Working Paper

How Should We Study Global Environmental Problems?

A Plea for Unconventional Methods of Assessment and Synthesis

Edward A. Parson

WP-96-157
December 1996

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Preface

One of the original goals of the IIASA project on Implementation and Effectiveness of International Environmental Commitments (IEC) was to explore the possibility of using simulation or gaming techniques as a way of giving policy-makers a better understanding of the problems of developing and implementing international environmental agreements. Simulation has been used successfully to understand various complex policy, decision, and negotiation processes, but prior to this project had not been applied to the problem of implementing agreements once they have been negotiated. Professor Edward Parson of Harvard University undertook to develop a simulation exercise concerned with implementation of a global climate agreement as part of the IEC project. The approach and results of that experiment are presented in IIASA Working Paper WP-96-90. In this companion paper, Professor Parson considers the more general applicability, promise, and limits of simulation and related methods as assessment tools for global environmental problems.

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HOW SHOULD WE STUDY GLOBAL ENVIRONMENTAL PROBLEMS? A Plea for Unconventional Methods of Assessment and Synthesis

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1. Introduction:

It has been widely argued that issues of global environmental change are so novel, unique, and complex that they pose unprecedented challenges to policy and management.[1] This paper considers the implications of this claim for the methods and procedures used to inform policy-making.[2] Complex issues such as global environmental change, which have strong scientific and technical components, normally require expert advice for rational and informed policy-making. The processes of providing such advice, by gathering, synthesizing, interpreting, and communicating knowledge from various domains and disciplines, to help responsible policy actors think about problems or evaluate possible actions, are normally called assessment or synthesis. (Brewer, 1986; Carnegie Commission, 1992; Parson 1994, 1995).

Many methods for organizing and doing assessment have been proposed, but two dominate current practice: formal models, and multidisciplinary expert panels. This paper argues that global-change issues pose various kinds of knowledge needs, some of which these conventional methods can usefully address, and some of which they are systematically ill-equipped to address. To meet the knowledge needs that are ill-met by conventional methods,

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[1] These claims of novelty are similar, whether global environmental issues are conceptualized as negotiations (Susskind, 1994, p. 6-7), as international regimes (Young, 1989, 1994), or as problems of international law (Brown Weiss 1993; Sand 1990, 1993; Sands, 1994).

[2] Global environmental change takes multiple forms, but this paper illustrates assessment challenges using climate change -- the most salient, controversial, and complex global-change issue currently on the agenda. The arguments presented here also apply to other global-change issues, even more strongly if -- as has often been argued -- multiple coupled global-change issues (e.g., climate, stratospheric ozone, acidification, and regional and long-range air pollution) are assessed and managed jointly.

the paper argues for the use of a set of unconventional assessment methods, known by various names including Policy Exercises, simulation-gaming, and scenario exercises. These alternative methods, if designed and implemented skillfully and interpreted with appropriate caution, can make valuable incremental contributions to well-informed global-change policy. The high stakes of global-change issues can make these potential contributions worth the considerable expense and difficulty of using such methods.

The plan of the paper is as follows. Section 1 discusses the variety of knowledge needs of global environmental policy, and proposes a taxonomy to organize them. Section 2 reviews the two conventional methods normally used to help inform such policy choices, and summarizes their strengths and their most significant limitations. Section 3 introduces the proposed alternative methods, identifies their common characteristics, and summarizes their use in other policy areas. Section 4 argues that these methods can help advance understanding in ways that complement the weaknesses of conventional methods, and that address some of the most intractable characteristics of global environmental problems. Section 5 identifies the most serious risks and cautions associated with these methods, while Section 6 draws brief conclusions.

1.1 Global Environmental Problems, and What Makes Them Hard

Global environmental issues have high stakes, and exhibit two characteristic classes of difficulties, which will here be called "complexity" and "obscurity".[3] Whether or not these difficulties are as unique or unprecedented as has been claimed, the challenges they pose to both policy-making and assessment are serious. For assessment, they affect what questions are relevant, what answers are reasonably attainable, and what methods are likely to be useful.

By "complexity", I mean complexity of decision and policy-making. It includes, but is broader than, political conflict. Global environmental issues are decisionally complex because of the number of actors whose choices matter, and the ways their choices and preferences can interact. Important outcomes are determined by the decisions of many agents, whose scale of concern and authority can range from the local to the global. These agents' interests bearing on the issue may be common or conflicting, and are most frequently mixtures of the two. Absent international governmental authority, policy decisions must be negotiated, and negotiating parties may act strategically. Managing the issues may require major institutional changes, which change the rules, authority relationships, and opportunities under which large numbers of independent actors operate. Implementing policy may require coordinating the actions of many large routinized organizations, as well as further negotiation. These various forms of decision complexity would make policy-making difficult, even under conditions of full knowledge.

But full knowledge is not available. Global-change issues are also obscure, in that their basic characteristics as policy issues -- the relevant actors, their choices, the consequences of

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[3]Many authors have identified these two kinds of difficulties, under various names, as central to the problem of global environmental management (e.g., Funtowicz and Ravetz, 1985; Lee, 1993). Clark (1986, p. 12) expressed them by imagining the earth as a garden: decision complexity as the problem of deciding what kind of garden we want; and obscurity as the problem of determining what kind of garden it is possible to have.

choices, relevant causal relations, and the values at stake -- can be uncertain, unrecognized, or contested. Obscurity includes, but is broader than, uncertainty about the biophysical world, which limits understanding of the causal links between decisions and valued consequences. In addition, agents may or may not recognize the issue, or conceive it in the same way. Their set of relevant choices and actions, as well as their preferences and values, may be ambiguous, poorly known, contested, or rapidly changing. They may or may not recognize how their decisions contribute to the issue, or their interests in it. The consequences of their choices may lack salience because they fall on people who are unidentified or physically remote.

The difficulties posed by the complexity and obscurity of global environmental issues are compounded by the issues' long time horizons and global spatial scale. These factors increase the number of people and institutions involved in decision-making, widen the distance between actions and consequences, and ensure that significant consequences of present choices are borne by people not represented in the decision-making because they are not yet born (Brown Weiss, 1989). Complexity and obscurity also interact, in that knowledge and uncertainty are typically unequally distributed among relevant actors, and are subject to partisan exploitation.

1.2. The Knowledge Needs of Global Environmental Policy

Policy issues vary in their knowledge needs. Issues without substantial scientific or technical content, or that are routine, low-stakes, or primarily distributive, may be effectively informed through normal sounding of political preferences, and hence may not require assessment. Issues with high stakes and significant scientific content may require assessment, but if the relevant choices and goals are clear and uncontested (or imposed), the mission of assessment is also relatively clear: providing expert judgment on the feasibility of choices, and on instrumental relations between choices and goals. For example, could technological improvements raise the fuel economy of the new US automobile fleet to 32 miles per gallon? What would be the effect on vehicle safety? Could this goal be accomplished through raising the fuel economy standards? At what cost, and with what other consequences?[4] Such information is presumed normally available from appropriately chosen groups of scientific and technical experts, while active bodies of research and scholarship have considered the related questions of what to do when the experts cannot answer, cannot answer in time or specifically enough, or cannot agree (e.g., Weinberg 1972; Ravetz 1971; Brooks, 1987).

But the goals of assessment are only so straightforward under very restrictive, and rarely met, conditions. Even if only instrumental statements are sought, these usually depend not just on information about the world -- dynamics of atmosphere and oceans, ecosystems, biogeochemical cycles, and the properties of technologies -- but also on information about people -- behavioral, strategic, and political knowledge about the potential choices, preferences, capacities, and strategies of other actors who matter. For unless an assessment's audience is an omnipotent dictator, the consequences of their choices will depend on how

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[4]This simple view of assessment, estimating consequences of well-defined policy choices for a known set of valued consequences, is employed for pedagogical clarity in the classic texts on systems analysis and policy analysis (e.g., Miser and Quade 1985; Stokey and Zeckhauser, 1978), but also appears in many discussions of assessment and policy in which such a simple model is not appropriate (e.g., CENR 1994).

others choose and react. If the others who matter are numerous enough, and act through markets meeting the requisite conditions, their reactions can be projected without thinking strategically. But if the others who matter are few, large, and make discrete strategic choices, this is not so. The consequences of a US decision to raise fuel economy standards cannot be assessed without considering the responses of the automakers, nor the consequences of a US carbon tax without considering the response of OPEC. These unknowns might be called "strategic uncertainties".

Under the conditions of obscurity and complexity that typically characterize global environmental issues, the potential knowledge needs of policy -- and hence the potential jobs of assessment -- become broader, more various, and more difficult to discharge. The questions assessment might seek to answer, or the knowledge needs of policy, can be disaggregated into eight categories: the two identified in the preceding paragraphs, plus six others.

1) Framing: for an issue that is novel and little understood, identifying its basic character, bounding its importance, and determining what questions to ask;

2) Agendas: clarifying what set of actors, contributing factors, causal relationships, impacts, values, links with other issues, and responses, are plausible and relevant; identifying new ones to add to, and current ones to drop from, the agenda;

3) Scenarios: Identifying reasonable assumptions for future trends in background variables that will mediate the consequences of particular choices, such as broad population, economic, technological, political, and social trends. Because these trends affect many issues, assessments of particular issues normally adopt such projections from official sources or prior modeling projects.[5]

4) Instrumental Relations: predicting the consequences of particular choices for particular valued consequences; such predictions are normally contingent on particular scenarios, and specify choices as changes in emissions, behavior, or technology, rather than as policies intended to elicit such changes;

5) Valuation: defining values of, and tradeoffs among, relevant consequences;

6) Ordinary Uncertainty: Describing probabilities of unknown events and probability distributions of unknown quantities; characterizing how much is known, and how confidently, about relevant natural systems;

7) Strategic uncertainty: projecting the consequences of choices or actions by some actors for the actions of others, and hence for aggregate changes in emissions, behavior, or technology;

8) Guiding enquiry: Identifying and prioritizing key policy-relevant knowledge needs, to direct subsequent research.

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[5]Consistency of background assumptions across projections and assessments for distinct policy issues is not often achieved. This was the original purpose of the global 2000 project (Barney, 1982).

There is a natural, though only partial, temporal ordering among these classes of knowledge needs. Some clarification of the basic character of an issue and what questions to ask must precede any attempt to inform decisions. Determining what set of sources, impacts, responses, and background scenarios to consider must precede attempts to determine instrumental relations. This relationship is not, and should not be, unidirectional or linear. Adopting and keeping the problem characterization that first comes to mind, or was imposed, runs the risk of considering a prematurely and inappropriately restricted set of factors and choices, and hence giving precise answers to the wrong questions.

Meeting these knowledge needs for global environmental change issues poses two requirements that merit emphasis. First, useful answers to many or all of these questions will require integrating knowledge from a wide set of disciplines and domains, often with wide variation in the degree of confidence or precision attainable. Useful assessment methods must be able to accommodate such integration. Second, answers involving judgments of value or significance depend on one's perspective: one cannot answer "how important is climate change", without specifying how important for whom. Hence, useful assessment methods must permit examination of the issue from multiple perspectives.

2 Conventional Assessment Methods

For global environmental issues, the importance of assessment, and for assessment methods that integrate knowledge from disparate domains, has been widely recognized (Clark, 1986; Dowlatabadi and Morgan, 1995; Parson, 1995; Nakicenovic et al, 1994). The past five years have seen a great deal of assessment activity on global climate change, but nearly all this activity still follows two classic, conventional methods that have dominated both practice and research for twenty years: formal integrated models, and expert advisory panels. Official assessment for climate change is dominated by expert panels, assembled internationally by the Inter-governmental Panel on Climate Change (IPCC) and nationally by a variety of bodies; research interest in climate assessment is dominated by the development of increasingly ambitious formal integrated-assessment models. This section summarizes the characteristics, strengths, and weaknesses of these two methods.

2.1 Formal Assessment Models:

Formal computer modeling is the most active area of research activity on assessment of climate change (Weyant et al, 1996; Rotmans et al, 1996; Parson, 1995). Such models are widely used as research tools in the social and natural sciences, and have been widely used -- and widely criticized -- for assessment in other policy domains, such as energy, security, and military planning (Brewer and Shubik, 1979; Greenberger, Crenson, and Crissey, 1976; Greenberger, Brewer, and Hogan, 1983). When used for global change, such models draw components from specific disciplinary models, most often from atmospheric sciences and energy economics, and inherit their integrating mission from the "World Models" of the 1970s (Forrester, 1971; Meadows et al, 1972; Ashley, 1983). They have been used for two global-change issues: long-range air pollution, particularly acid deposition (Alcamo et al, 1990; Gough et al, 1994); and since 1990, climate change.

Since the IMAGE 1.0 model (Rotmans 1989), there have been about twenty projects to construct integrated-assessment models of climate change (IPCC). These models pursue end-to-end integration of the climate issue by coupling either pre-existing models, or simple heuristic models custom-developed, to form a causal chain from the determinants of

emissions to the valuation of impacts. They hence must combine, at least rudimentarily, knowledge about the following factors: the human activities that drive greenhouse gas emissions; the atmospheric, oceanic, and biological processes that link emissions to atmospheric trace-gas concentrations; the radiative and dynamic processes that link trace-gas concentrations to global and regional climate; the ecological, economic, and socio-political processes that link changed climate to impacts that people or societies care about; and the processes by which such valuations are made. Some integrated-assessment projects also seek, in preliminary form, to close the causal loop back to the determinants of emissions, by modeling the emissions changes from ecosystem response to climatic and atmospheric change, and/or human adaptation, particularly through land-use change. Some seek to examine uncertainty by specifying probability distributions for unknown quantities and propagating uncertainty through cascaded models. Most, though not all, use exogenously specified scenarios for non-CO_2 emissions, and for those aspects of the problem not modeled explicitly, which often include population change, technological change, and economic productivity growth.

Such integrated-assessment models provide an assessment framework that can be used, depending on particular model characteristics, in four ways: to project the consequences of particular policy choices; to identify least-cost policy choices to meet a specified atmospheric or environmental constraint; to balance costs and monetized benefits of emissions abatement, permitting the identification of optimal abatement levels; or, given explicit treatment of uncertainty, to identify priority policy-relevant uncertainties so as to help guide research priorities.

Earlier use of formal models for assessment, particularly in energy policy and military planning, has been charged with several serious faults: concealing bias; using inadequate data; appearing to transcend adversarial processes while merely shifting them out of public view; and directing attention away from the input assumptions, often the most important part of an analysis (Brewer, 1986; Brewer and Shubik, 1979). Relative to this earlier work, current modeling for integrated assessment of global climate represents a substantial improvement in intellectual integrity, mostly through greater circumspection about predictive claims, and a shift in the use of models toward exploring, characterizing, and prioritizing policy-relevant uncertainties.[6] But this current work also shows very serious limitations.

Some of these limitations, widely recognized by the modeling community, are weaknesses of representation. Current integrated-assessment models of climate change are weak in their representation of climate impacts and adaptation, of policies and responses, and of the basic drivers of long-term emissions trends, particularly demographic and technological change. Some of these weaknesses reflect computational limits and analytic tractability, while others reflect limited underlying understanding of basic processes. These are the areas of most vigorous work in the assessment modeling community. Other limitations, less widely recognized and more essential to the process of model-building, affect the range of knowledge needs that assessment models can reasonably be expected to address. These are discussed in Section 2.3 below.

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[6]This approach was present in Nordhaus and Yohe (1983), and is explicitly advocated in Dowlatabadi and Morgan (1993), and Hope (1993). Using IA models for this purpose turns one of the strongest earlier criticisms of integrated modeling, that they rely on inadequate data, on its head: models can be used to assess the data, and to identify priority policy-relevant areas for getting better data.

2.2 Multidisciplinary Expert Panels

As an alternative to formal modeling, the collected expert judgment of people whose knowledge and experience span the domains relevant to the problem can be gathered together through senior advisory panels. This is the most venerable approach to assessment, practiced on global environmental issues since their initial appearance on policy agendas in the early 1970s and much longer on other science and technical-intensive policy issues (Grobecker et al, 1974; SCEP, 1970; SMIC, 1971).

In recent years such bodies for global environmental issues are increasingly established under international auspices and have formal standing in international policy-making. The most ambitious examples are the Montreal Protocol Assessment Panels, which have recently completed their third full assessment process, and the IPCC, which has recently completed its second. Similar bodies, operating on a smaller scale or more recently established, exist for several other issues.

Such bodies typically review and summarize various fields of knowledge, possibly drawing on formal models as well as disciplinary knowledge. They may draw collective judgments of likely consequences, feasibility, significance, or relevance based on this knowledge, to answer specific questions about the implications of policy choices.

A crucial part of their work is drafting policy-makers' summaries, in which they distill the most significant implications of the knowledge they have gathered for policy. This process can represent a difficult negotiation, for finding language to serve the knowledge needs of policy-makers may require statements that would not normally be acceptable in scientific debate, due to their breadth, their normative content, or their explicit characterization of the confidence with which certain things are known.

Such bodies contribute principally through their reports. These can be valuable and important, not least as educational reading for newcomers to an issue. Moreover, they can be an effective synthesis method when they reach consensus, effectively removing certain questions from contention (Clark, 1986). But as procedural devices that seek to draw on broad-ranging expert authority to serve policy-making, they lie between the domains of science and politics, and hence are liable to attack (either sincere or partisan) on grounds drawn from either domain. For example, the IPCC Scientific (WG 1) reports have been charged both by climate-change skeptics with corrupting scientific process by responding to political pressures; and by negotiators and NGOs from developing countries with non-representative, and hence politically illegitimate, membership (Risbey et al, forthcoming; Lunde, 1992).

To contribute effectively to policy debate, panel reports must be able to withstand both such kinds of attack. Consensus on the panel is normally a necessary (though not sufficient) condition for this robustness. Because of the importance of consensus, panels employ various methodological and management devices to help attain it. They may, for example, dilute statements to a level of vagueness and generality that raises no objections, and hence fail to present points sharply enough to yield relevance to decision-makers.

Another consensus-building device is to shorten the causal chain of the issue, restricting enquiry to areas where uncertainty is manageable and consensus is strong. In both the Montreal Protocol and the IPCC, this process has yielded "Science" Panels that consider only

certain aspects of atmospheric science. Even other areas of natural science, particularly those concerned with ecosystem impacts, are placed in separate working groups with separate reports, and in some assessments omitted entirely. Despite widespread current endorsement of "integrated assessment", this approach in effect yields dis-integrated assessment, leaving the hard and complex task of re-integrating information about atmospheric science, impacts, and policies -- if it is undertaken at all -- to the audiences of the assessment.

2.3. Knowledge Needs Filled and Unfilled by Conventional Methods.

Both formal models and expert panels can make useful and important contributions to assessment, but both have important weaknesses and gaps in meeting many of the knowledge needs of global environmental issues identified in Section 1.2 above. These weaknesses are not absolute, since neither of these methods is a precise single thing and particular adjustments of process, methods, or organization can help mitigate any particular weakness. But there are certain knowledge needs that these methods are well suited to meet, and others that they are not.

Formal models are particularly strong for characterizing instrumental relations, for characterizing ordinary uncertainty, and hence (with some limits) for identifying key uncertainties and guiding enquiry. They may also be of some use in valuing consequences, since under the stringent assumptions necessary to justify valuation through willingness-to-pay methods and benefit-cost analysis, they can identify tradeoffs and welfare-maximizing policies.

But formal assessment models are of little use on the other assessment dimensions. In seeking to understand problems that are not well-posed, formal models cannot help and may hurt. They cannot help because what questions to ask must largely be specified in model design. They may hurt because in the course of model-building, a specific, restrictive, and unexamined set of choices may be made by default, effectively imposing one definition on the problem, its boundaries of relevance, or the goals of policy.

Because formal models require economy of representation, they are not well suited to expanding the set of options, responses, or contingencies considered.[7] Nor are they useful in representing strategic or behavioral uncertainty; indeed, their weakness in representing policies and their effects is partly a consequence of this more general weakness.[8] In current assessment modeling, strategy and behavior appear only implicitly, in the external specification of scenarios (e.g., suppose all nations reduce their emissions by 20%).

Formal models can effectively integrate knowledge from domains that permit precise specification of quantitative and causal relationships, but cannot readily integrate qualitative, intuitive, or strategic knowledge except to the extent that it can be credibly represented as probability distributions. Moreover, they are unlikely to yield to even the best-intentioned attempts to make them pluralistic in the viewpoints, values, and intuitive causal models they incorporate. Two current projects to put alternative subjective valuation criteria or

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[7] There are conditions under which models can help with this task, if the process of formalizing facilitates searching systematically over the space of relevant options; but this mitigating factor is narrow, and arises infrequently.

[8] It also partly reflects the limited spatial and sectoral scale of current integrated-assessment models, which make it impossible to represent reasonably complex and realistic policy responses.

probability distributions into models may hold some promise of progress, but the fundamental problem remains that it is hard for modelers to get inside other peoples' heads (Dowlatabadi, 1995; van Asselt and Rotmans, 1996).

Expert assessment panels can make useful contributions to knowledge needs through bringing forward and integrating identified pieces of knowledge; through finding plausible, authoritative projections of background information; through combining these to project consequences; and through characterizing the state of knowledge and prioritizing knowledge needs, though working with formal modeled representations of uncertainty can be of great help in the latter task.

In meeting the more open-ended knowledge needs -- framing and characterizing ill-posed, novel problems, and identifying risks, sources, contingencies, impacts, values, and responses -- panels' performance is of variable quality; some bodies hold to an inappropriate initial characterization of the problem, while others work hard to ask whether they are posing the right questions. Most panels favor considering specific issues and options already on the agenda, rather than seeking to identify new ones. This conservatism may, though, reflect panels' specific mandate and formal advisory role to an authoritative decision-making body, rather than an intrinsic weakness of expert panels as an assessment process. Such a setting, in which a panel's report or even the content of their deliberations may meet political criticism, discourages free-wheeling generation of issues and options, or consideration of alternative problem framings (Fisher and Ury, 1981). The political body may be daunted by the issue's complexity and so want the panel to resolve questions and remove issues from the list, not add new ones and make their lives still harder. Moreover, if the political body is sufficiently broad and diverse, any particular issue, option, or impact a panel raises may offend some political actor who wishes they had not. Panel members may know they can escape certain forms of attack if they stay precisely within the terms of their charge, but are vulnerable as soon as they stray outside. In general, free searching over ill-formed questions, or any contributions in the form of ideas, suggestions, or possibilities, rather than authoritative answers or summaries, are best provided by an assessment process well insulated from direct lines of political authority.

The experiences of both the IPCC and Montreal Protocol panels support this contention. IPCC Working Group 3, in which some chapter teams sought to avoid controversy by writing general academic-style reviews of currently discussed policy approaches, still had to defend themselves against delegations who did not want certain options mentioned at all. The Montreal Protocol Technology Panel has done an admirable job of searching for and identifying specific substitution technologies for ozone-depleters, but has done it by taking refuge behind specific charges, including definition of criteria for, e.g., "availability" of a technology, provided by the parties.

Similar difficulties confront panels in assessing strategic uncertainties. Such assessments depend on judgments and speculations of what choices by particular actors are plausible or likely. When panels report to a pluralistic political body, many such judgments or speculations are liable to offend somebody in the room. They are also likely to require modes of thought and work different from the normal business of committees or panels, including serious efforts to put oneself inside other people's heads. This can best be facilitated through approaches that bring together diverse expertises and views, shake people up, provoke non-conventional thinking, and let people have fun, which conventional panel deliberations are unlikely to provide.

In summary, there are several important classes of knowledge needs, highly salient for global environmental policy issues, that current conventional assessment methods -- models and panels -- are not well equipped to provide. Moreover, current research on, and criticism of, these methods are not targeting these omissions. Most current work on assessment models seeks better representation of uncertainties, technological change, and impacts. Most current reflections on assessment panels consists of either specific criticism of their membership and reports, or attempts to deconstruct their scientific authority and objectivity by demonstrating social and political processes influencing their membership, process, and reports. Neither of these lines of work addresses the omissions identified here.

One further problem common to both formal models and expert panels is obtaining consensus estimates of the values, or probability distributions, of unknown physical parameters or other facts. Models require specified point estimates or distributions for all input parameters, and are of limited help in developing them (though in some cases estimates can be obtained as outputs of other models, assuming that these models' inputs are specified). Panels may tabulate published estimates for unknown physical quantities or summarize these to a range, but they rarely aggregate them to a consensus estimate or distribution and the working process of a panel provides no systematic way to pursue this.

Two approaches have been taken to this problem, one computational and one procedural: formal combination of individual judgments derived through expert elicitation; and procedural devices to promote consensus, of which the best-known is Delphi. Both are devices to generate a single estimate or distribution (or at least a greatly narrowed range) from a divergent set. Expert elicitation seeks to generate carefully constructed and consistent representations of individual experts' subjective probabilities. Combining such estimates is formally simple, but controversial -- principally for the inevitable arbitrariness in deciding which experts to include and how to weight them, and for the associated presumption that the probability of a view being true is proportional to the number of experts who hold it (Pate-Cornell, 1996; Keith, 1996).

Delphi is a procedural approach to the same problem, iterated expert polling with unattributed sharing of responses between rounds. Estimates generally converge over successive rounds, but this may reflect subtle pressures for conformity in addition to (or instead of) genuine development of consensus.

These methods both extend the range of conventional assessment methods, but they address the narrow problem of dissent over specific factual knowledge, not the broader weaknesses discussed here. In a variant of Delphi that is widely regarded as more useful, full (but still anonymous) arguments for each participants' estimates are exchanged between rounds, rather than the estimates alone. This variant has some commonality with the alternative assessment methods proposed here, which are discussed in the next section.

3. Alternative Assessment Methods.

There exists a set of alternative methods for assessment and synthesis, which can help some of these areas of knowledge needs in which conventional methods are weak. Thus far, these methods have seen little application to global environmental issues, though these issues appear particularly suitable for them. The methods have accumulated substantial experience

in other policy domains, which has revealed both great promise and a set of characteristic risks.

The origins of these methods lie in military planning,[9] while other areas of extensive application include foreign-policy crises, emergency management, and competitive corporate strategy. Related methods are used as research tools in group decision-making and bargaining, and for teaching and training (Parson, 1995).

These methods can take various forms. Their varieties include exercises in which participants construct, elaborate, or critique scenarios, either freely or within constraints, such as Scenario Planning or Policy Exercises; exercises in which participants take on roles and tasks -- planning, negotiation and decision-making, separately or in teams -- within an imposed decision context or scenario, such as Political-Military Exercises or Simulation-Gaming; and exercises in which participants collaborate in constructing formal models of a policy issue or contested decision that reflect their collective knowledge, judgments, and values, such as Adaptive Environmental Assessment and Management (AEAM) (Schoemaker, 1995; Huss, 1988; Toth, 1994; Svedin et al, 1987; DeWeerd, 1967; Parson, 1995; Holling, 1978).

These various forms share basic defining characteristics. They are all representations of a complex decision problem or policy issue; they all involve human participants in dual roles, as inquirers and as objects of study; and they all present a context somewhat removed from immediate decision responsibilities -- both in authority, in that the exercise is not intended to advise authoritative decision-makers on specific decisions, and in substance, in that the exercise's context is made somewhat hypothetical, set in the future, set at a different level of abstraction or generality, or in some other way distinguished from immediate decisions. These characteristics are elaborated below.

The use of human participants, and participants' dual roles as inquirers and as objects of study, are both essential to these methods. Participants undertake specified tasks of planning, projection, negotiation, or decision-making, most often in teams. While their dual roles are essential, the relative priority of the two roles can vary widely. Participants are inquirers, working in partnership with the researchers and designers who create and manage the exercises. This partnership of enquiry implies that participants' tasks cannot be completely specified, but must leave some latitude for participants to question and revise the structure imposed by designers; and it implies that instructional objectives are never wholly absent from such exercises, though not in the simple form of designers teaching specific things to participants. Participants are also objects of study, in that how they engage their tasks (both in substance and in process) is material for observation and critical reflection, for the exercise designers and researchers but also for the participants themselves. If participants are not inquirers but only objects of study, these methods collapse into social-psychological

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[9]The prominence of these methods in military planning reflects the uniquely hypothetical character of a military organization's job. Preparing for infrequent, novel threats requires detailed attention to contingency planning and rehearsal, to test the organization's responses to hypothesized threats whose character is never perfectly predictable, and to develop the necessary coordination of hundreds of different organizational routines that comprise the response of a huge, hierarchical military organization (Brewer and Shubik, 1979; Bracken, 1990).

experiments; if participants are not objects of study but only inquirers, these methods collapse into seminars, committees, or expert panels.

These methods are all representations of a complex policy issue or system by a simpler one with relevant behavioral similarity, which permits learning about the complex system by observing the simpler one.[10] The representation resides partly in the participants and their problem-solving, decision-making and negotiation, which represent the behavior of the agents and organizations whose actions shape the real issue being studied;[11] consequently, participants must normally have substantial expertise or authority in the issue. And the representation resides partly in other components of the exercise, including the definition of participants' tasks and roles, and other information, scenarios, models, or tools provided.

Finally, these methods involve displacing participants' attention from their real and immediate tasks, roles, identities, and decision contexts. They pose decision situations that are future, hypothetical, fictitious, or counter-factual, to move participants outside their normal habits and positions, and encourage creative thinking, new ideas, and insights. These goals cannot always or reliably be met, but careful choice of participants, control of the setting and context of the exercise, and protection of participants through such measures as non-attribution can increase their willingness to explore incomplete ideas and take risks, and so make these benefits more likely. One implication is that these methods are not appropriate when direct advice to authoritative political bodies is required.

These methods are distinguished from formal or mechanical simulations and models, by their use of human participants; from social-science experiments and operational simulators,[12] by participants' role as co-inquirers; from seminars, committees, or panels by their attempt at representation and by participants' role as objects of study; and from games for amusement by their serious assessment purpose and their attempt at sufficient representational realism to contribute usefully to policy and decision. The distinction from games for amusement may become increasingly blurred by advances in computer and modeling power, though, which permit the development of simulations and games that are ambiguous in both their degree of representational fidelity and their intent. Such simulations, particularly when widely distributed, are liable to charges of perpetrating grievous widespread public misunderstanding, analogous to the excessive confidence formal models have long been charged with within regular policy processes (Starr, 1994).

Other than these defining characteristics, these methods can vary widely in design. Typical design elements may include various definitions of participants' tasks, roles, relationships, and the rules under which they operate; rich scenarios that provide context for participant decisions; various means of treating time and uncertainty, working forward or backward, or covering the same situation repeatedly under different conditions; formal models that provide information, projections, analysis, or consequences of participant decisions; and a control

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[10]This is drawn from Brewer and Shubik's (1979) definition of "simulation", p.9.

[11]In the classic division of simulations into "all-person", "person-machine", and "all-machine" exercises, the methods discussed here include the "all-person" and "person-machine" types. "All-machine" simulations correspond to physical or computer models.

[12]Such as are used for training and design in complex systems such as commercial aircraft or nuclear power plants.

team that determines consequences of participants' decisions, represents the decisions of other actors and nature, and injects surprises.

One important design variant is that such methods may have more or less of the character of a "game". While some authors argue that the hypothetical character of these methods makes them all games, it is more common to define games by some combination of the following conditions: structure and rules guiding participants' choices;[13] outcomes determined as the collective consequences of decisions made separately; and separate participants or teams planning and deciding without knowing what others are planning and deciding (Schelling, 1964; Levine, 1964a, b; Shubik, 1975).

Since the 1960s there have been recurrent periods of vigorous development of such methods (under various names), and of enthusiastic, sometimes excessive claims of what they can achieve, punctuated by intermittent harsh evaluations of the intellectual integrity and utility of the methods as practiced.[14] The following sections argue how these methods can be useful in global environmental policy, why they may make a incremental contributions to understanding, and how to avoid or mitigate their most serious risks and weaknesses.

4. Using Alternative Methods for Global Environmental Change

Because global environmental issues have high stakes, and because conventional assessment methods fall short of meeting important knowledge needs, novel or unconventional methods have a presumption in their favor. If they can plausibly offer to advance understanding, particularly with respect to the knowledge needs where conventional methods are weak, they are presumptively worth exploring and developing.

But such a presumption can only take you so far. A serious case to try a novel method cannot rest entirely on an argument so generic that it would equally support consulting oracles and fortune-tellers -- though these assessment methods have been employed by political leaders both ancient and modern. The methods proposed here keep bad company, and have a record of intemperate claims and mis-applications (Smith 1987). Consequently, an argument for their serious development and use, and for granting them the time and attention of busy senior participants, must make the case that they are unlikely to do much harm,[15] and that

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[13]Of course, rules may be provisional. It is of the essence of participants role as "enquirers" that they be permitted to over-ride, revise, or at least critique, the rules.

[14]The long-standing criticisms include excessive and confused claims, bias, arbitrary assumptions, using bad or unverifiable data, poor documentation, no peer review, and little progress in development of professional standards. See for example, Levine (1964a); Schultz and Sullivan (1972); Brewer and Shubik (1979); and Meadows and Robinson (1985).

[15]Certain biased or polemical applications of simulation exercises and war games have caused, or risked, grave harm. Bracken (1977) reports two instances: rigged Japanese naval war-games prior to the battle of Midway being used to mislead senior decision-makers into authorizing the engagement; and highly conservative, worst-case estimates of UK air casualties being publicized and causing grave harm to morale. In one chilling example, the U. Md. Nuclear History Program (1992, p. 302) reports a US Air Force war game whose director drew the conclusion that the US could selectively use nuclear weapons on military targets to force concessions from the USSR without escalating to general nuclear war.

there are specific reasons to expect them to make a positive contribution to understanding or policy-making. Such a specific argument would have to engage the particular difficulties and knowledge needs of global environmental problems, the weaknesses of conventional assessment methods, and the characteristics of the proposed methods.

The proposed methods have two characteristics that help them address these unmet knowledge needs. Relative to both panels and formal models, the alternative methods are better able to incorporate diverse preferences, conceptions, and normative perceptions; and they are able to integrate (weakly) across a broader set of knowledge domains.

It is by including diverse participants that these methods can incorporate multiple perspectives. Participants carry their disparate perspectives on the issue, both positive and normative, into the exercise with them. These methods integrate "procedurally", posing collective tasks that clarify participants' views and force them to engage each others'. The collective tasks can take many forms. They can include, for example, collective decisions, projects, negotiations, arguments, or constructing projections or narratives. These are all sufficiently broad and demanding that participants' knowledge, expert judgment, opinions, preferences and values are all relevant, and must interact. The consequence is a more engaged consideration of multiple perspectives, and one that more effectively reflects diverse normative perspectives as well as distinct bodies of positive knowledge, than can normally be accomplished by conventional forms of group work or assessment.

Moreover, these methods avoid the most common failing of Delphi and simple aggregation of expert judgment, the forcing of diverse views to a single blend or an inappropriate consensus. For example, the playing out of adversarial roles can push participants to detailed articulation and development of their views, permitting both the identification of potential points of commonality and clarification of the basis of dissent. Alternating between adversarial and collegial roles can facilitate identifying the presumptions on which disparate views are based, new pieces of data or evidence that would change actors' views or favor particular choices, or policy options that are robust to particular forms of dissent.[16] These benefits are all advanced by the heterogeneity of the participants. Indeed, many of the benefits of these methods come from the alternation or exchange of roles, as participants observe, question, and learn from each other, and experience decision problems from multiple perspectives.

Similar arguments support the ability of these methods to integrate positive knowledge across a broader range of domains. Participants bring their experience, knowledge, professional training, and intuitive judgment about both scientific and technical matters, and behavioral, strategic, and political uncertainties. These methods can provide a variety of means for synthesis and integration of such knowledge.

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[16] It is instructive to note that for the problem of judicial decision-making, which is also contentious and uncertain, though typically low-stakes for society (high-stakes for the individuals involved), the conventional solution is to rely on a set of process rules for admitting and weighing evidence, and deciding who has authority to decide and what procedures they must follow in deciding -- in effect, abandoning the search for authoritative right answers and relying on the process. Various proposals to base high-stakes social or political decision-making on similar procedural foundations (e.g., the "Science courts" proposal of early 1980s) have been decisively and repeatedly rejected.

Moreover, knowledge can be brought into such exercises by other vehicles than the minds of the participants. Relevant information can be provided through briefing materials, decision-support tools, or formal models, and integrated into collective outcomes and insights to the extent that participants engage it. Indeed, combining formal assessment tools such as models into these methods can permit focused, demanding testing of the policy-relevance and usefulness of the tools and models.

Relative to conventional assessment methods, the alternative methods proposed here better incorporate multiple perspectives, and can integrate knowledge from a broader set of domains. In addition, they pose decision situations somewhat removed from the immediate policy agenda, and they manifest the unpredictability that comes from generating collective outcomes from separate centers of decision. Together, these characteristics encourage both the generation of novelty -- from their intrinsically unpredictable character, and from their stimulation of individual and group creativity -- and the critical examination and refinement of ideas and insights that are generated.

Consequently, these methods are well suited to both the generation and the critical examination of new ideas and insights on precisely the dimensions of knowledge needs that are ill met by conventional assessment methods. They can help specify and clarify the basic character of an issue, help elaborate and refine lists of relevant sources, impacts, responses and contingencies, and identify overlooked factors and connections. Through observation and reflection on the interactions of participants' decisions, acting in self-interested roles and under relevant constraints, these methods can provide more useful insights into strategic uncertainties -- plausible choices by significant actors, and their consequences for other actors -- than mere speculation, even by the same group of people.

Insights from such methods may take the form of changed views of relative importance of different aspects of the problem; promising new ideas for negotiating stances, design of policies, institutions, or responses to specific contingencies; or newly recognized plausible consequences of specific proposed initiatives, including unanticipated potential pitfalls. If the exercise attains sufficient representational fidelity, these insights are likely to be of relevance to the real problem. Many of these come from the unpredictable character of such methods, and their ability to help extend the list of "things you would never have thought of" (Schelling, 1964).

Examples of such insights gained from these methods are highly diverse. Schelling (1964) reports a military crisis exercise concerning Soviet invasion of northern Iran in which one military planner realized that the supply of jet fuel readily available in Teheran was ten times larger than had been thought, because kerosene (an acceptable substitute) was used for domestic cooking. In a 1990 simulation of reorganization of the UK National Health system to create internal markets, budget pressures led the newly created health-care purchasers to press hospitals to lower quality of care, revealing the unanticipated necessity of advance negotiations to develop quality indices and allocate responsibility for health objectives among the newly created institutions (East Anglia Regional Health Authority, 1990). A series of simulated negotiations on international emissions trading for global climate change revealed sharp disparities among developing nations in their ability to trade, and competition for resources between emissions markets and administrative financial mechanisms like the Global Environment Facility (GEF) (Parson, 1992).

In sum, these methods are strong in precisely the areas where conventional methods of assessment are weak: issues whose basic character and relevant factors are not well understood; issues on which the values at stake are unclear, ambiguous, or contested; and issues for which some of the basic uncertainties concern behavior, strategy, or values. Moreover, the origins of insights within such exercises are transparent once they arise. If something happens, you can ask why; if some insight arises, you can ask what made it seem persuasive within the context of the exercise, and what conditions would weaken or reverse it. Hence, insights from such exercises are subject to discussion, questioning, refinement, and to a limited extent, testing -- at least by the criteria of plausibility to the expert participants and observers.

5. Problems and Challenges:

Attaining the benefits summarized above from these methods poses serious design challenges, and there are many ways to err.

The two most basic potential sources of potential for error in these methods also afflict conventional assessment methods: bias, and too-confident generalization from small samples. Both participants and designers can introduce bias. Designers can introduce bias in the choice of participants, in unintentional hints, in the structure of the exercise, or in the basic definition of what is deemed relevant and essential (DeWeerd, 1975). Even without systematic bias in design or participants, all implementations of these methods represent small samples of highly rich, complex events. Under these conditions, much of what is experienced is non-generalizable variance, so general conclusions must be drawn from such methods only with the utmost caution.

Both these risks are exacerbated by the experiential vividness of these methods, which tend to lend excessive confidence to the lessons drawn from each implementation. This risk may be no worse, though, than the widely observed tendency of decision-makers to draw too-confident inferences from vivid historical images, or their own prior experiences, both of which are also tiny samples of complex events (Etheredge 1985). Indeed, the possibility of these methods to incorporate diverse perspectives, and the possibility of reviewing particular problems or scenarios repeatedly under different conditions, both suggest that the risk of excessive generalization may be less pronounced from these methods than from real-life experience.

An important defense against both kinds of error is distinguishing clearly between the heuristic goals these methods can plausibly attain, and the stronger goals -- principally prediction and hypothesis testing -- that they cannot, and the pursuit of which is liable to lead to serious errors (Brewer 1990; Parson, 1995). Even attaining the heuristic benefits, though, depends on the method's attaining a sufficiently persuasive level of relevant behavioral similarity to the issue being studied, while still shaking up participants normal habits of thought enough to generate useful insights. In part this similarity depends on the choice of participants, for insights from an exercise are only likely as good as the set of participants they came from. But this requirement also defines the most basic design tension of such methods: keeping the representation close enough to the real issue to be relevant, while separating the decision context enough from the precise present problem to provoke new approaches.

A further, related challenge, concerns the difficulty of designing settings in which participants with the required expertise are willing and able to step out of their roles. Most participants who have expertise and authority in the issue also have existing positions and relationships with other participants. Bracken (1990) has identified a set of predictable pathologies associated with using simulations within large, bureaucratic, hierarchical organizations. When participants do not come from a single organization but do have established positions and professional relationships, a different but equally serious set of pathologies can arise: e.g., refusal to accept the hypothetical premises of the exercise, acting so as to bolster preferred views in outside interactions, or withholding or distorting relevant information.

Many of these pitfalls are mitigated by the fact that most implementations of the methods advocated here include a lengthy critical debriefing. In the debriefing, the significance and legitimacy of the problems posed is explored; potential implications are considered of decisions taken and plausible alternatives not taken; and the relevance and generalizability of insights drawn from the exercise are critically examined. Here the critical faculties of both participants and designers are fully engaged in criticizing the experience of the exercise, rather than living it, and potential design bias, partisan attempts to bias outcomes by participants, and over-strong generalization are all held up for critical examination.

The preceding challenges apply generally, to any use of these methods. Other challenges are specific to their application to global environmental issues, principally concerned with ways that it is difficult on these issues to attain sufficient representational realism.

The first concerns the use of time in assessment exercises. Global environmental issues typically have long time-horizons; the consequences of current choices may not be fully evident for decades. Consequently, in exercises in which participants make decisions and consequences are determined by models, designers, or a control team, the required time-steps between successive decision episodes must be long and it is hard to avoid a sense of arbitrariness. This may weaken participants' sense of realism and continuity. Of course, not all such exercises require a continuous realistic narrative sense between episodes. One may decide to manage the exercise more intrusively, in effect making up a new scenario (but one that plausibly follows from previous events) for each episode, possibly deciding in advance what the most crucial problem will be for each round. This problem of managing long time-horizons makes the use, and the design requirements, of such methods for global environmental policy contrast sharply with their more common use to study crisis response.

In assessment exercises that require the construction and updating of narrative scenarios over time, both designers and participants are likely to be tempted to resort to *deus ex machina* solutions for the environmental problem studied. Several past implementations of such exercises have posited massive technological innovations, or transformative social, political and religious movements, that solve the problem studied or make it insignificant. Exploring such possibilities can be useful for moving participants out of "business-as-usual" thinking and sensitizing them to the wide range of possibilities that applies over several decades. But resorting to these innovations can also let the group off the hook, permitting them to digress from difficult but plausible considerations of how to manage the problem, to speculative exploration of major discontinuous events about whose origins and causation essentially nothing is known.

Finally, the central dependence of global environmental problems on complex and contested scientific information poses several specific challenges for the design of such exercises, concerned with ways of integrating complex information or formal models into open-ended exercises driven by the participants. Models tend either to become the center of attention of the exercise, or to be ignored entirely. When participants use models, they may demand complex real-time runs that exceed the capacity of the systems available and require rapid entry of large quantities of stipulated data, posing serious risk of errors. In some settings, model inputs or outputs may offend or alienate participants, and may need to be filtered for acceptability.

6. Conclusions:

The alternative assessment methods proposed here are likely to be useful for certain classes of decision problems. These include new, ill-posed issues whose character and relevant aspects are ill understood or contested; issues for which major institutional changes are proposed; and issues for which the consequences of even relatively simple or small policy or decision are hard to assess or predict because of the number of affected actors and their range of potential responses. Global environmental problems clearly have these characteristics, as do other current important policy issues.[17]

Of course, the benefits plausibly attainable from these methods are not guaranteed. In any particular implementation of these methods the seemingly new insights that arise might on reflection be wrong, already well known, or caused by particular arbitrary characteristics of the exercise, and hence not applicable to real policy or decision. The goals of broad integration of knowledge and incorporation of diverse perspectives may not be achieved if participants cannot understand each other, argue past each other, or are unable to engage the breadth of information provided.

Indeed, the few implementations of such methods so far for global environmental problems have provided ample evidence of their expense and difficulty, and the insights they have offered, though real, have been of modest scale. But since these methods are meeting an important class of knowledge and integration needs that conventional methods alone cannot meet, and since even the beginning efforts undertaken so far continue to show evidence of larger potential contribution, the case for their value remains persuasive. Moreover, the early experience gained suggests that the risks and design challenges associated with these methods can be effectively mitigated.

The issues for which such methods are suitable lie in some important ways outside current experience, and insights on such questions do not come easily. But the issues are not utterly novel; rather, they are typically increases or combinations of elements for which experience does exist. It is this character of partial, or intermediate novelty, that makes the proposed methods potentially useful. We have some knowledge about biophysical and ecological systems, about the capabilities of technology and institutions, and about patterns of behavior of actors and states, that can help us understand or explain pieces of the problem; but we lack

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[17]Other current policy with similar characteristics, potentially suitable for investigation through methods such as proposed here, could include reform of domestic health-care systems; managing fiscal stability of public pension systems; and developing new constitutions and institutions for newly independent or transformed states.

methods to synthesize or integrate these bits of knowledge into a coherent synoptic view (Jones, 1985). The role of these methods is linking and integrating, with more flexibility or power than standard methods of formal models or expert panels can provide. The contribution they can make in the domain of assessment is hence analogous to that argued by Guetzkow (1972) in the domain of research inquiry, "bridges linking islands of theory".

It is also important to note that the extent to which an issue is well posed and understood determines what kind of questions can be coherently asked, and what kind of answers are plausibly available. No assessment method can overcome this fundamental limitation, or provide useful answers to questions that cannot yet be posed coherently. On issues such as global environment, some further, at least provisional, elaboration of the more open-ended questions identified as knowledge needs in Section 1.2 must precede attempts to seek, e.g., judgments of the specific consequences, or the desirability, of particular policy choices. That the more open-ended assessment methods advocated here cannot provide such answers as well as more closed methods such as formal models does not indicate a weakness of the methods, but rather their greater suitability to the investigation of issues at earlier stages of specification. In defending the use of "manual gaming" methods in security studies, a class of the methods advocated here, Brewer (1990, p. 99) cites the two complementary misunderstandings that afflict such methods: failing to appreciate that the loose heuristic insights they offer are of great value, particularly for ill-posed problems; and demanding, or worse, claiming, that they can offer firm predictive results, when these are in fact infeasible.

The appropriate criterion for assessing the utility or effectiveness of any particular exercise is its persuasiveness to those who must make practical use of it: researchers, who will tell whether the exercise helps them identify important questions or new hypotheses; and practitioners, who will tell whether the insights generated are useful for their practical understanding, or to help them discharge their responsibilities. Evaluating an exercise this way carries some dangers: any skillfully designed and run exercise will provide a vivid, intense, and engaging experience for the participants; and its outcomes will be vastly over-determined, hence rich in interpretive ambiguity and rife for oracular projections. But the heuristic and prospective orientation of these methods precludes any more formal testing of results for validity, so participants must act as evaluators of the insights generated; indeed, this is implied by their basic role as co-inquirers. As with the specific pitfalls identified above, a vigorous critical debriefing can mitigate this danger.

The contribution of the proposed methods is incremental. These methods can make contributions that conventional methods as presently practiced cannot, and they differ from conventional methods in important ways. But this is not to claim either that the contributions of conventional methods are insignificant or that conventional and alternative methods cannot be combined or blended. The defining characteristics of the methods discussed here are in most cases continuous, not discrete. Indeed, while pure alternative assessment methods are feasible and potentially useful, creative hybrids or combinations of conventional and alternative methods might plausibly be even more so. Formal models can be integrated into more open-ended methods as decision-support tools or to define part of the scenario in which participants deliberate. Alternatively, model-development exercises can be designed that involve diverse expert participants in the development of scenarios, assumptions, and relationships. Expert assessment panels could under some circumstances use simulation, scenario, or policy-exercise methods as part of their deliberations. All these hybrid approaches are worth exploring. The possibility of adjusting conventional approaches to

integrate the alternative methods proposed here is one indication of the potential value of the alternatives.

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