Science, Policy, and Acid Rain

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INTRODUCTION

Throughout the 1970s and 80s there was an ongoing scientific and policy debate about the effect of sulfur deposition (popularly referred to as "acid rain") on ecological resources in the United States (Russell, 1992; Regens, 1993). Politically, there were strong advocates for policy positions ranging from retaining existing regulations on sulfur emissions in the absence of compelling adverse ecological effects, to requiring additional, more stringent, sulfur emission reductions costing billions of dollars based on existing ecological information. Misinformation over the ecological aspects of the debate, as well as other technical aspects, was widespread (for a summary of some of the early debates, see Rubin, 1991 and Rubin, et al., 1991).

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To provide a scientifically sound assessment of the extent of the acid rain "problem," the U.S. Congress passed, and President Carter signed, the Acid Precipitation Act of 1980. The Act directed the United States Government to undertake a ten year assessment to determine the causes and consequences of acid precipitation and to develop options for reducing known effects.

The National Acid Precipitation Assessment Program (NAPAP) was the interagency organization created in response to the act (Roberts, 1991). NAPAP involved twelve Federal agencies and hundreds of scientists, and cost more than a half billion dollars over ten years. Congress directed that NAPAP be policy-driven; research or other scientific activities undertaken by NAPAP were to help answer specific public policy questions. The agencies responsible for NAPAP interpreted the law as a congressional directive not to come up with a *recommendation* of a preferred policy option, but rather to produce a credible *evaluation* of the consequences of various policy options. NAPAP was not to be a basic research program as such, although it was anticipated that some applied research would be required to help answer some of the assessment questions. In hindsight, it is obvious that the assessment and policy questions asked by congress would be much more difficult to answer than most individuals initially realized.

NAPAP was organized under an interagency task force headed by the administrator of the National Oceanic and Atmospheric Administration (Department of Commerce), the secretary of Agriculture, and the administrator of the Environmental Protection Agency (Oversight Review Board, 1991). The program, originally designed for completion in a decade, was reauthorized by the 1990 amendments to the Clean Air Act to evaluate the efficacy of the additional air pollution regulations authorized in the amendments. Our conclusions are based on experiences with NAPAP during the 1980s.

Participating in NAPAP was sometimes painful for many scientists, but also extremely stimulating and challenging. Advocates from all sides attempted to use the program to support their own policy marketing efforts, or to disparage those of their opponents. Scientists tended to get classified as being for one side or another of policy debates. Some very good science was accomplished, but many scientists look upon their NAPAP experience with mixed views. For many NAPAP participants with scientific backgrounds, the NAPAP was their first exposure to an assessment program.

We developed a number of "lessons learned" from our experiences as scientists and science managers working nearly full-time in NAPAP for much of the 1980s. Others have developed "les-

sons learned" from their study of NAPAP as an enterprise, or from their actual experiences with NAPAP, but few of these have been written by scientists.

NAPAP involved hundreds of scientists, within and without government. It is not our intent to offer consensus views, but to present the lessons that we learned in our role working at the interface of a scientific enterprise and policy analysis.

LESSONS LEARNED: CREATING AN ASSESSMENT PROGRAM

Get the policy questions clear! The formulation of policy questions is highly value-based and likely to be an extremely divisive exercise, as it was for acid rain. Regardless of the outcome, agree to the fundamental questions up front and put them in writing. Which policy questions need additional research? Be very careful of words like *degradation*, *adverse*, and *damage*, which are value-driven and require a "political" input; scientists and other technical experts should not permit their personal values to influence the formulation of policy questions.

Many of the disagreements among scientists, science managers, and policy analysts in NAPAP were fundamentally over different opinions of what the key policy questions were (or should be). Obtain clear and formal consensus on the questions(s). Clearly state who the client is, how the client intends to use the information produced, and who ultimately decides how the policy issue is to be resolved. Unclear (or differently interpreted) policy questions will cause continuing difficulties for scientists and policy analysts.

An example of shifting questions dealt with whether policy questions should be limited to sulfur alone (e.g., the policy question of whether there ought to be additional controls on sulfur even though other air pollutants might be important) or whether analysts and scientists should look at the suite of air pollutants (e.g., in the case of forests, should the ecological effects of ozone and other stressors be determined as part of NAPAP). Assessments require very different data depending on which pollutants are of concern and how many ecological interactions are considered. In many ways, determining the effects of sulfur deposition on biota was a much simpler scientific problem than doing so for nitrogen deposition or other pollutants such as ozone. Fundamentally different assessment and research programs would be warranted, depending on how this particular policy question was resolved.

Although it serves a very important function, science cannot and should not answer policy questions. Instead science should provide the consequences of various alternative answers.

Focus science on science questions! Although it serves a very important function, science cannot and should not answer policy questions. Instead science should provide the consequences of various alternative answers. Don't get sidetracked into answering inappropriate questions such as: "When will scientists tell us what to do about this policy question?" Much of the NAPAP debate that purportedly was over "science" was really over value-based choices.

For example, a typical (and inappropriate) question often asked of NAPAP scientists was: "Is a X ton reduction in sulfur emissions sufficient?" Scientists can predict, at least within some error band, the likely *consequences* of such a reduction, but cannot answer whether it *should* be done. It is deceptively easy to cross the line between "is" and "ought." Scientists and policy analysts need to work interactively, but each has a very clear role, as do decision makers.

Feed the client regularly! Provide regular updates on the policy-relevant results of the research. Involve key scientists in these briefings, but prepare them well for the inevitable pressure to speculate on the significance of interim results. Interim briefings are a critical element of the assessment process and they will require far more attention than most scientists want to devote.

Look for appropriate conclusions as quickly as possible and always bound them with confidence estimates. Often, policy analysts will be content with confidence estimates such as "best current guess" or "fairly likely to be correct." For other, more critical elements of the policy analysis, a statistical confidence interval might be necessary. Not every piece of scientific information is of equal value in a policy analysis. "Educated guess" is acceptable for some; "near certainty" is required for other questions. It is important for scientists and assessors to provide regular updates to policy analysts and decision makers.

Conduct an assessment at the end—and at the beginning! Conduct an initial assessment to identify the critical research gaps necessary to improving the assessment. Update the assessment regularly throughout the research effort, including formal peer review, as frequently as feasible. The scientific credibility of the assessment process will be questioned at every conceivable opportunity, so expect it and prepare for it.

For example, early in NAPAP research priorities were set on the basis of prevailing opinions among scientists regarding scientific uncertainties. Later, after preliminary policy analyses were conducted, it became clear that certain scientific unknowns were absolutely critical for evaluating options. The research program became much more fo-

cused on answering a few specific questions. If the assessment program is to make significant progress, it is crucial to have sufficient leadership from assessors to forcefully shape the research direction. Otherwise, researchers will tend to include peripheral scientific issues and diffuse the available resources.

LESSONS LEARNED: FOR SCIENTISTS

Learn to live with 80 percent! Assessment and policy analyses do not require the same degree of thoroughness or statistical confidence of scientific data as is typical in research. For example, most scientists, especially in basic research, do not reach a comfort zone before reducing the likelihood of a mistaken conclusion to 1 in 20, or even 1 in a 100. No such degree of certainty exists in policy analysis for any but the simplest policy questions.

Not every policy question requires the same degree of scientific certainty. Typically, certain scientific questions are extremely critical in assessing the consequences of certain policy options; it is these questions that require the highest degree of certainty. Other scientific questions are not nearly as critical to the policy analyst, and these can be answered with the least scientific precision.

There is an important role for the science or research manager to communicate effectively between policy analysts and scientists. Policy analysts (and decision makers) must be forced to establish priorities among all potential research topics. The research manager, in turn, must be forced to realistically determine the likely research payoff from each priority.

Recognize that research enterprises are more easily corrupted than individual scientists! Beware of political efforts to use the scientific enterprise to focus on questions that tend to support a particular political position. This is not usually a sinister endeavor, but rather a reflection of the goals of different organizations that fund research. Scientists tend to be goal oriented, so the easiest way for an organization to influence the scientific enterprise is to focus on goals and scientific questions that show your organization's political position in the best light.

Most scientists will do good research, but they can be easily influenced by the nature of the question asked (e.g., research direction will be fundamentally determined by the nature of available funding). The research is technically sound, but tends to emphasize or support a particular policy position. For example, some organizations in NAPAP leaned toward emphasizing research on natural influences in ecological changes, while others emphasized the role of human activities. Neither is scientifically wrong but the results will tend to focus discussion on different causal agents.

Scientists who provide impartial scientific information may not generate many headlines, but they enjoy the respect of their scientific colleagues. In contrast, those who offer policy advocacy embedded in science may generate headlines, but they run the risk of losing credibility among their colleagues.

Keep the "is" and the "ought" separate! There is an old and still vigorous debate over the role of scientists and other technocrats in public policy. One view is that experts have an obligation as citizens to advocate "good" policies. Another view is that scientists and technocrats should play a role analogous to that of physicians as counselors: provide information on the consequences of each policy choice, but advocate none.

The "is" and "ought" separation is a problem in all assessments that attempt to link science and policy. A recent and highly visible example is the intergovernmental assessment program dealing with potential climate change (Bolin, 1994). In NAPAP there was constant pressure on scientists from some in the media and government to answer questions such as "Do you know enough now to set a standard?" Or "Is the proposed policy sufficient to protect aquatic resources?" These are not questions scientists can answer as scientists, but require "ought" or "should" judgments.

Realistically, many scientists have political positions, publicly stated or not. Predictably, in NAPAP, scientists who tended to advocate policy positions were sought out by the media. Scientists who remained impartial and followed the "physician as counselor" model (providing expertise but no opinion of what *should* be done) typically were not sought by the media.

Avoid hubris before the mahogany table! The decisions concerning acid precipitation would potentially cost billions of dollars. Each political option had major winners and major losers. Some scientists, for perhaps the first time in their careers, were involved in very high profile research. It is nice to be listened to, but stick to science. Ignore the siren call to substitute personal values for scientific independence. In testimony to congress and elsewhere, stick to scientific questions and do not under or overestimate uncertainty. It is very easy to be caught up in the importance of one's science in such impressive surroundings.

Most of us never sit with a few colleagues on one side of a very large ma-

hogany table and answer questions from members of congress. For most scientists, being called by a congressional committee to offer testimony is a major professional and personal event. It is deceptively easy under these circumstances to step outside the role of scientist and into the role of policy advocate. Scientists who provide impartial scientific information may not generate many headlines, but they enjoy the respect of their scientific colleagues. In contrast, those who offer policy advocacy embedded in science may generate headlines, but they run the risk of losing credibility among their colleagues.

It is a small step to move from the scientific "is" to the policy "ought" under the guise of sound science. Such behavior may cause loss of scientific credibility among colleagues that will be remembered long after congress and the public have moved on to other issues.

LESSONS LEARNED: FOR CLIENTS

Remember that the distribution of benefits and costs is crucial in formulating policy questions! Our experience indicates that the political process considers the distribution question to be crucial (i.e., who is causing the problem, if there is one, and who will pay for its solution). Most scientists tend not to view technical problems this way, so be sure that the policy question formally addresses this.

The question of winners and losers tends to drive policy options; scientists naturally tend to be concerned with "global" effects. For example, the fact that there might be effects of acid rain on lakes of the Northeast is relevant, but the divisive question is who is causing this and who should pay for the solution. Science can potentially answer the cause and effect part of the question, but not the part of who should pay.

Complex public policy questions are almost never successfully solved by rationally selecting the best solution, but more often by choosing the emotionally satisfying one (Allen and Gould, 1986). Scientists tend to be strongly rational in their world view. They regard discussion based on grounds other than science as irrational. This doesn't make one type of decision making inherently better than another, merely different. After all, do any of us make our personal purchases on completely rational grounds? Clearly we do not; decisions are a mix of rational and irrational elements.

Appreciate that research budgets follow fear! Successful researchers, especially those operating in the American "free market approach" to deciding what research to fund, are great opportunists when seeking funding: "good news" or "old news" does not result in financial support for research, but fear does!

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Researchers, especially those dependent on "soft" money are often very effective at marketing their own research priorities and frequently "hang their research on whatever (funding) hook is there." Elected officials and political appointees are apt to respond to the latest "crisis of the day" generated, at least in part, to secure research funding.

A strong management structure (and budget stability) can help avoid constantly lurching from one "crisis of the month" to the next. Don't underestimate the potential for pressure from scientists who would exploit a weak management structure to obtain funding for their area of research.

Put those resources on the table! Agencies must have their dollars (including staff) committed to supporting the assessment process and have these resources available to address priority needs. Organizations can be expected to protect their long-term turf and resist what they may view as a diversion of resources from "true science" to the "assessment" process.

For example, some of the agencies purportedly spending research funds on acid rain research essentially relabeled existing research programs, made a few changes in design, and treated the research as supporting NAPAP. This is, of course, common in government, but it becomes a major management problem when all the allocated resources are needed to answer critical research and assessment questions.

Help policy analysts and decision makers outgrow their science-envy! Many science questions, such as acid rain, are complex. The questions facing decision makers also are complex. Analysts and decision makers should not abrogate their roles and responsibilities. It is easy to be intimidated by articulate scientists. Worse yet is to fall into the trap of scientists who say: "When you policy people figure out what you want, let us know." While the policy people retort: "When you scientists tell us how severe the problem is, we'll start evaluating the options."

The scientific issues surrounding the acid rain issue are difficult, even for the brightest scientists. Clients typically are schooled in political science, public policy, government, or some other discipline of social science; some were and are intimidated by science and scientists. Often there appears to be an innate willingness to defer to (perhaps "hide behind") scientists to "solve" policy problems. Avoid this. Science and scientists have important roles, but these roles make up only part of policy analysis.

FINAL THOUGHTS

Did NAPAP meet its goals? The answer depends on what those goals were perceived to be. If NAPAP is viewed as a research program, the answer is clearly "no." Did NAPAP provide major contributions to the policy making process? The answer is clearly "yes." Most holding the view that additional, more stringent, controls on sulfur were warranted undoubtedly viewed the results of NAPAP as not helping their political cause (ecological effects were not as large as they expected). Similarly, those who argued against additional sulfur controls would tend to be disappointed because the estimated effects of sulfur deposition on surface waters and forests (ecological effects were small in their view) did not rule out the additional controls that were mandated in the Clean Air Act Amendments.

It is not surprising that policy advocates from all sides attempted to use the program to support their own policy marketing efforts, or to disparage those of their opponents. Further, it should be predictable that in such a politically charged atmosphere, scientists tend to get classified as being for one side or another of policy debates. The policy debates were neither simple nor brief. There were approximately 70 acid rain control bills introduced in congress during the 1980s, but none passed until very late in the decade.

Some very good science was accomplished with support from NAPAP, although it was a byproduct rather than a primary purpose of the program. The real and long lasting benefit of the program might be in providing an education in the assessment process to a relatively large group of scientists.«

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