to seek data quality assurance. Data can be fabricated, altered, and morphed and false documentation can be created. Librarians have created systems to lessen these risks but the ability to stay ahead of computer fraud is highly elusive.[67]

Recommendation 2. Create new categories of environmental impact documents

The federal government and the states should work together to implement more complete options for programmatic impact assessments and to further supplement these assessments with new types of comprehensive impact analyses. Programmatic impact statements would be enhanced in stature because they would build on accepted scientific studies, they would be subject to ongoing scrutiny and education, and they would invite many forms of quality control. This would be the highest tier of environmental impact consideration. They would include project specific data but also integrate scientific knowledge from other data generating and evaluating sources like those inventoried above. Options include sector level environmental impact assessments and baseline documents.

67. *See* UCI library web page. www.lib.uci.edu/online.

Some in the federal government have called for the elimination of environmental impact statements (EIS) for transportation projects. While we do not accept that idea, a high-tier environmental impact assessment of large generic transportation projects might be useful for streamlining project analysis, such as ramps and minor infrastructure changes. A high-tier assessment could also provide guidance on major transportation system change considerations, some of which have generic impacts.[68] Super impact statements can be useful in the ongoing need for decisions about management of wetlands, endangered species, forests,[69] military facilities, energy facilities, and, in general, ecosystems.[70]

Consider the value of such an assessment in major location decisions such as for nuclear depositories. "Ten thousand years is incorrect," Judge Harry T. Edwards was quoted in *The New York Times*[71] as challenging a government lawyer's conclusion for the Department of Energy that the agency could consider leakage from the Yucca Mountain site for only 10,000 years. Judge Edwards said the agency had "not obeyed instructions by Congress to follow the...[National Academy of Sciences]...advice in setting standards. The federal government argued

68. Recently, public comment opened on a 2000 page environmental impact report on a proposed 700-mile high-speed rail line linking northern and southern California. It will be years before the train may become a reality but a central means of collecting increasingly relevant and/or changing assessments of environmental impacts of the proposed route or segments thereof could be very valuable and avoid re-doing the assessment should political and economic conditions make it feasible.

69. The Forest Service prepares more environmental reports than any other federal agency and is seeking ways of standardizing its data reporting. Foster, *supra* note 53, at 50. Interestingly, the Forest Service also has experienced a period of loss of public trust. Kathleen E. Halvorsen, *Assessing the Effects of Public Participation*, 63 PUB. ADMIN. REV. 535, 535–43 (2003) (citing DAVID A. CLARY, TIMBER AND THE FOREST SERVICE (1986)). Recently, the federal administration has advocated limiting environmental impact analyses both for forest planning and for some major energy projects. While on its face the suggested reform appears directly contrary to our reforms, another interpretation exists. Undertaking credible, respected, available, and transparent enhanced environmental assessment could obviate the need for some case-by-case reviews.

The need for better science that agencies like the Forest Service can call upon is illustrated by a Ninth Circuit decision involving the Service. In *Idaho Sporting Congress v. Thomas*, 137 F.3d 1146 (1998), the court held that the Service's reliance on a three-year-old survey for a Finding of No Significant Impact (FONSI) determination was deficient and that the Service failed to reflect the cumulative effects of logging actions. This was in a situation where impacts on an indicator species, the bull trout, were involved.

70. Phillips & Randolph, *supra* note 47. Reportedly, the Bonneville Power Administration has prepared "a single, broad environmental assessment that would provide the foundation for a decision on an overall policy, but also encompassed the ability to decide future specific actions." Underwood & Alton, *supra* note 53, at 260.

71. Matthew L. Wald, *Court Hears Arguments on Waste Site in Nevada*, N.Y. TIMES, Jan. 15, 2004, at A22.

that 10,000 years was commonly used in other kinds of hazardous waste disposal."[72] Certainly policymakers are capable of collecting, organizing, evaluating and using the most respected science on this point.[73] Nevada's lawyer in the case, Antonio Rossmann, argued that the standard should be for 300,000 years or longer.[74]

The data for enhanced environmental assessments would be subject to more intensive scientific scrutiny. Whether the test would be one of peer review remains an open question. Peer review is a generally required process in much of the scientific community. There is not one universally accepted standard for acceptable peer review, but recent congressional testimony offers a good summary:

> Peer review is a documented critical review of a specific scientific or technical work product, conducted by qualified individuals (or organizations) who are independent of those who performed the work...but who are collectively equivalent in technical expertise (*i.e.*, peers). It is conducted to ensure that activities are technically adequate, competently performed, properly documented, and satisfy established quality requirements.[75]

On balance, peer review should be required of information that makes its way into this tier of environmental assessment, although there may be circumstances when the costs of doing so surpass the added value or benefit of proceeding with generally accepted quality data, not all of which has been subject to the rigors of peer review.[76]

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72. *Id.*

73. *Id.*

74. Or consider the value of generally accepted understandings, including in quantitative terms, of the effects of electromagnetic waves from power utilities and power lines. *See* Kim Sung-jin, *Electromagnetic Waves from Power Utilities Not Harmful*, KOREA TIMES, Aug. 8, 2002, 17:18. The report by a Korean research institute concluded, "The research project was conducted in accordance with the World Health Organization's Good Laboratory Practice to ensure its credibility. We hope the research results will relieve people living nearby or working in electricity facilities...." *Id.* Whether or not that is true from the specific study, if, over time, high-level science produces similar results that are communicated in understandable terms to policy makers' decisions may be better accepted.

75. *Independent Peer Review of Products That Support Agency Decision-Making: Hearing Before the Water Resources Subcomm. of the House Transportation & Infrastructure Comm.*, 108th Cong. (2003) (statement by Paul Gilman, Assistant Administrator Research and Development and EPA Science Advisor).

76. EPA itself has an interesting test that might be applicable: "It is unnecessary to conduct peer reviews of straightforward applications or transfers of accepted, previously peer reviewed economic methods or analyses....Additional peer review is not required if an application of an adequately peer reviewed work product does not depart significantly

To be included in this class of environmental assessment, results would need to be accompanied with a description of methods for data acquisition to a degree of specificity that would allow other scientists to review and replicate the study.[77]

Part of the challenge of improving the scientific basis of environmental impact assessments is in overcoming the inherent bias of the scientific method against acknowledging the possibility of negative impacts.[78] Scientists cringe at suggestions that, for the purposes of requiring full analysis of impacts in an EIS, the traditional legal standard of causation by a preponderance of the evidence, or 51%, should be used rather than the high scientific proof of causation requirement of 95%.[79] But this problem may be avoided by reframing what is being sought for the assessment. Scientists do not need to give up their norms to articulate the confidence that they put in an environmental analysis; they simply can address the level of confidence they put in the studies and pass to the decision maker whether to use the precautionary principle[80] or some other decision rule.

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from its scientific or technical approach." U.S. ENVTL. PROTECTION AGENCY, PEER REVIEW HANDBOOK 28, 36-37 (2d ed. 2000), *available at* http://www.epa.gov/OSA/spc/htm/prhandbk.pdf (last visited Apr. 9, 2005). Generating enhanced environmental impact assessment may provide an opportunity for objective and progressive use of the Data Quality Act if scientists and concerned citizens conclude that the data bases in these significant assessments contain questionable information. Under that act, government is required to create procedures for "ensuring and maximizing the quality, objectivity, utility and integrity of information." Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by Federal Agencies, 66 Fed. Reg. 49,718 (Sept. 28, 2001).

77. The Supreme Court's test for admissibility of scientific expert testimony uses several factors relevant for consideration of evaluation of information submitted to an assessment. "General acceptance" is not an absolute prerequisite to admissibility, and an agency has no obligation to calculate the precise probability of harm for a finding that a significant risk exists. The four nonexclusive factors are (1) whether a scientific theory can and has been *tested*, (2) whether it has been subjected to *peer* review, (3) its *potential rate of error*, and (4) its degree of *general acceptance within the relevant* scientific community. Daubert v. Merrell Dow Pharms., Inc., 509 U.S. 579, 589-96 (1983). *See generally* D. Hiep Truong, Daubert *and Judicial Review: How Does an Agency Distinguish Valid Science from Junk Science?*, 33 AKRON L. REV. 365 (1999-2000).

78. Bradley C. Karkkainen, *Toward a Smarter NEPA: Monitoring and Managing Government's Environmental Performance*, 102 COLUM. L. REV. 903 (2002).

79. *Id.*

80. The precautionary principle holds that, in the absence of scientific certainty, decisions nonetheless favor cost effective measures to prevent environmental degradation. Sometimes referred to as the "do no harm" principle, it is part of the United Nations Framework Convention on Climate Change. May 29, 1992, 31 I.L.M. 849, regime and that of other multinational environmental agreements. *See, e.g.*, Declaration on Environment and Development, June 13, 1992, Principle 15, 31 I.L.M. 874.

Numerous other sources of scientific intelligence are available and could be integrated into the larger assessments. These include technology assessments,[81] data generated in response to the requirements of various data provision policies,[82] and data generated for other regulatory specific programs.[83]

Recommendation 3. Support effective participation of interested stakeholders and of the public

There are many ways to involve non-official, interested people in the decision-making process. Several scientific analyses, including that conducted by Frank Fischer, discuss the effectiveness of the different approaches.[84] That work should generate guidelines for improving public participation in the environmental impact process. Among the suggestions that are promising are utilizing means of interpreting data for decision makers; providing face-to-face communication between stakeholders, the citizenry, involved scientists and decision makers; allowing for "friendly" examination of official views; and providing fora where interested persons can explain their identification and their understandings of impacts, including their own perspectives. This last procedure can highlight ideas on causation that previously were not considered.[85]

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81. D. Loveridge, *Technology and Environmental Impact Assessment: Methods and Synthesis*, 11 INT'L J. TECH. MGMT. 539, 539 (1996).

82. Such as the transportation/air quality conformity process. There are three reasons to include this information:

> the level of technical detail required for conformity analyses meets or exceeds the level of technical detail required for NEPA; unless conformity is taken into account, alternatives and mitigation measures generated during the NEPA analytical process may later result in a negative conformity determination; and...public comment periods, unless coordinated, would run consecutively rather than concurrently, potentially delaying project implementations.

S. Shaheen et al., *Concurrent Air Quality Analyses Under the National Environmental Policy Act and Transportation Air Quality Conformity*, 49 TRANSP. Q. 55, 55 (1995).

83. The use of these statements may mean more negative declarations; this is a side effect of likely developing strong base line data and a good sense of the environmental conditions of a region or a program.

84. Frank Fischer discusses the Berger Inquiry, one of the oldest and most important examples of participant policy inquiry, as well as subsequent research. FISCHER, *supra* note 16, at 231–41; *See* Halvorsen, *supra* note 69; John Gaventa, *The Powerful, the Powerless, and the Experts: Knowledge Struggles in an Information Age*, *in* VOICES OF CHANGE: PARTICIPATORY RESEARCH IN THE UNITED STATES AND CANADA 21, 34–40 (Peter Park et al. eds., 1993); *see generally* PHILIP KITCHER, SCIENCE, TRUTH, AND DEMOCRACY (2002).

85. It is not our purpose to evaluate any specific participatory tools and strategies. Among those that have received favorable attention, however, is *decision-based scoping*, which "places emphasis on first identifying the potential decisions that may eventually

CONCLUSION

There is considerable discontent about the use and abuse of science in the emergent complexity of environmental problems. At one time, NEPA and EISs were heralded as successful tools for informing environmental decision making; however, routinization has dulled their effectiveness and eroded public trust and participation in the process. Other institutional models for generating and integrating improved information for policy making have been suggested. These alternatives are not as promising as reviving the latent possibilities of environmental impact assessment, a process that was and still is respected. Furthermore, many of the alternative models' attractive features can be designed into EIS reforms. The ideas that we have culled from analysis of a number of data generating and evaluating entities could combine to fill an important gap in decision making. By filling this gap, the thousands of individual, expensive, time-consuming, case-by-case assessments would aggregate to achieve greater general value.

Placing the information collected in environmental and other assessments under active management with continuous updating and integration solves the problem of "dead" data in past documents. The creation of a common data base gleaned from a variety of sources will be more likely to be accepted as even-handed, authoritative, and accurate. Providing information to and withdrawing information from the same foundation of common data will facilitate the construction of networks and trust among scientists, analysts, stakeholders, and decision makers.

These reforms go beyond programmatic impact assessment, but they do build on the concept. They aim to make the scientific base for environmental decisions more comprehensive, inclusive, and layered. The reformed approach is offered as valuable for a range of decisions including those of a regional, national, transboundary, and global scope.

Environmental assessments often have been segmented and separated from an overall context for several reasons. Some are jurisdictional: the lead agency is responsible for a particular locale rather than for a region or a natural system. Some are political: it would not be in the interest of certain groups to build environmental intelligence because that may risk further controls and/or suggest regulatory policy

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need to be made....Combined with other tools this can identify and more accurately assess actions, alternatives and impacts." Charles H. Eccleston, *The Decision-Identification Tree: A New NEPA Scoping Tool*, 26 ENVTL. MGMT. 457 (2000), and *outside agency audits of challenged assessments*, which is an alternative to the more complex processes suggested involving a science court or a generic legislatively mandated procedure such as under the Data Quality Act.

that is inconsistent with a given political theory. Some reasons are economic; for example, there is a thriving business of environmental impact assessment and changes in overall orientation create uncertainty and can challenge a market position. These obstacles remain but surely are not insurmountable in the face of the clear benefits of reform.