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Inventing the future: scenarios, imagination, mastery and control

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Abstract The complexity of mixed social, behavioral, and natural systems—such as those encountered while analyzing, understanding, and trying to manage aspects of climate change and sustainability, requires more common theoretical frameworks and technical tools than either can bear. How does human activity relate to greenhouse gas emissions, changes in the atmosphere, climate variability, and multiple impacts, outcomes, and effects? Some of the connections can be observed and measured, many cannot. Uncertainties of every conceivable sort can occur. As the time frame into the future extends, uncertainties essentially dominate conventional theories, tools, experiences, habits, processes, and so forth. The scientific consensus linking human activity to climate change is now all but settled according to The Fourth Assessment Report of the Intergovernmental Panel on Climate Change. The consensus says little, however, about who should be doing what and for what reasons under this singular, even unique circumstance. There are no data about the future on which to rely. We are challenged to imagine many different and possible "futures" as humankind seeks to exert its mastery and control. This essay considers and then weaves together several basic issues, ideas, and topics: complexity, the concept of human intentionality, several means used to exert control in organizations and social systems, and different methods being used to imagine, invent, and communicate the future.

Keywords Global climate change · Sustainability · Human dimensions and intentionality · Organization and system control · Heuristics · Scenarios · Integrated assessments · Models · Simulations · Games

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Introduction

No one has any idea whatsoever of what human systems or decision pathways will look like 25, 50, or even 100 years from now. Who in 1907, or even in 1957, could have predicted how energy, transportation, warfare, agricultural, health or just about any other human system and its attendant decision processes could have gotten to where they are now? Remember when energy "too cheap to meter" would sustain and enrich our race in the early and enthusiastic atomic era? Eugenics was predicted to be the only possible salvation of the human species in an earlier, sinister time. Or consider the apocalyptic standby of inevitable mass starvation in a world whose population is inexorably increasing and out of control. The historical examples of failed predictions, both utopian and apocalyptic, about human systems are almost too numerous to count.

By now we should have learned to be wary, even when the predictions emanate from the minds of the "best and the brightest". But yet again we face a seeming scientific consensus about the likely (even inevitable) destruction of the planet, presented as the specter of global climate change (IPCC 2007). "Global warming is changing the world", is but one of a growing list of headlines vying for our attention in even the most staid scientific media (Kerr 2007, p. 188). Dire prediction follows dire prediction until one's mind freezes up. What is there to do, and who should be doing it? Images of melting glaciers and "drowning" polar bears hardly help. Indeed, they may even literally contribute to the apocalyptic mood in which "God destroys the ruling powers of evil and raises the righteous to life in a messianic community", and thereby sets the stage for indecision or despair (Webster 1999, p. 54). We must do better than this.

No one can predict the future, but we can invent and make the future because we know how to do so and we have done so consistently through our history as a species. Inventing and making however mean thinking clearly about where we wish to go and then creating and devising the means to get there.

This essay is meant to be uplifting, not apocalyptic. It appreciates the capacity of the human mind, and individual human beings, to understand their circumstances in the past, present, and into the future. It does, at the same time, strive to accept and accommodate our limitations, especially with respect to the ways in which we approach and deal with matters such as complexity, imagination, power, control, and most importantly, how we communicate among and respect one another.

Complexity

Social systems are complex, made up as they are of a large number of parts interacting in non-simple ways. Herbert Simon long ago summarized it:

> In such systems the whole is more than the sum of its parts, not in an ultimate metaphysical sense, but in the important pragmatic sense that, given the properties of the parts and the laws of interaction, it is a non-trivial matter to infer the properties of the whole system. (Simon 1965, pp. 63–64)

Confronted with such complexity, the usual response is to simplify. Some things are highlighted while a great many more are not. Human beings are simply unable to deal with complex systems as wholes. In short, the complexity of social systems and our limited intellectual and operational capacities require us to simplify. Seldom are the implications flowing from these limitations considered very well, if at all.

Overlapping interactions among numerous elements, positive and negative feedback control loops, non-linear relationships, and continuous structural changes inhere in social systems. These characteristics largely account for the astonishing diversity of real social systems and behavior. Our limited intellectual apparatus, however, prompts us to seek simply-ordered regularity despite the reality (Sinsheimer 1971).

With increased complexity come increases in the number and diversity of system interpretations, in part because of the biased and distorted views individuals bring to a social setting or problem context. Depending on the issues at stake, various perceptions of them, and the meanings concerned participants ascribe to each, these diverse interpretations may seriously affect the decision process and overall system operations. Diversity of viewpoint may be a positive thing, particularly in situations where sufficient time exists to elicit, integrate, and weigh various views and values before choices must be made. Lacking time, however, usually means that choices fall into one or a limited number of types: Incrementalism, standard operating procedures, vacillation and indecision, and doing nothing at all. Creativity in any case is seldom sought or celebrated.

Time is of the essence. As the time available to make a choice decreases, the search for alternative views and the chance to think through the possible consequences of various choices both decline. Thought yields to intuition, habitual procedure, brute force, or vacillation.

But what to do? The intellectual and practical challenges are significant, but can be identified in terms of several basic questions, taken together with respect to specific problem settings or contexts (Lasswell 1971, pp. 34–57).

- What goal values are sought and by whom? Or, who are the relevant participants/stakeholders and what do they want?
- What trends affect the realization of these values? Or, where did the problem originate?
- What factors are responsible for the trends? Or, what are the driving, influencing, and conditioning factors?
- What is the probable course of future events and developments especially if interventions are not made? Or, on what problems or opportunities should we focus attention?
- What can be done to change that course to achieve more of the desired goals, and for whom?

Such questions provide the context of analysis and suggest procedures for doing it. Problems designate theory and method, not the other way around, in sharp contrast to discipline-based and curiosity-driven inquiry. Raising and answering such questions reminds one of missing parts of an analysis and stimulates imagination to create policy alternatives for consideration. More importantly, such questions emphasize a problem orientation, contextuality, multiple methods, and an overriding concern for humans and what they value.

How one confronts problems implies much about the nature of the problems themselves. The point has been recognized in the social sciences although it is less commonly encountered in the natural sciences (Brunner and Byerly 1990; Nisbet and Mooney 2007; Clark 1996). Defining a problem, rather than just identifying or describing a problem, "suggests a constructionist (rather than an objectivist) view; i.e., problems do not exist 'out there'; they are not objective entities in their own right" (Dery 1985, xi). Schon (1979, p. 261) makes the point concisely as follows:

"Problems are not given. They are constructed by human beings in their attempts to make sense of complex and troubling situations". Problem definition is a matter of representation based on human experience and expectation. Moreover, people generally "represent the world in such a way as to make themselves, their skills, and their favorite course of action necessary" (Stone 1988, p. 116).

Real-world problems do not exist independently of their socio-cultural, political, economic, and psychological context. The need for multiple perspectives and multiple disciplines to illuminate matters is evident, challenging as it has proven to attain in practice (Brewer 1999).

Coping

Coping with complexity and working to reduce uncertainty about possible decisions are certainly desirable goals, and numerous practical procedures exist as means to these ends. Several of these are summarized below (Table 1), with respect to the basic intellectual tasks required to define a problem thoroughly and responsibly.

The selection of procedures is an important judgment, seldom acknowledged, about one's understanding of the problem at hand. When one simply aggregates existing data and conducts a well-known and familiar analysis of it, complexity may not be reduced at all—appearances to the contrary. Many other intellectual tasks besides data collection and modeling must be attended to.

If done well, efforts to cope with complexity may reduce uncertainty, but not always or necessarily. Complexity and uncertainty are not the same. Insensitive efforts to reduce complexity often produce the result of increasing uncertainty, as when actual problem elements that matter to human beings are devalued, overlooked, or eliminated (Simon 1985; Larkey 2002; Table 2).

Table 1 Procedures to cope with and manage complexity

COLLECT INFORMATION
TRENDS
Create data banks: Social accounting schemes, adaptation of existing (administrative) data bases, e.g., census and economic.
Establish ecological monitoring systems.
Improve communication networks: Information clearing houses, library and archival activities, web and Internet-based associations.
Elicit expert opinions: Commissions and task forces, interviews, literature reviews, expert systems.
Enlist stakeholder participation: Public hearings, conferences, surveys, interviews.
Build and improve information processing capacities: Early warning systems, computer networks, blogs.
MODEL THE COMPLEXITY
CONDITIONS AND PROJECTIONS
Decompose, simplify: Treat elements serially, reconfigure: Causal models, mathematical analyses, simulations.
Calculate risks/rewards: Risk assessment, actuarial tables.
Identify materials, flows, processes: Input/output models, macroeconomics, industrial ecology.
Reconstruct from elemental parts: systems models (politically based--local, regional, world and ecosystem based—multiple biologic possibilities).
Synthesize: Integrated assessments.
AGGREGATE PREFERENCES
GOALS
Model the preferences: Utility theory, public choice models, decision theory.
Estimate payoffs: Game theory.
Optimize: Linear programming, dynamic programming.
Appreciate subjectivity/irrationality: Surveys, interviews, risk perception.
GENERATE AND TEST ALTERNATIVES
ALTERNATIVES
Generate alternative futures: Scenarios, Utopian and anti-Utopian scripts.
Experiment: Prototypes, demonstrations, social experiments.

Likewise, also paradoxically, efforts to reduce uncertainty may contribute to it, as in cases of open social systems where human intentions and interventions stimulate structural changes or in natural systems where changes occur slowly and over long periods of time (Kates et al. 2001; Pielke 2001, p. 151). Uncertainty itself may be misused and complicate decision making or even add to complexity where science is poorly communicated to decision-makers or where uncertainty is "manipulated to discredit science or to justify inaction" (Ascher 2004, p. 437). Such manipulations may stem from uncertainties of incomplete knowledge or from unexpected, random, or surprising phenomena.

Human-centered aspects of uncertainty are more fundamental than instances of simple manipulation and misuse.

> Uncertainty means that more than one outcome is consistent with our expectations. Expectations are a result of judgment, are sometimes based on technical mistakes and interpretive errors, and are shaped by values and interests, As such, uncertainty is not some feature of the natural world waiting to be revealed but is instead a fundamental characteristic of how human perceptions and understandings shape expectations (Pielke 2000, p. 116).

The relationship of human perception, different levels of understanding, and scientific uncertainty was a central problem identified in work done for the Third Assessment Report of the Intergovernmental Panel on Climate Change, and the result was a ten-level scale equating different Bayesian probabilities with plain language descriptors (Moss and Schneider 2000). Weiss (2002) in an extension of the IPCC work, relates Bayes and the IPCC to more common human and formal legal terms and categories (Table 3).

Under these circumstances, different perspectives and methods shed different light on actual problems. Contextuality requires one to figure out how different individuals or groups are perceiving and constructing a common situation. "Likely", "very probable", "clear showing", and "80–90% probable" convey very different appreciations, even though they are interchangeable descriptors, of a common problem (Revkin 2007).

Table 2 Procedures to reduce uncertainty

COLLECT INFORMATION
TRENDS/CONDITIONS
Compute: Determine expected value of obtaining additional information, e.g., economics of information.
Estimate: Time to make decision vs. time required for additional information collection.
Collect data: Secondary sources, primary sources.
Investigate: Intelligence collection, both overt and clandestine.
MODEL THE UNCERTAINTY
CONDITIONS/PROJECTIONS
Forecast: Time-series models and extrapolations, critical event analyses, path analyses.
Compute: Objective probability distributions, subjective probability distributions.
Strategize: Game theory, risk analysis, utility analysis and models, decision theory and models.
GENERATE AND TEST ALTERNATIVES
ALTERNATIVES
Heuristics: Brainstorming, free-form and scenario-based games, free-associative and other psychiatric techniques.
Simulate: Simulation and sensitivity analysis.
Experiment: Small-scale models, prototyping, demonstrations, social experiments.
AFFECT CONSEQUENCES
GOALS
Refine objectives: Means-ends analysis, goal clarification techniques.
Diversify: Develop different tactics and strategies to attain objectives, indifference analysis, strategic planning.
Contract with context: Control markets, co-opt possible opponents, delegate subordinates.

Contextuality also emphasizes relationships between the parts and whole of a problem. It helps one formulate a clearer sense of the past, present, and future of events as they interact and change through time. Being contextual requires a comprehensive framework to direct one's attention to possibly significant phenomena in a specific spatial and temporal setting. It also requires one to maintain a tentative, evolving appreciation of the whole.

Obviously many disciplines and methods can contribute to the analysis of a problem. The problem, embodied in one's evolving appreciation of it, points out, perhaps demands, which disciplines and what methods should be brought to bear. Calling attention to multiple methods lessens a prevalent tendency to celebrate methodology at the expense of substance. Methods have blind spots that focus attention on highly selected aspects of a problem while blocking others (Stern 1986). One must counteract this by viewing problems with different methods or approaches and working to assemble their partial insights into something approximating a composite whole. Furthermore, picking a problem to fit a method, a commonplace, is no guarantee that the problem is worth considering at all.

The human dimension

Emphasizing the human dimension forces one to raise questions about the relevant participants. Multiple possibilities exist, depending upon the actual problem and setting at hand.

The so-called case-wise method is one interesting possibility as it identifies classes or groups of individuals and then analyzes how forecast outcomes will potentially and differentially affect them (Brunner and Kathlene 1989, pp. 18–21). Children riding public school buses who are exposed to exceptionally high levels of particulate-laden diesel exhaust or specific groups of people living on low-lying island or coastal regions are illustrative. In the first case, average or mean levels of particulate exposure tell one very little about the special case and group, whose exposures are far more than the mean and for whom such heightened exposures result in far higher than average health problems and outcomes (Wargo 2002). In the second case, estimates of global sea level increases over some forecast time period will obviously count for more and be more consequential than for other groups not living on the seashore.

Focusing on readily identifiable groups or classes is another possibility. Business people, or within this group those in the insurance industry, perceive of climate change in importantly different ways. The decisions being reached are important and different, too, from those a climate change scientist might imagine and make (Mills et al. 2005; Pleven 2006, p. C-3).

Figuring out who the audience might be for any of the many scientific studies of global climate change is both problematic and indicative. The problem is that the audience is seldom clearly identified or evident. Some parts of these studies are intended for "decision-makers" of many different possible kinds. Other parts, one infers, are aimed

Table 3 Scientific, popular, and legal equivalences of uncertainty

Level	Bayes %	IPCC Scale	Popular	Legal
10	100%	(not in scale)	Firmly established. Explains broad range of phenomena	"Beyond any doubt"
9	99	"Virtually Certain"	Rigorously proven	"Beyond a reasonable doubt"
8	90-99	"Very Likely"	Substantially proven	"Clear and convincing evidence"
7	80-90	"Likely"	Very probable	"Clear showing"
6	67-80		Probable	"Substantial and credible evidence"
5	50-67	"Medium likelihood"	More probable than not	"Preponderance of evidence"
4	33-50		Evidence increasing, not preponderant	"Clear indication"
3	10-33	"Unlikely"	Plausible, some evidence	"Probable cause" "Reasonable belief"
2	1-10		Possible	"Reasonable grounds for suspicion"
1	<1%	"Very unlikely"	Unlikely	"No reasonable grounds for suspicion"
0	0%	(not in scale)	Violates well established laws	

Adapted from Charles Weiss, "Scientific Uncertainty in Advising and Advocacy," *Technology in Society*, vol. 24, no. 4 (November 2002): 375-386, Table 1 at "modelers" or the "scientific community" (or some subset thereof). "The public" (undifferentiated and not specified, in contrast to the case-wise examples) may be referenced, especially if they are not behaving "rationally" or otherwise need to be "educated." Toxic and nuclear waste disposal studies are notorious in this way.

Asking the crucial question, "Who are the relevant participants?" is uncommon. Once this question is asked and answered, more questions surface about the participants' value demands, expectations, and identifications. Who are the participants, what do they want, how might they be affected, and what resources do they have? How do they use these resources to affect outcomes? Many human values are potentially at stake, as are the institutional means to express these values (National Research Council 1994, 1996; Stern et al. 1999; Nordlund and Garvill 2002).

Specialists able to do the basic scientific analyses of climate change comprise a powerful group whose biases and limitations require consideration. Analytic methods require the projection of order on a problem. Breaking a problem down into its parts and ordering these to fit the requirements of a method leave out or distort what is important. Simplification embeds ethical presumptions and biases possible outcomes. Each method represents a unique perspective and carries ethical implications based on an individual's training, past experiences, present job responsibilities, personality traits, and many other factors. These factors help the specialist orient toward a new situation by providing cues and guidance to some aspects while weighting others less. Outcomes deciding what is right, best or most appropriate are understandably biased as a result (Morgan and Keith 1995).

Human beings orient themselves to both the past and the future, as evidenced in what Emerson termed the "primal conflict" between tradition and progress (Lasch 1991). A society's collective image is evident in the policies it pursues and decisions it takes. This image is the product of many individual renditions, each filtered through a unique value system based on one's identities, expectations, and experiences. The experiential component is particularly important as a means to link past, present and the future.

> Conceptions of the past are far from stable. They are perennially revised by the urgencies of the present. When new urgencies arise in our times and lives, the historian's spotlight shifts, probing at last into the darkness, throwing into sharp relief things that were always there but that earlier historians had carelessly excised from the collective memory. Thus the present incessantly reinvents the past (Schlesinger 2007, p. A-23).

The future is characterized by numerous potentialities which individuals imagine and appraise according to personal values before selecting the "best" (Gallopin et al. 1997, pp. 5–16; National Research Council 1999).

An individual's simplified view of the world often yields acceptable and workable courses of action especially for a given person in specific circumstances. Eliciting, reconciling, aggregating, and assessing the relevance and value of different individual views creates special challenges as experience with public participation in environmental decision making reveals (Chess and Purcell 1999; Busenberg 1999). Consistent challenges are to solicit and incorporate specialized perspectives, to identify and employ different methods and procedures, and to synthesize possible courses for a society to take (Brewer 1986). That only one of many possibilities will occur in no way lessens the importance of imagining and exploring the many beforehand.

Humans are mostly left out of climate change studies, and this makes for some real problems.

> The social and behavioral sciences provide an essential but often unappreciated knowledge base for wise choice affecting environmental quality. These sciences can help decision-makers of all kinds to understand the environmental consequences of their choices and the human consequences of environmental processes and policies, as well as to organize decision-making processes to be well informed and democratic (National Research Council 2005, p. 1).

Humans are the cause and humans suffer the consequences of a goodly portion of what passes for the "climate change" problem. So where are the humans? The lack of socio-economic, behavioral, and human dimensions in climate change studies and debates is a critical limitation demanding redress.

Control

A social system's resilience or capacity to absorb stresses is after some point inversely related to centralized power and efforts to direct and control. The idea is counter intuitive but actually not remarkable. Consider the manifest and spectacular failures of socialist command societies at the end of the twentieth century and the marked and disturbing incompetence of the American superpower at the beginning of the twenty-first century. Indeed, a clearer picture emerges from these experiences about the tasks government should perform. These include understanding human limitations (both intellectual and institutional) to deal with complexity, promoting diversity and competition, preserving public health, enforcing safety (including international), and limiting value accumulation of any sort, which results in reductions in the previous tasks.

The balance between central control and decentralized problem solving and decision making is the issue at hand. The goal is to attain effective control that does not subvert, ignore, or otherwise diminish the desires and capabilities of those not dominating the center. Experience suggests that people left to their own devices and armed with adequate resources are usually capable of dealing with both the complexity and uncertainty dealt them by changing circumstances.

Despite experiences, we are drawn to an illusion of control—a mania for predictability, a need to manage risk especially in situations of extreme threat or risk (Barrett 1978). The dominance of the short term, especially with respect to financial objectives and other managerial obsessions presses hard as well.

Effective control and acceptable risk are products of policies that appreciate complexity and promote a diversity of views, values, and social institutional forms. Mostly one must resist central authorities' predictions and direction of outcomes. Resilience, multiple pathways to objectives, tolerance for ambiguity and risk, and a heightened appreciation for diverse evolutionary possibilities in biological as well as social terms must be encouraged.

Control in social systems varies inversely with load, the degree of stress, tension, or disequilibrium, and lag, the time a system takes to respond to a stimulus. Control also varies directly with the amount of lead, the time between the present and when in the future the system can still be forecast. Corrective action, or gain, taken for or by the system in terms of its outputs compared to its inputs, also relates directly to control but only to the point where over response ensues.

Coping with complexity and reducing uncertainty are high-order system requirements in any case. Of all the means and measures to cope, increasing lead time may be the most critical objective of all. Inventing the future in a timely fashion becomes an essential element in the maintenance of social control.

The limiting, but all too common, result of short sightedness is crisis decision making. With a short or nonexistent lead time to decision, little or no possibility of considering alternatives, and vastly reduced opportunities for meaningful human engagement and participation, a crisis mode of decision making is all but assured. Under these circumstances, the need and application of more "gain" in control theory terms (or "power" in political ones) is necessary to get any significant response. Higher risks and greater uncertainties in both outcomes and effects usually abound. The indirect costs and consequences of crisis decision making need mention, too: misallocation of resources, diversion of attention from other important (noncrisis) agenda items, erosion of trust and confidence in the leadership with consequent longer-term erosion of legitimacy and so forth.

Besides reducing the number of or even avoiding crises, why else should one try to understand, analyze, and invent the future? Several basic reasons stand out (Ascher 1978).

- Forecasts help define problems by selecting out certain aspects while downplaying others and by fixing boundaries concerning the size and timing of potential events.
- Forecasts aid in problem recognition. When poorly done, however, they may result in missed opportunities or reduced decision-making effectiveness.
- Forecasts aid in the creation of alternatives and hence influence the kind and quality of possible choices and outcomes realized.
- Forecasts help create a general mood or climate with respect to a given problem, e.g., optimistic or pessimistic, hopeful or fearful.

Inventing the future means discovering imaginative ways to increase our mastery and control (Bell and Olick 1989, pp. 116–19). A difficult challenge, it is well worth the effort given the stakes and costs for failing to do so (Swart et al. 2002).

Thinking creatively

The crucial task is to think creatively about exceedingly complex phenomena, interacting and evolving over periods of time and space. Component subtasks identify knowledge about particular phenomena, assemble this into a coherent whole, discover pieces for research and stimulate thought about what human interventions to set in motion to avert unwanted outcomes and to secure human benefits.

The creative and imaginative capacities of stakeholders need to be recognized and taken into account. It helps to adhere to the previously noted five intellectual tasks and practical questions of goals clarification, trend sampling, condition specification, projection forecasting, and alternative generation to help focus and guide the process. Practically, not all participants nor every possible perspective can be considered or given equal weight. Choices must be made to reduce complexity and uncertainty while inventing the future, the immediate task at hand (Tables 1, 2).

Such methods and procedures have a potential role in inventing the future, but those related to generating, formulating, and testing alternatives go directly to the heart of the matter since they emphasize discovery and creativity rather than prediction. The key distinction is that one may simultaneously be concerned about complexity and uncertainty while working to discover and invent in an operational sense (Brewer 1990, pp. 103–104). Gross simplification need not be a foregone consequence of trying to manage complexity or to reduce uncertainty.

Different kinds of operational applications exist to guide alternative generation, formulation, and testing: exploration; intra-group communication; individual, group, and expert knowledge and opinion elucidation; and advocacy purposes, among others.

Free-form, scenario-based games and models have long existed and been used to satisfy these purposes.

War games and scenarios

War games

"War games" are probably as old as human conflict (Brewer and Shubik 1979, Chap. 8). The earliest versions of war games were certainly manual, in the sense that individual participants or players used maps, representative tokens for men and materiel, and other means of representing conflicts, strategies, and settings both past and imagined in the future. The game of chess is in fact a highly abstract manual war game. Manual games continue to this day in the military realm, as for instance, field exercises meant to test plans and equipment or to train personnel.

Military origins need not detract from the appeal and appropriateness of war games in other settings. Complexity, uncertainty, and high stakes are common denominators and attributes of many problems to which these methods apply.

This analytic form offers comparative advantages in four areas: (1) to study poorly understood dynamic processes, (2) to study poorly understood institutional interactions, (3) to open participation to many different perspectives and special competencies, on a continuing basis and over time, (4) to prepare players for future research, analysis, and even operational responsibilities.

Global climate change seems well tuned to these advantages. Many pockets of scientific information about environmental problems lack coherence and integration. Much information is dynamic, where matters of rates of change or time and structural adaptations figure prominently. Other aspects are not well connected or related, such as those involving social and political means to control biogeochemical processes. In the confusing global climate change debate, for example, what might it mean for economic and political institutions to sustain major ecological disruptions? No one knows much about this, although the problem itself is beginning to loom.

The institutional issue, identified in the discussion of "control," also surfaces in terms of the weak or nonexistent global authorities or arrangements to manage global change. There is no blueprint to cope with or reverse tropical deforestation, species depletion, or genetic degradation. It remains to be drawn, its institutional implications explored, and its possible concrete forms tried out. None of this will happen soon. In the meantime, conventional institutions must cope and adapt to these new challenges.

War games provide procedural means to confront such challenges. Not played once and for all, manual war games historically did not produce a single solution "the answer" to the formidable problems they addressed. Rather, they provided a setting, framework, and collection of procedures to generate, formulate, and test ideas. One master gamer, Harvey DeWeerd, referred to this as a "contextual approach" to manual gaming, a specific reference to a general need expressed previously.

> The research community has long recognized the utility of embedding complex problems in a clearly defined context. A contextual framework helps one to exclude irrelevant materials and permits a concentration on the central problem under analysis. One needs a context to avoid wasting time in reaching a common approach to the subject (DeWeerd 1974, p. 403).

Many technical issues receive attention in this form of analysis because the scenarios are accessible and relatively transparent. Participation of diverse participants is enhanced because the proceedings are carried out in plain language. Manual games also allow those with specific information to share it with other participants. Questionable matters of fact can be identified and areas of agreement and disagreement quickly discovered. The implications of initial simplifications and the power of assumptions are also more likely to be exposed in this form of analysis than in most others.

Because human players are involved, the elements of the game and analysis become familiar and open to critical exploration. A great deal of the discovery or learning occurs in the detailed criticisms following actual game play. Criticism of this sort is extremely uncommon in computer-based studies or numerical models.

If there is one overriding comparative advantage of manual gaming approaches it is their capacity to stimulate numerous alternative pathways to the future. Running frequent, inexpensive, and expert-based studies encourages exploration, group opinion, shared experience, and the clarification of individual and institutional preferences.

Scenarios

The scenario is the common feature of all analyses, not just manual and free-form varieties of it.

> After all, it is from our anticipation of the environment in which our systems are to operate (the

> state-of-the-world, the conflict situations, and the tasks these systems are expected to accomplish) that many of our criteria for *evaluating* the *performance* of a given system emerge. Thus, having a casual attitude toward the scenario is often tantamount to have a casual attitude toward the selection criteria. If we accept the proposition that our analyses can be no better than the criteria we employ, then we must accept the corollary proposition that our analyses can be no better than our scenarios (Brown 1968, p. 300. (*emphasis in original*)).

The scenario is the crux of analysis. It is the basis for bounding and structuring a model and it contains the criteria to appraise the work. Since scenarios usually rely on words, they are accessible and relatively transparent. They are easily altered because they are tentative and contingent. They are future oriented, as they depict past and present with both likely and desired future possibilities. In effect, the five intellectual questions and practical tasks Lasswell specifies for problem-oriented, contextual analyses are all included in a well constructed scenario.

"The scenario tells what happened and describes the environment (context) in which it happened" (DeWeerd 1967, p. 2). For Brown a scenario is "a statement of assumptions about the operating environment of a particular system being analyzed" (Brown 1968, p. 300). These basic definitions are necessary, but not nearly as satisfying as the following from Daniel Bell, where the invention of the future is singled out prominently:

> Scenarios are the representations of alternative futures (by which) analysts sketch a paradigm (an explicitly structured set of assumptions, definitions, typologies, conjectures, analyses, and questions) and then construct a number of explicitly alternative futures which might come into being under the stated conditions (Bell 1967, pp. 865–66).

Scenarios capture and tell stories about possible futures. A given scenario "identifies some significant events, the main actors and their motivations, and it conveys how the world functions. Building and using scenarios can help people explore what the future might look like and the likely challenges of living in it" (Shell 2003a, p. 8; see also, Schwartz 1992, pp. 4–5).

As a general matter, the scenario is the analyst's image or conception of the process or system being represented. It is not strictly speaking a prediction. It is, rather, an imaginative explication of the possibilities. To emphasize the point, try to imagine a negative or anti-scenario: an explicit statement of what the analyst is not trying to represent. Indeed, when was the last time anyone encountered a policy study or analysis where possibly important parts of the analysis not directly considered were even acknowledged?

The scenario contains what its designer believes is important. It also sets up the initial conditions of a setting and provides time-based cues for possible interactions of persons and events. In this way, scenarios used in manual or free-form games allow diverse participants to explore, to examine alternative development pathways, and to formulate options that might be taken at various times to see how they potentially affect outcomes (Van der Heijden 1996). The creative potential of discovering and learning in the process stands out.

Prediction, discovery, and intentionality

A commonplace in scenario design and use is the failure to distinguish well enough between predictive versus heuristic or discovery purposes of the method (Brewer 1990, p. 99). The failure is generally noteworthy when scenarios are employed by those primarily trained as scientists, for whom prediction represents a high disciplinary objective (Freudenberg and Gramling 2002, pp. 130–32). As a specific set, climate and energy models and modelers have demonstrated a consistent preference for predictive ends in their scenario activities (IPCC 2001; Maccracken et al. 2003; Craig et al. 2002).

A predictive end assumes that past trends will prevail into the future and that the underlying and responsible generative systems, most particularly the human ones, will not experience structural or intentional changes. Physical systems are often exempted in these terms because they are immutable. The laws of physics are the laws of physics, more or less. That granted, the complexity of natural and biological systems may nonetheless overwhelm human abilities to comprehend, model, predict, and control (Pilkey and Pilkey-Jarvis 2007; Wunsch 2007, pp. 171–172). Similarly, in climate and energy problems, the human element is not so easily presumed or held constant, especially when the time frame of the analysis is long; say decades or generations in length (Araújo and Rahbek 2006). Humans are mutable and they are also "irrational", especially with respect to our personal, interpersonal, and political habits and means (National Research Council 1992; Beck 2007).

The heuristic end favors consideration of creativity and innovation, as when one focuses on outlier or aberrant behavior that in time and with basic system change may prove "normal". It allows one to probe risk and uncertainty by posing and then analyzing the classic "What if?" form of questions to highlight the unknown (Schoemaker 1993, pp. 196–198). On rare occasions, the heuristic end may allow one to stumble onto some combination of elements and events that yields up an insight into a genuine "unknown-unknown".

Humans act intentionally and so affect natural as well as social system outcomes and effects. Intentionality is considered in our laws, decision processes, and related activities designed and meant to control and is also clearly encountered within the range of normative social thought and theory. "That is, not only does prediction lead to control, but control leads to prediction," which helps to explain why so much in our lives is intentionally designed or engineered (Bell and Olick 1989, p. 130). Humans are the causes of many natural and physical problems and we also suffer the consequences of our acts. Some of our plight is best judged as irrational.

Human "irrationality" however is ordinarily considered within the confines of psychological or psychiatric theory and practice, if it is considered at all. The near total absence of social and behavioral elements in climate and energy models, analyses, and related considerations is a major shortcoming not readily resolved or mitigated by simple cutting and pasting of "human dimension" elements onto physical constructs and models.

The use of scenarios is one promising means to help redress this deficiency. Adopting a heuristic purpose may facilitate matters as well. For instance, rather than trying to predict the date when global mean temperature will increase by 2.0°C, and then spending lots of time and money worrying about the spatial resolution or data quality used in one General Circulation Model versus another, suppose the analysis began with a stipulated end state at some agreed-to year in the future. The following simple hypothetical illustrates the point.

> Stipulate the future conditions: it will be 2.0°C warmer globally in 2075 than it is now. Regional differences will range both higher and lower than the global mean and can be assumed as follows: describe the differences. Likely consequences following from these conditions are the following: postulate them. Many of these consequences are costly in various human terms. Some, however, may be beneficial, as with the "winners and losers" economists are fond of reminding us about. Characterize more desirable or more acceptable end-state circumstances for the year 2075.

Under these circumstances, how might we work our way back to the present conditions with their specific historical trends to eliminate, reduce, or mitigate the unwanted or unacceptable consequences? What changes are required in existing human systems and arrangements to achieve a more acceptable end state? This strategic planning application and use of scenarios (Table 4) is becoming an accepted form of analysis in many multinational corporations (Bobbitt 2003).

Another way to engage human considerations, especially as a means to discover, is to rely on scenario-based games that mimic the classic "crisis game" known in military circles and analyses. The scenario in this case initiates a sequence of plays or responses meant to discover and explore various decision outcomes in circumstances never experienced, e.g., thermonuclear war. The initiating scenario can be played by the same teams multiple times to elicit and generate different decision paths or it may be used by entirely different teams to explore and discover responses from different individuals, groups, or cultures. The so-called "A and B Teams" employed by the intelligence communities at the height of the Cold War are illustrative. The "A Team" would operate in the business-as-usual mode, and often employed those responsible for that business, versus a "B Team" for whom decidedly contrary pessimistic or sometimes even optimistic views and assumptions about the world were featured. In effect, the larger intellectual challenges of exploring different views, values, expectations and demands are directly engaged, albeit in abbreviated form given the many possibilities.

The scenario in the classic crisis game "works" to the extent that it engages the human participants and helps them "think about the unthinkable," in the morbid turn of phrase attributed many years ago to Herman Kahn. That this approach and mode of thought can be beneficial is attested by concrete decisions made over the years not to rely entirely on strategic bombers but to deploy ICBMs on the ground and in submarines, in decisions to secure nuclear weapons with permissive action links (PALs) to prohibit the "Strangelove scenario" from ever taking place, and in numerous improvements in communications, command, control, and intelligence (C^3I) across the entire strategic force. A modern equivalent focuses on the hideous prospects of nuclear terrorism (Dowie 2005).

These constructive uses and means have scarcely been employed in the existing array of scientific studies and analyses of climate change—this despite that fact that no one has any idea whatsoever of what human systems or decision pathways will look like or exist in the future some 25, 50, or 100 years hence. With only a few notable, proprietary exceptions, the record is hardly better for energy models (Shell 2003b; Craig et al. 2002). Simple extrapolation of "business as usual" is hardly satisfactory.

Discovery is not prediction; human intentionality and creativity are both worthy objects of inquiry. Furthermore, scenarios can be usefully employed for an uncommon variety of different and appropriate purposes and reasons, especially when the subject is global climate change.

Table 4 Applications of operational procedures and methods

APPLICATION	CHARACTERISTICS
EXPLORATION:	Stimulation of constructive explorations of problems that are either not well understood or are misunderstood. Especially in free-form, scenario based versions, discovery and realization of unimagined difficulties are opportunities that occur.
PLANNING:	Usually linked to evaluation. Technical, doctrinal, and procedural inquiries meant to prepare for or assess operational systems, e.g., logistics systems, organizations, economic systems, ecosystems, weapon systems, information systems.
CROSS-CHECK:	A back-up procedure to provide additional insight and confidence to recommendations devised with other means. For example, expert opinion or consultation—primarily based on experience—may be examined with games or simulations to discover flaws or inconsistencies not reported or overlooked.
FORECASTING:	Making predictions, especially about poorly understood problems, is far less interesting an application than several of the others here characterized. Users must know what they want to forecast, be able to judge the value to be gained from additional forecast accuracy, and have confidence that the builders of the forecasting device possess a good abstraction of the system being studied.
GROUP OPINION:	Most realistic policy decisions are based largely on expert opinion and judgment. While little explored or used, games and simulations have operational potential for eliciting, clarifying, and improving expert opinion, considered individually and in groups.
ADVOCACY:	A competent modeler can build just about any bias imaginable into a game or simulation. A one-sided case can be presented, unintentionally too, in support of a partisan policy or position. In a bureaucratic context, the use of models, particularly large-scale, machine-based ones, has led to considerable confusion about the differences between political processes and scientific ones. Advocacy need not be pernicious, especially if its existence is openly admitted and its benefits are consciously sought.

Benefits/costs

Global climate change is one of the largest, most all-encompassing and long-range problems ever to confront humankind. It is naïve to presume that there will be only a few straightforward answers to it. There will be hundreds or thousands of localized efforts to address and cope with aspects of the problem, and these aspects will not be commonly or universally experienced, perceived or valued. China is not Brazil. The Gulf of Mexico is not the Arctic National Wildlife Refuge. California is not Massachusetts. Context matters, and it matters in determining what different individuals will even see as being a problem.

Does climate change challenge us with problems? Most certainly, and all over the globe.

Do we need to do something about these problems? Again, most certainly. Doing nothing or continuing business as usual is what got us into these circumstances. Doing nothing is a substantial decision, with consequential outcomes and effects.

But we need to spend more of our time and attention figuring out what works and fits local realities and circumstances, and this we are only recently beginning to do, albeit unevenly, in fits-and-starts, and with inadequate means to learn from our efforts. Noteworthy examples include multi-state compacts to work together to limit green house gas emissions (Kruger and Pizer 2005); California's individual efforts along the same lines (Fialka 2006); consensus-seeking rather than partisan searches for solutions (Doniger et al. 2006); and the more familiar struggles to create effective commodity markets for carbon (Schlesinger 2006, p. 1217).

What is "manageable" in local circumstances matters. It is also tangible and pragmatic. What are the benefits and what do they cost? Who gains; who pays? Can outcomes of decisions be measured and controlled, especially if the choices turn out badly? Can local experiences be assessed with the immediate goal of improving them and with a longer-term goal of generalizing successes and employing them elsewhere? (Walters 1986; World Wildlife Fund 2006; Berry et al. 1998; Lee 1993).

The environmental cost-benefit equation too often works as follows: costs to mitigate or prevent some environmental harm are emphasized because they are incurred now, are readily calculated, and are paid by easily identified individuals and organizations. Benefits are less "real" because they come in the future, are hard (if not impossible) to calculate, and will accrue to many individuals—including some indeterminate "future generations, yet unborn." When the beneficiaries are indeterminate and/or located all over the globe, instead of within one's congressional district or even one's nation, the matter becomes even more problematic.

The political benefit-cost equation is very different, and herein resides one of the major stumbling blocks in the climate change setting. For starters, in the political calculation, in contrast to the cost-focused environmental one, benefits come first and hold top billing over costs. The political benefit-cost equation works as follows: benefits come now or in the near term, are easily identified and promoted, and can be ascribed to well-defined individuals and groups. Costs are put off into the future and their eventual value is either heavily discounted or dimly considered.

Cynicism aside, what guidance does this basic understanding provide for addressing and acting on problems related to global climate change and sustainability? Among other things, it helps place the focus on actions and decisions that have at least some plausible and immediate benefits for identifiable individuals and organizations. The so-called "no regrets" strategies of doing things that make immediate sense, such as using more efficient energy devices or production processes, fit into this approach. The newly formulated "interim targets" strategy to improve the prospects for climate treaties has a similar character (O'Neill et al. 2005). Both strategies also place much higher value than normal on the importance of many different, localized and manageable, settings (MacLean 2006). The reasoning here is that local details matter and that working to solve local problems may scale up and attribute both benefits and costs in humanly understandable ways that global problem solving does not.

Communications: experts, decision-makers and the rest of us

Concerns about sustainability consistently reveal fundamental problems of specialization and communication. The specialization occurs as many different kinds of experts bring what they know into the conversation. Difficulties communicating among and between specialists are commonplace; difficulties in the conversation between the experts and decision-makers are at least as common and probably even more challenging. In all of this the public (actually an enormous variety of different publics) has been barely considered at all. One is reminded of an old Paul Newman film, Cool Hand Luke, where Newman's character continually ran up against a nemesis who claimed "What we have here is a failure to communicate", just as he inflicted great pain. In the sustainability case we also have multiple failures to communicate, but there is actually far less need for pain than for some straightforward making of amends. Several of these are procedural and well enough known, if not practiced. Others are more inventive.

Various possibilities for communication are portrayed in Table 5 as interactions between each of the three general groups. A somewhat surprising characteristic is the growing use of scenarios as a common means to facilitate communication.

#1 Expert-to-expert

The most common expert-to-expert communication is what occurs in the usual pursuit of knowledge, especially in science: peer reviewed articles, conferences, books, and internet-based modes and means. As mentioned previously, the domination of the natural and biological sciences in global change and sustainability conversations has prompted numerous recommendations to include the "human dimensions" specialists as well. Social, historical, psychological, economic, ethical and other cultural factors are neglected at some peril. Questions of human perspective, motivation, incentives, preferences, values, and the like are and should be central in all considerations of the past, present, and likely futures for global change. Problems are not given; they are constructed by us. And "us" must solve them.

The atmospheric chemist's view of what constitutes "the problem of global change" for instance is important, but it is only one of many expert views that must be taken into account. Eliciting and then synthesizing relevant expert inputs are not all that common, particularly when disciplinary boundaries are well and clearly drawn. However, the need has been recognized, if not satisfied, in efforts to conduct policy exercises and to do integrated assessments.

In an early attempt to turn the desirable features of scenario-based, free-form, manual war games to environmental subjects and sustainability ends, I created a specific procedure and synthesis method called the policy exercise (Brewer 1986). The occasion was the launching of one of the world's first major analytic groups and projects on sustainability located at the International Institute for Applied Systems Analysis, IIASA, under the direction of William Clark and Ted Munn (Clark and Munn 1986).

Table 5 Communications: experts, decision makers and the public

	EXPERTS	DECISION MAKERS	PUBLIC
EXPERTS	#1	#2	#3
DECISION MAKERS		#4	#5
PUBLIC			#6

#1: EXPERT TO EXPERT: "Regular science." Human dimensions added/placed at center of analyses. Policy exercises to facilitate interdisciplinary communication, research priority setting, and imaginative alternative generation. Integrated assessments to include relevant technical specialties and to create a common, scenario-based language and means of communication to others.

#2: EXPERTS TO DECISION MAKERS: "Usual practices," i.e. consultations, hearings, think tank studies for specific clientele. Next generation and more sophisticated integrated assessments. Technical forums, e.g., Energy Modeling Forum, designed specifically for decision makers. Specialized indoctrination, training and field courses and experiences. Crisis games involving actual decision makers, e.g., pre-Katrina scenario-based games in New Orleans.

#3: EXPERTS TO PUBLIC: Environmental education. Improved science and math education. "Outreach" by scientists. Risk education meant to better align risk assessments with risk perceptions. Training the media. Internet-based, interactive games. Social planetarium.

#4: DECISION MAKER TO DECISION MAKER: Public/private/nonprofit forums. Seminars and conferences, general on sustainability and specific on focused topics such as insurance or emerging markets and regulations. Market creation, e.g., carbon trading and permitting, alternative fuels. Best practices/certification and standardization, e.g., "Green Seals" of approval, ISO. Priority setting for foundations and other grant makers.

#5: DECISION MAKERS TO THE PUBLIC: Public speeches, town meetings, surveys focus groups.

#6: PUBLIC TO THE PUBLIC: Internet-based games at the local, regional, national and global levels.

The policy exercise is generally meant to create circumstances and incentives that attract many different disciplinary specialists together and well in advance of trying to inform or influence decision-makers. The spirit here is to let the experts "get their acts together" before they try telling others what to do.

> A policy exercise is a deliberate procedure in which goals and objectives are systematically clarified and strategic alternatives invented and evaluated in terms of the values at stake. The exercise is a preparatory activity for effective participation in official decision processes; its outcomes are not official decisions (Brewer 1986, p. 468).

The imaginative, creative, and inventive tasks associated with discovery are emphasized.

> Substantive knowledge, insight, an ability to abstract, flexibility, and a willingness to build and rebuild many representations of interesting phenomena are additional ingredients that one can imagine adding to the success of a policy exercise (Ibid.).

The general attitude sought for members of the policy exercise is one of critical imagination (Ibid., p. 470).

In the 20 years since its creation, many others have tried and adopted the method for a variety of different sustainability issues and problems. The International Simulation and Gaming Association (ISAGA) even recognized a special interest group at its annual meetings: IPEG, the International Policy Exercise Group. Stalwart practitioners of policy exercises, many of whom have been associated with IIASA, include Peter Duinker, Ferenc Toth, Sten Nilsson, Jac Guertz, Craig Dilworth and Ted Munn (Toth 1988; Toth et al. 1989; Nilsson 1992; Dilworth 1997; Munn 1991).

In years to come I believe that the essential role and functions performed by IIASA and its scientists during the 1985–2005 era to advance our understanding and dealing with global climate change will be recognized as being nearly singular and certainly crucial. The policy exercise was only a first step, but it was taken in the right direction.

A better known and more recent form of expert-to-expert communication is the integrated assessment (or IA). Three early efforts to summarize integrated assessments in global climate change include Parson (1994), Parson and Fisher-Vanden (1995), and Dowlatabadi and Morgan (1993).

> Assessment normally does not mean doing new science, but rather assembling, summarizing, organizing, interpreting, and possibly reconciling pieces of existing knowledge, and communicating them so that an intelligent but inexpert policy-maker will find them relevant and helpful in their deliberations (Parson, 1994, p. 1).
>
> Because there is an immediate need for policy decisions on how to prevent or adapt to climate change and how to allocate scarce funds for climate research, we need to move beyond isolated studies of the various parts of the problem. Analyses frameworks are needed that incorporate our knowledge about precursors to, processes of, and consequences from climate change (Dowlatabadi and Morgan 1993, p. 1813).

Aspirations to inform decision-makers aside, the fragmented state of expert knowledge about global climate change has meant that integrated assessments are primarily a means for different experts to pool their specific knowledge, usually in computer-based models no real decision-maker can understand, much less trust enough to use as a basis for choice. There is a common tendency for those heavily invested in these models to begin thinking and acting as though a model is the world rather than being a simple, frail representation of highly selected aspects of the world. The problem is clearest when lots of time and energy get invested in only one or a few scenarios or stories and where these scenarios depend heavily on "data" that in fact are being generated by other computer models. In short, the "model is right, the world is wrong". Competing technical and professional egos play a greater role than is healthy in such circumstances. All of these factors appropriately limit the expert-to-decision-maker potential of integrated assessments (Dahinden et al. 2000).

Technical and theoretical constraints also limit. Often the apparent goal of the integrated assessment has been to tell one or a very few "stories" about pathways to the future. Efforts to forge a consensus about these few possibilities further limit the exercise. This obviously renders the expert-to-decision-maker opportunities for conversation problematic at best. In the setting of global climate change, possibilities are in fact numerous if not even boundless. Why take only what the technicians want? Besides this technical constraint a theoretical one related to poor disclosure of the underlying assumptive bases of the integrated assessment have also limited these attempts to inform decision-makers (Ascher 1978; Craig et al. 2002).

Integrated assessments are a way for experts to compare their wares and to talk to each other (Nakicenovic et al. 1995). Based on the record until relatively recently, they have not been a particularly effective means to influence choices in the real world, despite their salutary effects on expert interdisciplinary conversations (Watson et al. 2001). Improvements are in the offing, however, in the next generation of integrated assessments now coming into use.

One interesting and positive finding is that scenarios are an evolving, important, perhaps dominant means of communication among and between experts, especially in the interdisciplinary realm (US Climate Change Science Program, 2007; Maccracken et al. 2003; Morioka et al. 2006).

#2 Experts-to-decision-makers

Expert-to-decision-maker communication is dominated by usual and conventional means and practices: consultations, formal hearings, conferences, executive education for business leaders, think tank studies for specific clientele, boards and committees of the National Research Council, and many others. While the opportunity to engage in a two-way dialogue exists, most "usual practices" feature the expert armed with special knowledge telling "decision-makers" what to do to avert this or that awful forecast outcome. Lack of specificity about which decision-maker and what possible decisions any of them might be able to consider and make are of only passing concern for the technical people doing the analysis.

The progression of integrated assessments in the last two decades has produced a new generation of more sophisticated technicians and more receptive decision-makers. Indeed the changes and improvements are welcome.

A key contributor to progress is the Stanford University Energy Modeling Forum, which was created in 1976 "to provide a structured forum for discussing important energy and environmental issues. ... Participants are leading energy experts and advisors from government, industry, universities, and other research organizations" (EMF 2007a). The forum has an admirable track record earned because of its ability to engage experts and decision-makers and to focus their collective attentions on important, specific topics. Global climate change stabilization scenarios are one of two current, major topics and efforts at EMF (2007b).

The next generation of integrated assessments is at least as "decision-maker friendly" as what one encounters at the energy modeling forum. Again, IIASA is the intellectual locus for the new and improved in the form of the greenhouse gas initiative (Wagner et al. 2006; Grubler et al. 2007). Familiarity with the basic data and core models used in the GGI framework allows more expert time and attention for the realities of decision making which is proving attractive to those actually having such responsibilities. At this stage of development, integrated assessments are finally beginning to deliver on the promises of expert-to-decision-maker communications.

Even more fundamental activities exist, such as specialized indoctrination, training and field courses and experiences for decision-makers. For instance, very few members of the US Congress are scientists; most are lawyers with limited or no formal exposure to environmental issues or science. Opportunities for training abound, as for example, the Organization for Tropical Studies more than decade long experience with its Costa Rican field courses for Washington and Latin American "decision-makers" (OTS 2007). However, full development of the potential or even a basic accounting of such activities has not occurred.

Also not well developed are specific opportunities for decision-makers to participate in what were previously called "crisis games" meant to explore, under realistic and controlled conditions, reactions and responses to different demanding scenarios. It has been widely reported, for instance, that just such a series of games was conducted by and for federal, regional, state and local officials in the Gulf of Mexico setting several months prior to Hurricane Katrina. The "unlikely," i.e. low probability but highly consequential, scenario of serious category 3 and higher storms was specifically considered, although it is now obvious that constructive steps were not taken as a result of what the game revealed. Nonetheless, the essential role of the scenario as the main means to organize and facilitate communication between experts and decision-makers was again demonstrated.

#3 Experts to the public

If one considers the long-term history of environmental education in this country, starting formally with federal legislation and funding in 1970, a great deal of expert-to-public communication about sustainability has already occurred (Brezina 1974; AGI 2007; EETAP 2007). This generation of citizens is demonstrably better informed about numerous environmental topics than previous ones, which is not to say that they are yet informed well enough. As study after study and report after report hammer home, too many children are being left behind, especially in science and mathematics—important fields contributing to environmental understanding.

A recent proposal by Alan Leshner, chief executive officer of the American Association for the Advancement of Science, goes right to the core of the expert-to-public link: "we must have a genuine dialogue with our fellow citizens about how we can approach their concerns and what specific scientific findings mean" and provides a constructive list of recommendations to improve what he calls "outreach training" for scientific experts (Leshner 2007, p. 161; Ham 2007).

The risk assessment field and profession should contribute more to improved public understanding and hence to better possibilities for communication. Differences between real and perceived risk have long been appreciated (Fischoff 1985; Freudenberg 1988; National Research Council 1993, 1996) but closing the gaps between the two has proven elusive (Garvin 2001; Shermer 2000).

Training professionals in the media is a topic and activity ripe with possibility. Training in this sense means scientific experts providing the best available information to media professionals who then communicate it to the public. The Society for Environmental Journalists, now in its 17th year, is one notable activity (SEJ 2007). Taking the outreach lead from Alan Leshner, it may be possible to locate sustainability scientists in television, cable, film, and print organizations for special projects or even for extended periods of time in the same way as certain physicians are now employed to explain medical matters.

The movie and documentary fields are promising venues to improve expert-to-public communication, but they are also not exploited sufficiently. The opportunities are commercial as well as educational. One of the most profitable movies of 2006 was Ice Age: the melt down. It cost $256 million to make and has already generated more than $1.1 billion in revenues (Edidin 2007). Al Gore's Inconvenient Truth has turned out to be both a film and book commercial success. It is listed as #10 on the non-fiction paper back book sales lists in January 2007.

The use of manual games of the sort previously described has recently gained notice and acceptance as an expert-to-public medium in the form of the "stabilization wedges" game designed by Pacala and Socolow (2004, pp. 968–972) that guides players through different strategies to limit carbon emissions over the next 50 years (Ham 2007, p. 1091; Coontz 2007).

An unexplored prospect may be for internet-based, mass appeal games that feature global warming topics, themes and challenges in their content. Imagine such games having an appeal on par with the World of Warfare: the burning crusade, the W. O. W. game or hundreds of other similar games that engage so many millions around the world (Schiesel 2007). The W. O. W. game currently has more than eight million subscribers, most of whom pay about $15 per month to play, because "it delivers an overall entertainment experience that goes far beyond what one might expect from a mere game" (Ibid.). Imagine a comparable game or series of sustainability games. The melting ice caps, sea-level rise scenario should be a winner in the game world, if not in the real one where we actually live.

#4 Decision-makers to decision-makers

Several important objectives motivate decision-makers to communicate among themselves better. Exploring emerging or poorly understood problems, checking on expert opinions and judgments, reaching for group consensus, and even seeking political advantage through advocacy (Table 4). The global climate change topic has created numerous needs but still insufficient opportunities for conversations among public, private, and non-profit organizations (Rondinelli and London 2003).

Seminars and conferences devoted to the global change topic are becoming more common. The World Business Council on Sustainable Development has been particularly active in providing places and opportunities for business leaders to learn about and react to fast-changing events (World Business Council on Sustainable Development 1997). The creation of entirely new markets and other positive business opportunities have motivated many (Hoffman 2005; Holliday et al. 2002), while the desire to avoid unwanted regulatory constraints has prompted other decision-maker-to-decision-maker communications (Roome 1998; Teitenberg 2002). The insurance industry in particular has been active in recent years (Mills et al. 2005).

Relationships between investors, trustees and organizations in the dynamic era of climate change are being reexamined and adjusted (United Nations Foundation 2005). The general point here is that if businesses will not seek emission reductions and other moves toward sustainability, then large-scale investor groups may be required either to force these matters or to invest elsewhere (Lubbers et al. 2004).

A specific issue where this kind of communication has been prominent and vital is the certification and standardization of best environmental practices. The ecotourism business is illustrative (Rainforest Alliance 2004, 2006).

Here, once more, the facilitating role scenarios play in virtually all of these decision-maker-to-decision-maker interactions is remarkable. They provide a common language and setting in which the complexity and uncertainties of global climate change can be grasped.

#5 Decision-makers to the public

The usual means of communication account for most activities in this pairing. Almost needless to say, the ineffectiveness of it, especially in the United States, is closely related to the polarization of political opinion and the public's low regard and lack of trust for its elected and appointed leaders (Garvin 2001). Under these circumstances, the direction for better communication might be from the public to the decision-makers—better listening in effect. Those in the risk perception and management fields have long pressed decision-makers in this direction (Covello et al. 1997; National Research Council 1993; Slovic 2000).

Listening better to the public could involve taking opinion surveys, doing marketing studies and using focus groups, engaging in "town hall" and other forums, and other methods of eliciting information about "the rest of us" in the public.

#6 Public to public

Modern technology, especially that enabled by the Internet, assures ever increasing communication among and between myriad "publics" around the globe. It is a monumental force for change in fact, whose dimensions, direction, and ultimate effects can only now be dimly discerned. That a well wired and tightly connected public will play a significant role in inventing the future and confronting the challenges of sustainability is hardly in doubt. Who will be master and how they will control is however the question.

Conclusions

Though wide-ranging, the main arguments are both apparent and challenging. Understanding and accepting them necessitate new ways of thinking and acting quite in keeping with the strikingly new circumstances presented us by global climate change.

More human involvement is required. This means informing and teaching citizens around the world so that the realities of global change may be understood and appropriate means to cope and contend may be imagined and put into practice.

More creativity in the alternatives we might consider is a tall order. If we are heading off into truly uncharted waters, where lessons from the past may offer little in the way of guidance, a premium must apply for those able to "think about the unthinkable" and to do so while imagining constructive means to cope and manage.

Certainly many more trials and experiments are required because circumstances are changing and new and so uncertainties about how to proceed will be considerable. If uncertain, it stands to reason that trial and error and even more formal experiments will be needed to test the waters and to generate information about what works, under what circumstances, and why. In this spirit the initiatives currently being taken by individuals, cities, states, regions, businesses, and other entities are to be encouraged and assessed. While one should always be wary of claims for universal solutions, it could well be the case that what works in California might even work somewhere else especially if enough contextual details in the two settings are sufficiently alike to make the analogy stand.

With lots of trials and experiments comes an unexpected demand to observe, collect information, and learn from the empirical efforts of those who are doing the innovations. Regular scientific practices have a certain role in this regard, but so too do unusual means such as those enabled by the internet and other powerful tools and technologies. Underlying the call for increased communication with and between the public is a desire to improve learning from such experiences.

The matter of social and institutional control must be given far more attention than it has had so far. "Doing nothing" about global change is consequential, and one of those consequences is the shortening of lead time to decision that ultimately must be made. Crisis decision making is, of course, the limiting and unwanted condition and result of little or no lead time. Increasing lead time, in contrast, opens up the possibilities for more thoughtful and participatory consideration of alternative courses. It also provides time to assess the possible costs and benefits of various courses in hopes of clarifying matters in advance of making decisions.

And finally, if there is one fundamental message I wish to convey it is that communication of every conceivable form and fashion must be brought to bear in ways far more creative and meaningful than is currently the case. The "invention of the future" is at best impoverished and at worst will be impossible without the active engagement and interplay of human minds of all kinds throughout the world.

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