J. Great Lakes Res. 34:12–22
Internat. Assoc. Great Lakes Res., 2008

Creating a Dialogue for Effective Collaborative Decision-making: A Case Study with Michigan Stakeholders

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ABSTRACT. *Although widely promoted, the importance of science as the basis of natural resources policy-making has proven difficult to both implement and evaluate compared to the many other inputs to creating public policy. Our goals were to bring together a diverse group of stakeholders in Michigan and develop means to create a dialogue on the use of water science in policy-making and to address the disconnect between the science and water policy at the state and regional levels. To achieve these goals, we developed a series of workshops and facilitated discussions to encourage active, productive discussion with a group of 35 Water Resource Fellows (Fellows). The discussions examined the role of science in Michigan water policy. The Fellows were representatives from academia, local governments, state agencies, environmental groups, industry, agriculture, and business. We surveyed the Fellows about their views on the role of science and water issues in Michigan. Nearly half (45%) of the Fellows stated that not enough science is currently being used in water policy decisions. Several themes emerged from the facilitated discussions. The Fellows recommended a recursive decision-making approach to using science in policy making. The Fellows also expressed the need for science to be accessible, relevant to the policy community, and communicated to regulators and the general public on an ongoing basis. The workshop series process for encouraging discussion among stakeholders can be used in other collaborative decision-making efforts.*

INDEX WORDS: *Water policy, stakeholders, Michigan, collaborative decision making.*

INTRODUCTION

It is often difficult to reconcile compromise-based policy-making with the objective practice of science. Consequently, defining the proper use of science in policy decisions, or lack thereof, has generated much debate in the United States (U.S.). All levels of government in the U.S., from local to national, have called for the use of sound science as the basis for environmental decision-making. For example, Krantzberg (2004) implored Great Lakes scientists to engage and expand communication in the region to ensure that the science and policy communities do not become isolated or disconnected. In most cases, little is actually known about how science is ultimately used in making policy (Francis *et al.* 2005). The information that does exist suggests that direct contact and open communication between researchers and policy-makers is the most effective means to address the disconnect and facilitate the use of science in policymaking (Innvaer *et al.* 2002). We agree. If we are to effectively manage the Great Lakes as a common resource we must find the nexus where the use of

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unadulterated science informs policy-making without prejudice.

At the core of the science-policy disconnect are two fundamental challenges: 1) both disciplines have well-established, though very different, modes of operation and 2) scientists and policy-makers have different goals, jargon, career paths, time scales for their work, and ideas of acceptable evidence (Choi *et al.* 2005). The public and politicians are often conflicted when it comes to science; both expecting science to provide solutions to a variety of modern problems, yet increasingly fearful of the side effects of modern technological innovations (Pereira 2004). Many view an ideal relationship between science and policy as one in which scientists collect facts and search for objective truth, decision makers develop policies based on these truths and pass laws to implement their policies, and finally government agencies enforce the laws (Ascher 2004, Oreskes 2004). Under this idealized system, societal problems are solved because the policy is based on a common and "true" understanding of nature provided by science. However, science does not provide absolute truths. Certainty does not play the role in science that many believe it does, and consequently it cannot play the role in policy-making that many desire (Oreskes 2004). As scientists continue to describe the natural world, uncertainty and new hypotheses emerge. Scientists can rarely provide a time-table for their discoveries or for reducing uncertainty. These areas of science are often difficult to address within a policy context. Consequently, environmental policy-making is often viewed as flawed.

There is also a need for collaborative decision-making which involves stakeholders in policy development. Many government laws and programs require some form of public participation. There are many definitions of collaborative decision-making; we use the definition by Conley and Moote (2003), who define collaborative decision-making as multi-party programs and processes that use a participatory approach. In this sense, collaborative decision-making is interdisciplinary, incorporates a variety of stakeholders throughout the decision-making process, focuses on participants educating one another, and uses consensus-building techniques (Bentrup 2001). Because integrative problem solving is needed to address modern water resource issues, stakeholder participation has received increasing attention in water resources management (Tippett *et al.* 2005). For example, in the Neuse River basin in North Carolina, the Total Maximum Daily Load process, which addresses impaired water quality, failed because regulations were based solely on the biophysical aspects of the basin and did not include socioeconomic or cultural factors (Maguire 2003). Including stakeholders in the policy-making process and addressing their concerns may have prevented this oversight and subsequent failure. Creating a common vision or goal and establishing a common language for communication are critical for success of multi-party regional natural resources management.

The people of Michigan and their elected public officials will have to make important decisions in the future regarding the protection and management of Michigan's water resources. Michigan, like other Great Lakes states, faces challenging water resource management decisions at local, state, and regional levels. Approximately 34% of inland lakes and 77% of perennial rivers and streams monitored by the state are not supporting one or more designated use (MDEQ 2006). Regionally, the Great Lakes states and provinces are working to implement the Annex 2001 Implementing Agreements, signed in December 2005, which focus on regional management of water withdrawals and diversions. Although Michigan passed legislation in February 2006 regulating water withdrawals, there will be challenges to implementing and furthering the goals of the legislation. These new regulations cover reporting, registering, environmental protection standards, and permitting requirements for withdrawing specific quantities from groundwater and surface water.

Beginning in January 2005, we instituted a workshop series and water fellowship program. Our objective was to create a venue for researchers, policy-makers, and stakeholders in Michigan to discuss the role of science in Michigan water policy given the rising prominence of water policy issues. We differ from previous studies of participatory or collaborative decision-making in that our goal was to create dialogue rather than to develop and/or reach consensus on a specific policy. As such, we had two primary interests: 1) creating a venue for productive discussion and 2) learning stakeholder views on the role of science in water resources policy. We focused on developing a process for generating productive discussion which can be used to inform other efforts using participatory decision-making approaches. We addressed six important water resource issues in Michigan, which were (1) groundwater-surface water connections, (2) the needs of ecosystems, (3) safe drinking water, (4)

wastewater treatment, (5) the economic value of water, and (6) watershed management. Through addressing these issues we sought to create a common vision among the participants for the role of science in water resources policy-making in Michigan as a first step in opening the dialogue among scientists, policy-makers, and stakeholders on water resource issues.

METHODS

We organized an Executive Steering Committee (committee) to assist in developing the series of workshops and facilitated discussions. The committee was composed of representatives from the Michigan Department of Environmental Quality (MDEQ), the United States Geological Survey, The Nature Conservancy, Neogen Corporation, Public Sector Consultants, and Michigan State University (MSU). The committee was responsible for designing the series, choosing speakers, and selecting Water Resource Fellows (Fellows). In addition, we worked with a professional facilitator who assisted with organizing the workshops and interacting with the Fellows at the workshops.

Selection of the Fellows began with the committee generating a list of potential Fellows. The committee's intent in generating this list was to assemble representatives from a variety of stakeholder groups across Michigan, to contact individuals or organizations involved in water issues in the state, and to focus on those who would be active participants. Once the list of potential Fellows was agreed upon by the committee, we sent invitation letters to 42 individuals or organizations inviting them to participate as a Fellow. We required that Fellows attend all the workshops and we also provided travel reimbursements and a small honorarium for their participation. For the organizations contacted, we asked them to choose one representative to participate in the entire series so that there was continuity in representation. In the end, 35 people agreed to participate as Fellows. The Fellows represented diverse stakeholder groups including local, state, and federal government agencies, industry, agriculture, academia, environmental organizations, and K-12 education.

All workshops were held at the MSU Henry Center for Executive Development in East Lansing, Michigan. The workshops featured internationally recognized scientists who are experts in various water resource fields, including public health, aquatic ecology, hydrology, and water markets. The committee chose six topics for discussion based on issues of concern at the time of organizing the workshop, such as pending legislation in the Michigan Legislature, and availability of speakers. The chosen topics were not meant to provide comprehensive coverage of all water resource issues, but rather to initiate discussion and debate among the Fellows.

Prior to the workshops, we conducted an orientation for the Fellows during which we gave them a survey about their interest in taking part in the workshop series and their views of water resource issues in Michigan. The survey was brief and used open-ended questions. A hard copy of the survey was provided to the Fellows at the orientation and posted on a secure website to encourage responses. The intent of the survey was to assist the committee in organizing discussions for the workshops; however, given that we used open-ended questions we were also able to gather information on the Fellows' views of science and policy in Michigan.

Each workshop began with a public lecture by the speaker introducing the latest scientific knowledge and cutting-edge technologies to address water problems in their specific field. Fellows received white papers authored by each speaker prior to the workshop. Private, interactive discussion sessions between the speaker and Fellows followed the public seminars. During the group session, Fellows were given the opportunity to ask clarifying questions regarding the seminar or white paper and to ask the speaker about any aspect of the topic of the day. After the group session, we organized small break-out discussion groups. We assigned Fellows to discussion groups to ensure that each group contained a mix of the stakeholders represented. We assigned new groups for each workshop so that Fellows were not in the same group for the entire series and the groups were always a mix of stakeholders. The break-out groups were given specific discussion questions to address the use of science in Michigan water policy at each session. These questions addressed the topic of the workshop and the Fellows' views of the use of science in policy. Although wording of discussion questions varied at each workshop, in essence the small break-out group discussions focused on the same two central questions: What scientific information does Michigan need to make water policy decisions and how should science be used in making public policy? Note-takers captured the discussions, both in the whole group and break-out groups, at all work-

shops. The workshop ended with reports from the break-out groups and a summary by the speaker.

Following the workshop series, we compiled all notes taken during the discussions. The notes were used to summarize the major conclusions of the Fellows in a concise report (Rose and Dreelin 2005). We distributed the draft summary report to the Fellows and organized one final workshop with only the Fellows to discuss and revise the draft so that it accurately reflected the Fellows' thoughts and views.

RESULTS AND DISCUSSION

Survey Results

A majority of Fellows agreed that the best public policy is made when the public, scientists, legislators, and interest groups come together and have an avenue for input to the policy-making process. The survey results showed that Fellows believed science should form the basis of water policy, yet values, costs, and feasibility should be a part of the decision-making framework. However, to many it appeared that science was often misused or excluded from the decision-making process. One Fellow commented that science may be included in the process, but at times it seems merely for show. Another Fellow gave the example of one group including a specific research result to bolster their political position, but the findings either were not subject to adequate peer-review or were not scientifically defensible. Fellows also commented that recommendations based on science may not be integrated into the decision making process because of expense, politics, or other factors.

Several key perceptions emerged from the survey results. First, the lack of information transfer between scientists and policymakers was one of the Fellows' main concerns and a primary reason for attending the workshops (Fig. 1a). Second, nearly half of the Fellows felt that not enough science currently is being used in policy decisions. Third, Fellows expressed a strong interest in learning more science and a desire to learn specifically about water resource issues. Fourth, approximately one quarter of the Fellows identified a need to improve science communication to stakeholders and policy makers as well as provide more opportunities for public education. Finally, the Fellows identified water use and withdrawal, providing safe drinking water, groundwater management, and protection of aquatic ecosystems as topics which they believed policy needed more input from science (Fig. 1b).

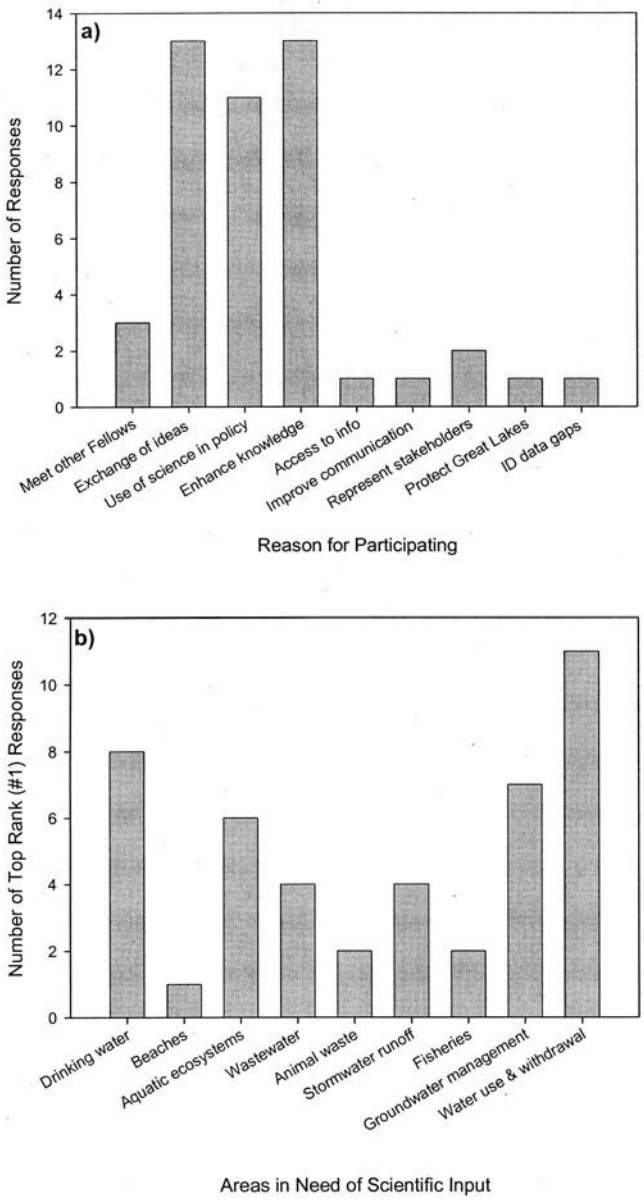

FIG. 1. Results from the survey of Fellows at the beginning of the workshop series. (a) Fellows identified information exchange, concern over the use of science in policy, and enhancing personal knowledge as the top reasons for participating in the workshop. (b) Fellows identified water policy issues which could benefit from input from science.

Group Dynamics

Because the Fellows were from a variety of backgrounds, and often opposing viewpoints, we worked with a professional facilitator to help manage group dynamics. Establishing "neutral terri-

tory" where each Fellow's contributions were acknowledged as valuable was critical for creating an atmosphere for productive discussion. At each workshop, we reminded the Fellows that everyone had valuable input and everyone would have a chance to share and discuss their views. We expected many of the Fellows to disagree and for these disagreements to fall along traditional group alliances (e.g., environmental interests versus industry). However, the majority of workshop discussions were harmonious with little conflict. By the end of the workshop series, the Fellows were focused on developing a model as a means to move forward. The Fellows worked together, crossing traditional barriers, to generate a model for using science in the decision-making process.

The majority of the Fellows' interactions with one another occurred in the small group discussion. At each workshop, the small groups were asked to report out to the whole group and identify points on which they agreed and areas where there was dissent in the group. We did not try to reach consensus on each topic discussed; rather, we sought to capture the views of the Fellows on each topic. For most workshops, there were a few dissenters. Many of the dissenting comments were actually refinements of the summary of the group discussion, although there were Fellows who did not agree with others in their group on major points. When dissent arose, our facilitator focused on leading the group to identify and understand the specific viewpoints of the dissenting Fellows.

The workshop on the value of water generated the most dissent among the Fellows. The Fellows fell into roughly two groups: 1) those who thought there could be no value put on water and therefore economics should not be considered and 2) those who believed economics could play a role in protection of water resources. The first group of Fellows expressed a concern over water becoming a commodity and only economic considerations coming into play when managing water resources. These Fellows expressed a concern that as a result of only considering economics, protection of water resources and aquatic ecosystems would be an afterthought to human uses. There were Fellows, however, who thought economics could capture a part of the value of water and economic arguments could be used for protection of water resources. These Fellows thought that economics were a critical input for decision-making or that economics could be used to make a stronger argument for resource protection rather than an emotional appeal. All Fellows acknowledged that a pure economic valuation of water does not include many components of the value of water.

Workshop Discussions

Five themes for enhancing science and policy in Michigan emerged from the Fellows' discussions throughout the workshop series. Common to all discussions was the need for improving communication and education.

Theme 1: An integrated, recursive decision-making framework for incorporating science into water policy is needed.

The Fellows generated a model framework (Fig. 2) for science and water policy which uses an integrated decision-making approach. This approach focuses on making decisions with the best available information from a variety of sources, monitoring implementation and effects, and revisiting the decision when more information is available. The approach included goals for collecting long-term monitoring data and continuous input from scientific research. This framework would aim to give policy makers a means to progress water policies, encouraging proactive rather than reactive decision-making. It also provides a means for interaction between the science and policy communities. The National Research Council (NRC) has recommended a similar approach for incorporating risk characterization into policy which relies upon integration of analysis and deliberation (Stern and Fineberg 1996). In this context, analysis refers to science and using scientific methods to gain knowledge. Deliberation encompasses the political process of communication and collective discussion about issues. Through deliberation, participants learn other perspectives and develop understanding of various perspectives. Analysis and deliberation should be integrated in the policy-making process; scientific analysis informs political deliberation and political deliberation helps frame questions for scientific analysis (Stern and Fineberg 1996).

The integrated decision-making framework is also similar to adaptive management programs. Adaptive management is often defined as "learning by doing," or using existing scientific information to construct predictive models about alternative policy options and designing management experiments (Walters 1997). Adaptive management often appeals to stakeholders because it seems simple and intuitive (Failing *et al.* 2004). However, there are few case studies of successful adaptive manage-

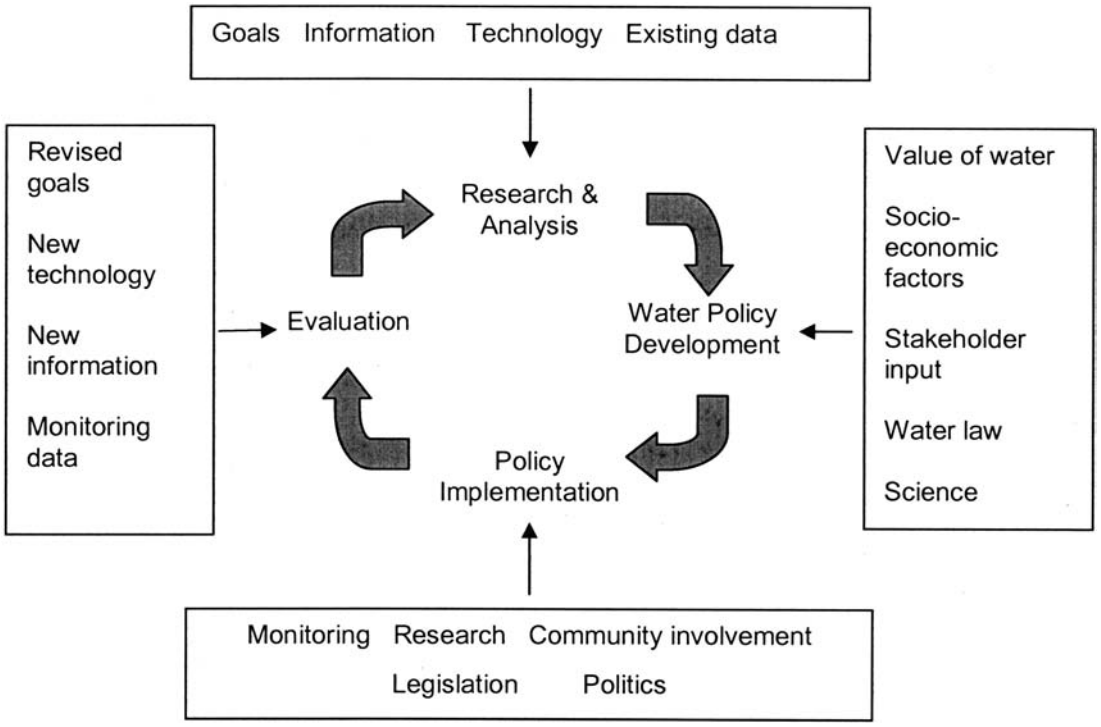

FIG. 2. The decision-making framework proposed by the Water Resource Fellows.

ment applications (Walters 1997). Failing *et al.* (2004) propose that viewing adaptive management as a guiding framework may be the cause for failure because other aspects of decision making become secondary to implementing adaptive management, or what is viewed as an experimental approach. Under these conditions, stakeholder views, other resource management options, and competing societal objectives may be ignored and consequently lead to failure. In the framework developed by the Fellows, however, these aspects are explicitly incorporated into the decision-making process. Adaptive management, in terms of experimentation and monitoring, is but one policy option. A broader definition of adaptive management (see Walters 1997), which goes beyond experimentation with management options to incorporating science as an input to all components of the decision-making process in order to make iterative improvements to policy (Halbert 1993), is more consistent with the framework recommended by the Fellows.

The adaptive management approach provides policymakers with a means to deal with the long-time scales and biological uncertainty inherent in managing natural resources. Many Fellows, from a variety of backgrounds, expressed frustration that water resources policy and management is often a reaction to crisis rather than proactive protection of resources. In addition, many felt policy-makers use scientific uncertainty as a reason to delay or forego action. The framework proposed by the Fellows encourages action based on current information while acknowledging uncertainty. The recursive component of the framework allows for continuous adjustments to reduce uncertainty and improve policy as new information becomes available.

Groups throughout the Great Lakes basin have recommended using adaptive management approaches. Researchers, managers, and stakeholders have recommended this approach for many programs, including fisheries, groundwater management (Morris *et al.* 2006), Remedial Action Plans (Hall *et al.* 2006), and Lakewide Management Plans. The framework recommended by the Fellows complements these existing efforts and can also be incorporated into future management plans.

Theme 2: Clear pathways for productive communication between scientists and policymakers are needed.

An essential component of the recursive decision-making framework is communication between policy-makers, scientists, and stakeholders. Fellows stressed that the process of developing water policy

needs to be inclusive, with a variety of decision-makers, scientists, and stakeholders participating in the process at the watershed scale. The Fellows recommended that the government should facilitate open communication between the science and policy communities. For example, the Fellows recommended that government use more science-based advisory councils and stakeholder committees, which would provide independent scientific information and focus on stakeholder involvement. They also recommended scientists communicate research results outside of academia and put results into common terms for the public and policymakers to use.

Fellows also emphasized using science as a communication tool to reach consensus. Many Fellows expressed the view that science can encourage progress by focusing on what is and is not known rather than focusing on political differences. However, there are limitations to the effectiveness of using science to build consensus based on sociocultural factors (Gutrich *et al.* 2005). For example, certain groups may be unwilling to express water issues in economic terms (Baron and Spranca 1997, Sagoff 2000). In fact, this issue caused the most conflict among the Fellows. Discussing natural resources in monetary terms is often contentious (Gutrich *et al.* 2005); other disciplines of science and methods such as modeling may serve as better communication tools for building consensus.

As we observed in the discussions regarding the value of water, many stakeholders often hold different mental models about water resources. Differences in mental models can result in failed communication and failed policy (Gutrich *et al.* 2005). Many of these conflicts arise because stakeholders commonly hold simple mental models which do not consider complexities such as time lags in responses, uncertainties, and non-equilibrium system dynamics (Costanza and Ruth 1998). Science-based models can serve as tools to correct misconceptions and to identify areas of potential consensus (Gutrich *et al.* 2005).

The need for communication is not limited to Michigan; communication is critical for effective public participation and collaborative decision-making. Public participation is often required under federal and state programs; however, much of the "participation" under these mandated programs is one-sided (Stave 2002). However, methods which promote two-way communication, such as this workshop series, are likely to be more effective. In the Great Lakes region, the Great Lakes Regional Collaboration Implementation Framework (GLRC 2006) calls for a public participation plan to provide opportunities for public input at "appropriate stages of implementation." The format used in the workshop series could be used to develop such public participation plans.

Theme 3: Continued, long-term investment in scientific research is critical for effective decision-making

The Fellows recommended continued investment in scientific research directed towards specific needs of the region. The Fellows identified 10 critical research questions for the state of Michigan for the six topics discussed at the workshop series (Table 1). The Fellows stressed that scientific research on water resources needs to be multidisciplinary (e.g., include the biological, chemical, physical, and social sciences) and that it be directed toward specific research questions that address societal needs. Stakeholders often support gathering

TABLE 1. Key research questions generated by the Fellows regarding the topics discussed at the workshops.

	Research Questions for Michigan
1	What is the role of groundwater in supporting ecosystem function?
2	What are appropriate indicators of ecological and socio-economic impacts associated with water use?
3	What are the biggest threats to our drinking water supplies in Michigan?
4	What are the overall infrastructure needs for improving water management in Michigan and when is it cost-effective to replace water infrastructure rather than repair it?
5	What new drinking water and wastewater technologies are appropriate for Michigan?
6	What incentives can encourage local governments to work together toward comprehensive watershed management?
7	What monitoring programs are currently active and are they coordinating efforts with one another?
8	How do groundwater withdrawals affect nearby groundwater and surface water resources?
9	How do different stakeholders in Michigan value water and how do these values influence stakeholders' views on water management?
10	Why do some communities make long-term investments in infrastructure while others do not?

more scientific information to serve as a better foundation for decision-making (Maguire 2003).

Fellows recognized that policy-makers require unbiased, credible information. The Fellows stressed that policy-makers should not rely on those with vested interests for important data and analysis when non-partisan, objective data and analysis are required. Many Fellows expressed a belief that relying on such vested interests encourages a battle of experts which often stalls policy development. Fellows recommended that universities, federal agencies, and state agencies provide the needed scientific information to policy makers to help inform decisions. Some of the Fellows, mainly local government officials, discussed the possibility of creating a state level science agency similar to the USGS. However, these Fellows acknowledged that this was not a probable outcome given the stressed economic conditions and limited resources of the state. Also, existing groups such as USGS, the International Joint Commission, Great Lakes Fishery Commission, as well as academic researchers can and do provide scientific information to managers. Organizations such as the Great Lakes Regional Collaboration, Council of Great Lakes Governors, and other regional groups can also assist in lobbying the federal government for more funding for research. Fellows again stressed the importance of communication between the science and policy communities. They noted that workshop series, such as the one designed here, could be used for the policy and science communities to exchange information on what each community needs.

Theme 4: Continued, long-term investment in monitoring is critical for effective decision-making

Fellows expressed support for a comprehensive state-wide monitoring network, which would evaluate water from its source to the tap and back again. Examples of the types of monitoring Fellows believe is required include water quantity and quality monitoring of surface and groundwater, compliance monitoring (e.g., regulated discharges and contaminated sites), and water quality monitoring at treatment plants, the distribution system, and the tap. Although the Fellows expressed the belief that monitoring information is critical for effective management, they recommended avoiding "monitoring for monitoring's sake." Fellows stressed that monitoring should be a part of a larger data analysis and management system. In addition, Fellows recommend that monitoring programs be designed to be long-term and to address existing gaps in knowledge and data via state pilot projects. Comprehensive approaches to water management should also emphasize efficient and cost effective monitoring programs. For example, Fellows suggested that the first step in creating a comprehensive monitoring program would be to identify and coordinate existing monitoring efforts. Each state within the Great Lakes basin has monitoring programs under Clean Water Act, Safe Drinking Water Act, and other federal and state regulations. In addition, many academic and government researchers, regional organizations, and citizen groups collect water quality data. These programs, and water resource managers, would benefit from coordination of monitoring and data sharing. Fellows stressed that monitoring efforts should all be continuous, long-term, cost-effective programs.

Theme 5: Continued support for public, K-12, and continuing education ensures the development of an informed citizenry and future decision-makers

Access to information and education is critical for making progress on water policy. Fellows stated that both the scientific and policy communities need to ensure information is available, readable, and transparent so that the information is accessible to all citizens. This is true for citizens across the Great Lakes basin. Also, lifelong access to education is critical to maintain an informed citizenry. Fellows recommended that government continue to invest in science education programs such as those delivered by Cooperative Extension and the Michigan Mathematics and Science Centers Network. For example, the MSU Extension Citizen Planner program, which educates new planning officials, could emphasize programs on natural resources, including water. The Mathematics and Science Centers Network, which provides technical support for science and mathematics teachers, will help create knowledgeable citizens and future decision-makers. The Fellows recommended statewide dissemination and teacher-training in the use of the new Michigan Environmental Education Curricula Support (MEECS) materials. Use of MEECS may help generate greater understanding of Michigan ecosystems, land use, water quality, energy resources, and air quality among Michigan students. These programs can also serve as models for the Great Lakes region.

In addition to public education, continued investment in proper training of all wastewater and drinking water plant operators is vital for protecting public health across the Great Lakes region. Michigan currently has an active operator training pro-

gram and Fellows stressed its importance given that plant operators are the first line of defense against many waterborne disease outbreaks. The recent outbreak in Walkerton, Ontario illustrates the need for operator training. In May 2000, approximately 2,300 people became ill and seven ultimately died from a waterborne disease outbreak of *Esherichia coli* O157:H7 and *Campylobacter*. An inquiry into the outbreak found that the plant operators failed to maintain the legally-required amount of chlorine in the water system, which would likely have killed the organisms that caused the outbreak (Hrudey *et al.* 2003). Operator error often is a contributing factor to waterborne disease outbreaks in the developed world (Hrudey *et al.* 2003). Thus, education and training programs across the Great Lakes and U.S. are critical for preventing waterborne disease. In addition, one of the issues facing states across the country is a declining interest in careers in the water treatment business. Not only do the Fellows recommend long-term investment in operator training, but also to find ways to interest young people in these essential fields. For example, Fellows recommended that universities offer science and engineering students programs which provide an interdisciplinary and holistic understanding of the future environmental and economic consequences of engineering decisions.

Relevance of the Workshop Series

Our goal for the series was to generate discussion about the role of science among stakeholders in Michigan. The organization of the workshops gave Fellows the chance to interact in a neutral environment. By the end of the series, the Fellows worked together to develop an adaptive management framework for incorporating science into policy. Thus, we were able to create an atmosphere where Fellows felt free to share their views, ask questions, and develop a common vision. A similar approach could be used by groups across the Great Lakes basin to encourage public participation, stakeholder involvement and collaborative decision-making.

Much of the success of the program lies in the Fellows' willingness to interact and learn from one another. Several other aspects of the workshop series contributed to its success. First, bringing in speakers from outside Michigan assisted in diffusing political tension among the Fellows because the speakers focused on the status of the science and technology rather than local issues or politics. Second, holding the series over several months allowed Fellows to get to know one another and build trust and cohesion as a group, which promoted discussion. Third, it was important to hold the workshops on what was perceived as neutral ground because some Fellows were commonly on opposite sides of political issues. Finally, it was important to set ground rules for participation at the beginning of the series. The facilitator gave rules of engagement at the orientation as well as the beginning of discussions at the workshops. These rules emphasized mutual respect and that each Fellow had valuable ideas to contribute. This also built trust among the Fellows and provided an environment which encouraged open debate and discussion and enabled us to meet the goal of providing a venue for communication among stakeholders.

This process for enabling discussion can be used for other programs where stakeholder input and collaboration are desired, such as the Great Lakes Regional Collaboration Implementation Framework. Patel *et al.* (2007) also examined processes to generate effective public participation and means to not only involve stakeholders but to encourage social learning. These researchers held a series of meetings to gain stakeholder input on different land use scenarios. Like the workshop we organized, stakeholders in the workshops by Patel *et al.* (2007) also worked in small groups with many opportunities to provide input. Our workshop series had similar outcomes as Patel *et al.* (2007), namely generating improved understanding of each other and the discussion topic, sharing knowledge and experiences, building trust, and social learning.

CONCLUSION

The Fellows identified critical research needs in the areas of groundwater-surface water management, ecosystem services, safe drinking water, wastewater, valuation of water resources, and comprehensive watershed management. For all of these topics, Fellows stated that continued investment in science, education, and monitoring is needed to make informed policy decisions. The discussions culminated in development of the decision-making framework, a guiding vision for the relationship between science and policy in Michigan. In terms of topics covered in discussions, the decision-making framework generated the most consensus among the Fellows. The Fellows generated this framework through their discussions and were not provided with models of recursive decision-making or adaptive management from the workshop organizers.

The research questions the Fellows generated can serve as a research agenda for scientists to address the needs of stakeholders and policymakers. The research questions focus on water quality, water use, and effective mechanisms to promote management actions. Although the Fellows focused on Michigan, these questions apply to the Great Lakes region as shown by the similar questions arising from the Great Lakes Regional Collaboration. Stakeholders and policy-makers across the basin will need to address issues such as determining equitable water use policies, developing new approaches to improve water quality, and protecting water resources even when the economic resources to do so are scarce.

We found that providing policy-makers, scientists, and stakeholders with a forum for discussion can generate a common vision for the use of science in policy-making. Fellows identified several roles science can play in policy-making which are similar to those outlined by researchers studying the interaction of science and policy (Houck 2003, Ascher 2004). These roles include identifying important issues society needs to address, assisting in identifying viable policy options, communicating scientific uncertainty, defining baseline or reference conditions, and providing information on why policies succeed or fail. In addition, at all of the workshops, Fellows stressed the need to increase communication between the scientific and policy communities and raise awareness about the need for education of elected officials and the public on key water resource issues. Conducting stakeholder forums for exchanging ideas outside the political arena can enhance personal knowledge, promote discussion, and build consensus by shifting the focus to commonalities among stakeholders rather than their differences.

Creating venues for discussion similar to the one we developed can improve stakeholder involvement and communication between the science and policy communities. Although we did not address a specific policy in this workshop series, we were successful in developing a common vision among participants. Working in small groups and providing multiple opportunities for input was a critical component of success in this and similar studies (Patel *et al.* 2007). Similar methods can be used to develop specific recommendations on policy, to encourage communication between the science and policy communities, or to gather substantive public input.

ACKNOWLEDGMENTS

We would like to thank our Executive Steering Committee and the Water Resource Fellows for their time. Special thanks to Jan Urban-Lurain who facilitated all the workshops. Thanks also to T. Fong, R. Ives, R. Katonak, S. Molloy, M. Schulz, S. Singh, and M. Wong for taking and compiling notes from the workshops. Funding was provided by Michigan State University, the MSU Homer Nowlin Chair in Water Research, the Sustainable Michigan Endowment Project, the MSU Institute of Water Research, and MSU Center for Water Sciences.

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Submitted: 13 November 2006
Accepted: 3 September 2007
Editorial handling: Joseph V. DePinto