The Role of the Scientist in Collaborative Environmental Policy Making

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As anthropogenic impacts on the environment have grown, the role of science has become increasingly important in the public policy arena. Greater public awareness of the complexity and uncertainty of impacts and interactions has stimulated the demand for scientific research to inform the decision-making process.

Despite the trend towards the use of scientific information, many scientists involved are concerned and frustrated both by their roles in and the outcomes of the deliberative process. Scientists desiring to preserve their policy neutrality feel constrained in interpreting their findings, but are reluctant to have uncertain outcomes over-simplified by policy makers in support of a particular agenda. “Advocacy science”, found or funded by stakeholders to bolster their viewpoints, nominally increases the scientific input. However, it often impedes the search for a common understanding, derails negotiation, and sends environmental decisions to the courts for lengthy and often unsatisfactory resolution.

Collaborative approaches to policy formulation hold promise for creating a decision-making model that will enable a more effective role for scientists. The US Geological Survey (USGS), one of the premier federal science agencies, is currently grappling with the question of how its scientists can best contribute to societal decisions while maintaining objectivity and excellence. At present, USGS scientists play many roles in policy-relevant science; each role has distinct advantages and pitfalls.

The Importance of Scientists in Policy Decisions

Over the past century, humans have greatly expanded their capacity to perceive and measure their impacts on natural systems from the local to the global level. Public policy has responded by undertaking active management of human interaction with natural systems. “Environmental policy” now ranges from risk assessment and site-specific cleanup regulations to climate change policy.

In the modern era, empirical information generated through the scientific method has become the primary legitimate basis for understanding and studying natural systems, and has therefore been used as a basis for policy concerning those systems (Jasanoff 1992; Sarewitz 2000). This view is being challenged by arguments highlighting the value of local knowledge and the importance of values in societal decisions. The complexity of environmental problems prevents any one discipline from fully assessing and addressing them and the uncertainty inherent in conclusions that scientific information can support leave scientists unable to answer policy questions definitively (Walker 2001).

Policy makers have turned to scientists and other technical experts to answer questions central to societal decisions concerning environmental systems. These decisions concern the distribution of both risks and benefits and have immense social and economic impacts. Scientists and others trained in methods of scientific investigation have a unique perspective and knowledge base that makes them invaluable not only as sources of information about natural systems, but also as aides in forming a conceptual understanding of the way in which we observe, measure, and influence those systems.

However, the actual impact that science has on policy decisions is not clear or consistent across cases. Susskind (1994) reports that while science is utilized in almost every phase of international environmental treaty negotiation, "when it comes to bargaining over the actual terms of a treaty, input from scientists is almost always negligible."[1] At the same time, public health decisions such as those regarding asthma and fish consumption risks in the Greenpoint/Williamsburg section of Brooklyn, New York were based almost solely on scientifically valid information. However, by ignoring other types of knowledge these decisions have left communities unprotected from underestimated risks (Corburn 2002). Many factors play into how science contributes to policy decisions. This chapter will focus on the role of the scientist in public decision making and the promise of collaborative approaches to fact finding.

Science and Values

The contributions of science have traditionally been seen as separate from the values that underlie policy decisions. The scientific community has identified itself as "objective" and "neutral". Many scientists see this objectivity and neutrality, or at least the perception of it, as essential to their legitimacy as producers of information (Jasanoff 1987). The traditional approach to integrating science into decision making attempts to protect that objectivity by keeping scientific investigation and value-based political negotiations entirely separate (Jasanoff 1987; USGS Ethics Committee 1994; Ozawa 1985). Values define society's needs and frame the problems solved by environmental management efforts. Science assesses those needs and develops alternatives to meet them, and values decide among the alternatives (Rig 2001).

The difficulties of reconciling these two sources of meaning have had the effect of limiting the contribution of scientific information to final decisions. When the full implications of scientific information are not adequately communicated to decision makers and stakeholders, neither can make the most well-informed decisions.

One problem is that science and the values of the individual researcher, his or her organization, or the scientific community within the relevant field may be inseparable. Values and bias may reside in what questions are asked and how they are framed, regardless of how objectively they are answered (USGS 2003). Two objectively conducted studies on the same topic based on valid measurements but answering slightly different questions can lead to radically different conclusions regarding societal response to an issue. This is a major dilemma of "advocacy science".

Research findings may also reflect subjective values that inevitably affect even the most objective scientist. In current discourse on policy-relevant science, significant value content is downplayed or ignored. How might a researcher extract his or her own values from the questions framed? A researcher hired by stakeholders with a particular point of view may not appear to have control over question framing, even if he or she does. Disagreements in which “objective science” supports both sides of an argument put tremendous strain on claims of scientific objectivity and throw doubt on its findings as “facts” (Ozawa 1985; Susskind 1994).

Compounding this problem is the variability with which objectively produced data can be interpreted. Most of the time, variation derives from uncertainty within the measurements themselves. The boundaries around what science can say with negligible uncertainty are quite small and they exclude most of what society actually wants to know. Thus scientists are asked questions that cannot be answered definitively. Scientists often go beyond the definitive in order to make their results relevant to their field or to questions of societal import; they qualify their answers by stating the quantified uncertainty of the results in various ways.

The statistical concepts and the intimate knowledge of experimental protocols often required to fully understand the nature of uncertainties integral to some conclusions are very hard to convey to untrained individuals. Unconvinced that all stakeholders share a clear mutual understanding of the uncertainty with which conclusions are made, scientists often fear that interpretations or conclusions, even when expressed with a full complement of caveats, will be attributed to them as unsupported statements of fact (USGS 2003). In this way, uncertainty draws concerns over standards and reputation into the dilemma of what types of information to provide. The gap between the definitive answer sought and the best answer possible may also create room for values to influence the conclusions of scientists, or at least for it to appear that way. As Sheila Jasanoff has written, “In areas of high uncertainty, political interest frequently shapes the presentation of scientific facts and hypotheses to fit different models of reality” (Jasanoff 1987).

It might be argued that to maximize their contribution to society, scientists should make their values explicit to stakeholders. Some researchers believe scientists should make their values explicit in order to pursue their own policy agendas (Clark 2001). One vision of this strategy is Peter Haas’s epistemic communities, in which loosely organized groups of scientists use scientific information to advance specific positions. Haas cites examples of European government scientists who have used international environmental policy discussions as platforms from which to influence the policies of their own governments (Susskind 1994).

However, most scientists believe that objectivity is still the most potent claim of science to legitimacy. Susskind (1984) responds to Haas’s vision by stating that widespread action of this type by scientists would place unrepresentative power in the hands of an unelected group of intellectual elites. Susskind further states that should these epistemic communities succeed, the existing political power structure might turn against them, thus ultimately reducing scientific contributions to societal decisions over the long term.

How might the scientist and the consumer of scientific knowledge separate relevant and useful research products from the values of the researcher and supporters of her work? Should scientists present their values for inspection and explore the value-content of their work, thus enabling them to meet all social demands? Or should they continue to pursue “objectivity” as the scientific community has defined it, to “best serve public policy by living within the ethics of science, not those of politics?”(Kendler 2003).

This dilemma has been addressed in some cases by severely limiting the types of comments or statements that scientists can make, restricting their contribution to providing data without interpretation or judgment. The USGS has rules limiting what their scientists say to the public or to decision makers (USGS 1994). Many USGS scientists are reluctant to make statements to clients or to the public that go beyond the simple reporting of data, even when they are asked (USGS 2003).

Often, when presented with a question, USGS scientists gather data and prepare a report based on studies designed to answer that question. Their role is then complete. The divisions between scientific and political or value-based investigation and decision-making are clear and definite. This role allows scientists no input into the framing of the questions or the interpretation of the results. Control over question framing is retained by decision makers or stakeholders.

Unfortunately, this approach does not take full advantage of the skills and experience of the scientist. Barring the scientist from helping to frame the question makes no use of their specialized expertise. This expertise can help others formulate questions that represent the current state of knowledge on a subject, that can be tested with available methods, and that will produce information on which a decision can be based. Once data is gathered, decision makers and stakeholders without scientific training can also have serious difficulties interpreting it and drawing accurate and useful conclusions. Decision makers who do not feel confident drawing conclusions from the data may then cast them aside in favor of other considerations that, to them, are more clearly articulated. The data's ultimate contribution to the decision is thus minimized.

Even when scientists do have the opportunity to become involved in the interpretation of data, they report great difficulty in doing so effectively. Most scientists lack the communication and educational skills required to effectively inform lay people about the content, implications, and limitations of study results (USGS 2003; Cannon 1996). Graduate students in the physical sciences rarely learn how to present data or abstract concepts to nonspecialist audiences.. According to one study, 75 percent of conservation biology employers and faculty surveyed stated that training on "explaining science and values of biodiversity to lay public" was a high priority, while less than 20 percent of employers or degree programs offered courses on the subject (Cannon 1996; Clark 2001).

In addition, this role may not fulfill scientists' goals and aspirations as professionals or map onto the reward structures in place within scientific organizations. Most research scientists enter the field because of a desire to pursue hypothesis-driven science, to discover new things about the world, and to advance human understanding. Basic data collection is not the most attractive aspect of this job, regardless of how helpful it may be to decision-making efforts. A USGS scientist complained "What I have more trouble with is people coming to me with projects that don't have a lot of science in them. They have a lot of data that needs to be collected or something, but you have to be fairly creative in figuring out how to make science out of some of that data" (USGS 2003). Academic and government research organizations generally reward scientists for publishing articles in recognized journals describing new discoveries. Scientists are generally not rewarded for outreach or educational efforts, no matter how beneficial those efforts may be to a community grappling with environmental problems (Jacobs 2003).

At the same time, giving the functions of question framing and interpretation over entirely to scientists can produce research questions that do not adequately address the concerns and interests at hand and may lead to investigative techniques and interpretation of results that do not accurately represent local reality. Many examples of scientific investigations designed according to pre-determined standardized methodologies have overlooked facts abundantly clear to many of the stakeholders involved. However, because the scientific investigation process was isolated from stakeholder negotiations and stakeholders were not directly involved in designing or conducting the investigation, these concerns never came to light until after the fact. The concerns are then used to discredit the study rather than improve it (Corburn 2002; Scherr 1997).

These dilemmas have been summarized by Cash, et al. (2003) as an effort to simultaneously maximize the credibility, salience, and legitimacy of the information scientists contribute to a policy debate. Credibility is defined as the scientific validity of information; salience is defined as its relevance to the policy debate; and legitimacy is defined as the trust placed in that information by stakeholders and decision makers. According to Cash, these three attributes are related in such a way that efforts to maximize one reduce the others (Cash 2003).[*] Efforts to maximize credibility generally concentrate on answerable questions with long-range studies and involve only highly trained personnel. Efforts to maximize salience may address questions that cannot be answered definitively on timelines that do not allow for in depth study. Efforts to maximize legitimacy might involve stakeholders and decision makers in data gathering using lengthy processes and specially modified experimental protocols to expose them to the methods and assumptions behind the results.

One Agency's Search for an Answer

USGS was founded in 1879 with the mission of, "classification of the public lands, and examination of the geological structure, mineral resources, and products of the national domain" (Rabbit 1989). Currently, the agency is exploring the appropriateness of different roles for its scientists in public policy debates. Many changes in the scope and mission of the agency have taken place over the last 124 years, but they have centered on providing high quality scientific information to support policy decision making. In the late 1990s the USGS was almost zeroed out of the federal budget and has since been working hard to maximize its contribution in the public realm. Today, USGS sees itself as "a world leader in the natural sciences through scientific excellence and responsiveness to society's needs." USGS defines its mission as "providing reliable scientific information to:

- describe and understand the Earth;
- minimize loss of life and property from natural disasters;
- manage water, biological, energy, and mineral resources; and
- enhance and protect our quality of life" (USGS 2002).

The USGS is currently holding intra-agency discussions between personnel from across the Agency to explore ways in which its scientists can best contribute to policy decisions. These discussions are collectively referred to as the Dialogue on Science Impact (DSI). They focus on the nature of science impact and on developing methods to maximize it. Science impact is one of three core values of the USGS (along with science excellence and science leadership), and "relates to the impact of science on societal decisions" (USGS 2002; emphasis in original). The

DSI is occurring within the context of a move toward more collaborative approaches to conducting policy-relevant science.

Because the mission of USGS is to produce scientific information for use in policy decision making, how USGS scientists describe their current roles and their ideas about making those roles more effective can provide great insight into the question of which roles scientists can play in general.

USGS scientists participating in the DSI have identified a number of roles that they have, could, or would like to play in policy decision-making processes including the following:

- data collector
- consultant/expert
- hypothesis-driven scientist
- stakeholder
- communicator
- convener/mediator

These roles may be defined from the perspective of the scientist, and his or her activities, obligations, and products.

The Data Collector

The best example of a science agency successfully playing this role is the USGS streamflow gauging system. USGS has installed and monitors gauges to measure the magnitude of stream flow along streams and rivers across the country. More than 850,000 station-years of data have been collected over the history of the USGS (USGS nd). However, according to the agency's own analysis (2002) these data are infrequently interpreted: The USGS "…[puts] out the reports and then the rest of the world can interpret them"USGS 2003) These data are used by governmental and non-governmental agencies of all kinds to inform regulatory and policy-making activities of every type and have achieved an almost idealized status as accurate factual information. According to commentators "…when people talk about USGS water data it is God's written law. It is correct" (USGS 2003).

The streamflow gauging system is an example of a large-scale constitutive program. This role is essential in providing baseline data for site-specific studies. One USGS scientist referred to this as "foundation science" because it provides shoulders for other studies to stand on (USGS 2003). In addition, this coincides with the role of "trend spotter" identified by Susskind (1994). A trend spotter is a scientist who, through measurement and observation, notices changes in environmental conditions over time that indicate problems which need attention (Susskind 1994). This is the most sensitive, and perhaps the only mechanism by which society at large can become aware of new environmental issues.

Scientists are also asked to do this type of basic data collection for site-specific projects. The dynamics of this role are very simple and compatible with almost any type of process. However, scientists generally respond that performing this role is not really doing "science."[*] It appears to take minimal advantage of scientists' valuable skills, and is least fulfilling to professional researchers. The data-collector role is appropriate for the scientist on a project-specific basis only when issues of problem definition, study design, and data interpretation are straightforward and can be done by informed stakeholders or technical personnel within a regulating agency. In these cases, the time and expense of collaborative approaches to fact-finding generally outweigh the benefits.

Consultant/Expert
USGS scientists refer to this role as "contract science" or "advisory science". In this role, scientists are paid, or their research expenses are covered, to conduct a study to answer a question formulated by a third party. This is the most common role for scientists to play in collaborative processes, with scientists hired by one or more participants to answer specific questions. Scientists have varying degrees of control over how the study is designed and how the questions are framed. In some cases, "USGS gets a problem, but they don't tell us how to answer the problem, they give us the problem to answer."[2] In other cases, "the funding agency determines which parts of a scientific inquiry" to pursue (USGS 2003), leaving USGS scientists with little input into how the science is done.

USGS scientists worry about being drawn into value disputes when they do contract work over which they have little control, and which addresses questions that they may feel are loaded. Funding is usually the primary incentive to take on these types of projects. One scientist stated that a way to maintain objectivity and quality in the science is to insist that the results of the study be published in a peer reviewed journal. He said that"…if we don't feel that we can define a research question…and produce a publishable product in peer-reviewed literature then we've not hesitated to walk away" (USGS 2003). Another scientist elaborated on this point:

> I think one of the critical things was being in a position to be able to walk away… But if you are in a position, it's a down year in your district or something, and you are desperate to bring in some funds you are not going to walk away from something that you could see some pitfalls for. Now, saying that, I don't think that I have even dealt with a [client] who came to me with an agenda that expected us to come up with certain results. Everybody comes to us because we are perceived as being objective and want to know what the truth of the situation is. That isn't to say that that isn't a problem sometimes in other places and doesn't have the potential to be a big problem in the future (USGS 2003).

USGS now funds a significant portion of their work through contract science and some feel that this is jeopardizing their reputation. Scientists have said "When you take somebody's money, the presumption is that you're working for them." "Regardless of how objective we really are, perception is everything, and if we ever lose that perception of being objective we are in really big trouble." Some scientists feel that USGS should reduce its involvement in contract science. "It's amazing to me that USGS has done as good a job as it has of maintaining a reputation for objectivity when so many of us are spending so much of our time just marketing. I would put forward the alternative that we should be doing markedly less science and paying for it ourselves (USGS 2003). One of the main conclusions from the first discussion of the DSI was that USGS should provide at least some of the funds for each study when possible to retain some level of autonomy.

It is also difficult for scientists to develop themselves professionally in this role. While the scientist gains varying levels of control over framing the question in this role, there is little control over problem definition. Clients coming to the USGS may bring their problems with them. A career of this type of work affords little opportunity for a researcher to pursue a particular area of interest. Some USGS scientists end up wondering, "How can a new research-grade scientist develop an area of expertise if she's… always answering a client's question" (USGS 2003). Serious concern was expressed within the DSI over this topic as it has consequences for the ability of USGS scientists to develop professionally and for USGS to attract top-quality personnel.

Hypothesis-Driven Scientist

Hypothesis-driven science describes basic academic-style research. According to one USGS scientist, this is "why a lot of us got in this business, but is a very small part of [what USGS scientists do]" (USGS 2003). This science has the potential to become "science that produces results that are so right and so true that they make it into text books. And then they change the fundamental framework of the next generation of decisions" (USGS 2003).

In this capacity, hypothesis-driven science has the potential to have enormous impact on policy. This impact can vary depending on how the hypotheses are generated. One USGS scientist argues that science based solely on internally generated hypotheses, without any input from external actors "has a tendency to lead to a little narrower focus. I think it leads to 'hobby science'. I think it can lead to less applied science" (USGS 2003).

However, USGS scientists find it difficult to formulate interesting and relevant hypotheses to research in the context of specific studies the scope and focus of which are defined by other parties. There is little room within contract science project budgets to "ask why" (as Herman Karl puts it); to investigate how the processes behind the observable phenomenon work (Karl 2003). Clients want to know things that are relevant only to that specific case and will usually not pay for more. Some of this science does get done in the space between these two scenarios. In one case USGS has been doing work coordinating short-term projects that, "although it's supported by [another government agency, we had a] sense of what needed to be done over the long term. So we're trying to do a 25-year study a year at a time. And it's mainly our vision that a long-term study was needed" (USGS 2003).

Adaptive management programs in which action and experimentation are integrated provide an excellent opportunity to conduct this type of research. They are generally long-term projects that allow for long-term study. The focus on learning that many adaptive management programs have also allows scientists to "ask why" because the fundamental workings of the system are highly salient to the policy question at hand as it is framed within an adaptive management context. Otherwise, there seems to be limited opportunity to pursue this type of science within the context of collaborative decision-making processes because the stakeholders generally control the direction of the investigation and rarely have strong interests beyond resolution of the problem at hand.

Science Communicator

This role is described frequently in the literature. Susskind has written that "communicators take responsibility for making the work of [other scientists] understandable to a larger audience" (Susskind 1994). The CALFED program established improved communication of scientific information as one of its major goals (Jacobs 2003).

USGS scientists are engaged in this type of activity but it is seen as a peripheral role. USGS scientists feel that communication is important and have put effort into it, but have become frustrated with the challenge of trying to reach the general public. One scientist recounted an effort to present the results of alternative flow regime models on the World Wide Web.

> Have you seen the stuff he's got on the web about what the different flow regimes mean to the river at different places? You know the data's there… but there's a great deal of people just ignoring the data… [Another scientist] and I worked really hard to try to make this thing comprehensible. And when I take it to people who don't understand how you read these graphs, or what it really means, it takes a minimum of a half hour. And they get it then. And they are just blown away by what they learn. When you put something like that on the web and expect someone to take a half hour to learn it by self-educating themselves…(USGS 2003).

This scientist reported that the project did not have the intended impact because it lacked a second but equally important part to the communicator role. This second part is the promotion of the products: the reports, web pages, and visual simulations. Even if they express the results effectively, people still have to use them for their contribution to the policy debate to be significant. This is described below.

> We did an analysis of all the historical flows [and modeled flow alternatives]… you put those two pieces of information together, anyone could make a decision on how to change the flow of the Missouri River any way they wanted. And yet they were not used to the level that they should have been in the decision making process. And there are a variety of reasons for that that you can't control. But one of them is that, for the most part, if we don't really hustle our products [they won't get used] (USGS 2003).

However, according to this scientist, there is little support within USGS for this type of outreach activity.

> There's very little reward system here for that next part... So say take for example, we could have held workshops on these things. We could have educated all kinds of people. But the money I got to do mine came from a contract. When the money's gone the product sits and it's over. And when [another scientist] did it he didn't get any money. He just did it on the side. And so there's no mechanism to move that to the next level. Nor is there much of a reward system for the scientists (USGS 2003).

The communicator is an essential role for collaborative processes because clear and frequent communication is essential to their success. Ideally, scientists should be able to communicate any part of an investigation so that stakeholders feel they have access to the entire process. Because of the depth of skills needed that are not part of a typical scientist's education or training, this role may be delegated to a writer or public relations specialist. However, stakeholders and decision makers are likely to feel more confident with information coming directly from the scientist doing the relevant research. He or she is the most effective communicator of its methods and results.

Convener/Mediator

If scientists' traditional role is "objective" and "neutral", would they not be suitable to play the role of convener or mediator in a collaborative process? The National Biological Service (NBS – Now part of USGS) did this in convening the Missouri River Environmental Assessment Program (MoREAP) in 1996. In response to new information needs created by the 1993 flood, NBS scientists "got the resources to basically pull together all the different technical groups within the [Missouri River] Basin and had a series of workshops. The consequence was basically the development of a document, which outlines what [science is needed to manage the Missouri River]" (USGS 2003). According to USGS scientists, they were able to convene many of the technical regulatory agencies, all with different agendas and constituencies because, "USGS has the credibility, the objectivity, the lack of advocacy. That's why they were viewed across the Basin as an entity that could do this in an objective fashion…an entity that had nothing to gain other than providing good information that everybody could use to solve the problem" (USGS 2003).

Scientists have not played this role often in the past and a broad new set of skills that most scientists do not possess would be necessary to play it effectively. In addition, mediating a dispute or decision-making process takes a lot of time that most scientists do not feel they have. In the MoREAP case USGS hired outside facilitators to manage the interface between scientists inside and outside the organization and between scientists and stakeholders and/or decision makers. For these reasons, the convener/mediator role may be played more effectively by a science organization than by an individual scientist. Specialized mediators and facilitators can accomplish these goals for the organization as a whole while allowing scientists to concentrate more on research. However, scientists must participate in these activities for them to be effective.

An organization playing this role resembles the "boundary organization" described by Cash, et al. (2003) which manages the boundary between scientists and policy makers. Boundary organizations have three main features in common:

"1. They involve specialized roles within the organization for managing the boundary between science and policy.
2. They have clear lines of responsibility and accountability to distinct social arenas on opposite sides of the boundary.
3. They provide a forum in which information can be co-produced by actors from different sides of the boundary…(Cash, et al. 2003)."

While they are grouped together here, convening and mediating are distinct functions that have different impacts on an organization's relationships with other actors. Mediation requires complete neutrality, which would bar the science organization from taking any stand on any issue. Most science organizations would be very comfortable with this. The act of convening a decision-making process may have the value of identifying and framing an issue for resolution. The science organization playing this role would have to be careful not to allow this function to interfere with its reputation for objectivity. This may be especially important if the science organization is part of a larger organization (e.g. USGS within the federal government) and is convening a process on behalf of, and under the direction of, other interested parties.

The convener/mediator role in its entirety is only appropriate for collaborative processes. For top-down approaches with little or no constructive engagement between different organizations, the communicator role is the closest analogue.

Stakeholder

Some members of the scientific community have argued that scientists, as producers of a unique type of knowledge, have a moral duty to advocate for the values that follow from that knowledge (Clark 2001; Leshner 2003). USGS scientists observe this phenomenon with other agencies who have scientific capacity and statutory authority to regulate certain activity. One person in particular recounted the situation before the MoREAP was convened, "remember a lot of these agencies and the States had statutory authority. EPA had statutory authority, the Fish and Wildlife Service, so… a lot of these entities, in a sense, were advocates" (USGS 2003).

USGS is also seen by some to have an organizational bias that leads them to advocate for certain positions. USGS does its utmost to maintain their reputation for objectivity. However, it is sometimes seen as advocating a position. One USGS scientist expressed fear of having independent research products meet a response such as, "Well, I know all you guys, because you're a bunch of environmentalists and you're answering the question that you want to answer that helps the river go this way or that way" (USGS 2003). The stakeholder role may be played simultaneously with other roles, even if it may compromise the effectiveness of those other roles.

Advocacy does not imply dishonesty (Susskind 1994). Whether or not a scientist is promoting his or her own personal agenda or that of a client, only the extreme case involves falsification of data. As one USGS scientist put it, "I want to be really clear that we're not talking about lying. I mean we're not talking about lack of objectivity in the sense of cooking data or lying. We're talking about the presumption of bias in where you do the work, exactly which questions get addressed, how that information gets provided, and to whom" (USGS 2003).

The stakeholder role frees the scientist to engage in all aspects of the decision-making process from issue definition to selection of action. However, within collaborative processes, this role strips the scientists of much of their distinction as unique sources of information. A stakeholder scientist's contribution becomes simply another viewpoint from which to try to understand the problem.

Susskind (1994) argues that "it would be disastrous if scientists became nothing more than just another interest group pushing their own agenda" because scientific information would then be suspect and its contribution to decision making would be lessened. This could happen if there were a general shift in the ethics of science that allowed or condoned advocacy. However, it is not clear that the consequences would be so dire if science ethics were to establish clear guidelines for the conduct of advocacy. These guidelines would require full disclosure of one's agenda, or at the very least, public repudiation of objectivity and neutrality within a particular decision-making process or investigation. It is conceivable that scientists declared as advocates could enjoy an increased freedom of action while other scientists enjoyed trust as objective experts.

Scientists' roles are changing and new social standards will be needed to guide them through the dilemmas described above. USGS's efforts to explore this issue have uncovered valuable insights into how scientists are currently performing and the difficulties and successes they are encountering. However, the perspective gleaned from this work is from scientists within a very specific and somewhat unique organizational context. Factors unique to USGS such as the personnel evaluation system, USGS's relationship to other agencies, and USGS's history and culture all affect the availability and effectiveness of these various roles for their scientists.

Further research should be directed toward scientists in other contexts such as government agencies with regulatory authority, scientists working for non-profit science or advocacy groups, and university scientists. Applied experiments evaluating the effectiveness of various roles within collaborative approaches would also contribute much to our understanding of the next generation of roles for scientists in public policy making. Nonetheless, we are concerned here with scientists' roles as a means to better understand the end goal of informed public policy. It is to this topic that we now return.

Citizen Participation and Collaborative Approaches

Critiques of the "separation of science and values" approach abound, yet this split remains the traditional paradigm for the role of the science in public decision making. New public commitments to concepts such as the Four Cs* are driving regulators to investigate alternative ways of including various types of actors in decision making (Norton 2002). There are calls for increased engagement of science with society and increased participation of citizens in science-based policy making as it begins to have larger and more pervasive impacts on the everyday lives of citizens (Leshner 2003). There are also calls for increased collaboration between experts of different disciplines to address the complexity of modern environmental problems.

Collaborative approaches to decision making, fact finding, and policy formulation offer a promising way to address several of the key dilemmas that scientists and decision makers currently face. These approaches are designed to create negotiated spaces in which different types of knowledge and frames of reference can interact productively. They can create a framework with mutually understood and accepted ground rules in which scientists can safely contribute to value-based negotiations, and in which stakeholders and decision makers can productively contribute to the design and conduct of scientific investigations. These approaches allow for increased stakeholder participation and mutual learning. Benefits of increased stakeholder participation commonly cited by scholars include:

- Participation is “good for the soul of the citizen” and “necessary for the viability of democracy.”
- Participation confers political legitimacy to the outcome of decision-making processes.
- Participation can “inform professional inquiry” by “clarifying to experts societal values and the policy choices embedded in technical decisions” and by communicating local or experience-based knowledge (Scherr 1997; Fisher 2000; Brooks 1984).

The first of these is an age-old maxim*, the truth of which will not be evaluated here. The second works by increasing public understanding of the process by which these decisions are made, and by increasing the sense of ownership that stakeholders and citizens feel over the decision that has been made. However, while greater participation in traditional adversarial decision-making processes such as public meetings and comment periods may increase the legitimacy of the decision in the eyes of the public, it may not produce an outcome that is more stable and resistant to challenge through alternative decision-making processes such as the courts.

Stakeholders are more likely to support a decision when they have active input into that decision and when their participation affords them a chance to see how that input affects the final outcome (Walker et al. 2001a). Citizen participation in scientific inquiry also exposes the process of scientific discovery to those that will use its products. Yaron Ezrahi has argued that scientific information draws much of its legitimacy from being observable and transparent (quoted in Jasonoff 1992). However, if the people who are to understand, trust, and use the data are not involved in its production, are unfamiliar with the methods with which it was produced, and do not have the resources to reproduce or independently verify the data, they must make the same leap of faith in trusting this information that they would for any other type of professional judgment. To overcome this difficulty, participatory processes must allow stakeholders to engage in participatory or collaborative learning with experts. Success on this front will generally produce more stable and lasting outcomes (Walker 2001a, 2001b; Ehrman 1999).

The third point is especially important because it improves the quality of information on which a decision can be based. Brian Wynne articulated a process of information synthesis that involvement of the public can bring:

> Understandings of science are not simply filtered down from the more pure and coherent accounts that are characteristic of formal science, but are actively reconstructed by the processes and circumstances under which the science is communicated and received. This process of “reconstruction” places science knowledge within a complex of local, and often tacit understanding, situated within socially shared views of the world and which include perceptions of the institutional nature of science and its trustworthiness with regard to a particular issue (Tytler 2001).

This reconstruction serves two important functions. It informs scientists of local knowledge that can affect how questions should be asked, studies designed, and results interpreted. It also gives the scientist and the decision maker guidance on what role for science will fit into the political and social context of the particular issue at hand.

Successful collaborative approaches also improve the technical content and preclude subsequent challenge of the outcome by creating a common understanding of the problem among participants. Integral to the production of this common understanding is the extent to which a process features technical pluralism. Technical pluralism is the interaction and representation of numerous expert disciplines in one process (Scherr 1997). Collaborative processes foster technical pluralism by involving numerous experts representing different parties and points of view in joint projects that answer questions which straddle the lines between disciplines.

This common understanding is essential for producing solutions to complex environmental problems. A common understanding reduces the likelihood that scientists will become involved in advocacy science conflicts (Ozawa 1985; Jacobs 2003). In working together, scientists from different disciplines expose to each other the "paradigmatic 'framing' assumptions" that underlie current thinking in each field. These assumptions can then be addressed, acted on, or discarded so that they do not become the basis for subsequent conflict (Andrews 2002). In addition, collaborative interaction of scientists with the general public, with concerned stakeholders, and with experts from other disciplines "[requires] that experts de-jargonize their work and acknowledge the fundamental value preferences that their views inevitably reflect" (Walker 2001b).

In this way, collaborative approaches may allow scientists to expand their roles and maximize their contribution to a decision-making process while control over value determinations remains in the hands of stakeholders. At the same time, they allow stakeholders to involve themselves in the research, which can ensure that local considerations are taken into account, and that decision makers and stakeholders have a familiarity and sense of ownership over the scientific data produced.

While collaborative approaches can create new opportunities for scientists to contribute to societal decisions, the question remains as to exactly what role they should play. The structure of collaborative approaches is tailored individually to each case in which they are used. While there will be no right or wrong roles for scientists, as previously discussed there may be better or worse roles; roles that conflict with institutional customs, organizational obligations, or principles of fairness; and roles that complement the resource- and skill-sets of various actors and the characteristics common to collaborative approaches.

Collaborative approaches to decision making, fact finding, and policy formulation are one way to address several key dilemmas scientists and decision makers face. A collaborative approach is defined here as a process in which the outcome is the product of an organized negotiation between various parties or stakeholders in which ideas and perspectives are shared by participants and examined by the group.[*]

These approaches are designed to create negotiated spaces in which different types of knowledge and frames of reference can interact productively. They can create a framework with mutually understood and accepted ground rules in which scientists can safely contribute to value-based negotiations, and in which stakeholders and decision makers can productively contribute to the design and conduct of scientific investigations. Collaborative approaches have the potential to increase legitimacy, credibility, and salience at the same time by fusing the production of scientific knowledge or consensus with the political and social processes underlying a particular policy problem.

Effective collaboration, such as the joint fact-finding approach, improves the salience of information by giving the scientist and the decision maker guidance on what role for science will fit into the political and social context of the particular issue at hand. Interaction with stakeholders can make plain to experts the social dynamics of a problem in a way that is very difficult to achieve through second-hand information obtained from other experts, regulators, or the literature (Brooks 1984). While productive interaction of this type requires an entirely different set of skills than those possessed by most scientists, it can help them tailor scientific inquiry and the presentation of scientific information to better fit the needs of the problem at hand.

An excellent example of this is a nutrient-loading model for the Neuse River estuary in North Carolina developed by Borsuk et al. at Duke University. In response to a 1998 requirement from the North Carolina Legislature to reduce nitrogen loading of the river by 30 percent, this group designed a model to predict the effects on the river of various management strategies. However, the group recognized that the presence of specific substances in the Neuse River was not what was negatively affecting the public or specific stakeholders. These scientists recognized that the real "problem" that public actors were trying to solve was the more tangible effects of that pollution. Thus, the model was designed not to predict the average concentration of specific biologically active nitrogen compounds, but instead to predict the likelihood of adverse effects of these compounds (Borsuk et al. 2001).

The group led the public through a survey, public meetings, and stakeholder interviews to compile a list of the most significant negative effects of nutrient pollution such as odor, toxic algal blooms, and fish kills. These items informed the selection of output parameters for the model. Scientists would not have been able to ascertain with any great reliability what effects were most significant to local populations without consulting them. Designing public consultation into this approach allowed the scientists to "link specific stakeholder interests to the scientific understanding of the ecological system" of the Neuse River (Borsuk et al. 2001). This completed an additional step in the calculations that the decision makers traditionally have to perform in isolation, without any input from scientists.

This case was not one of complete involvement of the public in all aspects of the project. This was not a paragon of devolved expert decision making and public involvement. The scope of the project was defined by the Legislature so that even though, "all of the stakeholders'… concerns are valid objectives … most fall beyond the scope of the current scientific modeling effort" (Borsuk et al. 2001). Experts generally maintained control over the actual design of the model and on how citizen input was used. In addition, the model designers stated that while "refinement of objectives may be possible via further stakeholder objectives; [even] with such iterations…eventually the analyst must exercise some judgment in the interpretation and representation of stakeholder preferences" (Borsuk et al. 2001). Despite this, the modelers believe the information produced is more valuable because of citizen input. This example shows that participation and collaboration is not an "all-or-nothing" proposition.

Collaboration between experts and stakeholders is important for the reasons discussed above. Also essential to solving complex environmental problems is collaboration between experts trained in different fields of study. Science-intensive policy problems (especially environmental problems) are often so complex that no one scientific discipline can claim total understanding of it. Kathi Beratan (2003) of Duke University uses the image of a large elephant (an environmental problem) on whom dozens of spear-wielding hunters (the scientists) cling to different parts, each working independently to subdue the beast. The scientists each seem successful in digging into their small part of the problem, but the elephant keeps on walking, not even slowed by the piecemeal efforts of the scientists.

Many times no combination of disciplines can either. However, coordinated investigation from various perspectives is the most effective way to tackle such problems (Beretan 2003). Technical pluralism, the interaction and representation of numerous expert disciplines in one process, is essential to this type of coordinated effort. Collaborative processes foster technical pluralism by involving experts representing different parties and points of view in joint projects that answer a question that straddles the lines between disciplines (Scherr 1997).

Recommendations

This analysis suggests four ways in which the role of science in environmental decision making could be made more productive and useful to all parties.

1. Actively move away from "advocacy science" toward "collaborative science".
Successful collaborative approaches improve the technical content of, and reduce subsequent challenges to, an outcome by creating a common understanding of the problem among participants. This common understanding reduces the likelihood that scientists will become involved in advocacy science conflicts (Ozawa 1985; Jacobs 2003).

2. Foster interdisciplinary work between scientists.
In working together, scientists from different disciplines expose to each other the "paradigmatic framing assumptions" that underlie current thinking in each field. These assumptions can then be addressed, acted on, or discarded so that they do not become the basis for conflict later (Andrews 2002).

3. Involve local stakeholders and increase the transparency of scientific work.
Collaborative interaction of scientists with the general public, with concerned stakeholders, and with experts from other disciplines requires them to avoid esoteric jargon and to acknowledge their own value preferences (Walker 2001b). Collaborative approaches may enable scientists to expand their roles and maximize their contribution to a decision-making process while control over value determinations remains in the hands of stakeholders. At the same time, collaboration allows stakeholders to involve themselves in the research, which can ensure that local considerations are taken into account, and that decision makers and stakeholder have a familiarity and sense of ownership over the scientific data produced.

4. Acknowledge, prepare and reward scientists for playing multiple roles.

The varying roles that scientists are asked to play need to be more clearly acknowledged and valued both inside and outside the scientific community. This may require revisiting the incentive structure of institutions such as the USGS, and revising the education and training which scientists receive to better prepare them for a more interactive and collaborative advancement and application of science.

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[1] Susskind, L. 1994. pp. 62-63

[*] The relationship between these attributes that Cash describes is similar to another that may be more easily grasped. A chemist once told me that one can obtain results of chemical analyses from a contract laboratory that are either accurate, fast, or cheap. One can get any two, but not all three. Fast cheap data will use inaccurate methods, cheap accurate data will take a long time to receive, and fast accurate data will be very expensive.

[*] See quote on page 10.

[2] USGS. 2003. p. 27.

[*] "Communication, Consultation, and Cooperation, all in the service of Conservation" The "new environmentalism" described by the Four Cs stresses citizen participation and partnership between government regulators and managers and the private sector.

[*] This idea is derived from Aristotle's *Politics*.

[*] This definition says nothing of the decision rule by which action is determined (e.g. consensus, majority rules, official decides based on legal authority, etc.)