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MANAGING THE GLOBAL COMMONS DECISION MAKING AND CONFLICT RESOLUTION IN RESPONSE TO CLIMATE CHANGE

Steve Rayner
Wolfgang Naegeli
Patricia Lund

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Report of the

Research Workshop

Managing the Global Commons Decision Making and Conflict Resolution in Response to Climate Change

August 1–4, 1989

Knoxville Hilton, Knoxville, Tennessee

Steve Rayner
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Patricia Lund[1]

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[1]The University of Tennessee

Research Workshop

Managing the Global Commons
Decision Making and Conflict Resolution in Response to Climate Change

Organized by the
Energy Division
Oak Ridge National Laboratory

Sponsored by the
Global Environmental Studies Center
Oak Ridge National Laboratory
and
Energy, Environment and Resources Center
University of Tennessee–Knoxville

as a contribution to the
global-change research initiatives of the
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and the
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ANNOUNCEMENT

The Second Annual Social Science

Workshop on Global Environmental Change

will be held at the

Clarion Harvest House Hotel,

Boulder, Colorado

November 11–14, 1990

Sponsored by Global Environmental Studies Center,

Oak Ridge National Laboratory

and the

Graduate School of the University of Colorado

at Boulder

The workshop will be hosted by the

Natural Hazards Center

Information from William E. Riebsame, Natural Hazards Center, Campus Box 482, University of Colorado, Boulder, CO 80309. Telephone: 303-492-6818.

REPORT OF THE RESEARCH WORKSHOP

MANAGING THE GLOBAL COMMONS DECISION MAKING AND CONFLICT RESOLUTION IN RESPONSE TO CLIMATE CHANGE

PROBLEM STATEMENT

The management of open-access and common-property resources has long been recognized as problematic. Garret Hardin (1968) vividly describes the infamous tragedy of the commons in which individuals persist in exercising their grazing rights even though the deterioration of pasture is clearly recognized. Such overconsumption is observable in almost any context where the conservation of finite resources depends on the voluntary coordination of individuals. Absent individual incentives or a central enforcement authority, it is not rational for a single person to limit his resource use. Doing so would incur the costs of finding alternatives, and merely make more of the common resource available to his rivals.

Today the issue is managing the global commons, especially the earth's surface, oceans, and atmosphere. All of these management problems are beset by extreme scientific and technical uncertainties. The workshop, however, did not attempt to resolve the uncertainties for anthropogenic climate change. The workshop papers and discussions focused on the varied responses of governmental and nongovernmental organizations and other constituencies concerned with global environmental-management.

Modern industrial development, particularly a wide range of energy technologies, is accompanied by a series of potentially serious changes in the world's atmosphere. Some changes, such as the increased incidence of transported acidic precipitation, are clearly recognizable and already have required the intervention of governments.

There is widespread disagreement about the ultimate extent and impact of other atmospheric changes, including anthropogenic climate change. Our understanding of the processes at work is not yet far advanced, however, the potential impacts of anthropogenic climate change are the subject of intensive study.

Great problems loom on the horizon, but we have not yet faced the very difficult management choices of the coming decades. For example, increased atmospheric carbon dioxide (CO_2) has not yet inflicted any demonstrable injury to the global environment. Stratospheric ozone modification, already the subject of a major international agreement and further serious international negotiations, still is barely detectable, notwithstanding the spectacular phenomenon of the Antarctic ozone "hole."

CO_2 is produced by a variety of local processes, including fossil-fuel and fuelwood combustion. Unlike chlorofluorocarbon use,

which can be managed by the industrialized regions of the world, management of atmospheric CO_2 will require global decision making involving distinctively different regional interests. Such decisions will embody important questions of regional and global equity, especially concerning the aspirations of developing societies for a share in the richer life that technology seems to promise. Compounding the institutional difficulties associated with such decision making are the vast technical uncertainties associated with the nature and extent of the problem.

National and international bodies currently are expending considerable effort on reducing uncertainties in the models of anticipated atmospheric changes and on devising novel technical and policy options to prevent or mitigate their impacts. However, relatively little attention has been paid to the decision-making problem. How will the global community decide which of the competing predictions to act upon? How will it choose between diverse prevention or mitigation options? Some propose a global framework convention on greenhouse gas emissions, and carbon taxes or emissions trading schemes. But, the larger implications of these proposals for a new global environmental order seldom are addressed. Despite the limited attention, there are already two quite different views of how such decisions might be made.

One view, derived from mainstream political science, probably represents the dominant assumptions of governments and their advisors. According to this view, global commons-management decisions directed at limiting consumption of fossil fuels will follow rationally from a careful analysis of options for preventing or adapting to expected environmental changes.

Such an analysis would employ conventional risk analysis, involving benefit-cost estimates for each course of action being considered, with appropriate allowances for uncertainties in the probabilities and magnitudes of each possible outcome. The analyst would value each effect based on his knowledge and preferences. Presumably, this rational technical assessment will lead to regional and global treaties that will be self-policed by signatory nations.

Another view derives principally from cross-cultural studies of decision making and institutional economics. Proponents emphasize that many real-world decisions are not made according to rational and explicit canons of social utility maximization. In particular, the valuation of potential outcomes is done not by specialized analysts, but by the various constituencies or stakeholders that are directly affected and are able to make themselves heard.

Formal risk and policy analysis is a relevant, and even vital, input to the decision process. But the decision to proceed in one way or another is more likely to be the cumulative result of complex stakeholder interactions, leading, over time, to a practical but not necessarily formal consensus.

Such decisions, like the current decision of the United States to have a moratorium on nuclear power while proceeding with research, often do not look like formal decisions at all. It is hard, if not impossible, to identify either the decision maker or the point at which the decision was made.

Although it relates to the incrementalist approach of some political scientists who view the evolution of policy as partisan adjustments and negotiation rather than rational analysis, this latter decision process is not well described outside of the anthropological literature on small-scale societies. Certainly it is poorly understood as it pertains to nation states, let alone to a world scale. Yet it is increasingly clear from cases such as the collapse of the international treaty on exploitation of the

oceans, that the traditional view of cross-national decisions about global problems requires a supplementary perspective. In the case of anthropogenic climate change, it is not at all clear how the world will react to a growing perception of increasing environmental changes when the more obvious remedies appear to conflict with the demands of economic development.

THE WORKSHOP

The workshop was convened to develop a better understanding of how these decision-making matters are likely to be resolved. Surely, the mode of decision making that is adopted will affect profoundly the kinds of technical information that are useful as well as the manner in which the information is presented. Selected speakers and participants in working groups were invited to address the issues of defining and managing common global resources in response to the conflicting demands of global environmental protection and world economic development (recognizing ultimately that failure to protect the environment itself may inhibit development).

The emphasis of these presentations was not on various preferred outcomes or alternative policy options, but on the essentials of the decision-making process; the steps which, if overlooked or undervalued, could thwart an otherwise promising line of technical and scientific progress towards human management of the global commons.

Participants in the workshop were drawn from the social science research community with the intention of exchanging perspectives and initiating collaborations that could better position that community to offer guidance to policy makers in government, industry, and the environmental movement worldwide. Participation in the workshop reflected this international orientation and included scholars from the United States, China, The Netherlands, Belgium, Canada, Hungary, West Germany, Austria, Kenya, and the United Kingdom. A broad range of social science disciplines was represented from universities, national laboratories, non-governmental, and intergovernmental groups and agencies.

The U.S. Department of Energy's (DOE) Office of Environmental Analysis funded some of the early planning for the workshop. The University of Tennessee's Energy, Environment, and Resource Center; the Energy Division of ORNL; and ORNL's Center for Global Environmental Studies organized and sponsored the workshop. The workshop was recognized both by the Social Science Research Council and the International Social Science Council as a contribution to their research programs in the human dimensions of global change.

WORKSHOP REPORT

This workshop report does not provide a narrative of the proceedings. The workshop program is included, as are the abstracts of the papers that were presented. Only the introductory paper on social science research by William Riebsame and the closing summary by Richard Rockwell are reprinted here. The other papers have been or will soon be published in various journals, including *Environment* and a forthcoming special issue of *Evaluation Review*. This brief report focuses instead on the deliberations of the working groups that developed during the workshop.

The questions around which these workgroups crystallized were:

- Is the international community capable of social learning?
- What institutional strategies could be used to manage indeterminate global uncertainties?

- What are the problems of equity and legitimacy facing a management strategy for the global commons?
- What are the potential big surprises that could thwart global cooperation?

The workgroups were encouraged to address the social science theoretical issues raised by these questions. The goal of the workshop was the articulation of research frameworks and research problems rather than description of empirical analysis or the elaboration of solutions.

In the closing session participants called for the workshop to be turned into an annual event, perhaps rotating among several locations and sponsors. Consequently, the University of Colorado, Boulder will be joining ORNL's Global Environmental Studies Center, in sponsoring the Second Annual Social Science Workshop on Global Environmental Change that will be held at the Clarion Harvest House Hotel, Boulder Colorado, November 11–14, 1990. The workshop will be hosted by the Center for Space and Geosciences Policy and the Natural Hazards Center.

PROGRAM

Session 1
Introduction and Overview

Introduction to the workshop. *Alvin W. Trivelpiece* and *E. William Colglazier*

Current thinking on anthropogenic climate change: State of the scientific understanding. *Michael P. Farrell*

Current thinking on anthropogenic climate change: Social perspectives. *William E. Riebsame*

Existing international agreements and cooperation in environmental conservation and resource management. *Peter S. Thacher*

Session 2
Participants in the Decision-Making Process

Characterization of organizations in climate-change issues. *Alan D. Hecht*

Ecopolitics in the global greenhouse. *William B. Wood*

The tension between local and global: Negotiating the dilemma. *Luther P. Gerlach*

Conflicts about process: Three decision-making modes. *Steve Rayner*

Banquet and Keynote Speech
Climate change and social science research: Future scenarios. *Roberta Balstad Miller*

Session 3
Synthesis I: Frameworks for Decision Making: Implications of National and Institutional Preferences

Presentation of group reactions and discussion with panel of speakers from Sessions 1 and 2.

Session 4
Decision Making When Stakes and Uncertainties are Large

The use of scientific modeling in decision making. *Kristin Shrader-Frechette*

Social learning in the management of global environmental change. *William C. Clark*

Session 5
Legal Instruments, Justice, and Equity

The role of international law: Formulating international legal instruments and creating international institutions. *Paul C. Szasz*

Distributive justice and intergenerational responsibility. *Douglas MacLean*

Developmental and geographical equity in global environmental change. *Roger E. Kasperson*

Session 6
Synthesis II: Reducing Decision Stakes and Increasing Resiliency and Responsiveness of Institutional Frameworks

Presentations of group proposals and interaction with panel of speakers from Sessions 4 and 5.

Session 7
Managing the Global Commons

Managing the global commons: Climate, population, and natural resources. *David Pimentel*

Compatibility of policy-implementation frameworks. *Sheila Jasanoff*

Bargaining among nations: Culture, history, and perceptions in regime formation. *Ronnie Lipschutz*

Session 8
Synthesis III: Achieving Consensus and Fostering Cooperation

Presentation of group reactions and discussion with panel of Thursday's speakers.

Session 9
The Next Steps: Conclusions and Recommendations

Presentation of strategies and synthesis of recommendations.

Summary and conclusions. *Richard C. Rockwell*

ABSTRACTS OF PLENARY PAPERS

SESSION 1
INTRODUCTION AND OVERVIEW

Current thinking on anthropogenic climate change: State of the scientific understanding

Michael P. Farrell
Oak Ridge National Laboratory

Recent research on global carbon-cycle processes has improved significantly our understanding of the increase in atmospheric CO_2 concentrations. Nevertheless, key uncertainties remain to be resolved before atmospheric CO_2 concentrations can be explained with sufficient accuracy to predict CO_2-climate interactions, and to determine both the effects of increasing CO_2 concentrations and of climate change on vegetation and renewable resources. Results from studies of past fluctuations in atmospheric CO_2 and climate suggest that current carbon-cycle models emphasizing the contributions from human activities may be doing so at the expense of natural feedback components involving terrestrial and marine systems.

Much of the problem stems from the inability of current models to generate more accurate estimates of CO_2 uptake by the oceans. The physical, chemical, and biological processes of oceans are complex and, therefore, credible estimates of CO_2 uptake probably can only come from mathematical models. One- and two-dimensional ocean models do not allow for enough CO_2 uptake to account accurately for known releases, so the models show higher concentrations of atmospheric CO_2 than was the case historically. Three-dimensional models may make better use of existing tracer data than do one- and two-dimensional models and will incorporate climate-feedback effects to provide a more realistic view of ocean dynamics and CO_2 fluxes.

Estimates of the net release of carbon to the atmosphere from deforestation also are incompatible with ocean-model CO_2 uptake. Furthermore, the estimated loss rate of terrestrial organic carbon from biota and soils is so small compared to the total mass of organic carbon, that these losses are largely undetectable and can be estimated only indirectly from models. Much of this uncertainty results from inadequate information about deforestation rates, forest carbon stocks, and land-use changes. Additionally, it is uncertain whether terrestrial ecosystems respond to changes in climate by releasing or storing carbon.

Current thinking on anthropogenic climate change: Social perspectives

William E. Riebsame
University of Colorado

Political and corporate decision makers have begun to consider how to respond to potential anthropogenic climate change, but what do we know about its full implications for social well-being? Since the global climate change issue emerged as a scientific and policy concern in the early 1970s, only a relatively small cadre of social scientists have addressed it. They have asked questions ranging from the implications of changes in specific elements like crop yields to the possibility of international equity of preventive actions.

Early supposition was that social-political mechanisms were so ill-suited to dealing with long-term, global-commons problems that little ever would be done to mitigate anthropogenic climate change. Nonetheless, the recent surge of public attention, and calls for unilateral and multilateral action to limit and prepare for global warming indicate that society does have mechanisms at least for recognizing and evaluating the issue. Whether this will lead to effective solutions remains to be seen.

The evolution of impacts assessment and policy analysis of global climate change over the last 15 years will be described briefly, followed by a state-of-the-art assessment of the social science understanding of human interaction with global change. This assessment will be organized by scale (e.g., individual, family, national, international), disciplinary perspective (psychology, political science, etc.), and possible responses to global climate change (prevention, mitigation, adaptation). Particular attention will be paid to responses by environmental decision makers and to differences between industrialized and developing countries that are shaping the response debate.

Existing international agreements and cooperation in environmental conservation and resource management

Peter S. Thacher
World Resources Institute

Early arms-control agreements, post-Stockholm agreements such as the Convention on International Trade in Endangered Species, as well as the London ocean-dumping and various regional-seas agreements, provided lessons that were applied in the 1977 World Action Plan on the Ozone Layer and subsequent agreements, such as the Vienna Convention of 1985, Montreal Protocol of 1987, and Helsinki Declaration of May 1989.

The Intergovernmental Panel on Climate Change is proceeding along similar lines. In May 1989, the UNEP Governing Council registered agreement to start negotiations in 1990 on an International Treaty on Climate Change. Various proposals also have been made about institutional responses to global change—including climate change—such as reactivating the UN Trusteeship Council, and the UK proposal to take up potential environmental threats in the Security Council. Many of these issues will come to a head in a 1992 UN Conference on Environment and Development, possibly embracing sustainable development as proposed in the Brundtland Report, *Our Common Future*.

Climate-change issues differ from the ozone-layer precedents in important ways, including a greater degree of human reliance on fossil fuel energy, longer lead times, and

demographic projections. Even if industrial countries significantly improve energy practices and reduce the rate of CO_2 accumulation, energy demands in the developing world by the middle of the next century will resume atmospheric heating at threatening rates.

New approaches are needed, and new ideas are on the table. There are proposals to provide the resources needed to encourage future energy strategies more in keeping with greenhouse-gas constraints. The recent Hague Declaration suggests that at least one major power might be willing to divest itself of the veto power for the sake of effective decisions to halt global warming. A major group of actors that have not yet been involved in this issue are the multilateral and bilateral development institutions whose combined $40B annual budgets assume strategic importance in a world of indebtedness.

SESSION 2
PARTICIPANTS IN THE DECISION-MAKING PROCESS

Characterization of organizations in climate-change issues

Alan Hecht
National Oceanic and Atmospheric Administration

The issue of anthropogenic climate change now has taken on significant new dimensions. At the recent (May 1989) international meeting of the Intergovernmental Panel on Climate Change (IPCC), nations moved one step closer to beginning international negotiations of a framework convention on climate. The United States will host a meeting in October to discuss the full range of financial, economic, technical, and legal issues for responding to climate change.

How the international community will organize itself to prepare for negotiation of a framework convention is unclear. At the recent UNEP Meeting (May 1989), the Governing Council adopted a resolution calling for UNEP and WMO to promote negotiations of a convention after completion of the IPCC initial reports (November 1990).

In the United States, the somewhat ad hoc and overlapping interaction between federal agencies on questions of climate change requires reexamination. This matter is crucial in light of several new pieces of legislation introduced by Congress and in light of international proposals for response to climate change.

In this regard, the National Security Council has established a Policy and Coordinating Committee on Oceans, Environment, and Science. This committee has overall responsibility for the development of U.S. foreign policy with respect to environmental issues. Under this body the Department of State has created a Working Group on Global Climate Change to develop and coordinate foreign policy issues related to climate change.
An additional body is needed to develop domestic policy options and to coordinate both science and policy issues related to climate change.

Ecopolitics in the global greenhouse

William B. Wood
Department of State

Public concern over a broad range of environmental issues is pressuring politicians and environment-related institutions worldwide to search for effective solutions. New "environmentalist" political parties, increasingly influential nongovernmental organizations, and more active supranational agencies are playing leading roles in determining new environmental policies at the local, national, and international levels.

This paper uses an ecopolitical framework to demonstrate the interaction among various environmental actors and to illustrate how the resolution of environmental problems becomes much more difficult as the actors move up the ecopolitical hierarchy from the local to the global scale. The economic implications of environmental problems as well as proposed solutions become particularly contentious in the context of international debates,

negotiations over global treaties, and deliberations regarding costs of programs.

The tension between local and global: Negotiating the dilemma

Luther P. Gerlach
University of Minnesota

"Think globally, but act locally" is a formula designed to resolve the tension between the promotion of superordinate systemic interests and the pursuit of narrow self-interests. The promotion and pursuit of these interests contribute to the evolution of global governance through a complex process which is predictable, but not controllable.

Modern society extols systemic and local goals. Both have been promoted since the 1960s by powerful crusades. Environmentalism promotes comprehensive management of the ecosystem. Rights movements have advanced individualism and myriad "ethnolocalisms," including those of place, gender, race, ethnicity, religion, age, life-style, and power sharing. These ethnolocalisms challenge top-down and widespread control.

But some ethnolocalisms promote central management. People interpret rights to mean liberty, but also equal access to opportunity. Social stability is enhanced if opportunities can be advanced for all without hurting any. Economic growth is supposed to make this possible, but environmentalism warns that economic growth hurts nature. According to 1960s' environmentalism, growth must be controlled within systemic limits; in the 1980s, development should be sustainable. Managing development to make it sustainable means managing people. Global management conflicts with global ethnolocalism. What can be done?

Many hope for solution in technology itself. Others expect that sociocultural change is necessary. Of these, some say that ordinary people are rising up to make these changes, and that it is precisely this local grassroots action around the world that is the key to saving the global ecosystem. Attempts to promote such local action by warning of the global threat and to coordinate it in networks constitute a globalization crusade that leads to systemic change. But people also manipulate the global-local dichotomy in its many forms to achieve tactical advantages in more immediate conflicts over resource uses. Both actions are part of the process by which the world order is evolving to a polycentric future.

Conflict about process: Three decision-making modes

Steve Rayner
Oak Ridge National Laboratory

This paper introduces the concept of management frameworks as institutional cultures. Nations and organizations tend to favor one or another of a variety of decision-making styles composed of unique combinations of only three basic types known as hierarchies, markets, and collectives. These decision styles systematically constrain discourse and lead decision makers to frame problems in specific, sometimes incompatible ways. Such constraints affect the selection of issues for attention, perceptions of urgency, and recognition of other stakeholders as legitimate participants in decisions. The paper explores the implications of these decision styles for climate decision making.

SESSION 4
DECISION MAKING WHEN STAKES AND UNCERTAINTIES ARE LARGE

Social learning in the management of global environmental change

William C. Clark
Harvard University

In seeking to manage global environmental change, we face not well-posed problems, but rather what Russell Ackoff has called "messes." Decision stakes and uncertainty are high, system complexity is substantial, and the time and space scales involved transcend those of most human institutions.

Under such conditions, traditional aids to decision—expert panels, formal analysis, and system modeling—are of limited utility. The challenge is not so much to get individual decisions right (which is impossible), but rather to get them better through time (which is merely unlikely).

Needed therefore, are concepts and tools to facilitate social learning in the design of long-term, adaptive strategies for the management of global change. This presentation explores some of the possibilities.

The use of scientific modeling in decision making

Kristin Shrader-Frechette
University of South Florida

This paper critiques the role of decision-theoretic approaches and ecological modeling in policy-decision-making processes. Building on previous research in risk analysis and technological decision making, the author surveys the merits and limitations of conventional uses of scientific modeling to policy and discusses the potential of knowledge-based systems to contribute to global environmental decision making.

SESSION 5
LEGAL INSTRUMENTS, JUSTICE, AND EQUITY

The Role of International Law: Formulating International Legal Instruments and Creating International Institutions

Paul C. Szasz
United Nations

To determine what legal instruments need to be formulated and institutions created, it is necessary to analyze the various functions of the proposed international regime for managing the global commons. These functions include:

- creation of international obligations through **norm-making**,
- **assistance** to countries in carrying out these obligations,
- **monitoring**, and
- **sanctioning** as a possible final step, to induce countries and other entities to comply with such obligations.

First of all it will be necessary to have a **constitutional treaty** to establish the regime and the organization to implement it. The treaty also would define the basic obligations of all countries, authorize suitable norm-making, provide for resource and technology transfers, and authorize monitoring and possibly sanctioning. Each of these functions would be governed further by **subsidiary treaty instruments**, some concluded among all participating countries but most of which would be entered into between the organizations and individual countries, as well as by resolutions of representative organs of the organization.

The organs required would be:

- **a general representative body** to govern the entire regime and to exercise the ultimate power of the purse,
- **one or more smaller executive bodies** to take decisions (e.g. the issue of regulations, the authorization of resource and technology transfers, the arrangements for monitoring, and determinations as to sanctions) on a rapid and routine basis,
- **expert bodies** to assist in norm-making and monitoring,
- **a judicial organ**, particularly if there are to be sanctions, and
- **a secretariat, or possibly several specialized secretariats**, to service the representative, expert, and judicial organs.

These requirements in terms of legal instruments and institutions would be essentially the same whether it is decided to establish a single regime to manage the global commons or, for practical or political reasons, to have separate regimes, e.g. for the atmosphere, for space, for the seas, for land-based activities, and for the Antarctic.

Distributive justice and intergenerational responsibility

Douglas MacLean
University of Maryland

Except for a few theorists who have allowed arguments to overwhelm their instincts, everyone cares about future generations. But the beliefs and values that constitute the foundation of people's

concerns for future generations differ markedly across cultural types. Libertarians either attempt to extend rights to future individuals, or else they include the right to pass on benefits (including environmental benefits) to their heirs among the basic rights of the current generation. Egalitarians tend to appeal to a social contract that includes the members of future generations. Utilitarians have perhaps the easiest time explaining the duty to promote the welfare of future generations, except for worries about the proper discount rate to account correctly for opportunity costs, etc. Moral conservatives or traditionalists can appeal to our heritage and our duty to pass on what we received from our predecessors.

While these basically different positions may all be trying to explain the same moral facts at some level, they do so in ways that can imply very different and incompatible policy recommendations, particularly for issues like climate change. Each of the philosophical positions, moreover, faces serious logical or conceptual difficulties. These differences and problems will be discussed and analyzed, and suggestions will be made for finding some degree of common ground for understanding our obligations to future generations.

Developmental and geographical equity in global environmental change

Roger E. Kasperson
Clark University

Change in climate and other portions of the global environment will have uneven consequences across countries and regions. These changes already may be underway, will remain highly uncertain, and will prove challenging to diagnose. The geographical separation between the sources of human driving forces and the affected areas is a potential source of international tension and conflict. Some of these changes will exacerbate existing social and economic inequities and threaten sustainable development.

This paper examines the major equity problems arising from the interaction of geographical discontinuities, uncertainty, and international development.

SESSION 7
MANAGING THE GLOBAL COMMONS

Interactions and interdependencies between decision making on climate change and on other global issues

David Pimentel
Cornell University

International negotiations concerning global climate change and control must be based on an understanding of the economic, political, and environmental links between emissions of greenhouse gases and human populations, deforestation, fossil-energy depletion, pollution, poverty, and hunger.

The world population is 5.2 billion and growing rapidly. At least half of the people live in poverty already and more than 20% are malnourished. Most of the world's arable land currently is in use, and large amounts of marginal land have been planted to crops. Soil degradation results in the abandonment of about 6 million hectares each year, and large amounts of fossil energy are used to substitute for the lost fertility of degraded soils.

Lost and degraded cropland is replaced by removing forests. Over 80% of the annual deforestation is due to the spread of agriculture. Forest destruction and the consumption of fossil fuels are the major contributors to the buildup of carbon dioxide and global climate change.

Climate change may manifest itself more strongly in altered regional precipitation patterns than in increased temperatures. Insufficient soil moisture is one of the principal factors limiting crop yields, and total annual rainfall is less important than its seasonal distribution. Deforestation makes regional hydrologic cycles more erratic and increases the risk of crop losses due to drought and flooding.

Air pollution also reduces crop yields, especially when it affects plants already suffering from moisture stress and soil degradation. The use of nitrogen fertilizers to boost yields contributes to the build-up of greenhouse gases, particularly during fertilizer production, but also after application in the field and through increased methane releases from bodies of water polluted by fertilizer runoff.

Loss of biological diversity—caused by deforestation, modern agricultural practices, and possibly by rapid climate change—is likely to diminish society's capacity to adapt successfully to altered climatic conditions.

Compatibility of policy-implementation frameworks

Sheila Jasanoff
Cornell University

Existing research comparing regulatory processes for environmental and health hazards in Europe and North America indicates that there are considerable differences in the ways that countries with quite similar legal and political traditions approach both the scientific evidence upon which policy is made and the frameworks that are used to implement such policy. Such differences may be even more extreme between countries with vastly different cultures and political traditions.

This paper describes and accounts for such differences in political, legislative,

administrative, regulatory, and judicial systems that may present obstacles to reaching international accord.

Bargaining among nations: Culture, history, and perceptions in regime formation

Ronnie D. Lipschutz
Pacific Institute for Studies in Development, Environment and Security

Students of regimes and regime theory tend to focus on shared principles, norms, rules, and decision-making procedures and the process of bargaining within regimes. However, the formation of regimes is a much more difficult matter, and debate on the subject forms the basis for a rather extensive literature. As a consequence, few students of regime, bargaining, and game theory, or any other related body of scholarly research, delve into what might be called the underlying cultural, historical, or perceptual elements that form the basis for the establishment of international agreements and organizations.

If notions about the establishment of regimes by hegemonic states are correct, then perhaps little matters beside what is seen on the surface. If, however, bargaining between nations over the formation of regimes is regarded as a slow and iterative process, culture, history, and perceptions do matter, for the position of individual states on different issues can mean the difference between a successful agreement and no agreement at all.

The goal of this paper is to see how these elements affect bargaining between nations over issues of the global commons. The paper has four parts. In the first two, the author summarizes competing ideas about the provisions of collective goods and theories of regime formation (related aspects of the same phenomenon). In the third section, the author suggests ways in which cultural, historical, and perceptual differences might be worked into notions about regime formation. Finally, in the fourth, the author addresses the implications of these ideas for managing the planetary atmosphere.

INTRODUCTORY PAPER

SOCIAL PERSPECTIVES ON GLOBAL CLIMATE CHANGE

William E. Riebsame

PROLOGUE

This paper is organized in four parts. The first portrays the problem posed for society by anthropogenic climate change, briefly assessing probable impacts on natural resources and other support systems vital to social well-being. The second part recounts the evolution of concern over climate change and social science approaches over roughly the last 15 years, using benchmarks such as research projects, climate events, and major publications. The final two sections evaluate climate and society research in terms of contribution to social theory, and suggest how traditional and synthetic social science concepts could yield a more holistic view of nature-society interaction.

Assessing the Impacts of Climate Change

A broad review of climate impact studies of the last decade and a half reveals a common and disturbing pattern of results (see Kates et al. 1985; Riebsame 1988; Parry et al. 1988). In short, the existing research indicates that:

(1) In essentially all natural resource sectors, relatively small climate changes can cause significant and potentially disruptive effects. Modern systems for managing and utilizing water, energy, agriculture, fisheries, and forests appear to be finely tuned to the current climate, and climate changes even substantially smaller than those that might accompany the benchmark doubling of CO_2 threaten to alter resource flows markedly, or even to cause the outright failure of systems and practices (see Parry et al. 1988; Bolin et al. 1986; Riebsame 1988).

(2) There are large disparities in our understanding of potential impacts: climate change effects on agriculture, water, and energy are relatively well understood, but we know much less about how fisheries, grasslands/livestock systems, human health, transportation, urban development, and the broader economy, might be affected (see Kates et al. 1985). Understanding of climate and resource interaction is especially fuzzy at environmental and social interfaces, where complex interactions occur between, for example, crops and soil (affected by soil temperature, erosion, etc.), fisheries and wetlands (perhaps de-stabilized by sea level rise), and different resource management institutions.

(3) There exists potential for catastrophic productivity declines associated with rapid climate change in some resource areas, for example: wildfire in the

forests, new pest/disease outbreaks in agriculture, extreme events in water resources, and habitat changes affecting species viability. There also exists a set of possibly mitigative effects, such as the biomass-enhancing effects of ambient carbon dioxide, improved fisheries due to warmer ocean temperatures or coastal inundation, or new technology and resource transfers between "winners" and "losers" invoked by the international policy response to the threat itself. At this time, however, the balance of positive and negative impacts can only be poorly discerned, though most analysts count global warming as a net loss, if for no other reason that it increases uncertainty.

(4) Finally, there is a growing sense that the impacts of global climate change would be socially divisive. It is widely held that resource systems in the developing countries are especially vulnerable because of narrow options and limited resources for adjustment and recovery from climate impacts (Jodha 1989; Woods Hole Research Center 1989). Experience with natural hazards and recent climate fluctuations supports this view, which also raises questions concerning the distributional equity of the benefits and costs of greenhouse gas emissions.

It appears that climate change, even at the lower rates projected by greenhouse effect studies, would be quite disruptive. In light of this, and notwithstanding the uncertainty of global warming projections, a prescriptive body of argument has coalesced around the goal of demonstrating why and how global warming should be limited (Mintzer 1987,1989; Lashof and Tirpak 1989). The technical feasibility of reducing greenhouse gases markedly has been well demonstrated, but the potential for the necessary social changes is less clear.[1] A common approach, given uncertainty over climate change, is to stress the logic of taking actions that pay off even if global warming has been overestimated (e.g., increased energy efficiency)—the so-called tie-in strategy, which links the less certain threat of climate change to the more certain environmental pollution effects of current energy systems (Schneider 1989).

Tie-in proponents assume that the threat of global warming sufficiently increments the cumulative risk of human impacts on the environment so that actions which people have not yet seen fit to take (e.g., pricing fossil fuels to reflect the environmental costs of their use) become compelling. While it makes good sense, this assumption has not been examined in light of resource management behavior studies which have identified several factors that limit people's ability to solve problems such as greenhouse warming (attitudes toward development, temporal discounting, limited ability to assess risks, and institutional constraints on individual or collective choice), nor has the assumption been supported with analysis of the full costs and benefits of global warming and/or its limitation.

If limitation strategies fail, and significant climate change does occur, the remaining option is for social systems to adapt. This possibility has received less

[1]The potential for limiting global warming is addressed by several other papers in this collection.

attention; indeed, one weakness of climate impact studies is that they are static. Climate change is imposed on resource systems attributed with little potential for change and innovation. The question of whether adjustment and innovation can override the negative effects of climate change remains ill-posed and unanswered. Some researchers expect social systems to adapt readily, through technological innovation (Wittwer 1980; Waggoner 1983) and economic adjustment (Easterling et al. 1989). Yet, the process of adaptation is rarely made explicit, and concern over global climate change continues to be driven mostly by an intuition that the rate of change will outstrip adaptive capacity. The truth probably lies somewhere between these two propositions. There is some evidence to suggest that, compared to the threat of global warming impacts, adaptive capacity is quite large in most agricultural systems and industrial processes, and relatively small in urban infrastructure and in the management of natural resources such as water, grazing, forestry, and fisheries in many areas.

A Brief History of Contemporary Climate/Society Research

The relationships between climate and society have been of intellectual interest since classical times, and received scholarly, though simplistic, examination in the early 20th century in a form now labeled *climatic determinism* (Riebsame 1985). The current level of concern can be conveniently pegged to the droughts, famines, and rapid global food stock decline (and price increase) of 1972—an episode that made climate change a visible public policy issue. Fears over a "coming ice age" and even the greenhouse effect were current in the 1960s and before (Schneider 1976), but the droughts and food price increases of the early 1970s significantly increased the priority of climate change on national and international policy agenda, in much the same fashion as did heat, drought, and scientist pronouncements about global warming in 1988.

In the early 1970s, concern over the impacts of a proposed fleet of supersonic transports (SSTs), the continuing Sahelian drought (which deepened through the mid-1970s), frosts in Brazil that killed millions of mature coffee trees, a series of spectacularly cold winters in the United States, and drought on the U.S. Great Plains and other mid-latitude grain regions, evoked and shaped the contemporary concern for climate change (see Kates 1985; Hare and Sewell 1986). Listed here are some milestones of that concern (with a focus on activities in the U.S.), each accompanied by a brief discussion of its contribution to understanding of the social dimensions of global climate change:

1975: U.S. Department of Transportation (1975) Climate Impact Assessment Project

This study was the first to link physical and social analyses and it furnished the first explicit micro-economic, expected utility, and rational choice models in climate change research. The protagonist was not the greenhouse effect, but rather the potential effects of supersonic transports. It pioneered the use of economic techniques (consumer preference and shadow pricing, cost/benefit analyses) to assess impact of global warming *or* cooling. These economic approaches were heavily criticized at the first World Climate Conference.

1976: National Academy of Sciences (1975 and 1976) Stratospheric Ozone Assessments

The assessments found no major threat from SSTs, but started the ball rolling in stratospheric chemistry studies leading to the current concern over ozone depletion by chloro-fluorocarbons.

1977: Journal Climatic Change initiated

The journal provided the first explicitly interdisciplinary outlet for climate change and impacts research.

Clark University Climate and Population (CLIMPOP) study initiated (Bowden et al. 1981)

This study represented the first substantial commitment of NSF funds to the social analysis of climate change. The Clark University group posed and tested two fundamental hypotheses about the evolution of societal vulnerability to climate fluctuations: that societies adjust to lessen successive impacts, while perhaps also exhibiting longer-term increases in vulnerability that inculcate the possibility for catastrophe. The group applied historical/geographical techniques to three case studies: the Tigris-Euphrates Valley, the African Sahel, and the U.S. Great Plains, at decadal to millennial time scales.

1978: National Defense University (1978) study of *Climate to the Year 2000.*

This report is an opinion survey of climatologists and agronomists which concluded that the climate of the next 25 years is most likely to be similar to the climate of the last 25 years. Later criticism showed that this conclusion was an inevitable result of the survey technique (Stewart and Glantz 1985). The result also may have reflected the transition from cooling to warming theories.

1979: (First) World Climate Conference (World Meteorological Organization, 1979)

Evoked chiefly by recent climate extremes rather than the threat of global warming, this conference ushered in the World Climate Program and aided and abetted formation of national climate programs. It led to the emergence of UNEP as lead agency for impacts research and climate policy formulation. There was much criticism of economic analyses at the conference, while the other social sciences were poorly represented. The concluding presentation by R. W. Kates (the "I don't feel so soft" speech[2]) drew

[2]"It is common though somewhat insulting to use such terms as 'hard' and 'soft' sciences to describe the differences between physical and social science, and I have been struck by how difficult it would be to apply such terms generically in the context of our common subject—climate...after a week of listening to the disarray of atmospheric theory of forcing mechanisms, of the debate over the so-called robustness of the atmospheric system, and the confusion of how to recognize signals of slow, pervasive cumulative change, I don't feel so soft at all. Some of our understanding is considerably harder than yours." (excerpt from Kates, 1979)

rapt attention to the difficult, but absolute by necessary, task of linking natural and social science in addressing climate change.

Climate and History Conference (Wigley et al. 1981)

The conference showed how climate fluctuations affected societies in the past, providing a basis for concerns over future impacts in the broadest social sense to date. The conference was highlighted by several rich historical studies, but these became more a curiosity than a useful input to current analysis, perhaps because of the difficulty of differentiating cause and effect in history. The historical approach was also less compelling given the mechanistic expectations that physical scientists have of climate and society research.

U.S. Department of Energy (1979) Annapolis Conference on Environmental & Social Consequences of a Possible CO_2-Induced Climate Change

This conference expressed formal agency interest in social issues and got more social scientists interested, but received little follow-through, though it set the stage for the joint DOE and American Association for the Advancement of Science (AAAS) social science panel.

DOE/AAAS Panel on Social and Institutional Aspects established (Chen et al. 1983)

This panel was the first well-focused social science assessment of the global warming issue, though curiously separated from the economics panel. Discussions evoked new sociological, anthropological, political, historical, geographical, legal, and psychological thought on the issue, but produced no new research per se, and few of the participants are actively involved in the issue now. The resulting volume is one of the best sources of social science ideas on climate change.

National Academy of Sciences (1979) *Carbon Dioxide and Climate: A Scientific Assessment* (1979)

This report was the first blue ribbon scientific assessment in which the atmospheric sciences community supported the reality and severity of the threat of global warming.

1983: National Academy of Sciences (1983) *Changing Climate* assessment published

This second blue ribbon panel assessment provided further scientific credibility to the climate change threat and offered the first NAS natural resource, social, and economic impact assessments, but it provided no response policy recommendations.

1985: "Villach Conference" (World Meteorological Organization, 1986)

This conference was the international version of a blue ribbon assessment that raised scientific and policy red flags, and further empowered the UN to move forward on impacts, adaptation, and mitigation studies, as well as to start toward a climate protocol or treaty. Physical

scientists (chiefly meteorologists and ecologists) did much of the social impacts analysis and writing.

SCOPE/UNEP Review of Impact Assessment Methods published (Kates et al. 1985)

This review produced a key volume that articulated an interactive model of climate and society and explored a wide range of analytical approaches, including scenario analysis, simulation modelling, and social impact measures. The volume is especially valuable for raising issues such as perceptions and attitudes, which are often neglected, and for illustrating the richness of relevant research and methods that emerged in the five years after the World Climate Conference.

1988 (a big year for the global climate issue)

IIASA/UNEP "Margins" Case Studies published (Parry et al. 1988)

This publication is a well-designed set of collaborative case studies that set the state-of-the-art for the use of common climate scenarios, linking physical and social models and assessing policy implications through decision-maker involvement. The report showed serious impacts from even modest climate changes in many cases. It also illustrated that no single set of social science approaches will suffice to provide full assessment—econometric modelling seemed informative in some cases (Saskatchewan wheat), analog approaches appeared to work in another (Kenya), while less formal case study methods were best in others (India, Iceland).

U.S. Environmental Protection Agency "United States Effects" and "Stabilization" Reports (Smith and Tirpak 1989; Lashof and Tirpak 1989—in draft at this writing)

These reports comprise a sophisticated, integrated impacts assessment based on linked simulations progressing from bio-physical to social effects. They include secondary economic impacts through a national U.S. input-output model and other neglected factors such as ambient CO_2 effects on crops, but pay little attention to social adaptation. They show remarkable impacts on Southeast forests, and water system simulations showed large sensitivities in some regions, especially California and the Great Lakes. The reports intensified the debate within the U.S. over the seriousness of potential impacts and advisability of taking preemptive steps to limit greenhouse gases. The Stabilization report especially is attracting attention vis. the economic implications of greenhouse gas reductions, alternative energy systems (e.g., nuclear or biomass), technology transfer, and the equity issues of global greenhouse reduction targets.

Resources for the Future Workshop on Abatement and Adaptation (Rosenberg et al. 1989)

The workshop was especially important for addressing the tension

between prevention and adaptation, mostly in terms of risk and economic analysis (benefit/cost and principles such as *safe minimum standard*). It also was important for discussing an optimal mix of prevention and adaptation. The workshop concluded that, obviously, both need to be considered, but the discussions showed some strains between those who conduct work on each.

Toronto Meeting on the "Changing Atmosphere" (World Meteorological Organization, 1988)

This signal policy event also illustrated the tension between prevention and adaptation issues. It reflected a trend in the late-1980s toward disregarding the abiding scientific uncertainty over global warming, in both scientific and political presentations. Mostly through in-fighting among the conference statement-drafting committee, the conference also evidenced disagreement whether the threat merited immediate action to reduce greenhouse gases. Debates between developed and developing country speakers foreshadowed the equity issue that will mark progress toward a greenhouse gas reduction treaty. It was an important event for establishing the path and impetus toward an international protocol.

IFIAS program on Human Response to Global Change initiated

At a September meeting in Tokyo, the International Federation of Institutes for Advanced Studies (IFIAS), the United Nations University, and the International Social Science Council initiated formal planning for a Human Response program to parallel the International Geosphere-Biosphere Program (IGBP). Also in 1988, hot weather in the U.S. and scientist pronouncements about record global warmth placed greenhouse issues before the public, increased news media coverage, and gave impetus to motion toward an international agreement on preventive actions.

From 1988, the issue evoked numerous meetings, projects, calls for proposals (e.g., NSF's Human Dimensions Program), reviews, and reports, too numerous to mention here. This ongoing activity is highlighted by the Intergovernmental Panel on Climate Change (IPCC), a formal, ministerial assessment and planning process leading to the Second World Climate Conference, set for October 1990, which will include discussions of a greenhouse gas reduction protocol.

These most recent activities continue to exhibit three problems that have marked the rapidly evolving concern over global warming. The first problem emerges in the tension between preventive and adaptive responses. Preventionists tend to be compelled by values of environmental protection and a reformist zeal, while those who discuss or study adaptation claim to be realists—expressing a concern that we need insurance in case limitation fails; they are often accused of being defeatists. Perhaps the debate reflects an awkward situation; we know the steps needed to reduce the risk of global warming, but do not know how big a risk it poses vis-a-vis social adaptability.

Second, the brisk progress toward some form of international climate treaty has been paralleled by rather slow recognition of the problem at the practitioner level in the core resource management professions (forestry, water, grazing lands, etc.) and related agencies. The reason for this is simple: current climate change projections do not offer sufficient credibility or detail for front-line resource planners actually to change their current management decisions. Little attention has been paid to helping resource planners cope with the emerging issue and uncertainties, despite the fact that they are coming under increasing pressure to take anticipatory action (Riebsame 1990).

A third weakness in the research response to the global warming threat is that much of the analysis of social implications and subsequent policy recommendations has come from broad-minded physical scientists, not social scientists. While the physical scientists' analysis is not necessarily flawed, there are differences in how they and social scientists conceive of social processes, even when both use a similar explanatory framework (such as a systems framework). These differences affect research results and policy recommendations. For example, physical scientists tend to take a mechanistic view of nature and society relationships, expecting stimulus-response processes inevitably to guide the system toward equilibrium. Social scientists more often recognize that social systems evolve along less predictable trajectories, driven by human choice, attitudes, beliefs, and values, rarely returning to some normative steady-state. This same view encompasses a sense that policy flows automatically from science. This conference was an attempt to address the need for more sophisticated social science analysis of the problem, one incorporating what we have learned about individual choice, social group behavior, risk taking, international relations, and the development process.

Finally, discourse on global warming in the late-1980s was marked by growing disregard of the substantial scientific uncertainty that surrounds both empirical evidence for, and projections of, global warming. After the 1983 National Academy of Sciences assessment and the UN's 1985 "Villach Assessment", analysts tended to cite the "consensus" for a 3-5°C warming with carbon dioxide doubling, omitting, or belittling the abiding uncertainties associated with the climate system's response. By 1989 this tendency was evoking a critical backlash (see Rogers and Fiering 1989; Michaels 1989) that will change the nature of the policy debate over the next few years and may temper the enthusiasm for quick preventive action with a more cautious approach (White 1989).

Social Theory and Social Dimensions of Global Change

The first comprehensive statements of social science research on climate change were organized by discipline (Chen et al. 1983), though this pattern was less strong in the SCOPE volume (Kates et al. 1985). The initial social science approach touched on a common constellation of perspectives and theories that can be distilled into four key dimensions:

> BEHAVIORAL: This perspective stresses individual behavior, perception, and choice (Whyte 1985), often linked to natural hazards research (see Warrick and Riebsame 1981) or to cognitive analysis of decision making and risk taking (Fischhoff 1981; Fischhoff and Furby 1983). The paradigm is cognitive; focused on individual

appraisal and decision making. Such studies are weak in explicating interactions between individuals and collectives. Yet, it can be argued persuasively that individual resource managers and policy makers, and their biases and personalities, play a pivotal role in coping with global change as they choose how to respond to the threat.

CULTURAL: Culture provides a focus on the meso- and macro-structures of a society (traditions, norms, values, beliefs, and taboos, as well as material artifact) which guide and articulate behavior and act as frameworks for codifying and passing on social learning. Theories on culture and environment typically are based on studies of how traditional societies adapted to past climate fluctuations and other environmental stresses or opportunities, and problems emerge in transferring lessons from traditional societies to rapidly changing ones and to the inter-connected modern world (Porter 1980; Butzer 1980). Even modern analyses tend to focus on isolated societies (Moran 1982; Torry 1983; Waddell 1975). Cultural models also tend to disregard individual innovation and choice, yet they command attention to important elements, such as tradition and belief, often neglected in positivistic social science.

POLICY/POLITICAL: Mann (1983) laid out a political research agenda for climate change including central concepts such as the role of interest groups, regulation, policy types, and models of modern political systems. Political processes obviously are central to social response to climate change, yet core political theories involving power relationships, government types and processes, and political behavior rarely have been injected into climate change research. Most political science studies thus far have been applied policy analyses (Glantz 1979; Schelling 1983).

ECONOMIC: Micro-economic approaches to climate change, pioneered by d'Arge (1979) and continued by Lovell and Smith (1985), treat climate as a commodity or resource that can be monetized (Ausubel 1980). Macro-economic or public welfare approaches assess climatic change as a public risk or distributive issue (Nordhaus 1980). Tools such as econometric modelling, cost-benefit analysis, and global simulation modeling have been proposed but rarely applied. The potential of market forces to reduce greenhouse gases and adjust to climate change is supported by hypothetical calculations (C. Weiss 1989), but not empirically validated.

The body of social studies of global climate change within these dimensions is marked by its pragmatic, problem-driven, and applied qualities; characteristics fashioned mostly by the need to inform policy response, not by goals of improving fundamental understanding of nature and society interaction. Social-analytical energy has been directed chiefly at impact studies and at assessments of the potential for changing industrial and energy systems to

reduce global change. These prescriptive studies are based on a mixture of logic, common sense, utilitarianism, and technology appraisal, and founded implicitly rather than explicitly on theoretical principle (typically rational choice and micro-economic concepts). This approach has not been particularly fruitful of new theory or conceptual models of nature-society interaction, nor has it illuminated the penultimate question of social ability to cope with rapid climate change.

Each of these thematic approaches has explanatory and predictive weaknesses. Taking a positivistic approach, however, and given a logical rubric for synthesizing and weighing the results of individual studies, we might begin to build a more holistic evaluation of social vulnerability to climate change by tallying the vulnerability and resiliency identified in each dimension. Assuming that societal integrity relies on all of these elements (and others), one could begin to identify weak links and vulnerable groups. Yet, such an additive approach still would not illuminate the broad questions of how large a threat global warming poses relative to other hazards, and how much effort should be invested in limiting and adapting to it at national and international levels. These questions have been neglected as we move quickly toward policy responses.

Building Linkages: Toward a More Unified Social Approach

Work within the traditional social science dimensions has helped analysts respond to demands for quick, policy-relevant studies, but has been less productive of the integrated concepts that seem, ipso facto, appropriate to the essential nature of global change. The overarching challenge in social scientific analysis is to link human dimensions of global climate change (in terms of both cause and effect) to integrative social theory.

It is probably wishful thinking to aspire to a theory of nature and society that unifies the social dimensions described above and encompasses the specific problems of contemporary interaction of climate and society. A grand theory would probably gloss over much of the real complexity of societies and their activities. When social scientists appropriated natural science concepts such as adaptation and evolution, they later realized that these models often were inadequate or misleading when applied to a social context. Biological models of adaptation, for example, only awkwardly apprehended the human quality of social response to the environment. They tended to stress equilibrium-seeking behavior despite the fact that social development has proceeded along a trajectory that scarcely reflects the dampening or negative feedbacks apparent in natural systems.

Rather than from grand theories (invented or borrowed), much of the progress in understanding the human place in the environment has come chiefly through synthesis of traditional knowledge structures (Turner 1989). Yet, social scientists have been slow to build linkages between their own disciplinary edifices (Chen 1983), suffer rivalry between hard (i.e., quantitative) and soft social science, and are far from fashioning an integrative concept of nature and society, or even a consistent body of explanation. Nevertheless, a few synthetic themes promise new insights on global change, especially as the corps of workers increases through the slow but steady drift of social scientists into environment-related research.[3] One focuses on collectives and their effect on individuals.

[3]Concerns over global climate change have increased the stock of environment-related research in the social and behavioral sciences, making it more acceptable and rewarding than just ten years ago.

INSTITUTIONS: New approaches to studying institutions as special social structures are emerging; institutions are viewed as displaying unique characteristics and response roles in the face of threats and as shaping the choices of individuals (Douglas 1986). Institutions may be as concrete as specific agencies or more conceptual, as in Rayner's (1984 and this conference) and Gerlach and Rayner's (1988) *institutional cultures*, regimes that encompass groups of similarly disposed decision makers. The institutional dimension also includes legal structures and mechanisms (E. B. Weiss 1983; 1989), but often with only a weak explication of how social values and goals are expressed through legal institutions. The perspective is weakened by organic or psychological metaphors (an institution's youth and personality), and by the lack of experience in social scientific analysis of political and bureaucratic processes vis-a-vis long term environmental issues (Mann 1983).

There is, indeed, a difference between how people behave individually and in groups, suggesting that institutions do not simply exhibit the additive characteristics of their constituent members. By spanning the micro/macro gap, perhaps through a searching analysis of institutional or political-economic constraints on individual choice (as begun in Rayner's work), we might also provide a tether between localism and globalism, as well as between individual decision makers (lay and professional) and the collectives to which they belong (e.g., natural resource institutions, farmer organizations, etc). Another important bridge has been built between politics and economics.

POLITICAL ECONOMY: The political economy is a traditional perspective that recognizes the intertwined structures of government policy and economics, but was neglected as social sciences specialized. It was resurrected chiefly by Marxists scholars and applied to several aspects of people-resource interactions, including drought in the Sahel (Watts 1983 and Glantz 1987), land degradation, and natural hazards, with a strong focus on culture. This revived dimension incorporates the split between narrow theories of how the economic world works (e.g., market economics—see Lovell and Smith 1985) and global theories about social processes, such as capitalistic transformation of traditional (non-market) systems (Watts 1983). More effort is needed to bridge this gap. One weakness is that the processes cited especially in Marxist analysis of the political-economy may be unique in history, thus offering little insight into further evolution of social systems in the face of global climate change.

Finally, a broad, and as yet rather poorly defined, research theme focuses directly on the relationship between nature and society at a broad scale:

NATURE SOCIETY: While traditional cultural ecology in anthropology highlighted culture per se, the contemporary version in anthropology and geography

(perhaps best termed nature and society to avoid the epistemological baggage of cultural ecology) is more concerned with the fundamentals of the nature society nexus, emphasizing resource management, and adaptation to environmental variability and constraints (Bennett 1982; Butzer 1989; Turner 1989). In geography the nature-society theme emerged as *human ecology* in landscape studies and natural hazards research, the former stressing human impact on the land and the latter focusing on social adaptation to the environment, mediated by perceptions, values, and beliefs. Several cultural ecologists now are involved in global change work, typically using a systems framework to link adaptation, human impact, and behavioral analyses (Butzer 1980; Kates 1985), occasionally in a cultural and historical context (e.g., Brookfield 1988). Perhaps a key weakness is the theme's adherence to a paradigm of equilibrium in which social systems are implicitly assumed to be seeking homeostasis with the environment. The mere fact of global change negates this assumption.

While broad and inclusive—and, for those reasons, congruent with the holistic concept of global change—the cultural ecology or nature/society theme lacks coherence and may simply remain a heterogenous collection of ideas and methods. Yet, in some fields such as geography it offers a potentially fruitful meeting ground for the often separated physical and social science sides of the discipline. Because of its genesis in cultural ecology and cultural geography, work in the nature society theme often incorporates the relationships between values, perceptions, beliefs, and environmental behaviors. This incorporation would aid our interpretation of the many attitude surveys likely to be conducted as we move toward a public policy response to the threat. More importantly, we could begin to establish a basis for answering the ultimate question posed by anthropogenic global change: what *ought* to be the relationship between nature and human society?

In terms of more concrete questions, work within these synthetic approaches, in concert with more traditional analysis, is needed to clarify the tension between prevention and adaptation. The rapid pace of greenhouse policy development makes the time frames of policy and science somewhat incompatible. Nevertheless, careful studies are needed to disclose how societies in different cultural, environmental, and developmental settings can cope with various aspects and degrees of climate change, and the most promising ways to reduce greenhouse gas emissions while maintaining economic development and social equity. A necessary condition for this progress is greater social science involvement in global change research.

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REPORTS FROM THE WORKING GROUPS

1. Is the International Community Capable of Social Learning?

Rapporteurs
David L. Feldman, Glenn G. Stevenson, Kai N. Lee, and William B. Wood

Social learning is the process by which a community or an institution observes and adapts to changes in its physical and social environment. The process encompasses the acquisition, processing, and dissemination of information in order to make behavioral and policy decisions. Obviously, communities or institutions do not literally make such decisions; rather social learning is the process by which the collection of individual decisions generates a course for the community or institution. The implicit goal of social learning is community or institutional survival. Hence social learning is the process by which a community or an institution adjusts its actions to suit environmental or social limits or new environmental or social imperatives.

Social learning is evident in a number of historical cases. For example, the migration to the Great Plains in the United States brought people to an environment for which old methods from the humid east, such as farming practices, water rights, living patterns, and other social conventions, were inappropriate. People devised new methods of dry-land farming and social institutions to adapt to the new environment. At the same time, the study of social learning investigates ways in which these settlers did not adapt to the new environment. For instance, they did not alter soil mining habits or adjust to the eventuality of 100-year droughts, which led to the Dust Bowl of the 1930s. Other examples of social learning include human migratory patterns as a result of losses of wildlife habitat or depletion of forests, as well as agricultural innovation in response to regional drought and desertification in other parts of the world.

Whether the international community can undergo social learning is uncertain. The people involved are more culturally diverse, communication is more difficult, and conflicts of jurisdiction may arise as interaction crosses national boundaries. In fact, these divergences bring into question whether these people even can be considered a "community," which is perhaps a prerequisite for social learning. On the other hand, the diversity in cultures may provide resilience and varying ideas of adaptation that a single culture might not offer. Which of these sets of factors is more important in social learning on a global scale? If the former, then it would be important to identify the elements that are necessary to create international cooperation to handle global scale problems. If the

latter, the disparate actors may be able to handle the problem acting severally.

Social learning defined as adaptation may take two basic forms. The first is an equilibrium form; participants resist change by adjusting social institutions to natural imperatives in an attempt to sustain resource use. The second is an evolutionary form in which greater social change occurs. Participants adapt to environmental imperatives with new behavior, and progress emerges. In either case, societies generally adjust their behavior at the margins, in order to minimize the inconveniences that have to be tolerated.

The study of social learning also investigates the level at which societies form policy. On one hand, agreement among the most important and influential actors in society may spearhead and lead the rest of society into action. This view holds that formal institutions emerge and manage problems, such as international agencies undertaking formal agreements on climate change. This hierarchical or elite-driven mode may work for some environmental problems. On the other hand, some argue that society, composed of individuals who go about their lives in spite of formal institutions, spontaneously and informally form the social course. Networks of individuals and institutions end up addressing environmental and social issues.

The institutional aspects of social learning present several angles of analysis. First, response to problems may occur in the building of either formal or informal institutions. The dichotomy between formal and informal institutional arrangements is closely related (but not identical) to the dichotomy between hierarchical, elite-driven institutions and individual and institutional networks addressing problems. Another institutional aspect of social learning is that it may involve either new or existing social institutions to solve problems. Evaluating the aspects of institutions and problems that are linked appropriately to each other and lead to solutions in some situations and not in others is one aspect of social learning studies.

Social learning also encompasses learning about the politics of social change. For example managing global climate change may require significant alterations in existing social, economic, and political structures. These changes could have such major impacts upon established, powerful interests as to forestall radical ameliorative measures. The necessary steps also may not generate sufficiently immediate payoffs to political leaders dependent on electoral or other forms of popular support to spur them to effective action. Societies generally do a better job of analyzing and responding to environmental and social problems in a short-term manner than they do in drawing up and implementing long-term strategies.

Social learning is a process of managing a long time-scale, high-uncertainty problem. The long time scale presents problems both for the community or institution undergoing change and for the social science researcher whose observations and analyses of social learning are made difficult. For the community, the uncertainty involved in the long time scale complicates decision making. Climate change exemplifies this difficulty. Scientific debate continues over the nature, extent, and time frame of climate change impacts, yet many call for immediate actions, lest delay in implementing social policy worsen the environmental impacts. Social learning, although slowed by the uncertainty, nevertheless results from the interaction among those who advocate action, those who say wait until the science is more certain, and the environmental changes observed along the way.

During the workshop, William C. Clark introduced the topic of tools and concepts to facilitate a conscious process of social learning. He discussed four aspects of the process: (1) determining the functions of social learning, (2) establishing criteria to evaluate the functions, (3) specifying the arenas and actors who learn, and (4) analyzing the structural factors that affect social learning. Clark suggested that the functions of social learning include assessing a hazard, assessing the options, managing the hazard, and gathering information for monitoring and communication. The criteria by which to evaluate these functions include adequacy of the assessment process, value (did we study the most important part of the problem?), effectiveness of the solution, and legitimacy (acceptance of the solution). Actors include individuals, government agencies, industry, political parties, scientists, the media, nongovernmental organizations, and supranational organizations. Finally, the structural factors that can affect social learning include the stakeholder structure (e.g., who wins and who loses), interest coalitions, the organization of science and technology, political institutions (e.g., European vs. American), and international relations.

Social scientists must resolve a number of problems in their study of social learning. One problem is measuring the phenomenon. Several measures may be appropriate, such as measuring adaptation, measuring vulnerability to environmental stress, or perhaps simply using survival or extinction of the community or institution. Also, some way of measuring learning on long time scales must be found. Another problem is whether observed changes in behavior represent real social learning or "superstitious learning." In particular cases, people may react to stimuli that the observer recognizes (presumably the stimuli to which one would react rationally) or they may react "irrationally" to unsuspected stimuli. Thus, what societies actually learn and what the scientific investigator believes they have learned may be different.

Several research areas emerged from the workshop discussions:

(1) How have communities and institutions learned to deal with socioeconomic and/or environmental change? Two types of case studies might provide insight into this issue: the first type deals with communities that have been forced to adapt to changing environmental conditions (such as farming communities in the Great Plains); the second concerns international institutions with mandates to manage some aspect of a regional or global commons (IPCC, UNEP, Mission to Planet Earth). Issues of scale would have to be addressed with respect both to the transportability of local learning to global knowledge and to the issue of appropriate levels of decision making.

(2) What is the international community? The plenary papers by Gerlach, Rayner, and Wood all emphasized the growing significance of nongovernmental actions. How do the actors and institutions that purport to membership in this community interact? Can we analyze the value of agreements and regulations passed in the name of the international community (i.e., UN conventions and protocols such as those discussed by Szasz and Thacher).

(3) How do different academic disciplines view social learning, particularly the responses to crises? How can scientists provide useful research amidst fluctuating funding commitments? A key research distinction is between perceived science (i.e., "our lakes are

dying, do something now") and factual, responsible science (given x, y, z variables and if we assume d, e, f, then a, b, c conditions may result). After the sense of impending crisis passes what happens to research activity on that subject—does it lead to a research dead end with little to show for the funds spent? Some case studies such as the synfuels program may have important lessons for climate change research. How does superstitious learning (i.e., forcing evidence to fit preconceived notions) affect funding programs?

(4) How do different groups perceive an environmental problem? How do these groups sustain themselves, given their perceptions? The focus here might be on cross-cultural surveys of different groups faced with similar problems (chronic drought or floods). Do these groups take a preventative, mitigative, or adaptive approach to the problem? What kinds of strategies do they use? How well do these strategies work and under what conditions? How might this line of research influence management of environmental commons issues (some of which is available in the literature on perceptions of natural hazards as well as in the literature comparing national chemical and nuclear regulations)?

(5) If there are two levels at which social learning may be implemented—by elites who are allowed to manage the commons and by communities who must adapt to new conditions or regulations—what is the relationship between the two and how can learning bridge the gap between them? What are the learning criteria for these different groups? How can their results be measured?

(6) How do social or institutional systems become better or worse at managing vulnerability? How can a vulnerability assessment of relative risk to institutions be carried out when there is little data?

(7) How do institutions learn to make tradeoffs between clear and flexible policies? How can tradeoffs be estimated? Are there institutional decision processes able to make tradeoffs once institutional patterns have been established?

(8) What are the effects of boundaries on the institution doing the learning? Does learning take place only at the individual level? How does learning informal organizations differ from market learning via competition? What is the process of learning among multilateral organization networks operating with mixed cooperative-competitive incentives?

(9) What is the significance of time scales: term of office, careers, business cycles, evolution of national economic leadership (e.g., Japan) and economic dependency (e.g., sub-Saharan Africa)?

(10) What is the relationship between substance and process? What are the limits of applicability of models of the learning process? Global change must be managed within a historical context, in which configurations of organizations, nations, power, and material resources are all given at the outset (as is the three-dimensional geography of the globe and atmosphere). We do not have the ability to observe or simulate all possible configurations of actors responding to all sets of circumstances. What are the strategic limitations imposed upon this single-play game?

(11) How important are leadership/mobilization styles, given the heterogeneous nature of participants (including citizens and firms affected by global change but only distantly coupled

to the management process). How can leadership continuity be sustained in a multilateral setting? What are the costs and risks of strategies for doing this? How can the dangers of panic and overreaction be handled?

To explore these questions, two types of case studies might be undertaken. The first involves studying communities that are forced to respond to changing an adverse environment. How have they evolved? How have they learned? How do they cope with change? How have they adapted? The study of change as people moved onto the Great Plains is an example of this type of investigation. The second involves studying international institutions, asking questions similar to those posed communities: how do they evolve, learn, adapt, and cope with change? Examples of international case studies that might advance the understanding of social learning through institutions include the history of international monetary agreements from Bretton Woods to the "EC Snake" to informal agreements on acceptable exchange rate ranges; the history of the Montreal Protocol on CFCs; the emergence of the Intergovernmental Panel on Climate Change; the successes and failures of international commodity price stabilization schemes; the evolution of the Med Plan and other regional seas treaties; and the history of international nuclear materials and technology regulation.

2. What Institutional Strategies Could be Used to Manage Indeterminate Global Uncertainties?

Rapporteurs
Ronald Brickman and Steve Rayner

This workshop proceeded from the characterization of scientific and decision problems of climatic change as nonlinear and highly complex. They can be represented by three kinds of scientific inquiry predicated by two variables, systems uncertainty and decision stakes (Fig. 1). Systems uncertainty describes the elements of inexactness, uncertainty, and ignorance encountered in technical studies; decision stakes refers to the costs and benefits of the various possible decision outcomes for all relevant parties[4].

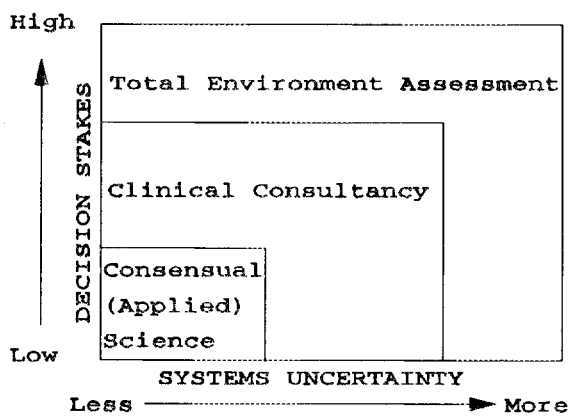


Fig. 1. Three kinds of science.

Low systems uncertainty and decision stakes describe situations in which databases are large and reliable, technological choices are straightforward, based on good statistical or actuarial information about past performances, and the technical community largely agrees on appropriate methods of investigation. This combination is the province of consensual or applied science. When both systems uncertainty and decision stakes are higher, but professional expertise is still a useful guide to action, we enter the clinical mode of technical consultancy. This kind of activity is exemplified by medical practice in which quantitative tools are supplemented explicitly by experienced qualitative judgment. Finally, when both variables are very high we find total environmental assessment, where differences in opinion are clashes of world views.

At the present level of knowledge, particularly in light of the very high uncertainties among scientists concerning regional distributions of impacts, it is clear that the climatic change issue ranks high on both systems uncertainty and decision stakes. Many participants in both the scientific and policy communities (e.g., by the International Geosphere-Biosphere Program) assume that reduction of systems uncertainty will make problem resolution more straightforward.

However, even spectacular progress on the scientific front may only reveal the limitations of reducing uncertainties in the complex interactive biophysical and socioeconomic systems that control the global environment to the level of consensual applied science that is susceptible to decision making with known probabilities and outcomes. If such proves to be the case, established models of decision making under risk (designed to reduce the occurrence or impact of undesired, but predictable, outcomes) are likely to prove unhelpful and may even mislead decision makers.

[4]Funtowicz, S. O. and J. R. Ravetz 1985. "Three Types of Risk Assessment: Methodological Analysis," in C. Whipple and V. Corello (eds), Risk Analysis in the Private Sector (Plenum) New York.

The workgroup, therefore, decided to explore the contrast between a formal analytic model of the rational "policy fix" approach appropriate to known risks and the formal properties of a deductive model of risk analysis and management designed to develop a "resilient response capability." The contrast between the two ideal-typical approaches is illustrated in Table 1 with respect to goals, equity, problem identification, preparation, early warning indicators, information sharing, and cost calculation.

The policy would be adopted if the proposed policy will solve the problem within a known time and cost. However, the flexible response strategy is oriented towards more open-ended problems that are recognized to involve different means and different actors over time.

Identification of consistent analytic packages of this sort need not imply that actual environmental management institutions will or need to adopt one mode to the exclusion of the other. The workgroup considered each mode to exhibit strengths and weaknesses. The question is rather one of what mixture of modes is best adapted for different problems or stages of a problem, and what mixtures actually can be achieved or sustained within different institutional contexts. It was suggested that strongly centralized institutions and those with strong oppositional agendas would favor the relative unambiguity of the policy fix. It was noted further that the UN system generally tends to favor the status quo as an example of bureaucratic, centralized design, notwithstanding the inability of UN organizations to implement centralized solutions.

Table 1. Two ideal-typical institutional strategies for climate change

Characteristics/strategy	Policy fix	Building resilience
Goals	Clearly stated with performance criteria	Discretionary action to reduce effects as costs and information permit
Equity	Liabilities clearly specified for actual damages	Wealth transfers as compensation in broad categories
Problem identification	Isolate problems in space and time (reductionist)	Link solutions (holist)
Preparation	Commit resources in advance of crisis	Expand coping capacity
Early warning	Monitor causal triggers	Monitor impacts
Information sharing	Transfer skills and technologies in advance	Maximize information flows
Cost calculation	Monetize benefits and costs	Include nonmonetized risks and costs

A series of case studies was suggested that would include a range of international institutions. These institutions were: the Organization for Economic Cooperation and Development (OECD), the UN Environmental Program (UNEP), the Intergovernmental Panel on Climate Change (IPCC), Greenpeace, British Petroleum (BP), the Organization for African Unity (OAU), the International Council of Scientific Unions (ICSU) and the Catholic Church. The workgroup made a self-consciously quick and dirty prediction of which strategy would be likely to predominate *ceteris paribus* in each institution (Fig. 2).

CASE STUDIES		
Inter-national Institutions	Policy Fix	Flexibility
OECD	X	
UNEP		X
IPCC	X	
Greenpeace	X	
BP		X
OAU		X
ICSU		X
Catholic Church	X	

Fig. 2. Workshop prediction of strategy preferences on eight international institutions.

Although extensive field research would be required to test these predictions, the notion that such prediction is possible raises a variety of research questions:

- What internal structural or organizational factors might lead institutions to favor a particular strategy or mix of strategies?
- Do strategy preferences vary with the decision arenas (i.e., do institutions favor different decision principles internally from those they would favor for societal choices)?
- What consequences for an institution's organizational capacity, appearance to constituencies, and longevity follow from choosing a strategy?
- How does choice of a strategy influence institutions' abilities for social learning?
- How is behavior and choice of a strategy affected by whether the situation is perceived to be a crisis or a chronic condition?

Finally, a series of criteria were proposed by the workgroup for evaluating any institutional strategy. These criteria included:

- instrumental effectiveness
- responsiveness to new information
- fairness
- ability to reduce opportunity costs
- ability to link protective strategies to other, uncontentious goals
- ability to achieve societal legitimacy
- ability to reduce transaction costs.

Consideration of institutional strategies raises the inevitable question, what is the relative *clarity* of material/environmental factors vs. social ones in dealing with social change? The material constraints imposed by the natural world appear to be better defined than the social possibilities of institutional change: we don't know how well societies can adapt, limiting the force of the argument for prevention; radically different ideas all seem equally plausible. It isn't apparent what is the scarce factor here, though the environmentalist argument is that

climate sets limits. If that is true, then the social alternatives are *not* in competition with one another; economically, we are so far from the possibility frontier that arguments about which ways work (better) are beside the point. So it may be better to proceed adaptively at the institutional level, finding out who does what better, rather than trying prematurely to settle on optima.

3. What are the Problems of Equity and Legitimacy Facing a Management Strategy for the Global Commons?

Rapporteurs
Robin Cantor and Roger Kasperson

Managing the global environmental commons raises many problems of equity and legitimacy, some obvious, others more subtle. Plenary papers on intergenerational equity by Douglas MacLean and on geographical and developmental issues by Roger Kasperson provided the starting point for the workgroup's discussion. The social, political, and ethical grounds for a range of common assumptions were questioned, including:

- Are we obliged to protect future generations from uncertain impacts that we understand only poorly?
- Will the legacy of risk created by global industrialization outweigh the legacy of benefits?
- Should protection of future individuals take precedence over current development needs, especially when protection of those individuals may result in them never being born at all?
- Is prevention of global environmental change morally preferable to adaptation?

No consensual resolution was reached on these issues, except that disagreement about them is likely to be continuing and pervasive in international negotiations over such policies as greenhouse gas reduction targets.

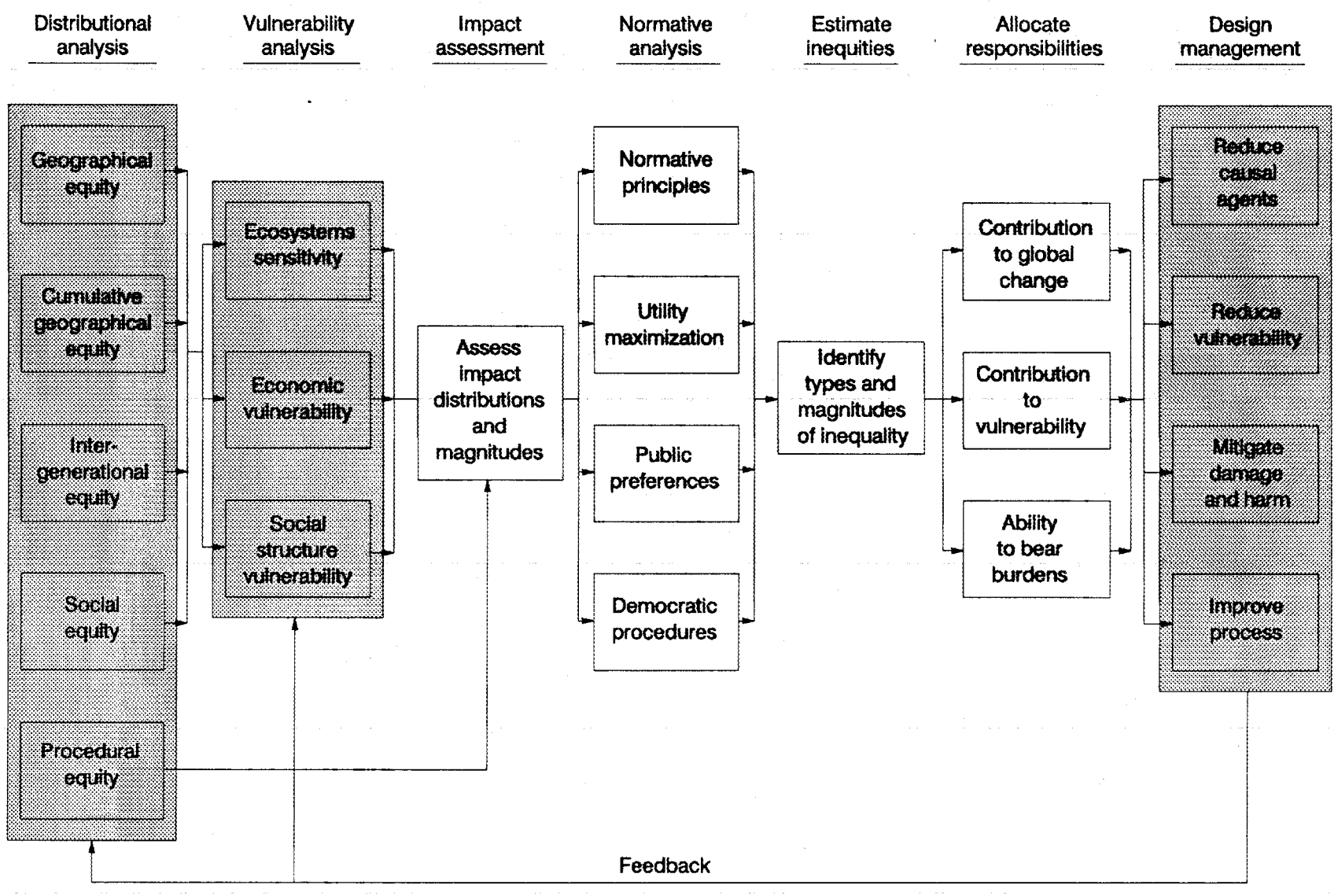
Whereas developed countries have contributed most to present increases in atmospheric CO_2, emissions from developing countries are likely to exceed those of the OECD early in the first decade of the 21st century. Whereas wealthy countries may be able to afford adaptation to climate impacts, poor countries are more vulnerable to even smaller perturbations of climate. Who should pay for technology transfer to developing countries so that they can develop without increasing greenhouse gas emissions? What is the ethical legitimacy of calls for ecological development funds to be provided by wealthy countries to assist poor countries to adopt higher cost CFC substitutes?

Following the Kasperson framework (Fig. 3) for equity analysis, the group also addressed the issue of how to design a research program to study equity and global change. In addition, the inputs to Kasperson's framework were considered and a model of the equity process was proposed.

A framework for equity analysis. To begin, Kasperson defined equity as the fairness both of the process by which a particular decision or policy is enacted and of the associated outcomes. This definition suggests that a framework for equity analysis needs to consider two major types of equity studies: distributional equity and procedural.

- *Distributional equity* refers to the fairness of the distribution of substantive outcomes, or impacts, arising from a particular project or development.
- *Procedural equity* refers to the fairness of the particular set of procedures used to arrive at policies and decisions for

FIGURE 3. FRAMEWORK FOR EQUITY ANALYSES OF GLOBAL CHANGE



managing global environmental hazards. Critical to procedural equity will be the determination of legitimate interests and the allocation of rights and responsibilities among them.

Distributional analysis. Depending upon how population groups are categorized and processes and outcomes defined, there are many potential types of equity problems. Indeed, the richness of the equity treatment depends heavily upon the diversity of theory mobilized for the analysis and the imagination of the analyst. Here, five principal equity problems are raised that each, in different ways, have received substantial attention (if not analysis). Four—geographical equity, cumulative geographical equity, intergenerational equity, and social equity—involve outcome or end state considerations; the other—procedural equity—focuses upon the processes employed.

Vulnerability analysis. The distributional considerations discussed above focus on outcomes over regions, generations, and social groups. Impacts, however, are not spread over a homogeneous surface at any of these levels. The magnitude of change or impact depends not only on the magnitude of environmental change—the centimeters of sea level rise or the number of hectares of low lying coastal land inundated—but of existing social and ecological conditions. Three sets of factors are important to the vulnerability of impacted populations: ecosystem sensitivity, economic vulnerability, and social structure vulnerability.

Risk/impact distributions. By examining the interaction between potential distributions of effects over regions, generations, and social groups and the respective vulnerabilities of the affected ecosystems and populations, some estimates of the risks and impact distributions that will have to be borne may be made. Currently these effects necessarily remain highly uncertain and only very grossly apparent. In many cases, the impacts will be suggestive only or conditional on particular scenarios. As noted above, the incident of impacts will not be locatable in space or (perhaps) time for many types of global change. Nonetheless, the state of empirical knowledge supporting equity claims and arguments needs to be confronted as clearly as possible. Indeed, it is highly likely that equity arguments will need to be framed *in terms of* certain types of ignorance and ambiguities.

Normative analysis. Armed with these empirical analyses, it is next necessary to make judgments concerning the major types and magnitudes of inequity that would be associated with particular types of global environmental change. But this is possible only if some normative principal or standard is available that defines fairness. No absolute consensual standard of fairness, in our view, exists, but alternative notions of fairness can be used to show differing pictures of inequity emerging from the application of different value systems.

Estimating types and magnitudes of inequities. With the application of one or more normative principles to the estimated risk/impact distributions, major patterns of inequity should become apparent. Again, while specification of absolute magnitudes of inequity certainly will elude any calculation, characteristics of types or gross magnitudes of relative inequity should be possible to discern.

Allocation of responsibility. The next step is some strategy for determining the allocation of responsibility among those who potentially could bear the burden for redressing inequities. This is likely to be a highly contentious part of equity analysis and claims made in behalf of equity. There are three primary bases for allocating such

responsibility: contribution to the global environmental degradation, contribution to vulnerabilities, and ability to bear the burdens for reducing potential harm.

Designing management strategies. Once the inequities have been characterized and responsibilities have been allocated, questions inevitably center upon what should be done. Much of the discussion flowing out of the analysis of physical causation and effects specifies that emissions should be reduced by X or that technology Y should be phased out by year Z, with scant or no attention to the socioeconomic or political feasibility of such interventions or to the impact upon other socially desired objectives (e.g., the burning of China's coal supplies for energy production). Indeed, for any type of global environmental change, a wide variety of policy responses is available, consisting of some mix of reduction in causal factors, reduction in vulnerability of those impacted, mitigation of the harm, and improvements in the policy process itself.

Modeling the equity process. The results of the workgroup's deliberations on inputs to the Kasperson framework are shown in Fig. 4. We began with the general proposition that conflicts over equity (or desired changes in the standing distribution of equity outcomes) arose because the rules and duties implied by a policy decision (or some other "shock" event) did not coincide with the preferences of various constituencies for these social and personal outcomes. The consequence of such a mismatch is social conflict and the labeling of the outcomes as inequitable by one or more stakeholders.

The group expanded this simple proposition by next considering how policy decisions gave rise to conflict. Each policy decision may be translated into a set of implied rules affecting distributional and political balances. These rules indicate new or changed duties, rights (both individual and over property), expectations of the effects of rules or future rules, and communication channels (how people can communicate their reactions to the changes). We call the implied rules matrix A in the figure.

Concurrent with the implied rules, stakeholders will have preferences for rules and outcomes. These preferences affect the acceptability of the implied rules as evaluated by the stakeholders. The preference matrix is labeled B in the diagram.

Finally, the political attention focused on all stakeholders, disgruntled or otherwise, is regulated by existing conditions of political and economic leverage in the larger social system (matrix C). We could have incorporated C in the implied rules matrix (A), but we felt that that area needed special modeling attention.

A policy shock, which might be as subtle as a change in the expectations of certain stakeholders, initiates the process. The changed rules (expectations, etc.) define new duties and rights that are evaluated by stakeholders with preferences. The results of this match lead to perceived distributional and fairness outcomes, all tempered by the leverage conditions. These outcomes are consistent with those required by the Kasperson model. The feedback arrows in the diagram indicate that the process has many complicated interactions, which may not be represented well by sequential process modeling.

After outlining the equity process model, we discussed how it might be applied to case studies to consider the usefulness of equity modeling. Some of the cases that occurred to us were: the Law of the Sea negotiations, post-WWII reparations, refugees, famine responses, natural disasters/ world crises, Montreal Protocol and responses, deforestation in the small and the

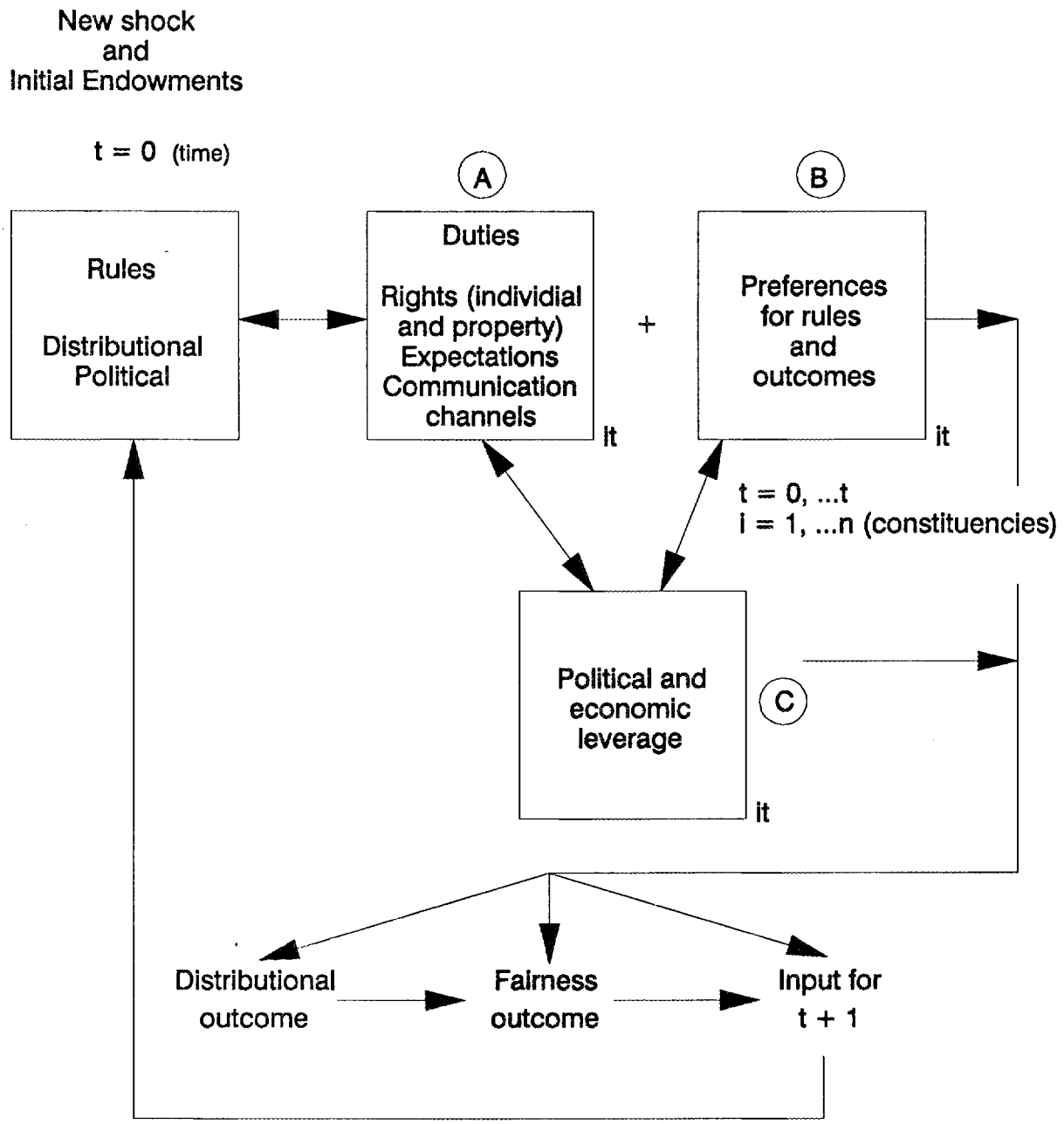


FIGURE 4. AN EQUITY PROCESS MODEL TO UNDERSTAND EQUITY INPUT TO THE KASPERSON MODEL

large, and the Iran/Iraq War. One point we did not discuss, but recognized as important, was the selection criteria for the case studies. This area, in addition to more thought about the model and its usefulness, requires further consideration.

Ethical considerations of international negotiations. The workgroup also addressed the issue of competing ethical negotiating paradigms that could exacerbate conflict in international efforts to manage the global environment. Multilateral management of problems involving the global commons will require bringing participants to the negotiation table. Enticing participants to negotiate a set of international agreements is complicated by multiple objectives, world views, abilities to pay and play, and sovereignty concerns. Two well-known models from the economics literature are relevant for the negotiation problem: Coase's model of social cost[5] and Rawls' criterion for social welfare.[6] These models were developed originally to address problems only loosely related to bargaining among economic agents (in fact, the Coase paper ignores the process of bargaining and Rawls was concerned with the distribution of social welfare). However, they have come to represent, either implicitly or explicitly in the recommendations of policy analysts, different paradigms underlying strategies for making international environmental bargains. The extent to which the strategies are incompatible, or unrealistic for the global warming problem, is a timely research question.

The Coase prescription for bargaining requires complete identification of the externalities of resource use, and consequently, of the winners and losers of economic decision making. Disputes are resolved, and economic efficiency is restored, either by winners compensating losers for environmental damages or by losers bribing winners not to pollute. Thus, discovery and clarification information about the distribution of environmental outcomes are fundamental inputs to a Coasian bargain.

The Achilles' heel of the Coase strategy is its assumption of equal bargaining power among participants, or zero costs of making the bargain. To apply the strategy successfully in the real world of climate damages, we need a better understanding of how to equalize bargaining power among participants or how to design a system where such power is powerless.

In contrast, the Rawlsian strategy uses the veil of ignorance about winners and losers to entice participants to strike a bargain. Since no participant can guarantee he/she will not receive a devastating outcome, risk averse players will want to minimize such possibilities. Thus, bargains are more likely to occur in an information-poor environment. Ignorance, not active discovery of information, is a valuable motivator for the Rawlsian bargain.

Because information is suppressed, intentionally or passively, Rawlsian agreements may be subverted by free riding and cheating. (Cheating may be a factor for the Coasian strategy as well, but it is likely to be exacerbated by poor information discovery.) Innovations for enforcement and compliance mechanisms that do not rely on winner and loser information will be necessary to make this strategy effective.

The two negotiation strategies not only dictate completely opposite roles for the discovery of information, but also suggest different emphases for research agenda that ultimately (hopefully) would contribute to

[5]R. H. Coase 1960. "The Problem of Social Cost" in *Journal of Law and Economics*, October.
[6]J. Rawls 1976. *A Theory of Justice*, Cambridge, Mass.: Harvard University Press.

bargaining among diverse international participants. Furthermore, the veil of ignorance is incompatible with the professional pursuits of those in the natural sciences who are somewhat compelled by the ethics of their disciplines to discover winner and loser information regarding climate change. Thus, policy makers attempting to follow the Rawlsian strategy for multinational bargains are racing against the production of scientific knowledge and the tenacity of the scientists who produce such knowledge.

What is needed to understand negotiation strategies more fully is analysis of the opportunities and constraints of pursuing either paradigm. Examining historical experience with agreements may be helpful. However, any serious attempt to implement either strategy will require a thorough investigation of the respective flaws.

Final observations. The issues addressed in considering the equity problems in global environmental change are sufficiently complex and our thinking about them sufficiently early that conclusions about our proposed framework are not possible. Rather we set forth several observations for further steps:

(1) important contributions of equity analyses associated with global environmental change could be to clarify the interactions of empirical and normative questions, and to distinguish basic from more superficial or transitory problems;
(2) credible equity assessment needs to be sensitive to, and capable of internalizing, history and the broader ebb and flow of societal interactions as well as the existence of other global inequities;
(3) the creation of global data bases and monitoring systems should be structured to provide information relevant to delineating equity over space and time and geared to relevant population groupings;
(4) the equity issues associated with global environmental change are distinctive as compared with more traditional equity domains in their high degree of uncertainty, ambiguity, and unlocatable impacts;
(5) competing normative analyses may be especially useful in a setting where cultural differences are almost certain to be diverse and rich and where little consensus on moral imperatives or tradeoffs between competing social goals may exist;
(6) the existing vulnerabilities in ecosystems, economic, and social structures may amplify and concentrate impacts and deserve greater attention in attempting to foresee possible consequences.

4. What are the Potential "Big Surprises" that could Thwart Global Cooperation?

Rapporteur
Carl H. Petrich

> If you act as though it matters and it doesn't matter, then it doesn't matter. But if you act as though it doesn't matter and it matters, then it matters.
>
> *message below a poster showing the Sydney Opera House being engulfed by sea level rise*

This working group discussion began as somewhat of a lark. The group had continued to discuss an earlier suggested theme way beyond the allotted time and found there was too little time to adequately work through the current theme before the end of the day's activities. A member mentioned that workshop conversations to that point had occurred in a vacuum: what if global warming were to *actually take place in a real world*, i.e., one in which sudden, unforeseen events might change everything? We decided to have some fun playing futurists, proffering alternative scenarios that could arise and upset the current understanding of managing global climate change. We also realized that the workshop did not appear to be considering the inexorable march, the apocalyptic inertia, of major social trends such as uncontrolled population growth and militaristic nationalism. So, as an add-on, these issues also formed part of our group exercise.

This report is an account of what was discussed, how it was received by the workshop, and some reflections on what that reception might have meant. Admittedly, the group acknowledges that one of its purposes was to tap the larger group's collective shoulder and politely remind them of the importance of time and the future of major biophysical realities and social issues.

MAJOR DISCUSSION POINTS

Big Surprises. Starting with the "Big Surprises," as we called them, the group differentiated between technological breakthroughs that might throw curve balls at the present understanding of the global climatic change challenge and human behavioral turnabouts that conceivably may occur (and perhaps be even more surprising).

Technoglitz. A mere listing of potential breakthroughs should suffice in providing a sense of the way the world could be significantly different from the one the whole workshop posited as it moved through its discussions during the first two days. To communicate a more complete sense of the far-reaching spirit—and implications—of the group's brainstorming, here is a slightly longer list than the one our group tendered in its short time:

- nanotechnology/molecular machines
- high-tech ("fine") ceramics
- high-performance plastics
- advanced composites
- biomaterials and biopolymers

- synthetic diamond films
- drugs offering significant life extension
- more equitable distribution of global information
- effective, simple, inexpensive, safe birth control
- inexpensive, high-temperature superconductivity
- attainment of the breakeven point in thermonuclear fusion
- through the human genome mapping project, the ability to predict precisely one's life expectancy.

Radical Changes in Human Behavior

- A dramatic global ascendancy of Postmodernist social organizations such as the Europeans' Greens, which transcend the modern world's individualism, anthropocentrism, patriarchy, mechanization, economism, consumerism, nationalism, and militarism... and support the ecology, peace, feminist, and other emancipating movements;
- through some now unknown mechanism, a global embracing of Herman E. Daly's (and others') idea of a steady-state economy (an economy with constant stocks of artifacts and people); an alternative to growthmania;
- implementation of True Peace (absence of organized violence, combined with social justice, human rights, prosperity, security);
- global recognition of the "New Heresy"; Willis Harman's ideas that a profound shift is taking place in the metaphysical assumptions underlying the modern world. For a large portion of the human race, neither religious ideas nor Cartesian, scientific reasoning provide satisfactory phenomenological explanations. They, accordingly, continue to define a new spiritualism;
- emergence of a charismatic leader, revered on a global scale, who can champion environmental values and empower individuals to choose their futures;
- dramatic acceleration in the rate of diffusion of new technologies;
- a new pandemic on the order of AIDS
- drug wars;
- racial and sexual discrimination paling in comparison with genetic discrimination based on human genome maps of individuals;
- end of history: were partial validity in the U.S. State Department's Francis Fukuyama's argument that, with the rise of Western Civilization since World War II and the apparent end to the Cold War, history is wholly evolved;
- convergence of capitalism and socialism: broad and growing consensus worldwide that democracy and loosely controlled free markets with built-in safety nets work better than any other system;
- caveats (possible ruptures to the end-of-history concept):
  - breaking up of the EEC,
  - serious social conflict in Japan,
  - global deflationary depression,
  - fierce U.S. protectionism,
  - nuclear accidents and sudden stop to nuclear programs: 67% of Americans now think that nuclear weapons are more likely to be used by terrorists or non superpowers,
  - discovery of a huge non-Middle East oil field,
  - Thomas Gold's nonfossil oil theory proved correct,
  - brutal and lasting break in Persian Gulf oil supplies.

The World Problématique. This concept embodies those apocalyptical trends that have positive feedbacks, compounding one another in a context of increasing terrorism and militarism. These trends may become the overarching issue for the next 40 years in the way the Cold War defined our view during the last 40 years, as Jessica T. Mathews has said. In the summary article in a special global environmental management issue of *Scientific American*, William D. Ruckelshaus writes that dealing with these problems will require "a modification of society comparable in scale to only two other changes: the agricultural revolution of the late Neolithic and the Industrial Revolution of the past two centuries." While those precedents were "gradual, spontaneous and largely unconscious," the environmental revolution, if there is to be one, "will have to be a fully conscious operation, guided by the best foresight that science can provide—an undertaking that would be absolutely unique in humanity's stay on earth."

While those attending the workshop are all generally familiar with a litany of apocalyptic problems, a brief listing, excluding global climate change and many other environmental challenges, conveys the idea:

- undeclared nuclear proliferation (China was last to announce, and that was 25 years ago). India, South Africa, Israel most likely now have nuclear weapon capability. Argentina, Brazil, Iran, Libya, Taiwan, S. Korea soon will have it;
- Third World potential for explosive demands for redistribution of world's wealth;
- militarization rates, especially in developing countries;
- population explosion: global doubling time = 39 years for world; Africa = 24; Central America = 27; South America = 33; Asia = 36; Soviet Union = 70; North America = 97; Europe = 269;
- megacities: the million-plus club reached 258 in 1985; 511 by 2010...associated urban dynamics, pathologies, vulnerabilities.

How Adequate are Social Forecasting Methods? The group raised the question of how society possibly can plan in the context of the above? One suggestion was that society needs better canaries to detect more accurately and earlier when some of these above forces are operating at or near critical levels for environmental/human coping. Some observers (e.g., Lester Brown) now argue that various thresholds already have been crossed. Someone else suggested that the country needs a state-of-the-environment measurement capability similar to the Bureau of Labor Statistics or Bureau of the Census. The problem, however, requires more than improved warning systems; society also needs improved capacities to listen and act—to translate the warnings into economics and politics.

INFLUENCE OF GROUP'S DISCUSSIONS ON WORKSHOP

The workgroup's discussions had an odd influence on the workshop. After the initial presentation of ideas to the larger group (at a decidedly secondary level of importance to the workshop's agenda), the concepts were never really engaged again[7]—but also never discarded. They survived to the end of the workshop when they were listed as some of the major conclusions of the whole effort,

[7]An exception is the presentation given by David Pimentel.

without ever being comprehensively discussed. We think this happened in part because forecasting is an imperfect and dangerous business. Whatever the domain to be forecasted, it is certain to be embedded in a larger system whose dynamics are poorly understood. At the workshop, it was safer to deal with *only* the uncertainties of how to manage global climate change.

The French believe that the future must be studied with a view to illuminating the present—*la prospective*—which is a mode of thinking *for* action and *against* fatalism. It supplies a key to understanding and explaining crises; it recognizes that the main focus of planning is not the plan, but the process of reflection and concentration which leads to it. For the larger workshop to discuss alternative futures that might influence how one thinks about global climate change, the workshop and its process would have had to give up some control. The need to predict creates the need to control. Effective control means reducing uncertainty. And how does one put a lid on the Pandora's Box that our group discussion opened?

CONCLUSIONS

Externality. As a workshop, we may have been guilty of what economists often do, we made into an externality whatever could not be quantified readily. That is, a disturbingly relevant factor that does not fit into the current mode of analysis is shelved to facilitate thought about some other current mode of analysis. Big Surprises became externalities.

Need to be "Pragmatic". As social scientists with at least a foot in the door to the political arena, we fear that we will not come across as pragmatic, i.e., that we will be accused of being idealistic or philosophically speculative, and therefore, ineffective at gaining the ear of decision makers. In short, when it comes to the normative side we frequently opt for reticence, whereas on the descriptive side we tend to present the whole *problématique* in all its horrific potential. At the root of these tendencies is the complex assumption that the current political structure of the world is a given. Therefore, recommendations for action must be designed to fit the conditions, despite our conviction that the existing structure is what generates the gridlock of problems we face. Such gradualism at the outset is itself a mental habit, or worse, a conscious strategy. Yet, it is also clear that those who have the power to make decisions today will barely listen even to whisperings of this kind. Thus the problem becomes: what is to be done when one is caught between incalculable events and institutional structures that often are uninformed and always unwilling to act beyond whatever it is that they have to consider as their immediate self-interest? We hardly have the language to express such thoughts, let alone the sensitivity to listen.

When faced with a multiplicity of problems, an even greater multiplicity of potential systems of intervention must be considered—and all at once. The inevitable, ever-present temptation is not to seek better understanding in order to bring into play hidden potentials, but to force reality by violating the complexity. Simplification relies on the concentration of power and/or the control of information. As the workshop repeatedly chose not to face the complexity represented by the alternative futures unfolding outside of the uncertainties of global climate change, what perverse results and linkages went unexplored?

The Doomsayers' Legacy. Donella Meadows remarked that once the researchers, *The Limits to Growth*ers, involved in the Club of Rome studies got saddled with the label *doomsday predictors*,

all thoughtful discussion of the contents of their reports ceased.[8] She relates that the message they were trying to get across was simply the old Chinese saying, "If we don't change our direction, we will end up where we are going." Not "Doom," but "Doom, if...." The danger of being perceived as one who accentuates the negative is that each new scientific discovery, each technological innovation, each new theory of society, strikes the popular mind as trouble to be avoided with no corresponding opportunity to be grasped. Worse than Cassandras or ones who are ignored, doomsayers risk creating a mindset that could paralyze the collective will to tackle new kinds of problems that pose the greatest threats to the human species.

There is a cultural sense that the future is not created by us; it is something that happens to us, not something that is chosen by us. Thus, a simple warning about how to avoid trouble becomes a doomsaying, an unconditional prediction of trouble. Donella Meadows points out that the very term *Cassandra* reinforces the idea that we are predicting instead of offering choices, and therefore affirms one of the information sphere's most damaging assumptions: people are helpless to affect the future. Even worse, it reveals a deep assumption that we as researchers may be making about ourselves: we are ineffective, and no one will listen to us. This assumption can become a self-fulfilling prophecy.

Most workshop participants likely have experienced the sense of not being listened to when speaking of the seriousness of environmental and other challenges facing the globe. In a sense, we at the workshop had a chance to stop disempowering ourselves by addressing these issues frankly, honestly, and creatively. We could have stopped expressing the Cassandra in each of us by improving our ability to see the consequences of present actions, by boldly presenting alternative courses of action, and—most important—by freeing ourselves of the curse of being ignored. However, we declined that opportunity, even among the safe company of our peers.

[8]A new round of label-mongering is occurring: *The Wall Street Journal* (October 5, 1989) editorially assigned the moniker "quasi-religious crusade" to the current talk in the national press about management of global environmental problems; called Lester Brown and Paul Ehrlich "perceptual apocalyptics" who "rattle off their anthemos of doom"; referred to these current issues as "a smorgasbord of apocalypse"; and referred to Stephen Schneider speaking on global warming as "a frisky environmental policy analyst."

CLOSING REMARKS

WORKSHOP SUMMARY AND CONCLUSIONS

Richard C. Rockwell

One of the aims of the organizers of this workshop was to contribute to the research initiatives of the Social Science Research Council. The organizers asked me to say how the workshop has done so.

To answer this question, I shall briefly describe the SSRC program. First, we must understand that the SSRC program is intrinsically *not* a social science program. Our program will be a failure if it develops and pursues an agenda rooted solely in the social sciences. It aims, instead, to tackle problems that arise at the interstices of the social and natural sciences. We are in search of problems that are significant across disciplinary boundaries and that researchers can define and pursue in interdisciplinary collaboration.

Second, the SSRC program focuses not on global climate change but on the whole range of environmental changes that occur on large scales of space and time. Among other changes of possible interest are the decrease of ozone in the upper atmosphere, acid rain, soil degradation and erosion and the consequent decrease in arable land, water shortages, long-lasting and widespread environmental pollution, and loss of biological diversity.

The SSRC did not attempt to define a new research agenda to connect social science to research on global environmental change. Instead, it simply lifted an agenda from study committees, commissions, and conferences over the past decade that identified key problems that are intrinsically both social and natural science in content. The agenda consists of six projects with which we will start our program, although the new Committee for Research on Global Environmental Change may well add to or subtract from this list. For each project, I will briefly describe a central aspect of the committee's work.

Land use: This project will develop a theory of land use that will be informative about the present map of global land use and that may instruct us about the range of possible global maps of land use in 2050. The committee will undertake this effort in collaboration with the National Research Council's Committee on Global Change.

Sustainable development: Is there any possibility for an operational definition of this concept? Is it plausible to identify a particular form of development as sustainable or unsustainable, and on what criteria? Or is the concept merely current political rhetoric?

Epidemiology of global change: This project is new to the extant research agenda, but it addresses a major assertion about

environmental change: environmental change will have negative health effects on human beings. Assessing such effects requires long-term knowledge of how the health and functioning of human beings is in fact affected by environmental change. This calls for a global epidemiology of global change. What do we need to be measuring on the world's population to tell us about effects on human beings?

Environment and security: What are the security threats, and perhaps the opportunities, created by environmental change? How might environmental change affect international relations and the abilities of nations to determine their own destinies?

Institutions and interdependence: This workshop focused on one aspect of this problem, that of managing the global commons, with special reference to the human response to climatic change. We hope to consider the whole set of management problems posed by environmental change.

Usable knowledge: How can science create and communicate knowledge, probably laden with uncertainty, so that policy makers can make robust decisions—decisions that bear the least possible risk of doing more harm than good?

We will form working groups of researchers for each project and support their work through meetings, workshops, conferences, and computer networks. In each case, our aim is to encourage collaboration among diverse researchers—those already at work in an area and those preparing to do so. The hope is that in this collaboration researchers will design and revise their individual research projects so their results will mesh with each other and their projects together will add up to something. This result will involve shared definitions and methods, comparative work, and perhaps a division of labor. Cumulative work of this kind apparently is common in the natural sciences, less so in the social sciences.

The committee wants to know of research projects in each of these six areas. The minimal ticket for admission to a working group is the draft of a proposal to some agency or foundation for a germane, substantive, and potentially productive research project.

Most of this workshop has dealt with institutions and interdependence, although what we learned and what we discussed here crosscuts the other five SSRC projects as well. Indeed, the six projects of the SSRC's program crosscut themselves at many levels, and a task before the committee is to provide for communication and synthesis across them.

What has this workshop brought to this research plan? We have chewed on themes long familiar in social science, often at an abstract level but with some hope of generating research questions. We again have illustrated the necessity for interdisciplinarity—at a minimum, to keep people in one discipline from making fools of themselves when they venture into the subject matter of another. We have shown how difficult it will be for many social and natural scientists to collaborate in this area, but we also overcame some of the barriers of differing language and methodological canons. We dealt with topics familiar in social commentary, such as legitimacy and equity, dissecting these concepts as they pertain to issues of global management.

In considering equity, we broached an argument that may be central in international debates about managing the global commons. However, we have not yet addressed the distinctions in meaning between *differences*, *equity*, and *equality*. When are differences between groups (social classes, nations, geographic areas) equitable and when are

they inequitable? Is blame an aspect of determining equity? Is there perhaps some tendency to think that *any* difference is inequitable, perhaps confounding the idea of equity with the idea of equality? Or is equity perhaps only a one-sided concern—a criterion employed by disadvantaged nations in their dealings with advantaged nations?

We considered the integral role of people and institutions other than governments in the process of managing the global commons. Modern theorists have been prone to see states as the key actors in management. However, the variety of human experience shows that this relatively new invention, the state, is not all that is available to us as humans or indeed all that will manage human response to global change.

Our discussion illustrated how difficult it is for social scientists to grasp problems simultaneously in both space and time. Our conceptual structures and our analytical methods are suited better to one-shot or repeated static measurements of discrete populations in which geographic location is of little importance. Continuous measurement in which location matters immensely is less well understood in the social sciences. We have lots to learn about this long-standing problem from the discipline in which space and time have always been fundamental: geography. Moreover, geography is the discipline in which the social and natural sciences meet around many environmental problems. Of course this discipline, just now when we most need it, is being discarded from many universities in the United States. Perhaps the bumper sticker for this workshop should not be "Save a Tree" but instead "Save a Geographer."

This brings me to the basic subject of needs for data for research on global environmental change. Social scientists often have shown a willingness to speak without benefit of quantitative data. While we were presented with several arguments based on qualitative empirical information, I was alarmed at how infrequently we discussed the larger data needs generated by the concepts we discussed. It is also perhaps meaningful that the one major topic that no one wanted to discuss out of six that we raised for possible discussion is the topic that involves data from square zero—social trends and social forecasting.

We must find a way to move from conceptual formation to nailing down our needs for new data and then generating concrete findings. One way to do so is implicit in the idea of social trends. Recall the draft EPA report circulated at the conference, with its table of individual measures that can each have a modest effect on emission of greenhouse gases from the United States. This list includes such measures as reforestation and improved energy efficiency. The analyst of social trends can ask of this list: which of these things is going to occur *even if* the United States takes no action whatsoever to reduce greenhouse gases? No matter how the politics of climate change proceed, we are likely to see, among other desirable steps, the phase-out of CFC's, reforestation, and energy efficiency gains. In fact, for most of these individual measures, there is a sound reason for pursuing them besides reducing greenhouse gas emissions. The forecasting question is then: what increment can a concern for global warming add to what is already underway?

Social science should generate several *baseline scenarios* that depict the future before taking global warming into account. What might the parameters of various climatological models and environmental forecasts look like if (a) no global warming occurs or (b) if we fail in political action on

greenhouse gases? What trends seem probable, before taking into account global warming, for world population size, the composition and distribution of that population, its urban/rural mix, the growth of GNP in various countries, the expected quality of life, etc. These baseline scenarios will require us to consider secular trends, environmental changes due to causes other than greenhouse gases, and socioeconomic trends due to reductions in the rate of population growth and other probable changes. This is an agenda in which the social indicators movement of the 1960s and 1970s may have renewed relevance and power.

At my side there is a board for "small thoughts." Among the several admittedly small thoughts posted there is the observation that perhaps social scientists are not invited into international decision making, such as into the IPCC, because they are simply a nuisance; they just get in the way. There indeed is some truth to that assessment, because our frequent conceptual fuzziness, lack of consensus on theoretical frameworks, and paucity of long time series for crucial data often add little to a discussion. I can understand why someone posted that small thought.

However, social science tends to make central that which is peripheral to natural scientists and engineers. It brings forward—front and center—social, cultural, and political aspects of what appears to be a purely technical issue. That may be a nuisance in decision making, but it is one with which decision making has to deal.

Let me take an example: nuclear power generation. This issue was widely viewed at the start as purely a technical problem. Social concerns recently have, in the United States, moved to the center, much to the frustration of the nuclear power industry. However, this trend was inevitable. Societies know that accidents are normal, that incompetence pervades our institutions, that there is dishonesty and there is malice. That is why this society has pushed technical concerns and technical progress to the side. It is my sense that for a rebirth of the nuclear power industry in the United States, we would need not only inherently safe nuclear reactors but also inherently safe social processes. I have never seen such a social process myself, although our lives depend upon one existing in nuclear deterrence systems both here and in the Soviet Union.

It is not enough, however, for social science simply to move social issues to the center. Sensitization is not all that society needs, and it may not even be responsible for us to seek only that. We have to find a way to move to understanding, to answers, to questions, to useful, concrete data. This route may not be the natural inclination of most social scientists (our history shows a preference for conceptual work), but unless we make such progress, I think that we will have let down not only our side but something larger than that.

WORKSHOP PARTICIPANTS

Elizabeth C. Anderson is a consultant to AID for organization of a conference on the role of foreign assistance to the developing world in managing globally significant commons, and for intra-agency collaboration on deforestation. At Indiana University, where she is completing a Ph.D. in environmental policy, she contributed to research on indigenous institutions for sustainable management of local- and regional-level common property resources. During the 1985 Young Scientists' Summer Program at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria, she assessed projections of global human population as input to a multi-national, interdisciplinary project on ecologically sustainable development of the biosphere. Her interests include the potential for global commons management found in extant international resources management; in foreign aid to developing countries to enhance sustainable use of common property resources; and in the experiences of nations such as the USSR, where all resources are "commonly" held.

Ronald J. Brickman is Project Director for the National Association of State Universities and Land-Grant Colleges and executive director of an EPA-funded program working with universities, government, and the private sector to promote training and education as a complement to environmental regulation. He expects to assume responsibilities this fall as an advisor to the Food and Agriculture Organization of the United Nations, to strengthen their programs on international environmental issues. He also is a former congressional staff member on environmental and international trade issues. His interests include comparative policy analysis, international organization, and environmental and science policy. He is familiar with novel institutional and policy approaches to solving environmental problems, both domestically and internationally; with determinants leading to national positions on environmental issues; the effectiveness of alternative international policy instruments; and with limitations of and opportunities for reliance on the private sector to address international and domestic environmental problems.

Kenneth L. Burgess is Director of Legislative Affairs for The Dow Chemical Company where he has been employed since 1957 in research positions involving product and process development, ecological impact, regulatory compliance, and health issues. Currently, he is the focal point for company investigation into the impact of global warming on the company, as well as identification of options for company research, operations, and communications actions. He has experience with development of regulations and advocacy of good science, and with practicality in the promulgation and enforcement of such regulations. He has chaired company and industry panels involved in developing health and environmental data, and in advocating that data in regulatory actions. He has a broad-based technical background,

intimate knowledge of the regulatory process, experience with trade association programs, and an industry perspective on the assessment of issues and actions.

Robin Cantor is Leader of the Social Choice and Risk Analysis Group and is a member of the research staff at Oak Ridge National Laboratory. Her major fields of study include public finance, econometrics, and international trade, with concentration on risk management and societal decision making. She and her colleague, Steve Rayner, developed and applied an interdisciplinary approach to social conflict and technology choice that incorporates ethical, political, legal, cultural, and economic comparisons of various constituencies. More recently, she and her colleagues have extended their interest in interdisciplinary research to a comparative analysis of the exchange process in both formal and informal economic relationships. Another extension of the approach has been to explore risk and information in a controlled laboratory environment using experimental economics. She also has been involved recently with a major study on greenhouse gases and government policy options.

Lewis F. Carter is Professor of Sociology at Washington State University. His research interests include health justice, waste repository siting, energy use, culture-development conflicts, and policy evaluation. He has spent the past year studying systems of environmental and resource accounting being developed and evaluated in several countries to inform development decisions by more properly reflecting resource-inventory drawdowns, defensive expenditures, resource depletion/degradation, and to measure sustainable social net product. The study compares American, French, Indonesian, and Norwegian approaches to developing national accounts systems as policy tools and linking these to resource accounts. He also was involved with the "Peace and Security Workshop" (at Stanford's Center for Advanced Studies, 1987), received an International Peace and Security Studies mid-career grant in 1988, and is a member of the fellowship screening committee for the Peace and Security Initiative, 1989.

Robert S. Chen is Assistant Professor (research) at Brown University, a geographer and climatologist whose current research focuses especially on multiple environmental threats to food systems. He has been a research fellow and consultant for the International Institute for Applied Systems Analysis (IIASA), the U.S. National Academy of Sciences, and the National Center for Atmospheric Research. Over the past decade, he has contributed to numerous national and international studies of climatic variations and global environmental change. He recently organized an IIASA meeting on regional climate scenarios for impact assessment (with P. Lamb). He has extensive knowledge of the problems of the developing world, particularly the plight of the poorest and hungriest individuals and nations, in the light of climate change and consequent efforts to manage the global commons.

William C. Clark ("Social learning in the management of global environmental change") is Senior Research Associate at the John F. Kennedy School of Government, Harvard University and formerly headed studies on "Sustainable Development of the Biosphere" at the IIASA. His research is focused around the stability and resilience of ecological systems, environmental policy analysis, risk-taking behavior, and development strategies in LDCs. He is a member of the National Academy of Science's Committee on Global Change and its Joint Committee (with the USSR Academy of Sciences) on Global Ecology, and he was a member of its Board

on Atmospheric Sciences and Climate and its Committee on Applications of Ecological Theory to Environmental Problems. He is coeditor (with R.E. Munn) of *Sustainable Development of the Biosphere*. He also is Executive Editor of *Environment* magazine and Editor of *Carbon Dioxide Review*.

E. William Colglazier ("Introduction to the workshop") is Professor of Physics and directs three research centers at the University of Tennessee: the Energy, Environment, and Resources Center; the Water Resources Research Center; and the Waste Management Research and Education Institute. He received his Ph.D. from the California Institute of Technology and worked at Stanford, Princeton, and Harvard Universities before coming to Tennessee in 1983. He is a member of the Board on Radioactive Waste Management of the National Academy of Sciences. His current research interests focus primarily on environmental regulation and management in the United States, including social and political, as well as technical considerations in setting environmental policy.

Robert A. (Rob) Coppock is Staff Director for the National Academy of Sciences, with training in physical science, public administration, and economics. In 1969, he joined the staff of Battelle Seattle Research Center and moved to the Battelle lab in Frankfurt, West Germany in 1973. In 1976, he became a Research Fellow at the International Institute for Environment and Society of the Science Center Berlin. He received a National Research Council Fellowship in 1985, and from 1986 to 1989 was on the staff of the National Research Council. He has conducted or participated in research on cultural regions of the United States, jury size and compensation awards, corporate social reporting, use of scientific evidence and knowledge in regulatory policy in different countries, industrial policy in the automobile sector, approaches to risk assessment and decision making in different countries, and environmental impacts of tourism in Nepal.

Paul Craig is Professor of Applied Science at the University of California—Davis, whose research and teaching interests focus on social-decision-making problems involving complex technology. Currently active areas of research include disposal of toxic substances and transportation energy use. He is attending the workshop on behalf of Lawrence Berkeley Laboratory. He and his colleague, Mark Levine of LBL, are cochairmen of the September 6–8 Davis Workshop on Global Climate Change, which will focus on energy strategies for mitigating carbon-dioxide emissions. The Davis Workshop is expected to lead to a UC/LBL/LLNL modelling and policy-analysis project relating to global climate change. His work emphasizes the importance of a broad perspective, including risks as well as benefits of climate-change mitigation strategies, and the importance of integrating proposed strategies with more immediate social objectives.

David Dessler is Assistant Professor of Government at the College of William and Mary, where he teaches survey courses in international studies and specialized courses in conflict theory and political economy. His primary research interest is the problem of development and maintenance of international cooperative relationships. He has extensive knowledge of international-relations theory, organizational decision making, national and non-governmental political structures, and regimes of international cooperation. His most recent publications

include "What's at stake in the agent-structure debate?" *International Organization*, Summer 1989 and "The use and abuse of social science in policy-relevant research," *SAIS Review*, Summer 1989. With a Ph.D. in international studies from John Hopkins University and a B.S. in Physics from Oklahoma University, he is able to mediate the different research orientations and vocabularies found in natural and social sciences.

Dieter Deumling is Research Director for EN FOR SYS and a consultant specializing in environment and forestry systems research. For the last eight years he has been involved with the science-policy interface of the European acid-rain issue, and he has conducted workshops for the relevant actors of this debate. In cooperation with the German Marshall Fund, he organized and conducted various fact-finding missions on the acid-rain issue for American gubernatorial and congressional committees visiting West Germany, and he served on the International Council on Acid Rain, which was sponsored by the U.S. Congress. He edits an international newsletter on forest dieback, air pollution, and energy policy. He also is a member of two West German NGO/research organizations with which he is working to formulate global-warming response scenarios. Through his experiences, he has observed and studied the reasons why certain mechanisms work in achieving transnational consensus on global environmental issues, and why some do not.

Srinivas Emani is a Ph.D. student in the Environment, Technology, and Society Program at Clark University. He also is a Research Assistant in the Center for Technology, Environment, and Development (CENTED), where he works with the Hazard Assessment Group on the social amplification of risk and on ethical issues in the transfer of hazardous technology to developing countries. Previously, he was a Project Associate in the Center for Energy, Environment, and Technology at the Administrative Staff College of India, Hyderabad, where his projects included cost-effectiveness analyses of risk reduction in coal-fired power plants in India, and corporate responses to environmental policies. He has extensive experience with development-vs-conservation issues as a professional, student, and citizen of a developing country.

Michael P. Farrell ("Current thinking on anthropogenic climate change: State of the scientific understanding") is Director of the Carbon Dioxide Information Analysis Center at Oak Ridge National Laboratory. As Department of Energy (DOE) Principal Scientist for information analysis, carbon-cycle research, and resource-effects research, he works closely with the staff of DOE's Carbon Dioxide Research Program and other institutions worldwide. Previously, as Research Associate with the Environmental Sciences Division of ORNL, he was a Group Leader in both Environmetrics and Resource Analysis, and Statistical Support. He was Adjunct Professor of Zoology and Biostatistician at Miami University and Research Associate at the Department of Experimental Statistics, Mississippi Agricultural and Forestry Experiment Station, Mississippi State University. He has over 65 publications in data management, statistical ecology, and the analysis of global climate change.

David L. Feldman has been a research staff member in the Energy Division of the Oak Ridge National Laboratory since 1988. He has a Ph.D. in political science from the University of Missouri at Columbia. His major fields of study include comparative and international

environmental policy, normative policy analysis, and water and energy policy. As a resource planner and policy analyst for the state of Missouri, he reviewed and evaluated river basin studies for state government. He has also participated in an ORNL report on Private Sector Responses to Potential Climate Change, has explored precedents for the implementation of global climate change agreements, has studied nuclear energy policy in Europe and the United States, and has worked in the area of public participation in the siting of hazardous facilities. He is currently investigating the lessons of the nuclear non-proliferation regime for an international treaty to ban chemical weapons and has completed a book on the relationship between environmental ethics and water policy. Finally, he is co-editor of a Policy Studies Organization symposium on "Global Climate Problems and public Policy."

Tamás Fleischer is Researcher–Adviser at the Institute of Environmental Economics in Budapest. A civil engineer and economist, he analyzes the macroeconomy of environmental problems and his current research interests include issues in environmental assessment and evaluation methods. He is a member of the Hungarian committee that oversees the fulfillment of international obligations in atmospheric agreements. His earlier research focused on regional economics and development strategies in infrastructure networks, and he deals extensively with the consequences of the East European centralized, redistributive decision-making policies. He also works with the Danube Circle, an independent movement for the environment, where he has analyzed the social, political, ecological, and macroeconomical aspects of the Gabcikovo-Nagymaros Danube dam project.

Luther P. Gerlach ("The tension between local and global: Negotiating the dilemma") is Professor of Anthropology at the University of Minnesota—Twin Cities and Adjunct Professor at the Hubert Humphrey Institute of Public Affairs at the same university. He is coauthor (with Virginia Hine) of *People, Power, Change: Movements of Social Transformation, and of Lifeway Leap: The Dynamics of Change in America*. His articles have appeared in several edited collections, and professional and popular journals. He also is the producer of several films on grass-roots energy, resource use, and systemic thinking. He was Visiting Professor at Caltech, Consultant to the Aspen Institute for Humanistic Studies, and Visiting Fellow at the Science Center, Berlin. A recipient of fellowships and grants from the Rockefeller Foundation, Fulbright Foundation, Solar Energy Research Institute, and Oak Ridge National Laboratory, he also is a member of the American Anthropological Association.

Bryn Greer-Wootten is Professor of Geography at York University; Director of York's Survey Research Centre; and Consultant to Ontario Hydro, Ontario Ministry of Energy, and Atomic Energy of Canada. His primary research since 1975 includes: risk-assessment methodologies and decision making processes with respect to nuclear power and nuclear-fuel waste management; comparative analysis of social-science research in risk assessment in North America and Europe; public participation in noxious facility siting and transportation of dangerous goods planning; household decision making behaviors in residential energy conservation and recycling; environmental group leaders' policy expectations concerning sustainable development and impact assessment processes. He has considerable research experience in resource-management conflicts, for example, empirical field studies of decision-making processes involving local interest groups and governments, regional

environmentalist organizations, and state proponents of waste-management facilities and hazardous-goods transportation plans. Recent work concerns implications of global change for Canadian public policy, especially evaluation of the Brundtland Commission for sustainable development in Canada, and the use of round tables in consensus building.

Alan D. Hecht ("Characterization of organizations in climate-change issues") is Director of the National Climate Program Office at the National Oceanic and Atmospheric Administration. His office was established by Congress in 1978 as part of the National Climate Program Act. He is chief spokesman for the National Program and is responsible for preparing a National Plan for climate research and services and for coordinating U.S. participation in national and international climate programs. He is U.S. coordinator for Work Group 2 of the Intergovernmental Panel on Climate Change. Since 1977 he has worked extensively with international scientific organizations and has negotiated and implemented scientific projects and exchanges with the Soviet Union under the US—USSR Bilateral on Environmental Protection and with China under the US—PRC Bilateral on Atmospheric Science and Technology. He was Program Director for Climate Dynamics at the National Science Foundation. He received his Ph.D. in geological sciences from Case Western Reserve University in 1970 and taught geology and ocean sciences for six years at West Georgia College. His major interests are in paleoclimatology and oceanography. He edited *Paleoclimate Analysis and Modeling* and is Chief Editor of the *Journal of Climate* and Associate Editor of *Climate Change*. He is a Fellow of the American Meteorological Society and the Geological Society of America.

Sheila Jasanoff ("Compatibility of policy-implementation frameworks") is Director of the Program on Science, Technology, and Society at Cornell University. She is author of *Risk Management and Political Culture* and coauthor of *Chemical Regulation and Cancer: A Cross-National Study of Policy and Politics* and several other books. She holds an A.B. in mathematics from Harvard College, a Ph.D. in linguistics from Harvard University, and a J.D. from Harvard Law School. She is a Fellow of AAAS, a contributing editor of *Science, Technology, and Human Values*, and a regular reviewer for numerous science-policy journals and the National Science Foundation. Her research interests include comparative policy analysis, the use of risk assessment in regulatory decision-making, and interactions between science and the legal process. She is the recipient of numerous grants and fellowships to study environmental regulation in Europe, India, and the United States. She has recently completed a study of peer review mechanisms in the regulatory process, entitled *The Fifth Branch: Experts in the Regulatory Process*. Her current major project is a book on science and the courts. She is a member of the International Committee of EPA's National Advisory Council on Environmental Technology Transfer.

Donald W. Jones is a research staff member in the Energy Division of Oak Ridge National Laboratory. He is an economist/geographer, with a Ph.D. from the University of Chicago. He has served on the faculties of the University of Chicago and the University of Colorado—Boulder. His research specialties have been in the economics of land use, economic development, and international economic relations. For the past four years he has been engaged in studying energy issues in developing countries, with topics including the

structural changes in energy use accompanying urbanization and analysis of wood-fuel savings from improved household cook stoves. Currently, he is studying the political economy of internalizing international externalities.

Roger E. Kasperson ("Developmental and geographical equity in global environmental change") is Professor of Government and Geography and Director of the Center for Technology, Environment, and Development at Clark University. He is editor of *Equity Issues in Radioactive Waste Management*, coeditor of *Nuclear Risk Analysis in Comparative Perspective*, and coauthor of *Corporate Management of Health and Safety*. He has directed numerous research projects funded by the Ford Foundation and National Science Foundation that deal with equity and value issues associated with risk management. Currently he is chairing a study group on Critical Zones in Global Environmental Change for the International Geographical Union.

Ard D. Kant is Project Leader of the large-scale study on Social Consequences of the Greenhouse Effect at the Energy Study Centre of the Netherlands Energy Research Foundation. This study focuses on three separate areas: media research, public opinion survey, and institutional design. The Energy Study Centre is the leading national institute on energy policy, and its reports are issued in frequent consultation with responsible policy makers at different ministries. Dr. Kant is also associated with the Faculty of Social Sciences at the University of Leyden. In this capacity, he has worked on projects involving the social consequences of nuclear war, social networks in Mexico City, and on influencing traffic mobility. He hopes his Workshop experience will be useful during the programing study of the National Advisory Board on Environment and Nature, planned for the end of 1989. The study will program future research in Holland.

Abyd Karmali is a member of the research staff of the Centre for Technology, Policy and Industrial Development at MIT, where he also is engaged in interdisciplinary graduate study in the Technology and Policy Program. His academic specialization is international environmental policy and decision making, and his current research concerns the ethical, legal, and scientific issues arising from the need to monitor communities exposed to toxic substances. The project also will provide guidance to the Agency for Toxic Substances and Disease Registry, Center for Disease Control, and Environmental Protection Agency on environmental and health risk communication between agencies and communities. He recently chaired an MIT model international negotiation of a first "United Nations Conference on the Law of the Atmosphere" and moderated at a UNEP conference entitled "Sustainable Development: Action for the Future". He also is a member of the Harvard—MIT International Environmental Issues Study Group. And he is engaged as an environmental policy consultant for an independent project headed by Mr. Kamal Ahmad of the World Bank, that is examining the possibility of setting up an institute in Asia to train local development practitioners in environmental management.

Willett Kempton is a Research Anthropologist in the Center for Energy and Environmental Studies at Princeton University. His research interests involve energy policy questions in the United States, specifically, the way that energy users and energy managers perceive and

conceptualize energy-using systems, and how that affects their efficiency in using those systems. Currently, he is conducting research on the lay person's conceptions of global warming and possible policy responses, a project he would like to expand to include concepts held by industrial and national decision makers. He also has worked with Hal Feiveson on a student seminar which developed a sample international protocol on global warming.

William V. Kennedy is Senior Programme Officer with the Global Environmental Monitoring System (GEMS) of the United Nations Environment Programme (UNEP). He also is UNEP's representative to the Response Strategies Working Group of the Inter-governmental Panel on Climate Change. A political scientist, he has held positions in the Environment Directorate of the OECD in Paris, the environmental impact assessment divisions of the Dutch Ministry of Environment, and the U.S. Environmental Protection Agency. Between 1976 and 1980, he was a research fellow at the International Institute for Environment and Society in West Berlin. He has served as a consultant on environmental impact assessment to various organizations, including the World Health Organization, the European Economic Community, and the World Bank. He has held EIA seminars in a number of countries in Europe, Asia, and South America.

Kai N. Lee is Associate Professor of Environmental Studies and Political Science at the University of Washington. He is a member of the economic assessment panel of the UN Environment Programme, preparatory to the renegotiation of the Montreal Protocol in 1990. While a member of the Northwest Power Planning Council in the mid-1980s, he became interested in adaptive management, an approach to natural-resource policy that treats implementation as a set of experiments designed to probe the natural system being modified by human action. Currently, he is at work on a study of the institutional requisites for adaptive management and its use in achieving sustainable development. Prior to his recent interest in global change, he worked primarily in energy and nuclear-waste problems in the Pacific Northwest.

Paul Leiby is a member of the research staff in the Energy and Economic Analysis Section of Oak Ridge National Laboratory. His formal training is in public policy, and his research specialities have been in energy policy and energy modeling. He recently completed a review of fiscal and regulatory policies to promote reduction of greenhouse gas emissions.

Changsheng Li is a Senior Administrator for the National Environmental Protection Agency of the People's Republic of China. He currently is working in the Office of Environmental Management and Planning in the United States Environmental Protection Agency. He received his Ph.D. in Agricultural and Life Sciences from a joint program of the University of Wisconsin—Madison and the Chinese Academy of Sciences in Beijing. Formerly, he was Deputy Director of the Research Center for Eco-Environmental Sciences in Beijing. He has considerable knowledge of the problems of air pollution and greenhouse-gas emissions in the PRC and is familiar with the Chinese perspective on global climate management.

Ronnie Lipschutz ("Bargaining among nations: Culture, history, and perceptions in regime formation") is Director of the Pacific Institute for Studies in Development, Environment, and Security. He is author of *When Nations Clash: Raw Materials, Ideology, and Foreign Policy* and *Radioactive Waste: Politics, Technology, and Risk*. He also has contributed to books and conferences on energy conservation, indoor air pollution, and the security implications of international resource flows. He was Research Fellow at the Institute of International Studies, University of California—Berkeley, Visiting Research Fellow at the Joint Energy Programme, Royal Institute of International Affairs, London, and Post-Doctoral Fellow with the MacArthur Interdisciplinary Group in International Security Studies, University of California—Berkeley.

Ruilan Lu is a Scientific Translator for the Research Center for Eco-Environmental Sciences in Beijing, and currently works with Resources for the Future in Washington. She received her degree from the Institute of Foreign Language, Xian, People's Republic of China, and in 1977 received the Scientific Translation Award, Guizhou, Department of the Environment, for her translation of Rachel Carson's *Silent Spring*. Her interests include the problems of international management of global climate change.

Douglas MacLean ("Distributive justice and intergenerational responsibility") is Director and Senior Research Scholar at the Center for Philosophy and Public Policy at the University of Maryland—College Park. His primary research interests are in moral and philosophical issues, risk analysis, and the foundations of policy science. He has published many articles and books on these topics, including *Energy and the Future, The Security Gamble*, and *Values at Risk*. He has served as consultant to several Government Agencies, testified before Congress, and served on several panels of the National Academy of Sciences. He also has been an advisor to the National Science Foundation's Program on Ethics and Values Studies and to the National Endowment for the Humanities' Program on Humanities, Science, and Technology.

Richard J. McNeil is Associate Professor in the Department of Natural Resources at Cornell University, where he currently teaches courses in international environmental issues, and environmental and natural-resource policy. His research interests include Third World development, natural resources and environmental protection and management in tropical and temperate regions. He has worked in more than 30 countries, has been a visiting scientist with UNEP in Kenya, has taught human ecology at IVIC in Venezuela, has served on two Commissions for IUCN, and advised graduate students from foreign governments, USAID, and the Peace Corps. He has experience with developing regions, foreign governments, and international institutions; and he has had many successful interdisciplinary teaching and research activities, combining physical and biological sciences, economics, ethics and values.

Roberta Balstad Miller ("Climate change and social science research: Future scenarios") is Director of the National Science Foundation's Division of Social and Economic Science, which has an annual research budget of over $30 million. She is a member of the NATO Advisory Panel on Advanced Research Institutes, Chairman of the Advisory Board of the Luxembourg Income Study, and a member of the editorial boards of several scholarly journals. She served on the boards of directors of the National Council on Public History and the

Consortium of Social Science Associations, of which she also was the founding Executive Director. She was Staff Associate at the Social Science Research Council and Research Associate at the American Institute of Architects' Research Corporation. She appeared in *Connections*, a PBS television series on the history of technology, and has taught at Catholic University, the University of Minnesota, Oberlin College, and Hiram College. She received the Ph.D. in history from the University of Minnesota. She is the author of *City and Hinterland: A Case Study of Urban Growth and Regional Development* and coeditor (with Harriet Zuckerman) of *Science Indicators: Implications for Research and Policy.* She has published numerous articles, including "Social Science under Siege: The Political Response, 1980-1984" in *Social Science Research and Government: Comparative Essays on Britain and the United States* (edited by Martin Bulmer).

Peter M. Morrisette is a Postdoctoral Fellow at the National Center for Atmospheric Research and a Research Assistant with the Natural Hazards Center and the Institute of Behavioral Science at the University of Colorado. His recent research is concerned with national and international political responses to the issues of stratospheric-ozone depletion and global warming, specifically an assessment of political similarities and differences between the two issues and the implications of the Montreal Protocol for the global-warming issue. As of October 1, 1989, he will join Resources for the Future as a Research Fellow in the Climate Resources Program, where he will assess the impact on less-developed countries of adaptation and prevention strategies for dealing with global warming.

Richard H. Moss is a Staff Associate at the Social Science Research Council, where he has worked on programs in international peace and security and social/political/economic influences on the making of foreign policy. Through his research, he has knowledge of relations between developed and developing nations, including familiarity with international institutions relevant to managing global environmental change; of political science research on international regimes and alternative world orders; and of the relationship between environmental change and international security. His planned research involves conflicts between developed and developing nations over tradeoffs between economic growth and environmental degradation in the Third World. He also is developing a course on international dimensions of global environmental change, to be given at Princeton University's Woodrow Wilson School this fall.

Wolfgang N. Naegeli (workshop organizer) is a Research Associate with the Energy, Environment, and Resources Center at the University of Tennessee. He has been a Consultant at Oak Ridge National Laboratory for the last four years. His recent work includes the assessment of climate-change policy options for the agricultural and forestry sectors and the development, for EPA, of a computer workstation to analyze the hydrogeology at hazardous-waste facilities. He holds M.S. and Ph.D. degrees in resource policy and planning from Cornell University. As a Research Associate at Cornell he analyzed data on soils, agriculture, and land use for the Land and Water 201 project of the Tennessee Valley Authority, the seven Tennessee Valley States, and USDA's Soil Conservation Service. He was Director of Information of World Wildlife Fund Switzerland and Marketing Executive in Germany for WWF International. He also was founder and Editor-in-Chief of *Panda*,

Publisher of a book series, and charter member of the Swiss Society for Solar Energy. His present research interests include international environmental policy, sustainable agriculture, large-area natural-resource and land-use inventories, and the adaptation of strategic planning methods and decision support systems for these areas.

Sherry Oaks is Director of Environmental Societal Interaction Studies at the Hazards Assessment Laboratory of Colorado State University and a Research Faculty in the Civil Engineering Department. Her research in earth science and social science is focused specifically on the areas of hazards and climatology, and her current research projects on risk assessment and vulnerability are funded by the National Center for Earthquake Engineering Research and the U.S. Geological Survey. She has considerable skill in facilitating linkages and transfers of information between physical and social science, between earth and atmospheric science, and research and application. She also serves as a consultant to several national entities and on the public policy committees of two major scientific and engineering professional organizations.

Carl Petrich is a research staff member at Oak Ridge National Laboratory, where he began work in 1976 after completing degrees in botany and landscape architecture at Duke University and the University of Michigan. Since 1985, he has been providing energy planning assistance to developing countries through work for the U.S. Agency for International Development. He has focused on such problems as the assessment of difficult-to-quantify environmental impacts and the evaluation of the adequacy and effectiveness of the environmental criteria that go into investment decision making. He has contributed to books, journals, and conferences on the aesthetic impacts of energy development and on the use of renewable sources of energy in developing countries. His long-term interests include the synthesis and presentation of disparate types of information for application in policy and decision making. He has performed energy/environmental consultancies in Africa, the Middle East, and Latin America.

David Pimentel ("Managing the global commons: Climate, population, and natural resources") is Professor in the departments of Entomology, Ecology and Systematics, and Natural Resources at Cornell University. He has published a large number of journal articles and books on pest control, ecology, agriculture, energy, and natural resources, including *Food and Natural Resources* and the *Handbook of Energy Utilization in Agriculture*. He began his international work as Chief of the Tropical Research Laboratory of the U.S. Public Health Service in San Juan, Puerto Rico, 1951–1954. He has been contributing to a better understanding of environmental issues and their interconnections not only as teacher, researcher, and author but also as chairperson or member of committees and panels of numerous governmental and non-governmental organizations, including Environmental Protection Agency, Department of Energy, Agency for International Development, Office of Technology Assessment, UN Food and Agriculture Organization, International Biological Program, International Union for Conservation of Nature and Natural Resources, American Association for the Advancement of Science, National Science Foundation, and National Academy of Sciences.

Martin Price is a Postdoctoral Fellow at the National Center for Atmospheric Research where he has spent the past nine months working on global climate change issues. He also is engaged in developing research agendas for social science relating to climate change for the NSF and to global environmental change for the ISSC. He is committed to interdisciplinary research, and has broad experience in environmental science and policy in the academic and private sectors. He was involved for 10 years in UNESCO's Man and the Biosphere Program; has studied tourism and its environmental effects on forestry; and has worked on policy issues for the Governor of Colorado and for non-profit institutions.

Steve Rayner ("Conflicts about process: Three decision-making modes") is Coordinator for Policy, Energy, and Human Systems Analysis for the Global Environmental Studies Center of Oak Ridge National Laboratory (ORNL). He also coordinates global environmental research in ORNL's Energy Division. His principal research interests concern the relationship between institutions and knowledge, focusing particularly on the unique decision-making issues that arise in responding to global change. He has published extensively on socioeconomic and cultural aspects of risk perception, communication, and management, where he has focused on the different concepts of fairness that institutional cultures use in decision making about technology policy. He is coauthor of *Measuring Culture* (with Jonathan Gross) and coeditor of *Rules, Decisions, and Inequality* (with James Flanagan). He was Visiting Scholar at Columbia University and the Boston University School of Public Health, and Research Associate at the Russell Sage Foundation and the Centre for Occupational and Community Research in the United Kingdom.

Sheldon Reaven works with the Waste Management Institute at the State University of New York—Stony Brook, and is a professor in the Department of Technology & Society. His current work concerns radioactive-waste management and global impacts of recycling, incineration, and landfilling, especially of plastics recycling and carbon storage. He has done extensive work on complex energy/environmental/risk issues, with an emphasis on underlying sources of scientific and ethics/policy disagreements. The work addresses conceptual, methodological, and theoretical problems that affect the assessment of scientific and non-scientific aspects of energy/environmental issues in policy deliberation.

Dean Hill Rivkin is Director of the University of Tennessee Law Clinic and Professor of Law. He is a nationally known environmental lawyer, who has published extensively on air quality, chemical-stockpile disposal, the environmental-impact-assessment process, administrative decision making, and citizen advocacy. His awards include the First Amendment Award from the Society of Professional Journalists, and Air Conservationist of the Year from the Tennessee Conservation League. He was Directing Attorney of the Appalachian Research and Defense Fund of Kentucky and Visiting Professor at UCLA Law School. He is a consultant for Oak Ridge National Laboratory and the Federal Legal Services Corporation.

William E. Riebsame ("Current thinking on anthropogenic climate change: Social perspectives") is Director of the Natural Hazards Research and Applications Information Center and Assistant Professor of Geography at the University of Colorado—Boulder. He has a Ph.D. in geography from Clark University, where he studied the social and economic

impacts of drought on the U.S. Great Plains. He served as an A.W. Mellon Post-Doctoral Fellow on the joint SCOPE-UNEP project on "Improving the Science of Climate-Impact Study" and taught at the University of Wyoming. He is author of the UNEP volume *Assessing Social Implications of Climate Fluctuation: A Guide to Climate Impact Studies* and of "Adjusting Water Resource Management to Climate Change," which recently appeared in *Climate Change*. His research focuses on social implications of environmental hazards and climate change. He recently organized workshops on climate impacts in India and Nepal under UN sponsorship, and is currently studying the implications of climate change for international management of selected river basins around the world. He also has recently given U.S. Senate testimony on Third-World implications of climate change.

Richard C. Rockwell ("Summary and conclusions") is an Executive Associate of the Social Science Research Council in New York, where he staffs the Committee on International Peace and Security and the proposed Committee for Research on Global Environmental Change. He received his Ph.D. in sociology in 1970 from the University of Texas—Austin, following an undergraduate degree in zoology. He is coeditor of *AIDS in Africa* and is now editing a special section of the *Journal of the American Statistical Association* on "Social Statistics and Public Policy." He has taught at the University of North Carolina—Chapel Hill and Columbia University. He was Chair of the Council of Professional Associations on Federal Statistics in 1987 and 1988.

Annie Roncerel is Coordinator of the Climate Action Network Europe, a recently funded organization that aims to act as an information exchange between member NGOs and a means of coordinating activities concerning global climate change. Previously, she worked for ten years as the information officer for the Institute for European Environmental Policy, based in Bonn. Since June 1988, she has worked in Brussels as information officer for the European federation of non-governmental organizations, called the European Environmental Bureau. She has considerable experience with European institutions, both governmental and non-governmental, and insight into how future actions on climate change will be conceived in Europe.

Kristin Shrader-Frechette ("The use of scientific modeling in decision making") is Graduate Research Professor of Philosophy at the University of South Florida. She holds an undergraduate degree in mathematics and physics (*summa cum laude*) and a Ph.D. in philosophy and philosophy of science. She has authored more than 90 articles and 5 books in the areas of philosophy of physics, philosophy of economics, environmental ethics, and science/technology policy. She has held professorships at the University of California and the University of Florida. Editor of the Oxford University Press monographs on "Environmental Ethics and Science Policy," her current research on using ecology as a basis for environmental policy is funded by the National Science Foundation.

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Alvin W. Trivelpiece ("Introduction to the workshop") is Director of Oak Ridge National Laboratory and Vice President of Martin Marietta Energy Systems, Inc., which operates the Laboratory for the U.S. Department of Energy. He was Executive Officer of the American Association for the Advancement of Science, Director of DOE's Office of Energy Research, Corporate Vice President of Science Applications, Inc., Vice President for Engineering and Research of Maxwell Laboratories, Inc., and Assistant Director for Research in the Division of Controlled Thermonuclear Research of the U.S. Atomic Energy Commission. He was Professor of Physics at the University of Maryland—Baltimore, Associate Professor of Electrical Engineering at the University of California—Berkeley, and Fulbright Scholar at the Technische Hogeschool, Delft, Netherlands. He also was Chairman of the Division of Plasma Physics of the American Nuclear Society, Associate Editor of *Physics of Fluids*, and Correspondent of *Comments on Plasma Physics and Controlled Fusion Research*. He has authored numerous journal articles and books, given more than 50 Congressional testimonies, and obtained several U.S. patents. He has received many awards and honors, including Secretarial Commendation, U.S. Department of Energy, Distinguished Alumnus of Caltech and California Polytechnic, and Guggenheim Fellow. He also is a Fellow of several professional societies.

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ways of coping with regulation at a local, national, and European level. The University of Utrecht plans to start a research center on global-warming issues with an emphasis on CO_2 problems, and the Department of Science, Technology and Society already is carrying out such research from a technical standpoint. Dr. Van Eijndhoven plans to contribute to the activities of the center from the decision-making perspective.

Jon M. Veigel is President of Oak Ridge Associated Universities, a private, not-for-profit organization of 49 colleges and universities and a management and operating contractor for the U.S. Department of Energy. He serves on a number of boards of directors and advisory committees, including the American Council for an Energy Efficient Economy, the Tennessee Center for Research and Development, the Council on Research and Technology, and the National Energy Conservation Coalition. Before joining ORAU, he served as President and Executive Director of the nonprofit Alternative Energy Corporation in Research Triangle Park, North Carolina. Prior to that he was an Assistant Director and Division Manager of the Solar Energy Research Institute; Head of the Alternative Energy Division of the California Energy Commission; and Program Manager for Energy, Office of Technology Assessment, U.S. Congress, where he held a Congressional Science Fellowship.

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