Finding Hope in the Millennium Ecosystem Assessment

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Abstract: *Over the past quarter century, a new scientific activity has emerged: collective assessments by large numbers of scientists from different disciplines combining their expertise to better understand human interrelations with nature and to inform policy. The Millennium Ecosystem Assessment exceeded all such assessments before it in both the breadth of its coverage and the depth of its analysis of socioecological system dynamics. The findings are not encouraging. Nearly all ecosystems are being degraded and will continue to be degraded for decades to come even if policy changes are initiated now. For scientists participating in the assessment, the MA had another disconcerting aspect. It clearly shows that our fragmented, disciplinary knowledges cannot simply be combined to form an understanding of a whole complex system. Counterbalancing the despair of the findings and scientific difficulties of aggregating specialized knowledges, the MA demonstrated the potential of a deliberative democratic approach to grappling with complex problems.*

Keywords: deliberative democracy, environmental assessment, epistemology, experiential knowledge, Millennium Ecosystem Assessment, shared learning, socioecological systems

Encontrando Esperanza en la Evaluación de Ecosistemas Milenio

Resumen: *En los últimos 25 años ha emergido una nueva actividad científica: evaluaciones colectivas por un gran número de científicos de diferentes disciplinas que combinan su experticia para un mejor entendimiento de las interrelaciones humanas con la naturaleza y para informar a los políticos. La Evaluación de Ecosistemas Milenio fue más allá de todas las evaluaciones previas tanto en el alcance de su cobertura como en la profundidad de su análisis de la dinámica del sistema socioecológico. Los resultados no son alentadores. Casi todos los ecosistemas están siendo degradados y lo continuarán siendo por décadas aun si hoy se iniciaran cambios en las políticas. Para los científicos que participaron en la evaluación, la EE tuvo otro aspecto desconcertante. Claramente muestra que nuestro conocimiento disciplinar, fragmentado, simplemente no puede ser combinado para formar un entendimiento de un complejo sistema integral. En contraste con la desesperanza de los resultados y las dificultades científicas para agregar conocimientos especializados, la EE demostró el potencial de un enfoque democrático deliberativo para enfrentar problemas complejos.*

Palabras Clave: aprendizaje compartido, conocimiento experimental, democracia deliberativa, epistemología, evaluación ambiental, Evaluación de Ecosistemas Milenio, sistemas socioecológicos

Introduction

The summary of the Millennium Ecosystem Assessment (MA) (MA 2005) has the measured tone one might have expected of a BBC newscaster elaborating on the launch of nuclear missiles in the era of mutually assured destruction:

> Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable

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> period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber, and fuel.
> The changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, but these gains have been achieved at growing costs in the form of the degradation of many ecosystem services, increased risks of nonlinear changes, and the exacerbation of poverty for some groups of people.
> The degradation of ecosystem services could grow significantly worse during the first half of this century and is a barrier to achieving the Millennium Development Goals.
> The challenge of reversing the degradation of ecosystems while meeting increasing demands for their services can be partially met under some scenarios that the MA has considered, but these involve significant changes in policies, institutions, and practices that are not currently under way. (MA 2005:1)

The deliberate wording and matter-of-fact tone reflect an interesting dichotomy that arose during the MA. As some 2000 environmental and social scientists from around the globe reread the available literature and combined their knowledge, many concluded that the human prospect is more dire than they had thought. At the same time, however, the process of conducting the assessment proved considerably more difficult than expected. The literatures of the environmental and social sciences are not easily synthesized into a systemic whole. As a result, many participants began to see that our ability to scientifically document our dependence on ecosystems and to forecast their decline is considerably weaker than they had expected. Coming out of the MA realizing that the human environmental predicament is probably more severe than foreseen and that our science is less capable than thought was doubly discouraging.

Yet an additional outcome of the MA process, a source of considerable hope, emerged as well. A significant number of scientists learned how to deliberate together, combine their separate disciplinary frameworks, and form a collective analytical ability that was more than the sum of their individual contributions. Personal or experiential knowledge (i.e., the things scientists learn through being engaged, informed citizens, in their general education and participation in scholarly communities and from their field research) played an important bridging role in the deliberative learning process. By the time I joined the MA as a participant-observer in its final year, this empowering aspect was becoming clear.

I provide a broad overview of the epistemic challenges of fitting disparate disciplinary understandings together, show how they can be overcome to some extent through a discursive process of shared learning and judgment, and interpret the nature and implications of the process for both science as a whole and future assessments. Finally, I argue that the MA provides an interesting "existence proof" of a deliberative democracy that could gird sustainable development.

Expectations

The objective of the MA was to derive scientifically credible, policy-relevant information for decision makers. The challenge for an assessment is to bring a diverse set of particular studies—with their different foci, grains, extents, and frameworks of analyses—together into a coherent whole that has broad policy messages. Scientists typically meet this challenge by selecting a general framework into which multiple studies fit and shifting to special frames of analysis as necessary to highlight critical points. This approach to assessment works when both the literature being assessed and the outlook and skill set of the scientists assessing it are fairly cohesive (Farrell & Jäger 2006). In the MA, however, scholars from multiple disciplines, and from rich and poor countries, evaluated a broad range of literatures. Agreeing on a conceptual framework (Fig. 1) proved to be a significant task and a major contribution (MA 2003).

Once the MA framework was derived, numerous scientists were drawn into the process to connect the details found in the literature to the conceptual framework. Most participating scientists understood that the MA was a social process entailing judgment. Most understood that it was a process of picking words carefully, sometimes directing and other times blurring their focus, just enough so that nearly all participants could agree. Saying less than some wanted was a common outcome. Most understood that the assessment was meant to be policy relevant but not prescriptive. The MA turned out to be more carefully, less universally, worded than many participants expected at the beginning, but it is well reasoned and clearly written.

The MA is already significantly affecting education, research, and policy, albeit unevenly, around the globe (Reid 2006). Thus, one can argue that the MA did exactly what it was supposed to do.

Despair

The process of preparing the MA had unexpected complications. Using the general framework to achieve systemic understanding proved problematic in practice for 8 tightly interrelated reasons.

First, the literature assessed reflects the fragmented, disciplinary nature of science. Studies in the environmental sciences rarely make linkages to the social system. Similarly, economic and social analyses rarely make adequate linkages to the environmental system. The MA could not overcome these limitations and draw the connections between social and ecological systems within the conventional expectations of how the separate sciences fit

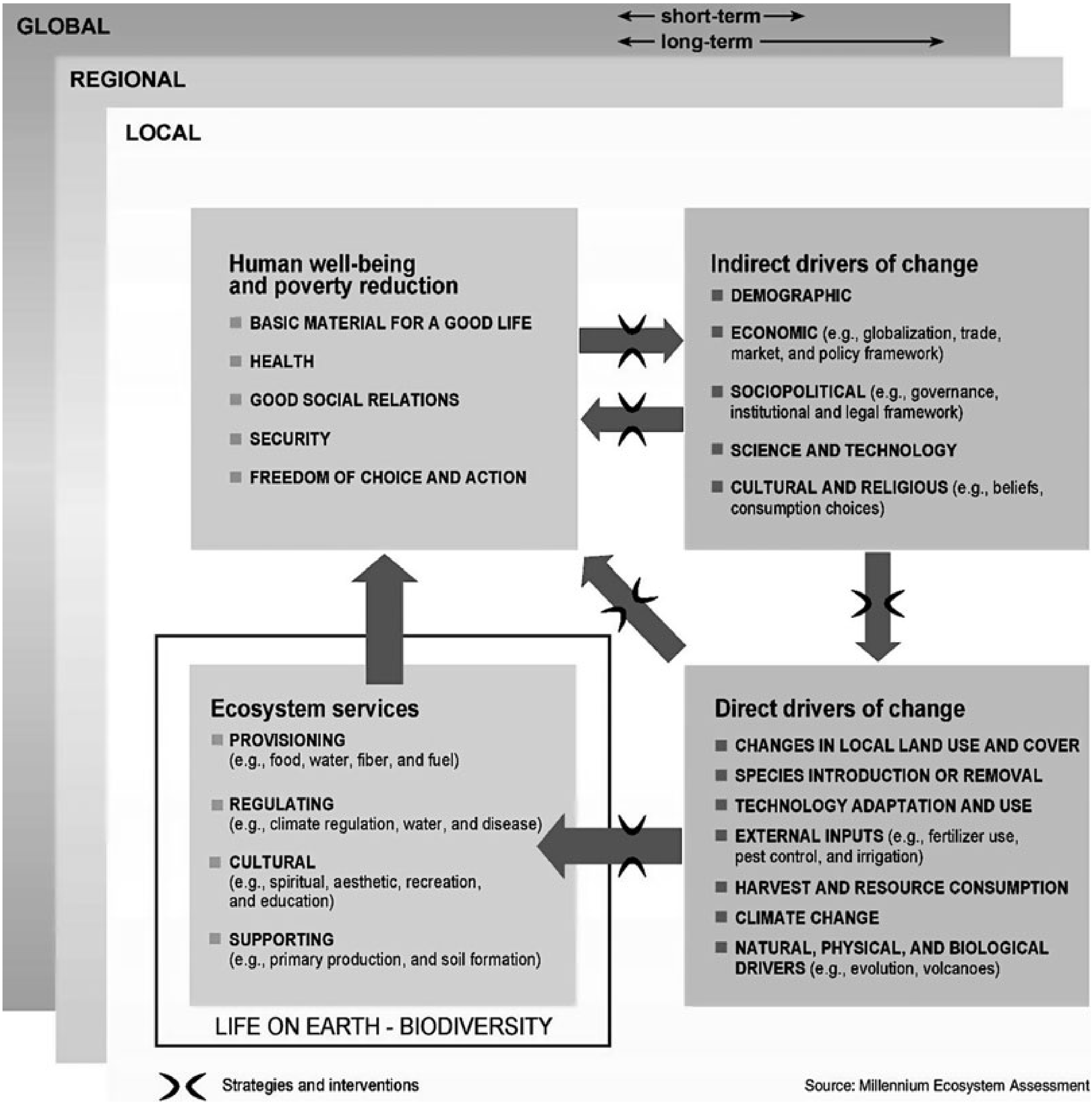

Figure 1. Millennium Ecosystem Assessment conceptual framework. Changes in factors that indirectly affect ecosystems, such as population (upper right corner), can lead to changes in factors directly affecting ecosystems, such as catch of fisheries (lower right corner). The resulting changes in the ecosystem (lower left corner) cause the ecosystem services to change and thereby affect human well-being. These interactions can take place at more than one spatial and temporal scale and can cross scales. Actions can be taken to respond to negative changes or to enhance positive changes at many points (black cross bars). (Adapted from text describing framework of the Millennium Ecosystem Assessment [MA 2003:37])

together into a coherent picture. Younger participants were surprised to discover the severity of the problem; even those from interdisciplinary programs had not systematically ventured across the fragmented fields of science. Older participants were frustrated that so little progress had been made following the efforts to encourage integration after the rise of environmental concern in the late 1960s.

Second, ecology consists of multiple formal frameworks such as food-web models, more interpretive approaches such as landscape ecology, and metaphors such as "environmental engineer." Even though each way of thinking is important to ecological understanding, the different ways do not fit together within an overarching metamodel. Ecologists see different bundles of factors and how they relate to each other in discrete ways, where the different models of ecology are doing the bundling. Ecologists' understandings of ecosystem services (lower left quadrant, Fig. 1) flow from contradictory patterns of thinking about what ecosystems, as stocks, are. Population biology and energetics fit the MA general framework, but focus on very different stocks and flows, whereas landscape ecology and evolutionary ecology do not fit the natural capital and ecosystem services pattern of thinking at all. Our understandings of each of the other 3 quadrants similarly rely on multiple formal frameworks, interpretive approaches, and metaphors that do not readily fit the conceptual framework.

Third, ecosystems do not have "inherent" scales. Rather, ecologists select the spatial and temporal extent and the grain of an analysis depending on the problem, ecological framework chosen, and the constraints of obtaining appropriate data while trying to complete a PhD thesis, achieve tenure, or inform a policy debate. Differing spatial and temporal extents and grains of analysis of the cases assessed complicated summarizing the literature (Levin 1992; Zermoglio et al. 2005; Wu & Li 2006). Furthermore, population biology, food webs, biogeochemical cycles, landscape ecology, and evolutionary ecology each play more important roles in ecological thinking at particular spatial and temporal scales. Simon Levin (Hlodan 2005) describes the challenge well:

> the dynamics of ecological systems take place on many different scales simultaneously, and the great challenges for us are to understand how processes change across scales, *how our perspective on systems affects the dynamics that we see*, and how processes on one scale relate to processes on other scales [emphasis added].

Fourth, MA participants became increasingly aware of the historical contingencies and local contextualities of the dynamics of socioecological systems. Although every event has multiple causes and multiple effects, particular analyses in the literature typically emphasize only a few, and different ones at that. What combination of stimuli perpetrated the crash of particular populations or instigated an ecosystem regime shift was no longer as easily explained when thinking within the integrated social and ecological framework of the MA. The variety of factors and their interrelations across scales that could have contributed to a crash or shift and the significant time lags between what seemed like possible stimuli and possible outcomes could not be documented given their complexity and the quality of the data available (Kinzig et al. 2006). There were parallel difficulties in explaining changes in social systems. Walker and Meyers (2003) propose a standardized typology for comparing stimuli and regime shifts in social-ecological systems to reduce this problem.

Fifth, because ecosystem thresholds are unknown, neither the MA conceptual framework nor the empirical literature reviewed distinguished between ecological services generated by sustainable ecosystem flows from those that were generated through degrading ecosystem properties that would result in reduced future flows. This distinction, critical to both popular notions and formal stock-flow models of sustainability, was not possible because no ecosystem and the ways it is embedded in larger systems has been adequately modeled and empirically calibrated such that the distinction between sustainable flows and degradation can be made. The concept of natural capital, ecosystem services, and sustainability as a matter of sustaining the stock all derive from stock-flow models of systems. Much ecological understanding, however, like that derived from evolutionary ecology, comes from models in which sustainability, even prediction, has little meaning. As climate scientists address the nonlinearities and thresholds of climate systems, they face similar difficulties (Rial et al. 2004; NRC 2007). Problems with the scale of analyses raised serious complications with respect to description and prediction because unfavorable changes in one place could be linked to favorable changes in another (Levin 1992). And even were it possible to model and empirically calibrate systems that are constantly losing components, reassembling around new invasives, and coevolving (Taylor 2005), it is not possible to measure net change if some desirable properties are being degraded while others are being strengthened without putting relative weights on the different properties.

Sixth, some biologists were intrigued by the possibilities of solving the need for relative weights through economic valuation, and some economists were prepared to use valuations in the literature. Participants from developing countries, however, argued that economic valuation methods weigh a dollar a rich person spends on ecotourism the same as a dollar a poor person spends on food and bus fare. The MA addresses future generations out of a concern that the current socioeconomic system does not address their needs (i.e., weigh them) adequately. For this reason some argued that it is illogical to use current preferences, behavior, or replacements costs to weight and aggregate details to inform new policy choices because the current system in which behavior and prices are being expressed is on the wrong course. Others pointed out that for there to be any rationality to relying on stated preferences or behavior, one would have to assume that lay people were sufficiently informed of the very complexities the MA scientists were struggling to understand. In short, the problems of using monetary values to weight phenomena are tightly embedded in the very socioeconomic system driving the problems of ecosystem degradation the MA sought to understand in order to better inform new socioeconomic policies (Norgaard et al. 2001).

Seventh, ecosystem change occurs through a great number of direct drivers: climate change, habitat fragmentation, toxic pollutants, nutrification, invasive species, and overexploitation. These direct drivers have differential impacts on different ecosystem services according to ecosystem type and local histories. The direct drivers, in turn, are propelled by an equally large number of indirect drivers: cultural values and social, economic, and legal system characteristics that drive private, corporate, and agency behavior. These, of course, are also spatially contextual and historically contingent. Now recall that for climate change, the central question is what combination of policies will best reduce greenhouse gas emissions and enhance sequestration. For ecosystem change the drivers are widely distributed yet still interconnected, which makes it impossible to identify any clear policy foci. Thus, a complex hierarchy of policies is needed that provide global guidance while allowing local flexibility specific to particular ecosystems and cultures and to the temporal dynamics or emergence of new problems. Furthermore, policies, global to local, should change as new knowledge unfolds along with new conditions (Folke et al. 2005). The inability of the MA process to scientifically determine clear policy directives further aggravated the sense that science as it is conventionally understood was not as powerful for informing policy makers as previously thought.

Eighth, there is a tradition of concluding articles with speculations about the universal significance of the findings on the basis of a case study. Some scientists came to the MA expecting to be able to validate their own findings with those of other scientists working in similar ecosystems. Such validation would also put the scientists in a stronger position to extrapolate findings to similar areas that are less studied. In practice, however, it was more difficult than expected to find either corroborating results in similar situations or an empirically valid basis for extrapolating existing case studies to other areas. The quality of social and environmental data is poor for most of the globe. The difficulty of empirically extrapolating findings from one situation to another was exacerbated by the increased awareness, highlighted by the conceptual framework, among MA participants of how a multiplicity of factors drive ecosystem change and how they interact differently under particular ecological, economic, and cultural conditions. Thus, speculations about the universal significance of case-study findings that appear in the literature became more speculative rather than less for MA participants.

The scientists participating in the MA grappled with the problems openly and honestly from multiple disciplinary, experiential, and cultural perspectives and from different positions in the world economic structure. The summary findings of the MA are conservatively worded to a considerable extent because of these 8 epistemological problems. Conversely, it is much easier to reach strong, clear conclusions among scientists with similar values, who know the same things and whose metanarratives protect them from complexities beyond their expertise.

Hope

By the time I joined the MA process, the participating scientists were quite aware that numerous methodological quandaries could not be resolved. Although the participants were not able to rationally deduce clear answers, they were able to engage in reasonable discussions and come to common understandings. Although a few scientists were still defending their own specific theoretical, empirical, and experiential knowledges, most had taken a public and "global" position and were open to different scientific and cultural perspectives; interested in sharing personal understandings; and fairly comfortable with ambiguity. In spite of the rational incongruities constantly being addressed, the process was reasonable in that it pursued diverse ecological and social rationalities pretty much to everyone's satisfaction. By sharing separate knowledges and perspectives and then thinking through questions together, MA scientists were addressing "the great challenges" noted by Levin (Hlodan 2005).

This process of working across multiple rationalities and scales typically arose in the context of a specific question. When a question was posed, scientists sequentially entered the discussion from different conceptual perspectives, looking at different spatial scales, focusing on different trophic levels, looking at different dynamic relationships over time, and bringing different experiential knowledges to the fore. The easy answers that a group of similarly minded scientists might reach were the first to be contested. Through intense discussions, often drawing on experiential knowledge omitted from their findings written for disciplinary journals, they selected appropriate models for specific cases, picked critical variables, and forged linkages between systems. Working together, the picture quickly became much richer and complex, and a whole new layer of feedbacks, some of which amplified problems, others of which dampened them, were being explored. This collective scientific "breakthrough" did not bring them closer to Bacon's dream of a god-like understanding of the whole. Rather, the repercussions of a change in one part of the socioecological system on other parts of the system became even more ambiguous. Still, they experienced a sense that they were capable of both exploring different frameworks and reaching a deeper understanding of the human predicament.

Some scientists initiated subglobal analyses (ultimately better characterized as multiscale assessments) to grapple more directly with the difficulties associated with scale and context. These assessments started with a particular place and general issue and then analyzed how the issue became redefined and characterized anew moving from the local scale to the global and back. By anchoring analyses in specific locales, the subglobal assessments were less plagued by the difficulties of analyzing across contextual differences between ecosystems and socioeconomic systems around the globe. The team members doing these assessments were especially adept at learning to reframe and rescale and then think through a problem together. This may be because they tended to be younger, more interdisciplinary, and hence more adept at changing frameworks compared with the scientists originally selected for the global assessments for whom stature in their specialties weighed heavily in their selection.

The MA participants formed a learning community to connect their disparate disciplinary perspectives on socioecological systems. The general framework helped the participants see what pieces were missing and to structure discussions, but filling in its details could not be done directly from the literature they assessed. To a large extent, judgment based on information beyond the scientific literature was necessary to winnow trivial from important phenomena and to make connections across scales and between social and ecological systems. Their judgments relied on personal knowledge gleaned through living and observing, including knowledge that as a scientist they picked up but did not report in the literature because that knowledge was outside the boundary of their disciplinary journals. The conversations between scientists were open-ended and reasonable in the sense that multiple perspectives were explored. This required both a change in how they thought about systems and in the way they attached imperfect data to interpret the conditions. Most of the discussions among scientists were centered on how to resolve the epistemological difficulties or accept their ambiguity.

Some participants adapted to this process better than others. Multiscientist deliberation requires considerable humility, hard work, respect, and patience. The MA scientists saw how the metanarratives of their own disciplinary cultures—the ways they imagine their individual scientific contributions fit into a whole picture and inform policy—did not mesh with the hard knowledge and critical questions of other disciplinary cultures. Some vocabulary was entirely new, familiar words had different meanings, and common patterns of thinking were referred to differently. Respecting the knowledge of scientists with different scientific backgrounds was easy when their arguments complemented their own. It was more difficult to hear and incorporate arguments that contradicted their own or even simply shifted the analysis to another spatial or temporal scale and "confused" the issue. It also took more than respect to keep the dialogue going; many times participants needed to sleep on the new arguments, or take a walk, to complete their thoughts. Not all scientists participated in the deliberative process sufficiently through multiple meetings to sense the power of shared knowledge. Many seemed to limit their participation to what proved comfortable for them.

The important thing about the MA assessment is that a significant number of the scientists participating made these shifts in thinking. To a large extent, the shift entailed becoming more humble and more comfortable with irresolvable ambiguity. These were the scientists who were most enthusiastic about the MA because it helped them see the complex interactions of people and the environment in a deeper way. It was a shared realization that although they were all limited by their training and brain capacity, they could still come to a deeper understanding of complex problems by discussing things together. Hence, there was considerable excitement, a tinge of euphoria, as the MA came to a close.

Implications for Future Assessments

Carpenter et al. (2006) argue that substantial advances in conceptual models, data collection and management, and interdisciplinary analytical capabilities are needed to improve the literature so that future assessments have a stronger scientific basis. Nevertheless, the hope that data and science will soon prove adequate has a long history. In 1864 George Perkins Marsh (p. 52) argued,

> The geological, hydrographical, and topographical surveys, which almost every general and even local government of the civilized world is carrying on, are making yet more important contributions to our stock of geographical and general physical knowledge, and within a comparatively short space, there will be an accumulation of well established constant and historical facts, from which we can safely reason upon all the relations of action and reaction between man and external nature.

Marsh, however, went on to argue,

> We are, even now, breaking up the floor and wainscoting and doors and window frames of our dwelling, for fuel to warm our bodies and seethe our pottage, and the world cannot afford to wait till the slow and sure progress of exact science has taught it a better economy. Much practical lessons have been learned by the common observation of unschooled men; and the teachings of simple experience, on topics where natural philosophy has scarcely spoken, are not to be despised.

What was prescient one and a half centuries ago is pressing today. In the midst of global warming and the sixth great extinction of biodiversity, we cannot wait for adequate science to accurately inform optimal policy. We still need the best science we have, and we need to improve it as we can, but we need something more.

The MA can help us see what that "something more" might be. In my judgment the most important product of the MA was the shared learning experience among the scientists who participated. Because of the MA we have a cadre of scientists who have come to a deeper understanding of the complexity and sensitivity of how people and nature interrelate and a keen sense of the direction the whole system is heading. These are the scientists who are now the most capable of informing better policy. These are also the scientists who are the best informed and the most motivated to seek better models and improve the interdisciplinary training of graduate students. We need many more such scientists, and the best way to produce them is to conduct further assessments at local and regional levels that build on the Millennium Ecosystem Assessment and contribute to the next global effort.

Implications for Deliberative Democracy

The MA has another important lesson with potential long-run significance. It helps us see how the lines between scientific ways of knowing and democratic ways of choosing continue to blur. The role of judgment in science, and the acknowledgment of this by scientists, is a critical part of the story. Choosing a problem, a model, and the key assumptions of an analysis are matters of judgment that are regularly rationalized within different communities of scientists (Hull 1988). Scientific knowledge of the relationships between choices and possible outcomes aids these judgments but is not sufficient. Disciplinary traditions play an important role in keeping outdated or unrealistic assumptions and interpretations in place. Partly for this reason, participatory research arose because those who directly experience problems that scientists are addressing have knowledge that can help design the research, interpret the results, and implement change (Narayan 1996). A committee of scientists working under the auspices of the National Research Council argues that lay interpretations of the nature of risk are as important as the judgments of scientists in characterizing risk, and thus lay people need to be brought into the process of science (Stern & Fineberg 1996). And because the direction of research has broad implications for the kinds of technology and hence society we will have, some philosophers and scientists are arguing that the process of choosing research priorities and selecting technologies to be deployed should be more democratic (Sclove 1995; Jasanoff 2003; Kitcher 2003; Stern 2005).

Many scientists fret that we need to better explain to lay people how science really works. But even with citizens well informed of sound science, hardball interest-group politics will still produce bad outcomes. The term *citizen science* has arisen to convey the idea that we need to constructively combine the strengths of science and democratic citizenship (Irwin 1995; Nowotny et al. 2001). We have made some progress toward incorporating what Marsh referred to as "the common observation of unschooled men; and the teachings of simple experience."

Think back to the origins of democracy and your images of the public square in Athens. Men are raising their hands. Are they voting? No, they are indicating they want to speak. Speaking is still a critical part of the legislative process in halls of governance, although listening and expecting one's fellow legislators to make meaningful contributions to common understanding has declined. Speaking is frequently a matter of documenting to interest groups that their voices are being heard. Democratic theorists acknowledge that the nature of interest-group liberalism, the dominant mode of democracy today, is inappropriate for resolving complex environmental problems. Interest-group liberalism assumes that values are fixed, whereas emerging complex environmental problems require the development of new understandings and associated values. In interest-group liberalism, political actors are expected to defend their own interests; the public good is merely an aggregate of preferences based on existing understandings.

Addressing complex interrelationships and reaching new common values, let alone the interests of future generations, is inherently difficult. For these reasons some democratic theorists are advocating a substantial shift away from thinking of democracy as weighing interests, or vote counting, toward thinking of it as a shared learning process through deliberation. Political actors bring different values and understanding into a deliberative process that enhances the understanding into a more coherent whole. Old ways of understanding and valuing are tested against the nature of emerging problems, and it is hoped that new understanding and values emerge. Deliberative democracy has distinct advantages for environmental problems that are newly emerging and complex, raise new ethical questions, and are best understood from multiple perspectives and through multiple rational frameworks (Dryzek 1987; Baber & Bartlett 2005).

The MA demonstrates that at least scientists can adapt deliberative and democratic approaches in order to learn together and develop a shared understanding of complex systems. The process of assessment across disciplines is a part of science just as it is within the disciplines. Accepting this broadens our understanding of the nature of science, the role of judgment in science, and the nature of the boundary between science and democratic choice. Thus, the MA also serves as an existence proof, albeit a highly select one, for the possibilities of deliberative democracy for reaching shared understanding on a larger scale, for developing an informed electorate capable of providing the political will to sustain humanity and life.

The MA produced well-reasoned conclusions, trained a new cadre of more thoughtful and interdisciplinary scientists, and demonstrated the possibility of deliberative democracy. In this there is hope.

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