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From Science to Policy: Assessing the Assessment Process

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1. Introduction:

The Global Biodiversity Assessment (GBA) was unveiled by the United Nations Environment Program (UNEP) at the second Conference of the Parties of the Convention on Biological Diversity (CBD) in November of 1995. At over 1,000 pages and with over 1,500 participating scientists from throughout the world, the assessment was designed to provide a comprehensive state of the science review of biodiversity and inform decision making for the national delegates to the CBD. In thirteen chapters authored by leading experts in the fields of ecology, conservation biology, ecosystem management and environmental economics, the final written report addressed such issues as the distribution of biodiversity, changes in biodiversity, and biodiversity in the context of ecosystem management. It attempted to integrate the current state of knowledge about biodiversity in much the same way that the Intergovernmental Panel on Climate Change (IPCC) had done 5 years earlier for the global warming issue and the World Meteorological Organization had done in the mid-1980's for stratospheric ozone depletion (World Meteorological Organization 1985; Intergovernmental Panel on Climate Change 1996).

Reviews that followed the release of the GBA were generally positive: "As the book consolidates both scientific and managerial aspects of this vast subject in one volume, it promises to become a very useful source-book for a wide spectrum of users." (Shrestha 1997, p. 292); and "…it is widely accepted as the "state of the art" with respect to the science of biodiversity." (Reid 1997, p16). Elizabeth Dowdeswell, then UNEP's Executive Director stated at the unveiling, "This unique assessment has the potential to shape the scientific agenda for the next decade…It could also be the starting point for future assessments conducted within the framework of the Convention that would begin providing a sound basis for policy-making." (United Nations Environment Program 1995).

The GBA was undertaken independent of the CBD, organized and funded by UNEP and the Global Environment Facility (GEF). It entrained authors from over 80 countries and drew on the expertise of international non-governmental organizations such as the World Conservation Union

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and the World Resources Institute. Through such independence from the politics of the CBD, and an assiduous peer-review process to assure scientific quality, the GBA sought to provide useful knowledge in an arena that was characterized by high stakes politics, large uncertainties, and divergent interests.

In the years since its publication, however, the Global Biodiversity Assessment has had limited success in attaining many of the goals of its sponsors or authors. The assessment did provide a wide-ranging review of the existing scientific understanding of biological diversity and outlined the important gaps in understanding for biodiversity protection and management. Despite these accomplishments, however, the GBA was largely ignored by the parties to the biodiversity convention. It did not help shape the political agenda for biodiversity conservation. It was not used as a source-book by individual nations for furthering domestic biodiversity conservation efforts. And it was viewed with hostility by some countries, particularly in the developing world (Raustiala and Victor 1996; Reid 1997; Biermann 1999; Kaiser 2000; Kaiser 2000). In the words of one of it's co-editors "it's not had the value many of us think it could have had"(Kaiser 2000, p 1677). Or, as it was more bluntly articulated by one of its participating scientists, "it [the GBA] sank like a lead balloon" "(Kaiser 2000, p 1677).

Why did the biodiversity assessment have such limited success? What lessons can be learned from this example about the design of large-scale integrated assessments for environmental problems in general? Questions of this sort have been the focus of the Global Environmental Assessment project (GEA), a research and training collaboration among scientists, assessment managers and assessment users that has sought to understand how environmental assessments can more effectively inform the complex and difficult process of environmental decision making.[2] Findings from the GEA project and elsewhere point to several general pitfalls into which assessment efforts can stumble (Global Environmental Assessment Project 1997). These pitfalls can be illustrated by difficulties faced by the GBA:

1) *Failing to appreciate context*: The GBA, initiated between the first and second Conference of Parties to the CBD, seems to have taken for granted that an independent assessment would be useful in that particular political context. In fact, however, that context was characterized by deep division about the role of a scientific assessment and, by some parties involved in the CBD negotiations, outright refusal to condone outside scientific assessment (Raustiala and Victor 1996). In contrast, the 1985 ozone assessment was published at a time when principal actors who would be involved in an ozone convention were seeking an authoritative scientific assessment (Parson 1994). Likewise, the IPCC was requested by governments precisely to "assess on a comprehensive, open and transparent basis the scientific, technical and socioeconomic information relevant to understanding the scientific basis of risk of human induced climate change, its potential impacts and options for adaptation and mitigation." (Intergovernmental Panel on Climate Change 1998, p.1).
2) *Failing to address the needs of potential users*: The GBA assessment may well have been "state-of-the-art" (by western standards), but it seemed to lack relevance for its intended audience: "Too much attention is given to issues of no relevance whatsoever to local, national, or international policy. "(Reid 1997, p. 20) As is the fate of many assessments, the GBA has remained largely unused by the policy arena. Its guiding model seemed to follow the mistaken notion that "If we just get the technical science right, it will inform decision making."

[2] Visit *http://environment.harvard.edu/gea/* for more information.

3) *Failing to treat assessment as a communication process:* The GBA focused almost entirely on producing a written report of its findings. In so doing, it largely neglected the process elements of assessment – particularly the two-way communication between the producers of the assessment and the intended users that has proven to be so important in producing effective assessments. Part of the reason for this was the desire for independence and avoidance of "politicization" of the science. Part of the price of this independence (in the quest for scientific "objectivity") was the lack of relevance noted above. In addition, however, the lack of communication signaled to some a lack of regard. As one critic noted, "The scientific community just decided we needed this and did it" (quoted in Kaiser 2000, p. 1677). Little attention was given to the multiple (and often difficult to negotiate) social interactions that are necessary for the production of trusted, relevant, and therefore useful information (Jasanoff 1990; Lindblom 1990).
4) *Failing to connect global and local levels of assessment:* Both vulnerability to biodiversity loss and effective conservation efforts are locally embedded in fundamental ways . But although *global* biodiversity issues are manifest at *local* levels, the GBA did not adequately address the multi-level nature of the problem. Moreover, it did not connect to on-the-ground national or local concerns about local exposure to risks, sensitivity to these stresses and the capacity to respond to them (Biermann 1999; Clark, Jäger et al. 2000).

Of the many recommendations of measures to avoid these and related pitfalls of assessment that have emerged in recent years, none has been so popular as "integration". But while there is little disagreement that greater integration is needed, less consensus exists on *what* needs to be integrated and *how* that integration should be accomplished. (Within this volume, for example, are discussions about the integration of disciplines, research methods, scale, science and decision making, and scope i.e., parts of the causal chain). Two interrelated trends of integration have nonetheless received particular attention: 1) an increasing interest in structuring assessments to better *integrate* science and decision making (Jasanoff 1990; Global Environmental Assessment Project 1997); and 2) an increasing effort to identify, assess and *integrate* social and biogeophysical linkages across multiple scales (Easterling, Weiss et al. 1997; Gibson, Ostrom et al. 1997; Cash and Moser 2000).

As reflected in this volume, these two trends have been promoted largely through a variety of *technical* mechanisms. These have been designed to produce more predictive models, models which capture more of what is happening "on the ground", and analyses that aggregate or disaggregate across scales in an effort to link global, regional, and local phenomena (Lins, Wolock et al. 1997; Wilbanks and Kates 1999; Harvey 2000; Peterson 2000; Easterling 2001). Such efforts seek to increase the utility of assessments by more accurately reflecting realities that are important to decision makers, by capturing uncertainty in meaningful ways, or by identifying connections across levels. But they leave key aspects of the *social process* and *institutional structure* of assessment largely unaddressed . Research by scholars and the experience of practitioners have increasingly recognized that institutional aspects of assessment are critical to understanding and better structuring the connection between science and policy in the environmental arena. The GEA project has focused on several key themes relating to these aspects of assessment. Two of these central themes are outlined below: 1) Understanding assessment as a social process, not just as a product; and 2) creating socially robust systems of distributed and integrated research, assessment and decision making.

2. Assessment as a process

The initial studies of the Global Environmental Assessment project, like most earlier work on the subject (e.g., Clark and Majone 1985), presumed that scientific "assessments" could be usefully viewed as formal reports of the sort produced by the IPCC or National Research Council. Our research quickly showed, however, that little headway could be made in understanding differential effectiveness of assessments if we adopted a restrictive, "output" oriented view. Much about what makes some assessments more effective than others seems to be associated with the *process* by which they are developed, rather than just the *product* itself. In particular, assessments seem to be more usefully viewed as a *social communication process* through which scientists, decision makers, advocates, and the media interact to define relevant questions (while leaving others unasked), mobilize certain kinds of experts and expertise (while leaving others out), and interpret findings in particular ways (Jasanoff 1987; Jasanoff 1990; Jasanoff 1995; Miller, Jasanoff et al. 1997).

Once one takes seriously the process dimensions of assessment, it is a natural step to begin thinking more systematically about the implications of the *institutional settings* within which the process is carried out. For sustained, complex assessment processes do not simply happen "out there." Rather, they are carried out in particular institutional settings with particular histories, rules, and norms governing what goes on within them. These institutional differences matter. Clearly, an identical report of scientific findings would be expected to have a different impact on the policy process depending on whether it emerges from an independent global scientific body such as the International Institute for Applied Systems Analysis (IIASA), an intergovernmental institution like the IPCC, a national governmental organization like the U.S. Department of Energy (DoE), or an advocacy group such as Greenpeace. Less obviously, the choice among such institutional venues for the assessment process seems to have a lot to do with what kinds of experts and policy makers do (and don't) get to communicate with one another, and with what kind of rules govern who has the final word on what.

One vein of GEA's research on assessment processes has emphasized earlier findings (e.g., Holling 1978; Walters 1986; Gunderson, Holling et al. 1995), that assessment institutions which focus on a single level or spatial scale of analysis are inadequate. This is particularly true with the recent ascendancy of regional analyses of global problems. The implications of global environmental change play out simultaneously at numerous levels (see in this volume Easterling 2001). Decision making and information production which occur on one level dynamically interact with decision making and information production at other levels. Farmers do obtain information about global climate change. Few, however, are likely to have a complete IPCC report on their bedside tables. Instead, they obtain their information from distributed institutional sources they have learned to trust for other information over the years – agricultural extension agents, local universities, seed companies, local media and the like (Kromm and White 1991; Cash 1998). In turn, these institutions go to their own trusted sources through a trail that may ultimately lead to the IPCC or its equivalent. In such a case, distributed institutions link science and decision making and facilitate such linkages across levels (see **Figure 1**). A similarly complex story about the chain of institutions linking global knowledge and local action emerges from a variety of case studies explored by the GEA project. These include Europe's efforts to deal with acid rain (Botcheva 1998; VanDeveer 1998; Eckley 1999), the use of ENSO forecasts in Africa (Patt 2000), and the assessment of technical options for mitigating stratospheric ozone depletion (Parson 1998).

In each of these cases, the line between detached assessment and active decision support blurs. This has led us to a view of one class of assessments as *distributed information and decision support systems* embedded in a network of institutions. This view has historical roots in fields such as agricultural research and extension, but is only recently emerging in the environmental arena (Bell, Clark et al. 1994; Cash 2000). In this view, assessment is still seen as a communication process. While formal outputs such as reports, models, or forecasts can still play an important role in such systems, the continuous and iterated communication of policy relevant technical information across different levels of the system is emphasized. Such assessment systems institutionalize and routinize the construction, provision, revision of information while integrating scientific information into the decision making process through various mechanisms of two-way communication and feedback.

Before turning to a more detailed discussion of such systems in Section 3, however, it is worthwhile to review some the GEA project's more general findings that seem to apply to a range of assessment systems, from those that are narrowly report focused, to those that are can be characterized as institutionalized distributed decision support systems. For all these types it is useful to systematically think about the effects of assessment.

2.1 What are the effects of assessments on the policy process?

It would seem that the ultimate impact of an assessment on policy might be to cause a change in the state of the environment by altering the behavior of key states or other actors. While assessments may well contribute to such changes, however, a direct connection between ideas and action in the policy realm is notoriously difficult to document because of the many intervening factors, conditions and lags involved in virtually all real situations. The GEA effort has therefore found it more helpful to evaluate the effects of assessments across a spectrum of policy-relevant factors such as:

- the environment (e.g., the role of European assessments supporting action taken within LRTAP that has decreased lake and forest damage due to acid deposition, Eckley 1999; Tuinstra, Hordijk et al. 1999);
- the strategies and behavior of key actors (e.g., the role of the Ozone Trends Panel in shifting corporate approaches to the regulation of CFCs Parson 1994);
- the pool of management options (Clark, Eijndhoven et al. 2001);
- issue framing and agenda setting (e.g., the role of the 1986 Villach assessment of climate change in elevating the greenhouse issue from the scientific to the policy agenda Franz 1997);
- identification of needed knowledge (e.g., Cash 1998); and
- the building of scientific communities, the creation and maintenance of issue networks, and professional advancement (e.g., Haas 1990; Sabatier and Jenkins-Smith 1993).

The list is not exhaustive or unambiguous. Its importance is merely in stressing that assessments can and do exert their immediate impacts – if any – in a variety of ways. The particular paths of influence are a matter for empirical investigation rather than definition or assumption. The question remains of what makes some assessments more effective than others.

2.2 What distinguishes more from less effective assessments?

Based on GEA investigations thus far, three characteristics of assessments seem to be most important in distinguishing more from less effective ones: we have labeled them "saliency," "credibility," and "legitimacy" in **Figure 2**. "Saliency," as we use it, is meant to capture the perceived relevance or value of the assessment to particular groups who might employ it to promote any of the policy changes noted above. "Credibility," as we use it, is meant to capture the perceived authoritativeness or believability of the technical dimensions of the assessment process to particular constituencies. "Legitimacy," as we use it, is meant to capture the perceived fairness of the assessment process to particular constituencies.

At one level, these distinguishing characteristics are little more than formalized common sense. Yet the disturbingly high ratio of ineffective to effective assessments in the real world suggests that formalizing common sense may have some value. For example, it seems clear that otherwise plausible assessments die (i.e., are rendered ineffective) from lack of saliency for a number of reasons. These include assuming that the questions important to the scientific community are the same as those important to the policy community; adopting a "one size fits all" approach to policy questions instead of tailoring assessments to specific users; and delivering assessments too slowly to play a meaningful role in rapidly evolving policy processes.

Death of assessments through lack of scientific credibility is also frequent. Credibility can be lost through inadequate quality control over technical arguments; unresolved disagreements over what constitutes appropriate standards of evidence and argument; or the appearance of substantive discrepancies between the body of an assessment report and its policy summary.

Failure to secure political legitimacy in the view of relevant stakeholders can also doom an assessment to ineffectiveness. For global environmental assessments, this most obviously occurs when certain countries perceive that they have been left out of a process largely run by a few wealthy nations, or that there is a perception that authority and responsibility have not been apportioned equitably or at the right levels.

Saliency, credibility, and legitimacy are not independent properties of assessments. Sometimes they reinforce one another, as when an effort to achieve political legitimacy through greater sensitivity to the views of previously excluded stakeholders results in an increase in saliency of the resulting assessment to those groups. At other times, they seem to compete, as when an effort to increase political legitimacy through inclusion of multiple perspectives results in what many perceive to be a lowering of the scientific credibility of the result.

2.3 On what do the saliency, credibility and legitimacy of assessments most depend?

If, other things being equal, assessments are likely to become effective by being salient, credible and legitimate, what imbues an assessment with these characteristics? We have found three sets of factors to exert a substantial influence: historical context, characteristics of the assessment user or audience, and characteristics of the assessment process itself. We summarize our tentative findings on all three factors below.

2.3.1 Historical context

A quite robust finding of policy studies is the so-called "issue attention cycle" (Kingdon 1995). Problem areas such as child abuse or auto safety or climate change are observed to persist for years as the concern of a relatively small group of specialists and institutions, rarely exposed to the limelight of high level political or media attention. Then, for one reason or another, the issue rapidly emerges onto national or international political agendas. During this emergent period, the issue may be framed quite differently by different institutions or interests, and not infrequently it is engaged by decision makers at the highest levels of government. Typically, however, after a few years of peak attention, the issue – often quite transformed – drops back out of the limelight. Although much may be going on in specialist communities behind the scenes, attention by the public and by high level decision makers drops towards earlier pre-emergence levels. After some period, the cycle may repeat.

It seems obvious that the kinds of assessment most effective for the technical communities that dominate the pre-emergence phase of issue development could be much less so for the political and management communities who dominate the post-emergence phase, and vice versa. In fact, however, we suspect that an important source of ineffectiveness in assessments about global environmental issues is the failure to make such distinctions. In particular, our admittedly limited evidence suggests an oversupply of pre-emergence assessment of policy options for which there is no decision making audience interested in listening. Similarly, as a *global* issue attains greater interest and concern at national and sub-national levels, there is often the adherence to assessment processes that were appropriate at the global level, but that are no longer appropriate at regional and local scales. In these cases, frustrating and ineffective assessments are the result.

2.3.2 Characteristics of the user

A second set of factors that can exert a substantial influence on saliency, credibility, legitimacy and thus the effectiveness of global environmental assessments involves characteristics of the assessment user or audience. This borders on a tautological conclusion once assessment is characterized as a communication process engaging technical experts and decision makers. Nonetheless, we suspect that a substantial amount of ineffectiveness in global and regional environmental assessments stems from problems at the user end of the dialog. Three particular factors stand out from our research on the user's perspective. We characterize these as *interest*, *capacity*, and *openness*.

For an assessment to constitute an effective channel of communication between scientists and decision makers, the decision makers need to be *interested* in listening to what the scientists are saying. We suspect that the most effective assessment processes devote a substantial amount of time and energy to negotiating with potential users the particular questions about which those users are most passionately and urgently interested.

Capacity constraints can be logistical or technical. Even when they have great interest in the outcome, some groups and nations simply do not have the resources to allow meaningful participation in the complex, extended process that constitutes most contemporary global change assessments.

Finally, the likelihood that a particular assessment will be effective in linking science and policy seems to depend on the *openness* of the society within which the use of the assessment might take place. *Openness*, as we use it here, reflects the degree to which decision makers are

exposed and potentially receptive to multiple channels of communication that could reinforce a particular assessment's findings.

2.3.3 Characteristics of the assessment

Our last set of factors exerting a substantial influence on the saliency, credibility and legitimacy of global environmental assessments involves characteristics of the assessment process itself. By and large, these factors are under the control of those designing and managing assessments, and thus constitute some of the most important avenues for efforts to improve their effectiveness.

2.3.3.1 Structure of the science/policy interface[3]

If assessment is a process of communication between the science and policy communities, the way in which that communication is structured seems to be crucial to the effectiveness of the conversation in promoting sound policy. The dilemma faced by assessment designers is most starkly posed through a caricature of the available options.

At one extreme is the model of cloistered scholars reflecting on the issue at hand until they are ready to issue a public report telling the policy community what to do. At another extreme is the model of policy makers consulting with "their" scientists behind closed doors until ready to issue a public statement of what actions they say are justified by the science. Clearly, few real assessments pursue strategies these extreme models.

Assessment designers and managers continually struggle with how to structure the science/policy interface in ways conducive to effective assessments. In trying to think systematically and critically about implications of different ways of treating the science/policy interface in global environmental assessments we have found it useful to draw from the broader science studies literature on the political use of expert advice (e.g., Jasanoff 1990; Gieryn 1995). This literature, resting on empirical studies in risk assessment, science advising, and technological controversies, conceptualizes the science/policy interface not as a sharp line or demarcation but rather as a fuzzy, dynamically shifting *boundary*. The boundary is contested, negotiated, and ultimately constructed by scientists and policy makers as they struggle to resolve the fundamental tensions of scientific assessment in the policy arena -- maintaining scientific credibility (by not politicizing the research) while assuring practical saliency (by producing information that is relevant and useful to decision makers) and doing so in a manner that secures political legitimacy (by being seen as fair and open to multiple participants). In some instances, *boundary organizations* – institutions that straddle this shifting divide between science and policy – are developed to help in these negotiations. The notion of boundary organization will be more fully addressed in the third section of this chapter.

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[3] This section draws heavily on an unpublished GEA research notes "The science / policy interface and the environment" by David Cash and David Guston (April 27, 1999), plus additional comments by Susanne Moser and Eileen Shea.

2.3.3.2 Participation in the assessment process[4]

Even granting that assessments function as a process of communication between the science and policy communities, the question remains of who from those communities actually gets to participate at what time in what parts of the conversation, and with what consequences for the effectiveness of the overall exercise. First, it should be clear that choices about participation can influence the effectiveness of assessments through all three of the paths noted earlier. Efforts to increase the *saliency* of an assessment may well want to secure participation of ultimate users in the assessment process so that they can make their needs known. Efforts to increase the technical *credibility* of an assessment may well want to secure participation of relevant experts in the assessment so that adequate and authoritative information can be brought to bear. Efforts to increase the *legitimacy* of an assessment may well want to secure participation of relevant stakeholders so that those most affected by policy based on the assessment will feel that their concerns have been fairly addressed.

In some cases, where users, experts and stakeholders are the same people (e.g., local farmers' involvement in a climate impact assessments), all these goals may be promoted by the same participation decisions. More commonly, however, participation choices involve tradeoffs such as when the IPCC's commitment to ensure credibility by only admitting experts with a relevant record of peer reviewed publications left them temporarily unable to recruit individuals with the needed expertise to carry out local impact assessments simply because such expertise was tied to practice rather than scholarly publication.

Our research on participation suggests that the ability to effectively resolve such tradeoffs depends greatly on an institutional framework within which the boundary construction is an explicit part of the process. Finally, our work suggests that it may be helpful to distinguish different purposes, kinds, and institutionalizations of participation in different phases of the assessment process (e.g., initial scoping of the problems to be addressed, subsequent technical analysis to mobilize information on those questions, ultimate review and communication of results), at different stages of an issue's evolution (e.g., before and after its emergence onto the political agenda), and at different organizational levels.

2.3.3.3 Scope of the assessment

A final characteristic of assessments that seems likely to shape their effectiveness is decisions regarding scope – what is included, and what is left out. The conventional wisdom in contemporary assessment literature of the last decade has been that scope should be maximized – i.e., that including as much as possible in integrated, end-to-end assessments is a viable strategy for enhancing effectiveness. This is in fact one of the underlying premises of the present volume. But at least since the work of Herbert Simon on bounded rationality, it has been clear that the theoretical benefits of comprehensive assessments can be practically realized, if at all, at a large cost (Simon 1982; Clark, Eijndhoven et al. 2001; Jäger, with et al. 2001). Our work on global environmental assessments adds empirical evidence to the long standing tensions over assessment scope (Clark, Jäger et al. 2001). First, if unsurprisingly, it is clear that the potential

[4] This section draws heavily on an unpublished GEA research note "Global environmental assessment: Four under-appreciated elements of design" by Jill Jäger, Alex Farrell and Stacy VanDeveer (April, 1999), a paper on "Stakeholder participation in the US National Assessment of Possible Consequences of Climate Variability and Change" by the National Center for Environmental Decision Making and Research (Tech. Rept. NCEDR/98-19, November 1998), plus additional comments from Susanne Moser, Thomas Wilbanks and Eileen Shea.

saliency of an assessment to some users can rise as that assessment expands "downstream" to incorporate impacts and their costs on things that particular decision makers value. Not so clear, however, are the costs that appear to be systematically associated with such expansions (see, for example Easterling's chapter in this volume). It does seem clear, however, that expansion of a scope from basic cause-effect relationships in the natural system into the domains of such areas as emissions scenarios and economic impacts place much higher demands on controversial domains of technical knowledge and thus run the risk of undermining the technical credibility of the entire assessment (Walters 1986). The least appreciated cost of increasing assessment scope, however, may run through the channel of political legitimacy. For while most stakeholders in an assessment can successfully negotiate a shared set of questions about how emissions link to primary environmental changes, they turn out to have a much harder time agreeing on *which* scenarios of emissions should be investigated, *what kind of* policy options should be considered, *how* impacts should be denominated and compared – all of which have significant impact on decision makers' interests. Such questions and tensions are at the core of the increasing interest in vulnerability assessments.

Once we begin to appreciate that apparently technical questions of assessment scope rapidly become overtly political questions of whose interests an assessment will serve, we are back full circle to the perspective of assessments as socially embedded processes of communication. From the perspective advanced here, however, attention is focused on the likelihood that it will be very difficult to build "one-size-fits-all" comprehensive assessments that simultaneously address the challenges of credibility, saliency and legitimacy for all potential stakeholders at once. The same perspective, however, suggests that significant progress may be possible in tailoring assessment processes to support the information needs of particular decision makers, while nonetheless connecting to basic scientific knowledge shared widely among stakeholder communities. It is to recent successful experience in efforts to shape distributed systems of research, assessment and decision support that we turn in the next section.

3. Regional Assessments for Multi-level Problems: Distributed Research Assessment and Decision Support Systems

As noted above, global environmental change is increasingly understood to have causes, consequences, and responses that span multiple spatial levels, from the local to the global (Gibson, Ostrom et al. 1997; Folke, Pritchard et al. 1998; Wilbanks and Kates 1999; Cash and Moser 2000). The multi-level nature of such problems has required a radical shift away from more centralized, top-down assessment efforts. This section illustrates that in an era of *global* change which is inexorably linked with *local* ecosystems and communities, efforts to address large-scale environmental change need to consider the merits of **distributed research, assessment, and decision support systems** (Cash 2000). Such systems share a number of characteristics: 1) They consist of networks of researchers and decision makers which span multiple levels; 2) they integrate research, assessment, and decision making across multiple levels, often utilizing "boundary organizations"; and 3) they structure the relationship between decision makers and researchers as a two-way, dynamic, iterated and adaptive process (not a "pipeline" from science to decision maker).

3.1 Regional Assessments of Global Problems

Two major trends in the assessment of global environmental problems have begun to complement large-scale assessments of problems with more regionally-based assessment efforts. First, subnational decision makers are demanding high-resolution information about the implications of global phenomena at the local level (Lins, Wolock et al. 1997). Heterogeneity of local exposure, sensitivity, and adaptive capacity, the interactions of multiple environmental stresses, and large geographic variance in costs and benefits highlight the need for linking assessment and decision making at multiple levels. This trend is manifest in the increasing demand for vulnerability assessments, which fundamentally link larger scale processes with place-based consequences and realities (Clark, Jäger et al. 2000; Downing 2000).

Second, there is a growing recognition in the scientific community that data and knowledge about fine-scale structures are necessary for understanding large-scale systems (Ayensu, Claasen et al. 1999). This is seen, for example, in the attempt by climate modelers to produce more accurate and predictive *global* climate models by incorporating greater *local* specificity of climate parameters (Harvey 2000).

These two trends have resulted in the emergence of new institutional structures to support regional assessment based on more distributed links between assessors and decision makers.

3.2 An Outline of Distributed Assessment Systems

Traditional assessment processes still dominate the landscape of large-scale environmental problems. But several recent efforts (some of which are outlined in this volume) illustrate the characteristics of distributed information and decision support systems that have been effective in addressing the multi-level nature of global change problems.

Distributed assessment systems vary in a number of dimensions, they share at least three common institutional features: 1) multiple connections between researchers and decision makers which cut across various political and organizational levels (polycentric networks); 2) boundary organizations - institutions that act as mediators between science and policy and across levels (sometimes the nodes in the network); and 3) sustained and adaptive organizations that allow for iterated interactions between scientists and decision makers.

3.2.1 Polycentric Networks

Two fundamental and related attributes of successful distributed assessment systems include institutionalized links between scientists and decision makers, and links between these players across multiple levels. As noted above, two-way communication pathways allow:

- research to be targeted at those questions that matter most to decision makers;
- the strengths and limitations of current scientific knowledge to be communicated to decision makers; and
- research findings to be packaged in the most useful ways by scientists.

Linkages across levels promote the parallel goals of rendering the implications of large-scale events for local conditions, and providing local-scale data for the understanding of large-scale systems.

An institutional structure that supports such linkages can be conceived of as a polycentric network of semi-autonomous research nodes spanning multiple levels and supporting decision

making at these multiple levels (Blomquist 1992; Ostrom 1998; McGinnis 1999). The concept of a "polycentric network of semi-autonomous research nodes" provides a mechanism for addressing a number of the challenges faced by regional assessments.

They provide for coordinated scientific efforts that capitalize on the scientific comparative advantages, or specializations, at different nodes. Modeling expertise, monitoring capability, local data collection ability, and other assessment activities might differ from locale to locale, and across levels. For example, national institutions might have the computing and technical capacity to produce complex models, will local agencies might have the ability to undertake local-specific data collection. Neither entity alone would be able to construct a model that would capture both the large-scale system dynamics as well as the local implications of such dynamics. A networked system, however, could provide the structure for harnessing the complementary comparative advantages at each level.

A polycentric network can provide coherence of data and methods across levels (Easterling 1997; Ayensu, Claasen et al. 1999). One of the major challenges facing regional assessment efforts is to build a process that is sensitive to both the interests and preferred methods of assessment at the local level, while providing data that can be comparable across areas. A network of researchers and decision makers can help balance these kinds of tradeoffs and potentially avoid top-down mandates that can seem arbitrary and lack legitimacy.

Finally, semi-autonomous efforts by local scientists and managers can lead to addressing important local environmental issues, linking local issues to global issues, and tapping into local and indigenous knowledge sources and knowledge production processes.

While successful distributed assessment systems take advantage of specialization, they also depend on duplicate or parallel sub-systems within the system as a whole. At first, these two efforts (specialization and duplication) seem mutually exclusive, but successful systems find a balance, using multiple and linked pathways to derive complementary benefits of both. Thus, in addition to tapping into the advantages of specialization (as outlined above), such a structure exploits several advantages of duplication.

First, it allows for redundancy, protecting the system as a whole from failures in one part. In this sense, such a multi-linked network constitutes a robust system that is more likely to weather disruptions (Fischhoff and Johnson 1997; Gibson, Ostrom et al. 1997; Sabatier and Jenkins-Smith 1999).

Second, and related to such protections spawned by multiple pathways, is the encouragement of innovation and flexibility. Multiple nodes where researchers and decision makers are assessing and addressing similar issues provide multiple crucibles for solving assessment and management problems, and thus numerous potential solutions.

Third, a network comprised of multiple nodes and entry points facilitates the ability to incorporate stakeholder and non-governmental organization participation in assessment and management activities, a trend that is increasingly embraced for environmental problem-solving at all levels. One advantage of such stakeholder involvement is that it fosters greater linkage of emerging *global* problems to pre-existing *local* environmental concerns, thus increasing the relevance and legitimacy of an assessment (Cohen 1997; Ogunseitan 2000).

Finally, a well integrated network fosters capacity building both horizontally (e.g., nation to nation) and vertically (e.g., nation to locale, and vice verse).

3.2.2 Utilizing Boundary Organizations

Recent research in the fields of political science and the science and technology studies point to the importance of recognizing the boundary between science and policy as porous and evolving, negotiated and contested continually by players on both sides of the boundary (see the previous section and Jasanoff 1987; Gieryn 1995; Guston 1999). Growing out of this work is the identification of institutions, termed **boundary organizations,** that facilitate the communication and provide important mediating functions across boundaries (Guston 1996; Guston 1999). These organizations have evolved in response to "the challenge of crossing the functional and cultural boundaries between domains of jurisdiction and scales of organization," and are seen as "institutions that straddle the shifting divide between politics and science" (Guston, Clark et al. 2000, p. 1).

Boundary organizations are hypothesized to perform a variety of functions that facilitate bridging science and policy across levels, and ultimately help support the construction and performance of the networks described above. Boundary organizations can mediate the ongoing demarcation of the boundary between science and policy, clarifying what can and cannot cross the boundary, and what qualifies as legitimate and credible actions and information originating on either side. Discussions about peer review, what data to include and exclude, and who can participate in what parts of an assessment are all discussions which demarcate the boundary. In order to undertake this potentially complex mediation across a boundary, members of a boundary organization must have legitimate standing on both sides of the boundary. One mechanism for ensuring this are formal or informal contractual arrangements in which accountability to parties on both sides of the boundary is clarified (Guston 1999).

A boundary organization can also provide a space to legitimize the use of boundary objects – items which are "both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain common identity across" boundaries (Star and Griesemer 1989, p. 393). Examples include reports, forecasts, or models (Tuinstra, Hordijk et al. 1999).

In addition to these functions which help link science and policy, boundary organizations also can help bridge across levels by: 1) helping negotiate the boundaries between levels (e.g., help defining what the scale of a problem is); 2) mediating multi-directional information flow across levels; and 3) helping capitalize on scale-dependent comparative advantages (as described above.) (Cash 2001).

3.3.3 Long-term adaptive institutions

Effective distributed assessment systems build *sustained* and *adaptive* relationships between science and decision making and across levels. Long-term institutionalized relationships allow trust and credibility to accrue over time, especially critical in an information/decision system which addresses contested and controversial issues (Holling 1978; Holling 1995; Lee 1995; Cash and Moser 2000). Iterative interactions between scientists, decision makers, and stakeholders, which are only possible in the context of long-term relationships, encourage the fine-tuning of research agendas, of the research process, and of information products over time. Moreover, an iterative process is a necessary component of adaptive assessment and management, in which policy experimentation can be attempted and assessment can consciously evolve to address changes in policy, science, and the natural environment. Such a process also fosters mid-stream evaluation, in which the assessment process itself can be examined and changed in order to reach initial or changing goals. Long-term flexibility in such a system also allows for the possibility of

cross-fertilization of issue-areas, and more useful analysis of the interactions between environmental risks (Gunderson, Holling et al. 1995).

3.4 Challenges

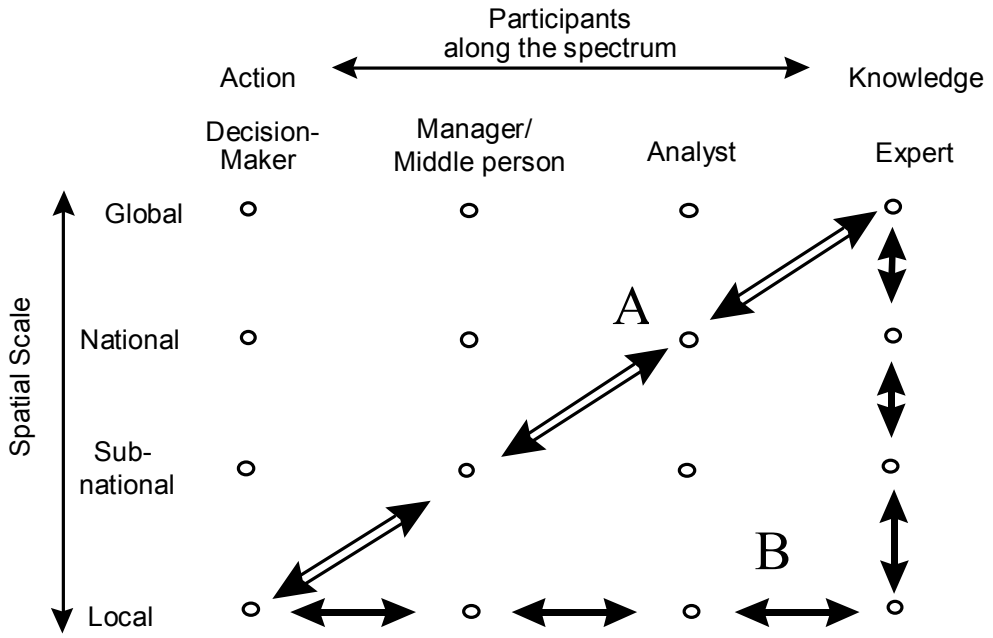
One of the most significant challenges facing the implementation of distributed assessment systems is the need to marshal the resources to create and sustain such a system. Building institutionalized linkages that currently do not exist is financially and politically costly, with benefits reaped in the future and by diffuse stakeholders. Clearly, one way of addressing at least part of this problem is by building on previously existing institutions and networks (Eckley 1999). Such building with existing pieces, or adapting old structures for new functions, is not only less costly than new network building, but it also provides an opportunity to take advantage of pre-existing credibility, and legitimacy and to relate established concerns to emerging and future environmental problems (i.e., increasing saliency).

A paradigm of distributed assessment and decision support also runs counter to conventional notions of how most assessments are currently designed and implemented. As noted above, top-down, centralized efforts focused on reports-as-products are well established, providing inputs to many policy arenas. Large communities of scientists and decision makers already participate in such efforts and have worked over the past decades in improving those kinds of efforts. Distributed assessment systems call for a new way of conceptualizing the boundary between science and decision making, one that fundamentally acknowledges a shifting and more porous boundary, and attempts to define and craft that boundary to better produce both credible science and useful information (Gibbons 1999). Such a change in the way the science-policy boundary is conceived is likely to be controversial and difficult to move forward in the face of already existing and entrenched conceptual frameworks, interests and institutions.

Moreover, while this section provides an initial sketch of distributed assessment systems, there remains today little systematic understanding of how to structure, design, and implement such systems, or how such system designs should vary under different conditions. For example, information and decision making systems might be differently configured if the function is primarily an advisory role versus a regulatory role.

Despite these challenges, the growing realization of both the global implications of local actions and the local impacts of global environmental change has pushed both scientists and decision makers to re-evaluate how research and assessment can effectively support environmental decision making. The resultant paradigm of distributed assessment systems, while far from fully understood and specified, offers a powerful and dynamic conception of how science and decision making at multiple levels are already being effectively integrated.

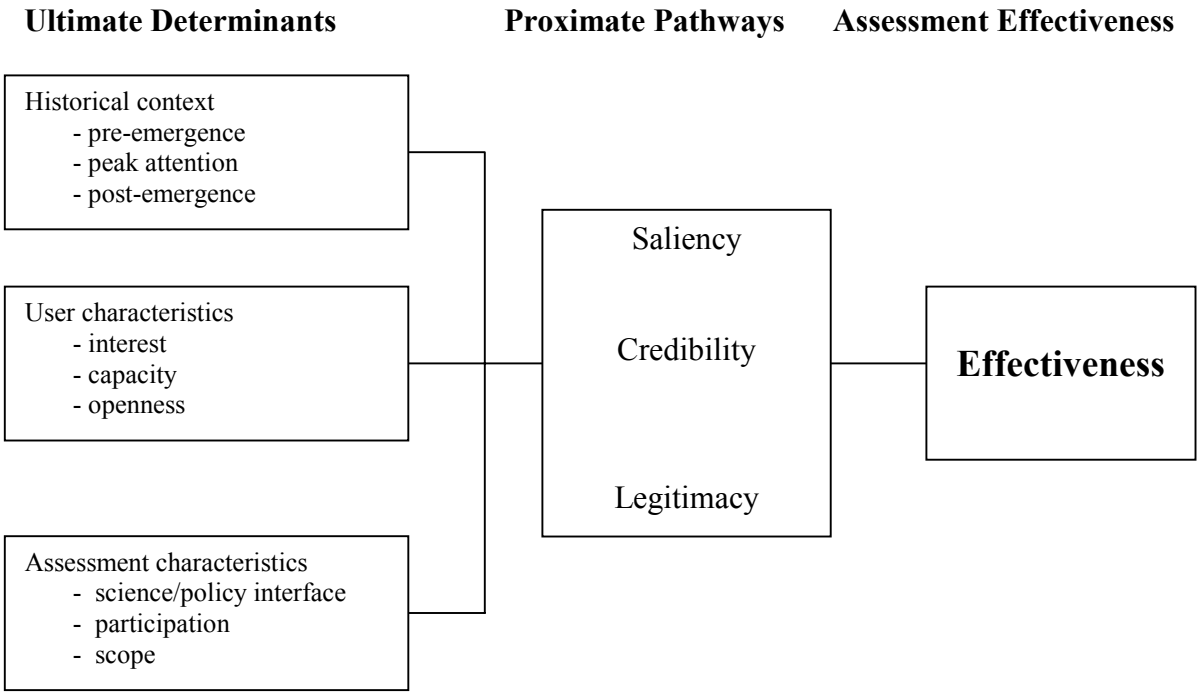
Figure 1. Assessment pathway heuristic



The bi-directional arrows indicate stylized pathways of communication and interaction among different actors in an assessment process. The two-dimensional template can also be used to map assessments to visualize the degree of cross-scale and science-policy integration. Two hypothetical pathways (Pathway A- white arrows, and Pathway B black arrows) are illustrated above. Adapted from (Cash and Moser, 2000).

Figure 2

Elements of a Conceptual Framework for thinking about Effective Assessments



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