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AUTHOR Jacobson, Harold K.; Shanks, Cheryl
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ABSTRACT

The International Geosphere-Biosphere Programme: A Study of Global Change (IGBP), a natural science research program, has been inaugurated by the International Council of Scientific Unions (ICSU). Recently, initial steps have been taken to develop an international social science research program on global change that would either be part of the IGBP or separate and complementary to it. The workshop reported in this document was held to consider social science research that could be relevant to global change and what actions U.S. social scientists should take to prepare for participation in this type of research program. This report: (1) describes the IGBP's development; (2) explains the importance of developing international programs that focus on global change; (3) chronicles the steps that have been taken to launch an international social science global change research program; (4) summarizes the workshop's general conclusions; (5) provides examples of social science research that would be relevant to global change; and (6) contains recommendations on how U.S. social scientists might be organized to participate in an international global change program. An appendix lists the workshop's participants. (JHP)

# Report of the Ann Arbor Workshop on an International Social Science Research Program on Global Change

Harold K. Jacobson
and Cheryl Shanks
Institute for Social Research
The University of Michigan

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**on Global Change**

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## Report of the Ann Arbor Workshop on an International Social Science Research Program on Global Change

### Summary

A massive international research program, the International Geosphere-Biosphere Programme: A Study of Global Change (IGBP), has been inaugurated by the International Council of Scientific Unions (ICSU). As currently conceived, IGBP is a natural science program. Steps have been taken to launch an international social science research program on global change that either would be part of IGBP or, though separate, would parallel and complement IGPB. A major scientific symposium will be held in Tokyo, Japan, from 19 through 22 September 1988, to develop a preliminary plan for this research program. A workshop was held at the Institute for Social Research in Ann Arbor, Michigan, 9 and 10 September to consider social science research that could be relevant to global change and to consider what actions U.S. social scientists should take to prepare for participation in an international research program on global change.

Participants in the Ann Arbor workshop joined the growing consensus in favor of launching an international social science research program on global change. Human actions have an immense impact on the Earth and its environment. Changes in the Earth system have tremendous consequences for humankind. The participants in the workshop concluded that an international social science research program on global change should encompass both human actions that force changes in the Earth system and human responses to changes in this system. The participants thought that the agenda of the social science research program should in large measure conform with the agenda that the natural scientists have already set; the program should

investigate the human dimensions of the problems that the natural scientists have chosen to study. Because some social phenomena have important indirect consequences for the Earth system, they also felt that the social science research program should contribute to and extend the agenda that the natural scientists have set so that it would include topics such as demographic and attitudinal changes.

The Ann Arbor workshop identified broad topics that would be relevant to an international social science research program on global change. These include: demographic changes and the economic consequences of such changes; surveys of attitudes and behavior relating to environmental issues; studies of the industrial metabolism of economic systems; and, studies of human response and control mechanisms.

Participants in the Ann Arbor workshop strongly felt that steps should be taken soon to organize the social science community in the United States and in other countries to facilitate the development and implementation of an international social science research program on global change. Recommended actions include: appointing social scientists to the existing committee structures that have already been created to organize U.S. participation in IGBP; the National Academy of Sciences creating an hoc committee or a sub-committee to plan U.S. participation in an international social science research program on global change; and mobilizing other scholarly bodies in the United States, such as the Social Science Research Council and the U.S. National Committee for the Man and the Biosphere.

The participants in the Ann Arbor workshop were enthusiastic about the potentialities of an international social science research program on global change. The participants believe that the problems that will be addressed in IGBP are enormously important. They also believe that, building on recent work in social science and utilizing modern analytical techniques, social science research can make a significant contribution to understanding these problems. The

participants further believe that an international research program on global change would contribute to the development and strengthening of social science.

# Report of the Ann Arbor Workshop on an International Social Science Research Program on Global Change

Harold K. Jacobson

and Cheryl Shanks[1]

## The Ann Arbor Workshop

A massive international research program, the International Geosphere-Biosphere Programme: A Study of Global Change (IGBP), has been inaugurated by the International Council of Scientific Unions (ICSU). This program aims "at a fuller understanding of the Earth as an interconnected whole."[2] As currently conceived, IGPB is a natural science program. It is clear, however, that human actions strongly affect the Earth and its environment and that human beings will be affected by changes in the Earth and its environment whatever the source of these changes. For these reasons, steps have been taken to launch an international social science research program on global change that either would be part of IGBP or, though separate, would parallel and complement IGBP.

A workshop on an international social science research program on global changes was held at the Institute for Social Research of the University of Michigan in Ann Arbor, Michigan, 9

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1. Although Harold K. Jacobson and Cheryl Shanks are solely responsible for this report, substantial portions of the section dealing with examples of social science research that would be relevant to global change are either paraphrases or direct quotations from memoranda prepared by Ronald Freedman, Philip E. Converse, Robert U. Ayres, Robert Kagan, Arnold Heidenheimer, and Joann Vanek. We are grateful to these individuals for allowing us to use the material that they prepared. We are also grateful to the participants in the workshop for the comments that they provided on an earlier draft of this report which we have unabashedly appropriated and incorporated in this version.

2. International Council of Scientific Unions (ICSU). The International Geosphere-Biosphere Programme: A Study of Global Change (Paris:ICSU, 1986.), p. 1.

and 10 September 1987. This workshop was supported by a grant from the U.S. National Science Foundation.[3] The primary purpose of the workshop was to consider social science research that could be relevant to global change and to consider what actions social scientists in the United States should take to prepare for participation in an international research program on global change. This is a report of the workshop. It reflects the general sense of the meeting, not necessarily the views of each participant. The authors are solely responsible for the report and for the recommendations contained in it.

The report has five substantive sections. The first describes the development of IGPB. The second explains why it is important to develop an international social science research program on global change. The third chronicles the steps that have been taken to launch an international social science research program on global change. The fourth summarizes the general conclusions of the Ann Arbor workshop about an international social science research program and global change. The fifth section provides examples of social science research that would be relevant to global change. The final section contains recommendations about how U.S. social scientists might be organized to participate in an international research program on global change.

## The Development of IGBP

The Ann Arbor workshop must be seen in the context of steps that have been taken to develop IGBP. In September 1986, the twenty-first General Assembly of the International Council of Scientific Unions established the International Geosphere-Biosphere Programme: A

3. NSF Grant SES - 8719237.

Study of Global Change. According to the resolution that ICSU adopted, the purpose of IGBP is:

> . . . to describe and understand the interactive physical, chemical, and biological processes that regulate the total Earth system, the unique environment that it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human actions.[4]

In the same resolution ICSU accepted the final report of the Ad Hoc Planning Group that it had created at its twentieth General Assembly in 1984.[5] This report contains detailed recommendations concerning the substantive content and the organization and schedule of IGBP. These recommendations were all accepted in the resolution.

Since ICSU's decision, the Scientific Committee for the IGBP has been created. The Scientific Committee will have responsibility for initiating the preparatory phase of IGBP and for implementing the operational phase. The committee held its first meeting in July 1987 and elected Dr. James McCarthy, Museum of Comparative Zoology, Harvard University, as chairman.[6] The committee decided that emphasis should be placed in IGBP on interactive biological, chemical, and physical processes. It decided that priority should be given to "those areas of each of the fields that deal with key interactions and significant change on time scales of decades to centuries, that most affect the biosphere, that are most susceptive to human perturbation, and that will most likely lead to practical, predictive capability."[7]

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4. ICSU, Document GA 19/86, 18 September 1986, "Resolutions," p.5.

5. ICSU, Ad Hoc Planning Group on Global Change, "The International Geosphere-Biosphere Programme: A Study of Global Change," Final Report of the Ad Hoc Planning Group, 4 August 1986.

6. The other members of the Executive Board of the Scientific Committee are: Rafael Herrera, Professor of Ecology and Environmental Studies, Caracas, Vice Chairman; Professor William Fyfe, Dean of Science, University of Western Ontario, Treasurer; Paul Crutzen, Director of Atmospheric Sciences Division, Max Planck Institute, Mainz; Vladimir Kotlyakov, Glaciologist from the Soviet Union; and Thomas Rosswall, Executive Director, microbiologist from Sweden.

7. ICSU, Scientific Committee for IGBP, "Study of Global Change," Press Release, 24 July 1987, p. 3.

To develop the research program, the committee established eight panels or working groups. These panels and their tasks show the nature of the program.[8]

1. Global Geosphere-Biosphere Modelling: Models will be developed that link the biosphere and geosphere, incorporating changes in transfer rates between different systems with due regard to the interior processes and boundary conditions.

2. Data and Information Systems: The major task here will be to select the key parameters, obtain information on the data available, prepare and disseminate appropriate data sets and stimulate the collection of data not yet available.

3. Techniques for Extracting Environmental Data of the Past: The group will assess the present state of the art and of future technological developments for documenting global change through reconstruction of past changes in the environment using ice cores, tree rings, sediments etc., and in real time.

4. Geo-Biosphere Observatories: A feasibility study will be carried out of the need for and location of a network of geo-biosphere observatories for the generation of long-term data sets, validation of models, ground truth observations linked to remote sensing, etc., especially in zones and ecosystems that are fragile or sensitive to change.

5. Biosphere Interaction with Atmospheric Chemistry: Significant biospheric sources and sinks of chemical constituents will be identified that are important for understanding atmospheric chemistry on regional and global scales and the impact on climate.

6. Biospheric Aspects of the Hydrological Cycle: In order to improve the formulation of global climate models, particularly with regard to the role of vegetation in the parameterization of the subgrid-scale hydrologic processes changes in the reservoirs and fluxes of the hydrological cycle will be determined.

7. Effects of Climate on Ecosystem Changes: Estimates will be made of the effects of climate change on soil, vegetation structure and species composition of ecosystems.

8. Understanding the Role of Marine Ecosystems: The principal focus will be on the interplay between physical, chemical and biological processes in the photosynthetically active layers of the oceans.

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8. The descriptions of the tasks are direct quotations from pp. 1 and 2 of the press release previously cited.

The preparatory phase of IGBP will last through the remaining years of the 1980s. ICSU's plans call for the operational phase of the program to begin in the early 1990s and envisage that it will last at least 10 years.

## The Importance of Developing an International Social Science Research Program on Global Change

As presently defined, the International Geosphere-Biosphere Program includes very little social science research. There are several explanations for this. The International Council of Scientific Unions includes few social science professional associations. The natural science problems that are to be addressed in IGBP are enormously complex even without adding social science considerations. Transdisciplinary and multidisciplinary research among scientists of closely related disciplines is difficult, and the greater the distances among the disciplines, the greater the difficulties of collaboration. Natural scientists have a tradition of international collaborative research; the tradition of international collaborative research in social science is much less well developed.

Social science can, however, make important contributions to understanding the problems that are going to be addressed in IGBP. The report of ICSU's Ad Hoc Planning Group underscores how human actions interact with natural forces and processes:

> The dominant changes that affect the environment and the course of life of Earth are natural ones, induced by such inexorable forces as natural selection, the shifting of winds and rivers, changing inputs from the Sun, the turbulent dynamics of the atmosphere and oceans, the drifting of continental plates, the building of mountains, and the expansion and contraction of ice masses. But imposed on these is now another set of changes, more recent and immediate in consequence, that are the clear result of human activities. Our uses of energy and practices of intensive farming and technology have altered the albedo of the Earth, the composition of soil and waters, the chemistry of the air, the areas of forests, the diversity of plant and animal species, and the balance of the global ecosystem. To read the impacts of human actions — or to forecast their effects — requires a

> fuller knowledge of the natural background of change on which they are imposed, and the processes and feedbacks through which they work.[9]

Human activities have consequences for the Earth system, and changes in the Earth system will have consequences for humankind. To fully comprehend global change, it will be necessary to understand the factors that condition human activities.

## Steps that Have Been Taken to Launch an International Social Science Research Program on Global Change

Several groups, including ICSU, have acknowledged the potential importance of social science research for IGBP, and initial steps have been taken to launch an international social science research program on global change. In December 1986, the sixteenth General Assembly of the International Social Science Council (ISSC) decided to create an ad hoc planning group that would prepare an outline of a social science research program on global change.[10] The ISSC appointed a Planning Committee on Global Change in February 1987.[11]

The International Federation of Institutes of Advanced Study (IFIAS) hosted a meeting in Toronto, Canada from 10 through 13 June 1987 to consider the implications for social science research of the IGBP. The meeting was titled "Human Response to Global Change: Toronto Ad Hoc Preparatory Group Meeting." In addition to IFIAS, the Toronto meeting was sponsored by several other organizations including ISSC.[12]

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9. ICSU, "The International Geosphere-Biosphere Programme: A Study of Global Change," p. 1.

10. ISSC, "Draft Summary Report: Sixteenth General Assembly, 9 – 11 December 1986, p. 10.

11. The members of the planning committee are: Estefania Aldaba-Lim, Psychiatry, Philippines; T. Fujii, Economics, Japan; Harold K Jacobson, Political Science, USA; Lesek Kosinski, Geography; and Kurt Pawlik, Psychology, Federal Republic of Germany.

12. The other co-sponsors were: The International Ecology Society; the United Nations Environment Programme; the International Institute of Applied Systems Analysis; the International Geographical Union; the International Development Research Centre, Canada; the United

There was consensus at the Toronto meeting that there should be a broad international social science research program on global change.[13] The Toronto meeting made three important recommendations to its sponsoring organizations to implement this consensus:

> 1. A symposium should be convened in the fall of 1988 in Tokyo, Japan to develop a preliminary plan for a social science research program on global change. The United Nations University agreed to host the symposium. Leading social scientists should be invited to prepare papers for the symposium and to present them at the symposium. The symposium should be designed to perform some of the same functions for a social science research program that the two symposia and the Ad Hoc Planning Group on Global Change performed for the natural science components of IGBP.
>
> 2. An interim steering group should be created to plan the Tokyo symposium. The steering group would be composed of representatives of the International Federation of Institutes of Advanced Study, the International Social Science Council, and the United Nations University.
>
> 3. Ian Burton, Director of IFIAS, should be asked to establish and head an interim secretariat to serve the interim steering group and to do the necessary administrative work in connection with the Tokyo symposium.

These recommendations have been accepted by the several organizations that sponsored the Toronto meeting. The interim steering group held its first meeting in Paris in November 1987. It was decided that the Tokyo symposium should be held from 19 through 22 September 1988. The process has been started to have an international social science research program on global change.

## General Conclusions of the Ann Arbor Workshop

The Ann Arbor workshop became part of this process. Participants in the workshop represented a variety of social science disciplines that are relevant to the problems addressed in

Nations Fund for Population Activities; the Canadian International Development Agency; the Atmospheric Environment Service, Environment, Canada; and the Royal Society of Canada.

13. See the report of the meeting: IFIAS, "The Human Response to Global Change: Prospectus for an International Programme," June 1987.

IGBP. Appendix 1 includes a list of the participants. The participants joined the growing international consensus in favor of launching an international social science research program on global change. The participants believe that the problems that will be addressed in IGBP are enormously important for humankind. They also believe that, building on recent work in social science and utilizing modern analytical techniques, social science research can make a significant contribution to understanding these problems. The participants believe that an international research program on global change would contribute to the development and strengthening of social science.

Human actions have an immense impact on the Earth and its environment. The quotation from the report of ICSU's Ad Hoc Planning Group cited above mentions human actions that bring about or force changes in the Earth system: uses of energy, practices of farming, and uses of modern technology. Participants in the Ann Arbor workshop amplified this list, stressing physical activities associated with agriculture and land settlement, such as forest clearing, grazing, plowing, fencing, fires, irrigation, and road-building, and the large-scale extraction, processing, refining, use, and dispersion (in altered form) of fossil fuels and minerals.

The participants in the workshop traced these actions that have immediate consequences for the Earth system to deeper and perhaps less obvious causes. Requirements for food, energy, and raw materials are ultimately driven by the number of people that inhabit the Earth, their demographic characteristics, and their spatial distribution. Human requirements for food and uses of energy and raw materials, however, are neither absolute, uniform, nor fixed. Technology; forms of economic, political, and social organization; and human tastes and attitudes are powerful mediating factors. Human uses of energy and requirements for food vary synchronically and diachronically and are subject to change.

Changes in the Earth system also have tremendous consequences for humankind. What is ultimately at stake is the habitability of the earth. It is clear that human beings have responded and will respond to changes in the Earth system and that the human instinct for survival is very strong. It is also clear that a variety of human responses to changes in the Earth system are possible, ranging from consciously taking no action, and allowing processes of natural selection to occur, to deliberately ceasing activities that cause harmful effects. Further, the effects of inaction or various types of action depend on the context in which they occur; something that may be effective in some circumstances may be totally ineffective in others. Human actions in response to changes in the Earth system can have unforeseen and unintended consequences for natural processes. In short, there is a partially-consciously-directed, continual cycle of interactions between human beings and natural processes. Humankind is an integral part of nature, and the Earth system needs to be understood in these terms.

The participants in the Ann Arbor workshop concluded that an international social science research program on global change should encompass both human actions that force changes in the Earth system and human responses to changes in this system. Some social science research projects will deal with human actions that force change in the Earth system, others will deal with human responses to such change, and still others will deal with both aspects. The research should include, as well, both the inadvertent effects on natural systems of human actions and those human actions that consciously involve intervention in natural systems.

Given the fact that the natural science research program is already relatively well defined and the clear importance for humankind of the problems that are being addressed through this program, the participants thought that the agenda of the social science [illegible] should to a considerable extent conform with the agenda that the natural sc[illegible] the program should investigate the human dimensions of the problems [illegible] have

chosen to study. As one participant put it, "If the natural scientists study ocean currents, we will study all of the human phenomena connected with ocean currents. We will study what they study." There was also agreement among the participants that the natural science definition of the research agenda probably would not include all relevant social science topics, particularly those, such as demographic changes and attitudinal shifts that result in transformations of life styles, that are not immediately and obviously connected with natural processes. An international social science research program on global change should include topics that social scientists could identify as having important though indirect consequences for the Earth system. The social science program should in this way contribute to and extend the research agenda set by the natural sciences.

The development of global models of the various components of the Earth system is seen as the unifying activity of IGBP. For these models to be complete, variables involving human activities will ultimately have to be included. Human activities that affect the Earth system cannot be assumed to be constant. Human populations grow, their technologies change, and human tastes shift; all these factors alter human interactions with the Earth. Human beings learn and modify their behavior as a consequence. Social and political organizations regulate human behavior. To be complete global models ultimately must include understandings about the extent of human activities that affect the Earth system and how these activities change. These understandings should encompass economic, social, and political factors, paying special attention to the spatial dimensions of human activities.

It would probably be unrealistic to believe that many equations concerning human activities and how they change could be added to the global models that will be developed in IGBP. Developing the models for the natural aspects of the Earth system will be a task of great complexity that will require gaining new understandings of key processes and the collection of

great quantities of data. The social processes that account for change in human activities that affect the Earth system are less well understood than many important natural phenomena and modeling of them is not well developed. Nevertheless, an important long-term goal of an international social science research program on global change should be to make it possible over time to add to global models of natural phenomena understandings about human activities that affect the Earth system and how they change.

Participants in the Ann Arbor workshop believe that an international social science research program along the lines that have been outlined could contribute significantly to the goals of IGBP and could enhance human capacity to preserve and improve the habitability of Earth. They also believe that such a research program could contribute significantly to developing and strengthening social science. Such a research program would integrate social science with a larger scientific enterprise and would focus social science research on an important set of research problems. It would also extend the time frame of social science research, lead to greater emphasis on discontinuities in human actions, and contribute to integration within and among the social sciences.

The natural science research program will concentrate on phenomena with time scales from decades to centuries. Demography deals with time scales of decades, but beyond this social science generally deals with much shorter time scales. To link a social science research program with the natural science program will require that social science attempt to deal with longer time scales than it normally does, and this could lead to innovations in the social sciences. An international social science research program on global change would force social science to give greater attention than it normally does to intergenerational change.

The natural science research program is interested in discontinuities as well as monotonic trends. Social science deals with regular trends with relative ease, but only seldom deals with

discontinuities, and then not easily. To give greater attention to discontinuities than social science normally does will be a significant challenge. Among other requirements, dealing with discontinuities will force social science to develop capacities to monitor events that occur irregularly and unexpectedly, and then to develop techniques for understanding their aggregate effect on collective behavior.

Most importantly, to relate social science knowledge meaningfully to the problems addressed in the natural science research program will require a hitherto unachieved integration among social sciences. Returning to the example cited above, to study all human actions related to ocean currents will require that several social science disciplines work together and integrate their findings. Putting the issue in different terms: demographers know a great deal about population dynamics; economists, about resource use; sociologists, about attitudes and attitude change; and political scientists, about the conditions for and consequences of governmental regulation; but few links have been established among these separate bodies of knowledge. Such links will have to be established for social scientists to make a useful contribution to understanding the problems that are the focus of IGBP.

## Social Science Research Relevant to Global Change

Designing an international social science research program on global change will require the gradual evolution of an international consensus so that the program will reflect truly global concerns. It will also require much effort involving many disciplines. The following disciplines and sub-disciplines would be especially relevant: Demography; Geography; Economics, especially Resource Economics; Environmental History; Systems Analysis; Risk Analysis; Human Ecology; Epidemiology; Anthropology; Sociology; Cognitive Psychology; Political

Science, specifically Comparative and International Public Policy; and National and International Legal Regulation. Many of these fields, especially Systems Analysis, Risk Analysis, and Human Ecology, involve individuals who themselves have interdisciplinary training and do interdisciplinary work. Often they involve individuals with engineering or natural science training who are now concerned with systems analysis or public policy. As should be clear from the illustrative list of disciplines, social science as used here includes aspects of law, engineering, and the health sciences.

Even in a brief workshop that did not include all of the disciplines and sub-disciplines that would be relevant, it was possible to identify research that would be important components of an international social science research program on global change. These relate to both human activities that force changes in the Earth system and human responses to changes in the Earth system.

In particular, four broad research areas were stressed in the workshop: demography; surveys of human attitudes and behavior; industrial metabolism; and, human response and control mechanisms. The first two areas have indirect but basic consequences for the Earth system. There are already established traditions of international collaborative research in each of these areas that would facilitate launching the research that would be required for an international social science research program on global change. The second two areas have direct and obvious consequences for the Earth system. In addition, the workshop considered issues involving the collection, compilation, and archiving of social science data on global change. Unless these data issues are dealt with at the outset of the research program, there is a great danger of incomparable data — and thus data of limited utility — being gathered. We present this list of topics and issues as suggestions and illustrations, not as the first draft of a comprehensive agenda for an international social science research program on global change.

## Demography

A social science research program on global change should give considerable attention to demography. The number of people that inhabit the Earth, their demographic characteristics, and their spatial distribution, will be primary factors affecting the requirements for food, energy, and raw materials. To understand how human beings affect the Earth, it is first necessary to understand population dynamics. Fortunately, there is already a highly-developed international research program in demography that has stimulated important methodological innovations, yielded a great deal of data relevant to public policy choices, and resulted in a greatly improved understanding of population dynamics.[14] It is important to note what has been accomplished, because there is already a substantial base on which new research can build.

Two biosocial characteristics, age and sex, and three change processes, fertility, mortality, and migration, are the basis of most population projections. In these terms, populations are closed systems over time. Basic data concerning these biosocial characteristics and change processes and other demographic characteristics have increasingly become available from periodic censuses, sample surveys, and various registration systems. Developing standardized definitions has been a necessity. A considerable body of methodology for defining, collecting, evaluating, and adjusting such data has been developed and disseminated widely. In addition, historical demographers have been increasingly successful in reconstructing demographic parameters.

Many methodological innovations have been made by demographers. Using the basic data for demographic projections, models have been developed that represent their dynamic

14. This section is based on a memorandum prepared by Ronald Freedman entitled "A Note on Internationally Comparable Demographic Data Sources Possibly Relevant for Global Analyses of the Geo-Biosphere." This memorandum is available on request.

interdependence and can be used to evaluate the accuracy of some of the elements, given most of the others. Demographers have been leaders in developing methods for evaluating and adjusting data and for making estimates where direct measures are not available.

Current demographic data are now available for 220 countries. In addition, every few years the United Nations Population Division publishes a set of population estimates for every country in the world with populations of at least 300,000 for periods since 1950 and projections extending to 2025.

The recently completed World Fertility Survey (WFS) was probably the largest comparative social data collection ever done. Between 1975 and 1985 sample surveys were completed under the auspices of WFS in 42 developing countries. Twenty developed countries also participated in the WFS with somewhat less standardized comparability. The WFS produced useful comparative data on fertility and other aspects of reproduction, infant mortality, and related social determinants such as education and labor force status. Hundreds of analytical reports have been published using WFS data. An important type of WFS-based study, that is especially relevant for global problems, is multilevel analyses in which macro-characteristics of countries, regions or communities are used to predict variations in relationships between socioeconomic and demographic variables within such units.

The World Fertility Survey was so successful that a new round of surveys was begun in 1984 called the Demographic and Health Surveys (DHS). As the name implies, questions of health were added to the survey. The DHS expects to complete 35 surveys in developing countries between 1984 and 1989, and the plan is to continue the program for an additional five years with surveys in other developing countries.

This international demographic research needs to be continued and strengthened. Because people drive the need for food, energy, and raw materials, such research would be a vital contribution to a social science research program on global change.

In addition, this research needs to be augmented by studies that devote greater attention to the economic consequences of demographic changes. Demographers' initial explorations of these issues indicate how much work is to be done and how interesting and important the results can be.[15] Research needs to be done on the interaction between rates of population growth, levels of income, and the demand for exhaustible and renewable resources. Another important topic is the interaction between rates of population growth, levels of income, and environmental degradation. Rates of population growth, mediated by levels of income, affect in ways not yet understood the propensity for technological innovation, scales of production, and the need for capital. These issues too, and many others as well need to be explored.

## Surveys of Human Attitudes and Behavior

Surveys of human attitudes and behavior should be a vital component of a social science research program on global change. Human beings can respond to global change in a variety of ways, ranging from accepting change and adapting to it, to attempting to limit change by modifying their behavior. The human response depends first on cognitive processes, on perceiving change and its consequences, and then on the possibilities that human beings see for affecting change and the values that they hold. Social scientists have begun to explore these issues on a global basis.

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15. See: National Academy of Sciences, Commission on Behavioral and Social Sciences and Education, Population Growth and Economic Development: Policy Questions. (Washington, D.C.: National Academy Press, 1987)

A number of surveys of human attitudes and behavior have been conducted simultaneously in countries throughout the world.[16] These surveys have produced important data and have also established networks of social scientists who do this type of research. Again, a strong base exists for further social science research relevant to global change.

As early as 1965, a survey of daily time allocations of populations in Belgium, Bulgaria, Czechoslovakia, the Federal Republic of Germany, France, the German Democratic Republic, Peru, Poland, the Union of Soviet Socialist Republics, the United States of America, and Yugoslavia was conducted under the direction of the Hungarian academician Alexander Szalai. The survey implemented a common research design involving 24-hour time diaries. Subsequently parallel data collections were developed in most of the Scandinavian countries as well as in Brazil, Japan, and other countries. How people allocate their time affects their use of resources.

Since then, other large-scale cross-national collaborations involving public opinion formation have taken place. One of the largest and most recent of these is the World Study of Values, conducted under the leadership of the European Value Systems Study Foundation of Amsterdam in collaboration with Gallup International. Here surveys were carried out with representative national samples of publics in more than two dozen countries in Africa, Asia, Australia, North and South America, and Eastern and Western Europe. Measurements of economic, religious, and social orientations showed, among other things, major differences in responses of older and younger generations in directions suggestive of changes in values concerning the environment. Younger cohorts exhibited greater concern for the environment and greater willingness to undertake actions to protect the environment. Essentially the same network

16. This section is based on a memorandum prepared by Philip E. Converse entitled "The Availability of Other Social Survey Networks." This memorandum is available on request.

of researchers is being reactivated to do a replication of the study in 1989, to examine the degree to which such value differences are truly generational, rather than representing repetitive maturation of individuals as they age in such populations.

Since institutions capable of mounting such studies are few in any given country, there is substantial continuity between the units that participated in early time-use research and those involved in later collaborations, although there have also been many new additions. The important point for an international social science research program on global change is that a network of survey research agencies, global in scope, has already engaged in collaborative research on human attitudes and behavior. This network has established relationships of trust and considerable joint experience in such thorny problems as the translation of interview schedules into various languages while maximizing equivalence of meaning. Future work would merely require the activation of such networks rather than building them from scratch.

Because human beings and their institutions are ultimately responsible for actions that affect the Earth system, it will be important to monitor public attitudes and behavior. The sooner that international base-line surveys of attitudes and behavior concerning the ecosystem are conducted the better, for such base-line surveys will be an essential step in attempting to monitor and understand attitudinal change with respect to issues that affect the Earth. The pressure, stemming from the time frame of IGBP, to extend the time scales normally used in social science and the potential importance of generational change in producing attitudinal and behavioral, change provide important stimuli for undertaking longitudinal studies of attitudinal and behavioral change.

Although some demographic studies and attitudinal and behavioral surveys that would contribute to an international social science research program on global change can and should be undertaken on a global basis, not all such studies nor all components of the social science

research program need have this character. There are many issues that involve research that should be undertaken in specified geographic domains.

Monitoring events that occur irregularly and unexpectedly necessarily involves research that should be done in specified geographic domains. Gathering and analyzing data about how individuals and economic, political, and social organizations respond to natural disasters, such as hurricanes and tornados, or those caused by human beings, such as the Bopal and Chernobyl incidents, would be examples of this type of emergency-watch research. Elements of the world-wide networks of survey research organizations could be activated for doing intensive local probes where crucial "natural experiments" involving special population-environment interactions are taking place.

## The Industrial Metabolism of Economic Systems

It is crucial to the goals of IGBP that the industrial metabolism of economic systems be better understood. Industrial metabolism refers to the equilibrium that is established and reestablished in demand and supply relationships in any economy.[17]

The industrialized economic system of today may or may not be in rough equilibrium in terms of supply and demand relationships, but it is very far from equilibrium in thermodynamic terms. The self-sustaining economy of small farms is a thing of the past, if not a textbook idealization. At present enormous quantities of fossil fuels and high quality minerals are being extracted each year to drive the economic engine. The economic system is stable only in the way a bicycle and its rider are stable: if or when forward motion stops, the system will collapse and fall down. Forward motion in the economic system is technological progress. Only by

17. This section is based on a memorandum prepared by Robert U. Ayres entitled "Industrial Metabolism." This memorandum is available on request.

continuously discovering ways to exploit mineral and fuel resources that are ever more inaccessible and or lower in quality, can the system keep going. In the long run, it may be possible to utilize solar energy effectively to replace fossil fuels, but the technology is still undeveloped and it will be a very long time, many decades at least, before the necessary infrastructure is put in place.

But even if human ingenuity develops a substitute for fossil fuels, there is no long-term substitute for other minerals and metals. As the best quality ones are extracted and used up, the accessible and recoverable ore bodies decline in quality. The amount of physical and chemical processing needed to extract the useful and desirable materials from the useless waste materials will inevitably increase over time. Recycling will, of course, also increase as industrial wastes and municipal and household refuse become competitive in quality with nature ores. But as long as humans demand material goods, or services from material goods, the need for materials processing would grow steadily over time, even if the population were stable and the quantity of material output of final goods remained constant. If population and incomes continued to grow, as they surely will, the aggregate amount of materials to be processed must grown even faster.

The environmental stresses resulting from material-processing arise primarily from the dispersion of biological active materials such as toxic heavy metals (e.g. copper, lead, zinc, and arsenic), sulfur, halogens, and nutrients (i.e. phosphorus and nitrates). In natural systems the toxins are mainly locked up in minerals that are mobilized very slowly by leaching and volcanic action, or in non-reactive salts. Phosphorus is naturally recycled through the oceans at a very slow rate and nitrogen is naturally cycled through the atmosphere, with assistance from bacterial action. On the other hand, industrial activities have created new and incessive uses for many of these materials. Moreover, many of the uses are not amenable to complete recycling. Examples include: solvents; reagents; catalysts; algicides; pesticides, herbicides, and fertilizers; paints,

dyes, and pigments; soaps and detergents; lubricants, flocullants, and fuel additives. In a word, many of the uses of materials in an industrial society are inherently dissipative.

More needs to be known about the productive-consumption cycle of materials. The flows and uses — especially inherently dissipative uses — in industrial systems have so far been studied only on an occasional ad hoc basis by a few researchers.[18]

Studies of this character should be done with respect to river basins and other defined geographical areas. Because the concept of industrial metabolism is dynamic, environmental history would necessarily be an approach used in these studies. Studies such as these could be closely linked with natural science investigations of: biosphere interaction with atmospheric chemistry; biospheric aspects of the hydrological cycle; the effects of climate on ecosystem changes; and, marine ecosystems.

## Human Response and Control Mechanisms

Studies of the adaptive capacities of human societies to diminish or reverse the course of environmentally detrimental activities are another example of the type of research that an international social science research program on global change should include.[19] Human impacts on the biosphere and geosphere cannot be estimated simply by extrapolating current trends. Human societies have the capacity to perceive the environmental perturbations they cause, and they are increasingly able to anticipate perturbations likely to occur in the future. Moreover human societies have at least some capacity to act on these perceptions, to diminish the rate or even alter the course of their environmentally destructive activities.

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18. For examples of such studies see: Robert U. Ayres, Resources, Environment and Economics (New York: John Wiley and Sons, 1978; and Robert U. Ayres and Samuel R. Rod, "Patterns of Pollution in the Hudson-Raritan Basin," Environment, Vol. 28, No. 4 (May 1986), pp. 14-20, and 39-43.

19. This section is primarily based on a memorandum prepared by Robert Kagan entitled "Human Response and Control Mechanisms." The section also draws from a memorandum prepared by Arnold J. Heidenheimer entitled "Comparative Environment Policy Research on Europe and the United States: Some Focal Points." Both memoranda are available on request.

Too little is known, however, about the actual strength and limits of these adaptive capacities. Perception is one thing, changing entrenched patterns of need-gratifying behavior is quite another. Nevertheless, socially-devised efforts can alter behavior, at least under some circumstances. But under what circumstances, and how much?

The answers to such questions are complex. The complexity, however, is not impenetrable. A variety of theoretical models and empirical techniques, developed by economists, political scientists, and sociologists, have been or can be employed to comprehend the effectiveness of such human self-regulatory processes. It seems both possible and essential, therefore, to encourage intensive study of the response mechanisms that may mitigate, or fail to mitigate, environmentally-threatening human activities. Markets and governmental regulation are prominent types of such response mechanisms.

Large-scale, competitive markets, linking profited-oriented production organizations, are powerful mechanisms for triggering responses to certain environmental changes. Through markets, increases in scarcity of valued resources are translated into price increases. Users are thereby encouraged to switch to more abundant alternatives or to devise ways of using the resource more efficiently. The implications for research are clear. To predict the rate of $CO_2$ accumulation stemming from fossil fuel consumption, to suggest just one example, one would want sophisticated econometric studies that estimate future price changes for petroleum and coal products, incentives to switch to other fuels, and prospects for developing more efficient methods of deriving energy from fossil fuels. It seems vitally important to stimulate further research along these lines for a broad range of resources whose continued availability is emerging as critical to the biosphere.

Conversely, unrestrained resource consumption often stems from market failures, situations in which restrictions on competition, information, or property rights undercut

incentives to economize. Some governmentally-created arrangements, such as cartels, subsidies, and import quotas, buffer producers or users from the price signals that would come from competitive markets. As in the oft-told tragedy of the commons, excessive resource consumption sometimes is encouraged by land-ownership patterns or unpriced modes of access to water supplies, fisheries, forests, and waste disposal sites. It would be enormously useful, therefore, to encourage a substantial increase in economic studies that would inventory market failures, anti competitive arrangements, and resource allocation patterns affecting those resources that are important to the maintenance of a habitable geosphere and biosphere, and to estimate the mitigating potential of introducing more competitive systems.

World-wide commodity and credit markets can have indirect effects on resource consumption. Price-increasing petroleum cartels stimulate burning of firewood and coal in petroleum-importing countries. Adverse trade balances or mounting debt obligations encourage governments of developing countries to stimulate exports of natural resources or cash crops, with attendant increases in use of fertilizer, groundwater for irrigation, and other environmentally-relevant actions. Consequently, study of environmental effects of financial markets and trade patterns, which of course are affected by political struggles over the rules governing lending and trade between developed and developing countries, is integral to an understanding of human impacts on the geosphere and biosphere.

The absence of property rights in the atmosphere, the oceans, large categories of the Earth's biota, and polar ice caps, to make only a partial list, mean that these resources cannot be protected by market mechanisms. In principle, however, impacts on these resources and systems can be reduced by consciously-contrived governmental regulation.

In fact, during the course of the past century, and especially the last quarter century, there have been dramatic developments in the sphere of governmental actions specifically designed to

influence or regulate economic activity that significantly affects the environment. Especially in Western societies, constituencies and advocacy groups interested in conservation of forest and wetlands, control or air and water pollution, and electricity conservation have been increasingly successful in placing their concerns on national political agendas and in stimulating enactment of environmental protection laws.

As recently as a couple of decades ago, political scientists and economists generally were skeptical about the capacity of governments to make and enforce regulations that conflicted with the immediate interests of important industrial or agricultural producer groups. Today, however, successful examples of regulation, along with the recurrence of unsuccessful ones, have changed the theoretical and research agenda. The issues are: under what circumstances are governments induced to enact and effectively enforce environmental protection schemes; and, what strategies of control are most potent? Such strategies include administrative specification and enforcement of control technologies and creation of appropriate incentives via pollution or consumption taxes. The answers concern humankind's propensity to use its capacity to anticipate and prevent environmental degradation.

Social scientists have made a start on this agenda by means of case studies of existing governmental regulatory programs, primarily within developed countries and with respect to regulations concerning pollutants with relatively clear, short-term consequences for human health and welfare.[20] The methods and hypotheses derived from these studies, however, could and should be employed in a wider range of inquiries. Examples of such inquiries include studies of: the pace or response-time with which scientific information about threats of

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20. For examples of such research see: Ronald Brickman, Sheila Jasanoff, and Thomas Ilgen, Controlling Chemicals: The Politics of Regulation in Europe and the United States (Ithaca, New York: Cornell University Press, 1985); Cynthia Enloe, The Politics of Pollution in a Comparative Perspective (New York: McKay, 1975); Lennart Lundqvist, The Hare and Tortoise: Clean Air Policies in the United States and Sweden (Ann Arbor, Michigan: University of Michigan Press, 1980); and David Vogel, National Styles of Regulation: Environmental Policy in Great Britain and the United States (Ithaca, New York: Cornell University Press, 1986).

significant perturbations in the geosphere and biosphere is translated into governmental action; how polities deal with scientific uncertainty; attitudinal and political preconditions for effective regulation or resource management programs in developed and developing countries; and, prospects for, and the strength of obstacles to, effective internationally coordinated regulatory and resource management programs addressed to problems of international and global environmental degradation. Such studies could be linked with studies of industrial metabolisms and could also be linked with natural science investigations.

Beyond being crucially important to understanding the interaction between humankind and the Earth system, studies like those just outlined would contribute to illuminating one of the most controversial issues in analyses of comparative public policy: the question of the extent to which policy processes and outcomes are shaped by the unique character of a particular policy area — the policy sector hypothesis — or whether they are a function of the distinctive historical, cultural, social, economic, and political characteristics of the country in which they occur — the national styles hypothesis.

This is only a partial agenda, meant to suggest the nature and general thrust of elements of an international social science research program on global change. Further dialogue among social scientists, and especially between social and natural scientists, undoubtedly would expand the range of important topics to be addressed by social science, while establishing more specific and focused priorities. At this point, however, the scientific importance of social research on human response and control mechanisms is clear, and the case for stimulating such research is compelling.

The Collection, Compilation, and Archiving of Social Science Data on Global Change

As is the case with the IGBP natural science research program, an international social science research program on global change would involve the collection, compilation, review, and dissemination of large amounts of data. Coordination of the efforts involved in these data-related tasks would be an essential component of a social science research program. Data must be collected and compiled so that they are comparable. Standard geographic units should be used whatever scholarly discipline might be involved. Special efforts should be made so that the results of global and geographically delimited studies could be related to each other.

International governmental organizations, including the United Nations, the agencies of the UN system, and the major regional organizations, have substantial experience in developing standardized data that are consistent cross nationally and over time.[21] The UN's Demographic Yearbooks and Statistical Yearbooks, the World Bank's World Tables, and the International Monetary Fund's International Financial Statistics and Direction of Trade are examples of data sets compiled and published by international agencies.

The statistical services of international agencies ultimately rely almost entirely on national data collection programs for provision of data and these data are usually collected directly from the countries using questionnaires. To varying degrees, data from the questionnaires are adjusted by the international agencies to achieve consistency internally and with other sources, and in some cases may be supplemented with data taken directly from national publications. In a few cases, estimates and projections are prepared by international agencies under their own responsibility, taking into account all available statistics and information, where international

21. This section is based on a memorandum prepared by Joann Vanek entitled "Notes on Sources of United Nations Data on Demographic Statistics and Statistics on Geographical Distribution of Population, Land Use and Migration." This memorandum is available on request.

comparability and availability are considered of unusually high priority and the necessary resources and basic data are available. In order to promote wide and consistent use of data provided to international agencies by countries and to avoid overlapping requests to countries, all of the international statistical services are committed to an extensive program of data exchange.

The data compiled by international agencies are vital to social science research and would be important resources for an international social science research program on global change. In addition, an international social science research program on global change should benefit from and build on the experience of these international governmental organizations in designing its own data collection and compilation efforts.

Provision will have to be made in an international social science research program on global change for archiving the data that are gathered so that they can be broadly available to social scientists throughout the world. The Inter-university Consortium for Political and Social Research (ICPSR) already archives major social science data sets. The ICPSR is comprised of more than 300 universities and groups of universities from different parts of the world, and its current holdings include more than 15,000 data sets. The ICPSR's experience would be relevant to an international social science research program on global change, and ICPSR could become a repository for data gathered in the program.

## Organizing the U.S. Social Science Community to participate in an International Social Science Research Program on Global Change

Participants in the Ann Arbor workshop strongly felt that steps should be taken soon to organize the social science community in the United States and in other countries to facilitate the development and implementation of an international social science research program on global change. The planning stage for IGBP is already underway. If social scientists are to make their maximum contribution, they should begin participating as soon as possible. As a group primarily composed of U.S. social scientists, the Ann Arbor workshop was especially concerned with the organization of the U.S. social science community.

The form of national organizations for participation in an international social science research program on global change should be dependent to some extent on the character and structure of the International Geosphere-Biosphere Programme. Many participants in the workshop hoped that social science research could be included as an integral part of IGBP. Most participants, however, including some who hoped for the inclusion of social science research in IGBP, felt that since the natural science research program had already achieved considerable momentum, integrating social science research at this stage might be difficult. If this proved to be the case, they favored developing an international social science research program on global change that, though separate, would parallel and complement IGBP. National arrangements should be flexible and geared to the evolution of IGPB.

When IGBP was in its gestation stage, an ad hoc committee was appointed by the U.S. National Academy of Sciences to suggest work that U.S. natural scientists might do and

priorities for the international program.[22] Now that the decision has been taken to launch IGBP, the National Academy of Sciences has created a full committee structure to manage U.S. participation in the program.

The way in which U.S. natural scientists have organized themselves for participation in IGBP is impressive. Some of the steps that natural scientists have taken should be emulated by social scientists. The organization of U.S. social scientists should also reflect the special characteristics, traditions, and institutional structure of U.S. social science.

On the basis of the discussions that occurred in the Ann Arbor workshop, three actions with respect to the organization of U.S. social scientists appear to be desirable and are recommended.

Where it is possible and appropriate, social scientists should be added to the committee structures that have already been created to organize U.S. participation in the International Geosphere-Biosphere Programme. This would facilitate contact and communication between natural and social scientists and sensitize both groups to the scientific concerns of the other. It would also insert some social science concerns into the planning for IGBP.

The National Academy of Sciences should appoint an ad hoc committee, or a sub-committee, to plan U.S. participation in an international social science research program on global change. The Commission on Behavioral and Social Sciences could play an important role in the creation and functioning of this ad hoc committee or sub-committee. Serious planning of the research program will be a complex and difficult task, one that will require the best possible scientific talent and strong staff support. The National Academy of Sciences could mobilize the

22. See the report of this ad hoc committee: U.S.A., National Academy of Sciences, Global Change in the Geosphere-Biosphere: Initial Priorities for an IGBP. (Washington, D.C.: National Academy Press, 1986).

best possible social science talent, and the National Research Council has a proven record of providing strong staff support. Having the National Academy of Sciences appoint an ad hoc social science committee would help to give the committee stature equal to that of the natural science committees. Since the National Academy of Sciences has created the existing IGBP committee structure, and since the staff of this committee structure is housed within the National Research Council, following the same course with respect to the social sciences would maximize the possibility for communication among natural and social scientists. If the social science research program largely follows the research agenda determined by the natural scientists, such communication will be extremely important.

Other scholarly bodies in the United States could also make important contributions to an international social science research program on global change. The Social Science Research Council (SSRC) has historically played an important role in the development of U.S. social science. Through the committees that its has established and the fellowship programs that it has managed, the SSRC has developed whole new fields of study within and across disciplines. SSRC's committees have been pioneers in the development of new concepts, and the council's pre-doctoral and post-doctoral fellowship programs have developed cadres of social scientists with new types of training and skills, scholars who have gone on to do highly innovative work and even to redefine fields. The Social Science Research Council could perform these roles with respect to aspects of the subject matter of the International Geosphere-Biosphere Programme. Examples of areas where the SSRC might be able to make an important contribution are in exploring the implications of population dynamics for economic activities and in developing environmental history. The United States National Committee for Man and the Biosphere could also undertake activities to promote and facilitate U.S. participation in an international social science research program on global change.

The participants in the Ann Arbor workshop hope and expect that social scientists in other countries than the United States, and in groups of countries, will begin organizing themselves to participate in an international social science research program. Movement is underway in a variety of places, and the Tokyo symposium will be an important catalytic event.

Clearly the Ann Arbor workshop only began to explore the potentialities and the issues involved in creating an international social science research program on global change. It did, however, rouse great enthusiasm among the participants for moving in this direction and excitement about the results that a research program could bring. The participants realize that the natural scientists took a long time to launch IGBP and that the pace of developing a social science research program should not be forced. At the same time, they feel a sense of urgency and hope that social science research can develop in a synchronized manner with the natural science research for IGBP.

## APPENDIX 1

Professor Robert V. Ayres
Department of Engineering
and Public Policy
Carnegie-Mellon University
Pittsburgh, Pennsylvania 15213

Professor Harvey Brooks
John F. Kennedy School of Government
Harvard University
Cambridge, Massachusetts 02138

Professor Ian Burton
International Federation of
Institutes of Advanced Study
39 Spadina Road
Toronto, Ontario M5R 2S9
Canada

Professor William C. Clark
John F. Kennedy School of Government
Harvard University
Cambridge, Massachusetts 02138

Professor Jerome M. Clubb
Executive Director
Inter-University Consortium
for Political and Social Research
Center for Political Studies
Institute for Social Research
The University of Michigan
P.O. Box 1248
Ann Arbor, Michigan 48106

Professor Philip E. Converse
Director
Institute for Social Research
The University of Michigan
P.O. Box 1248
Ann Arbor, Michigan 48106

Professor Ronald Freedman
Population Studies Center
University of Michigan
1225 S. University
Ann Arbor, Michigan 48109

Professor Arnold Heidenheimer
Department of Political Science
Washington University
St. Louis, Missouri 63130

Professor Harold K. Jacobson
Director
Center for Political Studies
Institute for Social Research
The University of Michigan
P.O. Box 1248
Ann Arbor, Michigan 48106

Professor Robert Kagan
Department of Political Science
University of California – Berkeley
Berkeley, California 94720

Dr. Roberta Balstad Miller
Director
Division of Social and
Economic Sciences
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550

Dr. John Perry
National Academy of Sciences
2101 Constitution Avenue, N.W.
Washington, D. C. 20418

Professor John Richards
Department of History
Duke University
6727 College Station
Durham, North Carolina 27708

Professor Thomas Schelling
Department of Economics
Harvard University
Cambridge, Massachusetts 02138

Dr. David Sills
Social Science Research Council
605 Third Avenue
New York, New York 10158

Professor Eugene B. Skolnikoff, Director
Center for International Studies
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dr. Gerald Soffen, Associate Director
of Space and Earth Science
Goddard Space Flight Center
Green Belt, Maryland

Mr. Peter Timmerman
International Federation of Institutes
for Advanced Study
39 Spadina Road
Toronto, Ontario M5R 2S9
Canada

Dr. Joann Vanek
Statistical Office
Department of International Economic
and Social Affairs
United Nations Secretariat
New York, New York 10017