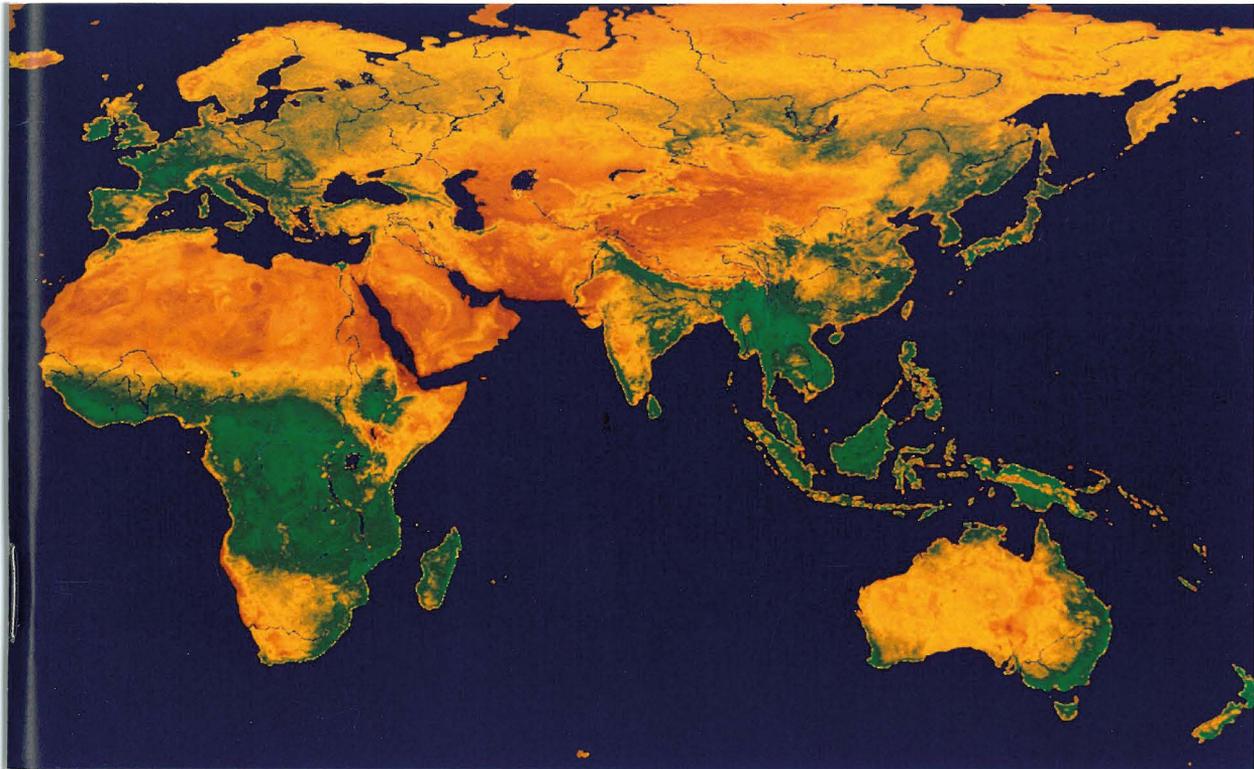


# GLOBAL I G B P CHANGE

REPORT No. 15

## GLOBAL CHANGE SYSTEM FOR ANALYSIS, RESEARCH AND TRAINING (START)

Report of a Meeting at Bellagio  
December 3—7, 1990



The International Geosphere-Biosphere Programme: A Study of Global Change (IGBP)  
of the International Council of Scientific Unions

Boulder, 1991

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Edited by J.A. Eddy, T.F. Malone, J.J. McCarthy, and T. Rosswall

Produced by the  
UCAR Office for Interdisciplinary Earth Studies  
for the  
International Geosphere-Biosphere Programme: A Study of Global Change (IGBP)  
of the International Council of Scientific Unions

Boulder, 1991



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## PREFACE

This report, intended for scientists and policy-makers in all nations, is a point of departure for the development of an integral element of a major undertaking by the world scientific community. As such it is a part of the broad initiative, now underway, to develop an adequate knowledge base to undergird sound national, regional, and international policy formulation and decisions on rapidly emerging issues of global change. That effort was initiated in 1986 by the International Council of Scientific Unions (ICSU) when it established the International Geosphere-Biosphere Programme: A Study of Global Change (IGBP):

*To describe and understand the interactive physical, chemical, and biological processes that regulate the total Earth system, the unique environment it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human action.*

As the planning process proceeded, it became clear that IGBP and the World Climate Research Programme (WCRP), sponsored jointly by ICSU and the World Meteorological Organization (WMO) and an integral part of WMO's World Climate Programme (WCP), were complementary and mutually supportive. Their importance was recognized in a UN Resolution (A/C.2.4/L.40/Rev.1) that urged governments to "...continue and where possible, increase their activities in support of the World Climate Programme and International Geosphere-Biosphere Programme..." and further recommended "that the international scientific community supports efforts by developing countries to participate in these scientific activities."

In June, 1990, ICSU's Special Committee for the IGBP (SC-IGBP) issued a programme plan (IGBP Report No. 12) which outlined an array of Core Projects designed to establish the scientific basis for quantitative assessments of changes in biogeochemical aspects of the Earth system. The report emphasized that "IGBP research must be carried out in all regions of the world in order to obtain the necessary understanding of global change processes." It went on to point

out the clear need to "stimulate IGBP research in developing countries." Regional workshops in Africa (Swaziland, 1988) and South America (Brazil, 1990) affirmed the conclusion that there were strong scientific reasons for regional collaboration, and practical reasons for giving special attention to this research in developing countries. Additional workshops are scheduled for early 1991 in Asia and Africa.

In a parallel—but converging—development, the International Social Science Council (ISSC), as well as other international groups including United Nations University (UNU), United Nations Educational, Scientific and Cultural Organization (UNESCO) and International Federation of Institutes of Advanced Studies (IFIAS), and several national groups have been addressing the human dimensions of global change, identifying research tasks and exploring institutional mechanisms (e.g., regional research centres and a fellowship programme) to complement the plans being developed in the IGBP and WCRP.

In late 1990, the report of the Intergovernmental Panel on Climate Change (IPCC) noted that IGBP and the WCRP are "both playing vital roles" in developing an understanding of the global climate system. IPCC observed that "unprecedented international cooperation" will be necessary to do this and that this cooperation will "require the involvement of all nations, particularly the developing countries."

The IPCC report was presented to the Second World Climate Conference (SWCC) in November 1990 and contributed to that portion of the SWCC Statement calling for "a special initiative (that) would create a network of regional interdisciplinary research centres, located primarily in developing countries, and focusing on all the natural science, social science, and engineering disciplines required to support fully integrated studies of global change and its impacts and policy responses...and (to) study the interaction of regional and global policies."

With the encouragement and support of The Rockefeller Foundation, a workshop was convened at the Foundation's Study and Conference Centre in Bellagio, Italy, 3–7 December 1990 by the ICSU Scientific Committee for the IGBP (which replaced the previous Special Committee in September 1990). The purpose was to develop plans for the infrastructure needed to promote regional cooperation and in partic-

ular the necessity of further supporting the scientific communities in developing countries to allow them to fully participate in the international research effort. The discussions during this meeting built on earlier SC-IGBP efforts to develop a set of Regional Research Centres as described in IGBP Report 12. This report summarizes the plans developed during the Bellagio meeting.

The Workshop affirmed the scientific rationale for establishing regional priorities for global change research in both developed and developing countries. It concluded that initiatives in developing countries are urgently needed. In addition, the needs of the IGBP Core Projects are immediate and highly relevant to the WCP, in which WCRP is a major component, as well as to the ISSC Human Dimensions of Global Environmental Change Programme (HD/GEC). There is also a compelling need to incorporate in regional studies the human dimensions of the problem through involvement of the social sciences.

It was concluded that the most effective configuration of regional collaboration would be a global system of regional networks dedicated to analysis, research and training. Each regional network would consist of an array of regional research sites and a regional research centre.

This System for Analysis, Research and Training, identified by the acronym START, would be responsive to the cogent argument advanced by the World Commission on Environment and Development in their seminal report *Our Common Future*, that "A major reorientation is needed in many policies and institutional arrangements at the international as well as national levels because the rate of (global) change is outstripping the ability of scientific disciplines and our current capabilities to assess and advise...A new international programme for cooperation among largely nongovernmental organizations, scientific bodies, and industry groups should therefore be established for this purpose."

The Bellagio Workshop was notable in three respects. First, there was remarkable unanimity and enthusiasm among the participants over our findings and recommendations. Second, there was agreement that a more intimate interaction was desirable between the social and natural sciences. Third, there was a sobering realization that a favorable human prospect can be ensured only by fostering

worldwide a dynamic and creative interaction between science and technology in the context of societal development. A profound implication of this realization is that national and regional policies must be formulated with full realization of their mutual interaction with global policies. Integration of the overall policy-making process requires an unprecedented collaborative effort to develop the knowledge base to support that process. The institutional arrangements urged here are in response to that need.

Finally, it should be remarked here that START is not intended to pre-empt or replace the array of institutions now in place to address issues of global change. START holds the promise of augmenting, even multiplying, their effective work.

**Thomas F. Malone**  
Workshop Chairman

## I. INTRODUCTION

As the second millennium draws to a close and thoughts turn towards the prospects for humankind during the third millennium, interest worldwide is emerging over environmental issues and the continued habitability of planet Earth. Issues such as greenhouse gas warming, depletion of stratospheric ozone, reduction in species diversity, deforestation, and desertification, have moved into positions of prominence on international agendas.

Even as concerted attention is being given to these urgent matters, scholars and policy makers are beginning to reflect on the fundamental social, scientific and technological developments that are elevating human activity to the level of a planetary force that drives global change.

One can identify two aspects of this driving force. The first is the exponential growth in the number of people to be supported by the resources of the planet. It required ten thousand lifetimes for the world's population to reach five billion. It is all but certain that another five billion people will be added within the next 50 years --- a single lifetime. Ninety per cent of that growth will likely take place in regions where human needs are not presently being satisfactorily met.

The second is the exponential growth in the global capability to produce goods and services to meet human needs and wants. The world economic output more than quadrupled during the past fifty years and now stands at a level of US\$ 18 trillion. A "business-as-usual" scenario suggests another quadrupling by the year 2040.

Taken together, the exponential growth in global population and world economic output will bring the life supporting capability of a finite planet Earth under severe stress. Estimates of the present load today suggest that 40 per cent of the photosynthetic productivity of the planet is being used, wasted, or diverted. A doubling of world population and a fourfold increase in global economic output over the next 50 years could place the well-being of society in jeopardy.

The effects of stressing planetary carrying capacity are exacerbated by the widening gap between the access to goods and services among nations at different levels of economic development. As this growing inequity is addressed, profound changes will be required in the way that society must manage its affairs.

As this insight into the driving forces of global change deepens, appropriate societal responses come under consideration. Two broad imperatives are recognized: (1) a compelling need to change our way of thinking and acting; and (2) an urgent requirement for bold and imaginative innovation in the institutional instrumentalities by which we manage human affairs on planet Earth for the long term.

The need to change our way of thinking has given rise to the desirability of pursuing a sustainable and equitable society. This would be one in which the needs and wants of the present generation would be met in a manner that would not foreclose options for future generations. It is one that would recognize the inextricable linkage among socioeconomic development, quality of the environment, and the integrity of environment and natural resources. It would seek stabilization of population and the transformation of the goods-and-services producing technology into an environmentally benign technology. It would pursue an objective of meeting human needs everywhere, while constraining human wants to levels compatible with the needs of others and the carrying capacity of the planet.

In order to address the need for socioeconomic development and the development of environmentally friendly technology, it is necessary to base the discussions on scientific assessments and prediction. At present we do not understand how the interactive physical, chemical and biological processes regulate the total Earth system and how this system will respond to anthropogenic influences. We need to develop a predictive understanding for possible fates of the Earth in the next decades to centuries in order to provide decision makers with a firmer base for national and international policy formulation. The scientific community has risen to this challenge by developing international research programmes that are aimed at reducing the scientific uncertainties. The scientific assessment of the IPCC concluded that: "The required programme of research will require unprecedented international research cooperation, with the World

Climate Research Programme (WCRP) of the WMO and ICSU, and the International Geosphere-Biosphere Programme (IGBP) of ICSU both playing vital roles. These are large and complex endeavors that will require the involvement of all nations, particularly the developing countries. Implementation of existing and planned projects will require increased financial and human resources; the latter requirement has immediate implications at all levels of education, and the international community of scientists needs to be widened to include more members from the developing countries."

To formulate wise public policy at all levels of society a knowledge base that embraces many disciplines and accommodates many cultures must be put in place to undergird sound and imaginative decisions by sovereign nations, acting in concert through intergovernmental organizations in an increasingly interdependent world. This requires bold and imaginative innovation in the institutions by which human affairs are managed on our planet Earth.

This report urges that a start be made by establishing a global system of regional research networks in a specific response to the needs of the IGBP, while allowing for the development of complementary activities under the aegis of the WCRP, and with a built-in capability to evolve in a way that considers all relevant dimensions of the driving forces of global change, including the social sciences and engineering.

With a 50-year horizon as the time in which global change issues might approach critical dimensions, there is a degree of urgency in this initiative.

## 2. THE START INITIATIVE (System for Analysis, Research and Training)

### Background

The IGBP, along with companion programmes that address global change research—specifically, the WCRP and the evolving HD/GEC programme—requires that research be carried out in all regions of the world. There is a critical need to stimulate and facilitate regional aspects of these global research programmes in both developed and less economically developed countries and regions.

To meet this need, the IGBP has developed the concept of a global system of regional networks for analysis, research and training as an essential component of the total programme. In this concept each region comprises several nations, and is generally of sub-continental size.

### Rationale for a Regional Emphasis

Global change research will require a regional approach for two reasons. First, the research needed to develop a global perspective demands that regional differences in characteristics such as biogeography and climate be taken into consideration. Second, the goal of a “practical predictive capacity” for global environmental change makes it necessary that this capacity be developed for distinct subcontinental regions. Global change predictions will be of greatest value to decision makers if they apply on a regional basis, and if scientists from throughout the region are involved from the start in the processes through which they are generated.

Cast in a regional context, global change research must address the following questions:

- How do regional changes in, for example, land use, industrial practices, energy production, and urbanization alter regional atmospheric composition, the regional water cycle, and local ecosystem structure and function?

- How can such changes **within a region** or in combination with those from other regions affect biogeochemical cycles and physical aspects of **climate on a global scale**?
- How will the ensemble of global change, acting through either direct effects or through altered feedback loops, **lead to further regional change** in the biospheric life support system?

Each of these questions calls for a better understanding of the fundamental nature of land-atmosphere, land-ocean, and ocean-atmosphere exchanges of energy, mass and momentum on decade to century time scales as well as a fuller understanding of anthropogenic changes during this period. The initial Core Projects of the IGBP and projects of the WCRP have been designed to address these scientific issues at the global scale. Every one of them will require additional regionally focused research, as will associated projects now anticipated in the social and engineering sciences.

Answers to the first question will provide essential input for the second and third, in the form of better knowledge and documentation of the factors governing regional change. The research required will include process studies, change detection, and modelling components. The second and third questions employ regional information in the larger, global context and provide for a regional interpretation of global models.

#### General Description of the START Concept

*The proposed System for Analysis, Research and Training (START) is a world-encompassing system of Regional Research Networks (RRN), each of which includes a Regional Research Centre (RRC) and a number of affiliated Regional Research Sites (RRS). The RRC serves as the information centre for the regional network (RRN), with additional coordinating functions both within and outside the region. RRNs, through RRCs, are linked together to provide a global system through which scientific information is disseminated and research is organized to implement the core research projects of major international programmes including, but not limited to, the IGBP and WCRP.*

**START** = System for Analysis, Research and Training  
=  $\Sigma$  RRN

**RRN** = a Regional Research Network  
= RRC +  $\Sigma$  RRS

**RRC** = the Regional Research Centre

**RRS** = an affiliated Regional Research Site  
= (research institutions and stations)

The underlying objective of an **RRN** is to **mobilize scientific manpower and resources** to address scientific questions concerned with global environmental change, as these are **defined by the Core Projects** of the IGBP, WCRP and other relevant programmes. However, both the regional nature and the close associations with the countries and scientific communities of the region require that **the specific focus of any RRN must also take into account the societal, cultural, and political needs of the region.**

In many of the regions where IGBP and WCRP research must be carried out, substantial research capability and facilities are already in place. In some, relevant research networks already exist and function well. In others, this capability will need to be developed or strengthened. RRNs will link diverse sites and facilities within their region, linking work within different disciplines and disparate facilities to **achieve a common purpose**. They will build upon and add value to existing research institutions and capabilities. **Certain aspects of research relating to inter-regional analyses, the development of regional aspects of global change models and the maintenance of centralized data bases** will be most effectively conducted at the **RRC**, which will act, in a sense, as the focus for research in global change in the region.

The **overarching function of the RRC** is **regional synthesis**, requiring that it **play an active role in facilitating interdisciplinary research and training** throughout the RRN. Since the RRN will be made up of a number of different **research institutions (RRSs)**, the RRC will assist in promoting effective interaction among them. The RRC should play an active role in enhancing existing research activities in the region,

and in facilitating collaboration among laboratories and other facilities which have expertise in a variety of disciplines. In addition, stations within the RRN will rely on the facilities of the RRC for coordination of cooperative research and training as part of the IGBP and other international global change research programmes. This will be guided by international core project planning and coordination.

The objectives of the RRNs are: (i) to strengthen environmental change detection research within the region; (ii) to conduct research aimed at improving the assessment of causes and effects of global change in a regional context, including adaptive capability and mitigation measures; and (iii) to forecast future changes, so that appropriate action may be taken to mitigate or respond to the effects of these changes.

#### Principal Functions of an RRC

Each RRC will engage actively in five functions, the first of which will be carried out principally through activities of the RRSs that comprise the regional network (RRN):

- Research, including Documentation of Environmental Change
- Training
- Data Management
- Synthesis and Modelling
- Communications between Scientists and Private and Public Sector Decision Makers

These are described briefly below.

#### Research

Research activities of an RRC must cover three broad areas of study:

- (i) direct contributions to the global and regional scale scientific objectives of global change research;

- (ii) research directed at the detection of global environmental change, through long term measurements and observation of regional aspects of global change phenomena; and
- (iii) scientific research directed towards assessing regional aspects of global change and its impacts, including research directed towards improved policy formulation including strategies for mitigation and adaptation.

In carrying these out, the RRC will serve the regional and global research enterprise in several ways. Primarily it will promote cooperation among scientists of the region for the purposes of: (i) facilitating coordination of IGBP and WCRP research as well as research on the human dimensions of global environmental change; and (ii) defining regional research priorities and identifying regional questions that have global significance. The RRCs will assist scientists in the regional network in organizing workshops and symposia to develop and execute coherent regional research. An RRC may also serve as one of the research sites within the RRN, and as such be involved in observational and experimental research projects of the region.

Each RRN will be constituted so as to provide suitable geographic coverage throughout the region with respect to field research. Great importance is attached to setting up long term commitments on the part of research facilities within the region to provide the measurements required for documenting environmental change. Institutional diversity within the RRN should ensure that sufficient interdisciplinary strength resides within the region to address key global change issues. The RRN sites will link local research to appropriate Core Projects of the IGBP and WCRP and other relevant international programmes of research.

#### Training

An RRC should design and coordinate education and training activities that support the scientific needs of countries within the region.

In most regions of the globe the effectiveness of an RRN will depend on the availability of scientists and technically skilled persons capable of addressing the critically needed global and regional change re-

search. In some regions such expertise is scarce. The RRC will seek to strengthen research capabilities of the region's scientific community by establishing training and exchange programmes, especially in the use of new technologies, data management and synthesis, and modelling. Training will take various forms, including short courses, internships, fellowships, and degree granting programmes at universities either within or outside the region. Success in this regard will bring considerable added value to the region as well as serving a global need.

#### Data Management

Each RRC will establish and maintain a data management and information system that focuses on regional phenomena and, through the continual exchange of data with other regions, on global-scale processes and conditions. In doing so, the RRC will provide a variety of data management resources to the RRN. It will maintain a catalogue of data sets relevant to regional and global research products, and will include on its staff the expertise to develop combined data products required for regional and global-scale models. In addition the RRC will serve as the central Geographic Information System (GIS) node for the region. Appropriate links will be established with the IGBP Data and Information System (IGBP-DIS), the World Weather Watch of WMO, GRID/GEMS of UNEP, and other networks for global data sets.

Data archives and projects leading to the development of new data sets relevant to regional and global change research already exist throughout most regions. An important function of the RRC will be to ensure that these data are freely exchanged among research groups both within and beyond the region. This is particularly important as discipline-oriented groups become involved in interdisciplinary research and require access to data from non-traditional sources.

#### Synthesis and Modelling

The RRC will carry the primary responsibility for synthesizing scientific information related to global environmental change at the regional level, including the assessment of regional aspects and impacts. It will also serve as the centre for modelling activities related to global

environmental changes within the region. To do this, it must maintain an effective computing capability and a team of support staff to serve the needs of the scientists and technicians at the RRC, and in many cases, throughout the RRN. Initially much of the synthesis and modelling work may be done by scientists within the region who will spend time in residence at the RRC. As the RRN matures, and a wide-area computer network is developed, scientists will be able to access the RRC computers from the RRN sites. In this context, the RRCs will play a major role in implementing the Global Analysis, Interpretation and Modelling project (GAIM) of the IGBP.

#### Communications between Scientists and Decision Makers

The RRC will develop mechanisms for distributing research results to scientists within the region and establish mechanisms for sharing the results with scientists in other regions. Periodic workshops and symposia will be organized for this purpose.

In addition, the RRC should promote the clear communication of scientific results to decision makers of the region. Envisioned is the assessment of issues related to global environmental change, in order to provide timely and responsible scientific information for regional and national needs within the region. This will include the scientific input required for the definition of strategies for mitigation and adaptation.

As needed, regional workshops will be held that bring together science writers, environmental policy specialists, policy makers in both the public and private sectors, and scientists to provide inputs to the decision-making process.

#### Structure and Organization

Below we describe an idealized RRC, the ways in which it would interact at the global level, and the mechanisms through which it would relate to regional networks and institutions.

To optimize opportunities to share resources, facilities, and staff, RRCs will normally be established at existing institutions where interdisciplinary teams of scientists now exist, or can be developed.

Locating RRCs within existing institutions will realize economies in cost and human resources; at the same time **the RRC organizational structure must be autonomous**, i.e., sufficiently independent of existing organizations so as to preserve its identity and allow for the independent responsibilities of the Centre to its own and other networks. Negotiated arrangements for establishing an RRC in any region will depend very heavily upon the characteristics of the institutions involved.

#### *An Example of a Regional Research Centre*

The organization of a typical RRC might consist of a **Board, Centre Director, Administrative support** and **five Divisions**: (i) **Research and Documentation of Environmental Change**; (ii) **Training**; (iii) **Data Management**; (iv) **Synthesis and Modelling**; and (v) **Policy** and Socio-Economic Assessment (Communications between Scientists and Public and Private Sector Decision Makers). The relationship and balance of activities between the RRC and the RRSs of the network will be largely determined by regional characteristics.

The permanent resident staff of each RRC will be small. **It is expected that each Centre will support a larger number of visiting scientists**, who may be located at the RRC or elsewhere in the RRN. In addition, it would be expected that staff from the institution that hosts an RRC, and from other institutions, might hold part time appointments in the RRC. Resident staff will collaborate with visiting scientists, scientists at the host institution and throughout the network, and with the Core Project scientists of the IGBP, WCRP, and other global research programmes.

The **RRC Board** will have the responsibility of selecting and retaining the **Centre Director**, of considering the **collective interests** of the region, of encouraging the **participation of funding agencies**, and of generally **guiding the programmatic directions** of the Centre. A **Scientific Committee of the Board** will, through processes of review and assessment, carry responsibility for ensuring the high quality of the Centre's research.

It may be **appropriate** that a **regional council of representatives of member governments and funding bodies** convene periodically to

consider the work of the RRC, and to advise the Board on **how well the RRC is serving the needs of the region**. Such meetings would also provide an opportunity for the work of the RRCs to be presented to science advisors of governments represented in the region.

#### *Relationship of the RRN with International Programmes*

A major function of each **RRN will be the implementation of research activities within Core Projects** of the IGBP, WCRP, and other emerging programmes that deal with global environmental change. This will require coordination with other RRNs, through the efforts of the RRC. **Overall coordination will be accomplished by establishing an international IGBP START Office**, which in turn will be guided by the **START Standing Committee**. This Committee, which is appointed by the **SC-IGBP** with representatives of **JSC-WCRP** and **ISSC**, will ensure the quality of the RRCs and provide necessary administrative links between START and the IGBP, WCRP, and ISSC global change research programmes.

Whereas **coordination within START is required to provide a truly global network of research activities**, this coordination role should not restrict the development of RRN activities designed to meet the **unique research needs of each region**. In view of the importance of the RRNs to regional analysis, synthesis and modelling, the START Standing Committee will have a particular responsibility to work closely with the GAIM Core Project of the IGBP.

#### *Funding of the RRCs*

The laboratories and facilities that might constitute the network of Regional Research Sites in any RRN now exist in some cases. What is needed to bring the START concept to reality is the designation and funding of the RRCs that will provide regional organization and that will initiate new activities related to the objectives of the Centre.

The **costs of establishing and operating an RRC** such as has been described is **likely to be several million US dollars** for initial development of facilities, including the costs of high speed computing and data handling facilities. Each will require funding of between five

and ten million US dollars per annum when fully operational. Research funding will be the largest single requirement once the RRN is operational, particularly at the onset. Synthesis of information derived within the region will become an increasing commitment, as will assembling information in databases, and the dissemination of information within and outside the region. Documenting environmental change may involve large expenditures, but once in place the cost of maintaining the service may diminish to a lower, long-term level.

Expenditure on research will vary from year to year, as major projects are completed and new ones arise. Expenditures for training may be expected to rise rapidly in the early years following the establishment of the RRC, and then continue at a relatively constant level until national capability in participating nations reaches a satisfactory level.

The sources of support for an RRC are expected to come from two sources:

(i) the national governments who will benefit from the work of the RRCs; and (ii) international agencies, private foundations, and research organizations whose objectives the RRCs fulfill. The first group includes both developed and developing countries. The second group may include UN agencies such as WMO, UNESCO and the United Nations Environment Programme (UNEP); the World Bank; the European Economic Community; benevolent organizations such as the Ford, Rockefeller, and MacArthur Foundations; and national development organizations.

Support derived from the more developed countries may come from both the national budget for science, and from the budget for foreign aid. Support from the first of these is justified in that the existence of the START network will contribute scientific information that is needed to aid the study of global environmental change, which affects the national interests of developed and developing countries alike. The relevance to foreign aid is that support to developing countries in the regions involved will strengthen their scientific and technical capabilities. Support from developing countries may include direct financial support, the significant contribution of the scientists and technicians of the region who will staff the RRCs, and the facilities of land and buildings made available in RRCs and other RRSs. Most

of the funding sought for the START concept will directly support programmes of research in developed and developing countries; a relatively small fraction should go toward administrative infrastructure. A portion will go to the RRCs, and some part of this will be allocated within the region to the various research sites that in different nations comprise the RRN. The START Standing Committee should take steps to secure funding for RRCs in developing country regions. Funding for other regions is expected to be secured through other national and international initiatives.

The RRC will not have a direct funding capability in the sense of funding research proposals from individual laboratories or investigators. The RRC can assist, however, in evaluating the overall balance of funding requests associated with the RRSs that constitute the RRN.

#### START International Fellowship Programme

A priority initiative in the development of the START concept should be the establishment of a fellowship programme coordinated by the START Standing Committee with particular attention to the needs of developing countries. These fellowships would be offered at the dissertation and post-doctoral levels and would be open to candidates from all regions. They would serve two general purposes: (i) to allow for fellows from within developing country regions to work under senior mentors in laboratories or institutions in any part of the world where research is conducted on relevant regional aspects of global change problems; and (ii) to encourage fellows who are trained in this way to work in other regions and to apply their expertise in the regional context. In both instances, START fellows will be active partners in RRN research, in either the RRC or in an institution affiliated with the regional network. The design of the START fellowship programme should be structured to meet the scientific needs of participating nations as these are developed by, for example, national IGBP committees and others concerned with global change research.

### 3. IDENTIFICATION OF REGIONS

#### Introduction

To implement START there is a need to define an agreed upon set of generally homogeneous regions that appropriately cover the globe, that meet regional needs, and that satisfy the scientific requirements of the Core Projects of the IGBP and WCRP and other programmes that deal with scientific issues of global change. Any such division will involve trade-off and compromise, since no single grouping can fully satisfy all of the many interests—both scientific and geopolitical—that are necessarily involved. It is nevertheless important to take the first step in what will be an iterative, regionally-driven process, and to set forth an initial proposed set that will constitute a viable basis for the establishment of RRNs. This proposed set must be referred to national committees and regional groups for their consideration and input, and weighed against other possible initiatives for regional grouping for purposes of global change research.

Participants at the Bellagio meeting stressed the need to involve the less developed countries in activities of the broad global change programme at the earliest phase, especially where indigenous resources are inadequate to permit active involvement.

One charge to the conference was to develop a list of criteria for defining and selecting representative regions; to employ these criteria to derive an initial, proposed set of regions; and to identify a small number from the set that are of highest priority in initiating the system.

#### Criteria for the Selection of Regions

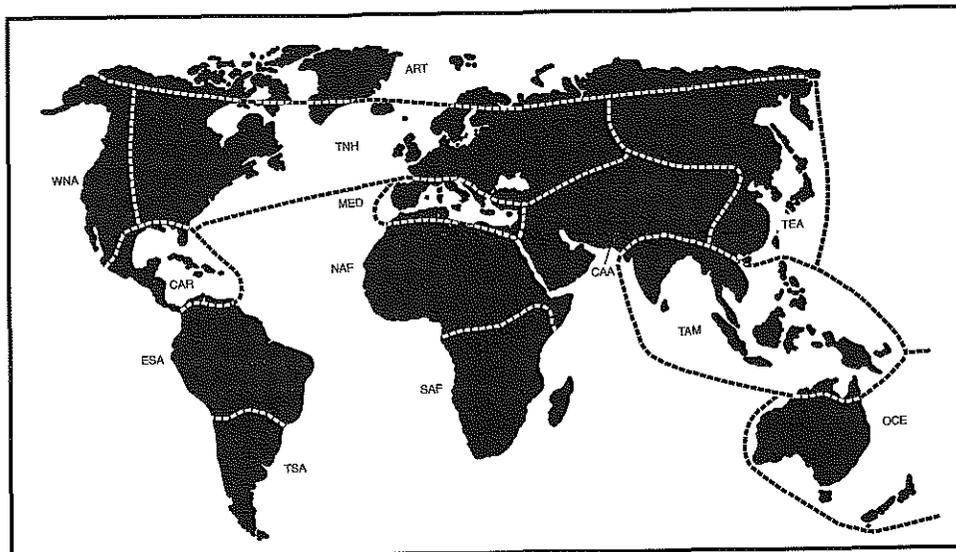
Regional boundaries should be defined so as to encompass a (nominally subcontinental) region that is sufficiently large to embrace areas that are generally homogeneous and representative in terms of vegetation and climate; at the same time they should ideally include biogeographical diversity adequate to allow the transect or gradient studies that are called for in a number of the IGBP Core Projects. Pragmatic issues such as national boundaries and existing regional infrastructure must obviously be considered.

The areas within which RRNs will be sited should be defined according to the following criteria, listed in order of importance:

- a. scientific needs of the Core Projects of the IGBP, WCRP, and other emerging international research programmes that deal with global environmental change;
- b. biogeographical representation, adequate to include the major climatic and vegetation regimes of the planet; and
- c. national boundaries and existing regional collaborative mechanisms.

### Proposed Regions

A total of 14 representative regions is proposed, defined by the approximate boundaries that are shown on the accompanying figure. A description of the rationale for the choice of each of them, including their identifying **biogeographical** and **climatic** characteristics, is given in brief below.



The 14 approximate geographic regions that are proposed in this report as a possible global set of RRNs. Regions and boundaries that are adopted for the global START initiative will be based on regional needs and desires, through discussions with appropriate representatives from the nations involved.

|     |                          |     |                               |
|-----|--------------------------|-----|-------------------------------|
| ANT | Antarctic (not shown)    | OCE | Oceania                       |
| ART | Arctic                   | SAF | Southern and Eastern Africa   |
| CAA | Central Arid Asia        | TAM | Tropical Asian Monsoon Region |
| CAR | Caribbean                | TEA | Temperate East Asia           |
| ESA | Equatorial South America | TNH | Temperate Northern Hemisphere |
| MED | Mediterranean            | TSA | Temperate South America       |
| NAF | Northern Africa          | WNA | Western North America         |

### Temperate South America

This region, embracing that part of the continent that lies roughly south of the Tropic of Capricorn, is climatically homogeneous, with well-defined seasons and a strong influence from cold fronts that develop from the south. It includes all or part of five South American countries and is of sufficient size to be significant in studies of global change. The southern Andes, though of a different climatic nature, offer the opportunity for east-west transects across the southern half of the continent.

The northern half of the region constitutes the main agricultural and cattle-producing area of South America: even small climatic changes in this region would affect continental food production. Moreover, significant climatic changes will bring additional socio-economic impacts, since this region encompasses the majority of the population of the continent and a number of the largest cities in the world.

### Equatorial South America

This very large region includes all of northern South America except for the Caribbean coast. It has a variety of climates and geographic provinces, and includes the great Amazon basin, which encompasses the longest river in the Western Hemisphere and the largest rain forest in the world. As such it is a critical area in terms of, for example, the global carbon cycle. The region is now undergoing rapid changes; land-use transformations within the Amazon region affect hydrological conditions, with associated effects on regional biogeochemistry and the chemistry of the atmosphere.

The area defines an important test-area for environmental modelling, including rainfall/runoff, the transport of riverine materials, and energy exchange.

The region's eastern, southeastern and northern parts are characterized by a transition into a very different climatic/vegetation regime, to include savannas and semi-arid environments. Included on the west and southwest are the northern Andes and the coastal regions of the northwestern fringes of the continent, representing a set of very different domains.

## The Caribbean

The region includes Central America, the West Indies, and lands in North and South America that border on the Caribbean Sea.

All parts of this area are climatically similar in that they are strongly influenced by ocean conditions; they are for the most part comparable biogeographically. As such, they face common problems in the scenario of future global and climatic change, including that of sea-level rise. They also define an area of severe environmental impact due to the heavy land-use changes and population increases in the last half-century.

## Western North America

The region includes North and Central America from the Rocky Mountain system westward to the sea. As such it is distinct, both climatically and biogeographically, from the temperate plains on which it abuts. Extending from the Arctic Circle to south of the Tropic of Cancer, the climate is greatly influenced by Pacific Ocean circulation and the distinctive topographic characteristics of the region. This segment of the continent has been characterized in recent times by considerable growth in population and economic output, with resultant stress on the environment and heavy demands on the available water supply.

## Temperate Northern Hemisphere

This vast area embraces most of the middle-latitude regions of the northern hemisphere, extending from the foothills of the Rocky Mountains in North America to an eastern limit at the forested regions of Eurasia. Its northern bound is the Arctic Circle. Included is almost all of Europe.

The characteristic terrain is made up of forests and grasslands, although today it is a zone of intensive land-use and economic development.

The region is both the major food-producing region and the major industrial region of the world. It has been hypothesized that the

forests of this region comprise a "missing sink" of the global carbon budget.

## The Mediterranean

Included are all those countries (or parts of countries) that border on the Mediterranean rim, in North Africa, Southern and South-Eastern Europe, and the Levant. They experience a common climate of dry summers and moist winters, and are biologically distinctive in being particularly sensitive to changes in the timing and duration of the dry season. The region is heavily populated and the land subject to a long history of extensive use. Common concerns include soil erosion and sea-level rise. These common concerns have led to a Regional Seas Programme of UNEP for the Mediterranean.

## Northern Africa

This large region, embracing almost all of Africa north of the equator, includes the equatorial rainforests and the gradient from these through the sub-Saharan savanna woodlands and the Sahel into the Sahara.

The region is experiencing a rapid rise in population and extensive changes in land use. It is also an area of considerable inter-annual climatic variability, and is known to be extremely sensitive to such variations, as witnessed by a series of recent droughts and concomitant human suffering. As such, it is of particularly high priority in terms of an improved understanding of its anticipated response to global change.

## Southern and Eastern Africa

This region, defined roughly to encompass Africa south of the equator, includes the African savannas and miombo woodlands, the southern grasslands and desert, and the Cape floral kingdom. In the north, it comes under the influence of the inter-Tropical convergence zone, and in the south the influence of the South Atlantic and Indian Ocean pressure systems.

The area is particularly sensitive to environmental stress in that it is undergoing a massive growth in human population and associated land-use changes.

## Oceania

This vast area of the southern hemisphere is regionally isolated and climatically subject to the influence of southern ocean and South Pacific weather systems. It includes all of the Australian continent except the northern sections that are influenced by monsoons, and the Melanesian, Micronesian, and Polynesian islands of the South Pacific, including Hawaii. While most of these islands are also subject to monsoonal conditions (the Monsoon Region described below), their most pressing concerns regarding environmental change will probably center on changes in land-use and in sea-level.

## Tropical Asian Monsoon Region

The region is defined as that subject to the strong influence of the tropical monsoons, including the Indian continent south of the Tropic of Cancer, the countries of South-East Asia and the Malay Archipelago. It constitutes one of the two regions of the Earth that contribute significant thermal energy to the atmosphere, receiving very high rainfall and containing an extensive array of tropical rain-forests. It is an area of a rapidly-expanding economy that is also very densely populated in the inhabited regions, and subject to intensive land-use change. The area is also important for studies of global biogeochemistry as a major source region for methane production.

## Temperate East Asia

This region covers all of East-Central Asia and South-East Asia north of the Philippines and south of the Arctic Circle.

Climate is in general humid and determined chiefly by monsoonal circulation, although there is a distinct differentiation in temperature from north to south. Vegetation changes systematically from north to south, from cool, temperate coniferous forest, mixed broad-leaved and coniferous forest, deciduous broad-leaved forest, subtropical monsoon evergreen forest, and finally tropical monsoon forest.

The region is one of the most densely populated regions of the world. Due to a long history of environmental exploitation and a modern increase in population pressure, it is particularly subject to problems of deforestation, soil erosion, salinization, and air and water pollution.

## Central Arid Asia

This region encompasses East-Central Eurasia, including the northern and northwestern parts of the Tibetan plateau, central Eurasia, and the desert lands of the arid Middle East, bounded on the southwest by the Red Sea.

The highest and most extensive mountain system in the world, large deserts and major river plains are included in this region, as is the most extensive loess plateau. The climate is arid and semi-arid with steppe and desert vegetation.

Due to the fragility and low-carrying capacity of its ecosystems, the region has been particularly degraded in the semi-arid ecotone, with rapid desertification.

## The Arctic

The region, as traditionally defined, is that north of the Arctic Circle. As such it encompasses the northern reaches of three continents: North America, Europe, and Asia. Included are the permafrost systems of the world, much of the boreal/taiga forest, extensive open coastline and vast areas of sea-ice.

Ecosystems in this region are particularly sensitive to environmental stress and the area is in this regard, as in climate, an early indicator of global change. The Arctic is likely to be the first terrestrial region to exhibit major changes in water and other biogeochemical fluxes and, through possible changes in the release of methane that may accompany polar warming, can exert a significant influence on global atmospheric composition.

## The Antarctic

This unique, protected, and little-studied region of the Earth is, like the Arctic, especially sensitive to global climate change. It is also a repository of much of the freshwater of the world, in the form of continental and sea ice, which are particularly important factors in studies of global sea-level change.

## Treatment of the Open Oceans

IGBP and WCRP Core Project research will be required in all regions, and the regional subdivision proposed in this report clearly encompasses all continents.

However, in recommending a set of globally-representative regions for the START concept, the participants at Bellagio deemed it unnecessary to specify at this time a corresponding set of regions in the open oceans. The rationale was that research in the deep oceans, as in the upper atmosphere, would be carried out as an important part of the programme of research within many of the RRNs that make up the START.

Although the logistics of ocean field experiments involving ships, buoys, aircraft, and satellites, are tremendously complicated, the equipment and techniques have a portability that allows ocean scientists to efficiently use such facilities for studies in multiple regions. The global ocean survey of the World Ocean Circulation Experiment (WOCE) and Joint Global Ocean Flux Study (JGOFS) and the basin scale process studies of JGOFS are examples of this. This is not to say that the observing capability of ocean science is adequate today; it is not, but this need should be addressed separately from the land-based needs for establishing networks of research sites.

The START could, however, be of particular value in ocean oriented Core Projects. The domain of the coastal ocean, as it pertains to the Land-Ocean Interaction in the Coastal Zone (LOICZ) project of the IGBP, is meant to be included in the regional subdivisions proposed in this report. In fact, unique aspects of coastal issues should at some point be factors in designating boundaries for regions. A case can also be made for the great Southern Ocean surrounding the continent of Antarctica. Because of its vastness, the remoteness of this ocean from the nations that have historically conducted much of the research in this region, and the likely significance of this ocean region in global climate change scenarios, oceanic and atmospheric research related to the IGBP and other programmes would be facilitated considerably by the establishment of an RRN that specifically includes the Southern Ocean.

## Priorities

All of the regions defined above are important in terms of global change; each is in a sense distinctive, and only together can they provide a complete representation of environmental changes in a global system.

In some, there is already considerable scientific collaboration underway that is now or could be directed at questions of global change, including regional analyses. In these, it remains only to formalize a regional research system, including refining the geographical definition of the region and setting more comprehensive scientific goals. This will require agreement among the nations concerned on all of these issues, as well as a broader agreement on the conditions that will link regional systems into a global network.

On the other hand, those of the regions that include largely less developed nations will be unlikely to establish regional research systems without the buttress of external financial support.

With this in mind, and considering the combined factors of sensitivity to global and climatic change, scientific unknowns, and the availability of existing infrastructure, the Bellagio conferees identified three regions as of highest, immediate priority for assistance in establishing and funding RRNs. Three others, listed next, are clear candidates for second tier emphasis. None of the six is likely to establish an RRN without external assistance. RRNs comprising more developed countries may also be established early.

Of highest priority, in the opinion of the Bellagio participants, are:

**Equatorial South America**, which is particularly important scientifically because of issues related to tropical rain forests and rapid land-use change. It was also identified by the IGBP Regional Meeting for South America in March 1990 as the highest priority for initial emphasis;

**Northern Africa**, which, as described earlier, is demonstrably extremely sensitive to climatic variation; any shift in climate will have immediate and possibly severe consequences for the human population of the area; and

Tropical Asian Monsoon Region, which must be included in the first tier on two counts: first, as a major global source of biogenic gases and source of thermal energy to the global atmosphere, for which very little detailed information is available. Second, the area is very densely populated and will be acutely sensitive to shifts in climate and sea-level. In addition, land use changes profoundly affect coastal waters, which will be further affected by climate change.

A preliminary assessment suggests that three others are of high priority on scientific grounds, and also likely to require external assistance in establishing an RRN/RRC. These are:

Temperate South America,  
Southern and Eastern Africa,  
and Central Arid Asia.

Interest has already been expressed by the governments of France and the U.S. to support RRCs in the less developed world, specifically in areas that we have identified as Northern Africa, Equatorial South America, and the Tropical Asian Monsoon Region. In the case of France, the initiative has already resulted in the definition of a Sahara and Sahel Observatory, whose goal is to provide new impetus in the struggle against drought and desertification in North, East, and West Africa.

We can hope that RRNs will be established in the remaining areas through the impetus of nations in the regions concerned, ideally through parallel efforts that would bring them into being on the same schedule as the six listed above. Nations within these more developed regions should be encouraged to initiate this effort. In a number of these, some external financial assistance may also be required.

#### 4. STRATEGY FOR IMPLEMENTATION

##### Overall Strategy For Implementation

We outline here a strategy for the development of START, including:

- a set of guiding principles,
- recommendations to facilitate the development of a global system for research, analysis and training; and
- an overview of funding requirements and formal mechanisms needed to establish the system.

While the recommendations and guidelines developed at Bellagio provide an expanded framework for initiating the START concept, the establishment of any of the component RRNs will require substantial additional analysis and development. Full recognition of the needs and interests of the region in which they operate can only be accomplished by the nations which would together comprise any RRN. Recommendations given here are meant to facilitate the rapid establishment of several RRNs during the next few years.

##### Guiding Principles

The development and establishment of RRNs should be guided by a series of founding principles.

- The overall strategy for developing START should be to begin immediately to bring into being about three RRNs in developing countries, and then to review progress, problems, and the integrity of the process before expanding the network further. It is hoped that RRNs will be simultaneously established in developed countries.
- The choice of an RRC and the combination of affiliated institutions and entities that will make up the associated RRN should be designed for long-term stability of interest and support.

- An RRC must include a mix of scientific and technical personnel adequate to maintain the highest levels of scientific capability and excellence; that is, its scientific credibility must be unchallengeable.
- A key element in the process of developing an RRN will be the optimization of partnerships of different types—partnerships between governments and the scientific institutions in the region itself, supplemented by partnerships between institutions (governmental and non-governmental) within the region and similar institutions outside the region, and funded both by governmental organizations and private foundations working under an overall, agreed-upon plan. These partners all should be involved in the development of an RRN as early as possible. The initiative to establish an RRN should evolve from within the region involved. A flexible strategy should be employed, respecting local needs and interests, with the primary initiative coming in most cases from the governments involved.
- The establishment of RRNs should recognize the principles outlined in the United Nations' Resolution on the IGBP (cited in the Preface to this report), the recommendation of the Second World Climate Conference to establish a "network of regional interdisciplinary research centers with global orientation to address cross-cutting issues," and recommendations of the Intergovernmental Panel on Climate Change (IPCC) regarding scientific steps to be taken to address global climate change.
- The financial support of an RRN should be derived from both governmental and private sources such as foundations, business, and industry. Initial and near-term support may often be provided by private sources, with some government participation. It should be recognized that long-term financial support will of necessity be derived from governments, both within and outside the region.

#### Recommendations to Facilitate the Development of START

It is recommended that START be initiated immediately through the following steps:

1. Appointing an IGBP Standing Committee for START. To guide the development of START, the SC-IGBP should immediately establish a Standing Committee for START. This should be done in consultation with the Joint Scientific Committee of the WCRP (JSC) and the governing body for HD/GEC. Some of the members of the Standing Committee should be scientists who are familiar with the research programmes of these other bodies. The Standing Committee will have primary responsibility for developing and implementing a comprehensive plan for START. It should proceed by:

- refining the criteria for developing RRNs and for prioritizing the allocation of resources among RRCs;
- developing the guidelines, principles of operations, functions, and policies essential for full complementary interaction both within and among the RRNs. This requires full cognizance of the science infrastructure of the regions involved. Thus, although the Standing Committee is officially responsible to the SC-IGBP, it should consult with a variety of bodies, including the WCRP-JSC, Chairs of National IGBP Committees, the IGBP Scientific Advisory Council (SAC), appropriate ICSU bodies, ISSC, UN organizations, and other appropriate scientific bodies;
- promulgating the overall plan for START, both through appropriate publications and by working with and through international bodies, countries, regional institutions, and scientific organizations at all levels. The Standing Committee should seek the endorsement of the United Nations Conference on Environment and Development (UNCED). It should also seek an appropriate relationship with the IPCC, so that regional interests of the IPCC can be served by the RRNs;
- facilitating strong and effective coordination and communication between each RRN and international global change programmes including the Core Projects of the IGBP, WCRP, and the other appropriate international research programmes;
- reviewing at regular intervals the status of existing and planned RRNs, and recommending appropriate action to the SC-IGBP and science funding bodies; and

- establishing and overseeing an **International START Fellowship programme** to facilitate the involvement of young scientists in the research functions of the RRNs.

2. Documenting the START Initiative. The Report of the 1990 Bellagio Workshop should be widely circulated by the IGBP as a first step. Subsequently, the IGBP Secretariat should **consult** the **WCRP** and appropriate entities concerned with **HD/GEC** regarding the further development of START. Final documentation, agreed upon in this manner, should detail the concept, goals, and objectives of the START; the specific functions (i.e. research, data and information management, education and training, etc.) of the RRNs; a proposed plan for each of the functions; an outline giving guidance for the structure, organization, and management of an RRC; and a proposed set of global change research regions with the rationale for the choices made, such as we have proposed in the preceding section of this report. This document should also outline the scope of the worldwide START, including the number of RRNs, priorities for their initiation, and estimated levels of financial support required.

3. Establishing a START Secretariat. The SC-IGBP should immediately establish a modest secretariat to support the work of the Standing Committee for START and to provide day-to-day support to the process of developing a full network of RRNs. Initially, the START Secretariat should report to the IGBP Secretariat in Stockholm. Efforts should be taken to secure the necessary financial support to establish such an office without delay. The detailed scope of operations, the personnel required, and the general assignment of responsibilities for the START Secretariat should be developed by the Standing Committee.

4. Stimulating and Nurturing the Development of RRNs. The IGBP Standing Committee for START and START Secretariat, with links to the WCRP and HD/GEC, should initiate discussions with potential partners in each of the three initially suggested regions, with the goal of stimulating and fostering the development of an RRN and RRC in each of these regions. The development of each RRN should build upon existing interests and capabilities in the region. Identifying and building on such interests and securing full participation of all partners should be a precursor to the development of any RRC,

and **should evolve naturally from the specific needs and interest of the region.** The National IGBP Committees in the region are particularly well qualified to advise on such matters and hence should be consulted in the development of an RRN. During the development of an RRN, substantial efforts should be made to develop linkages, within the region, to government agencies and bodies; to other regional institutions; to universities and other appropriate academic institutions such as research laboratories; to industry; and to appropriate bodies outside the region.

5. Designating Specific RRNs. Partners seeking to establish an RRN should design and develop their proposal for an RRN in a manner that serves regional needs, following the general guidelines recommended in this Workshop report. The Standing Committee for START should further develop and carefully establish the criteria required to qualify as Global Change RRN. The guidelines and procedures to be followed for such designation should be published and widely promulgated.

#### Funding Requirements and Formal Mechanisms

The financial levels of support necessary for each RRN will vary considerably depending on regional differences, but when fully developed each may require an annual operating budget in the range of **\$5 to \$10 million.** Additional one-time funding for major capital expenditures will also be required, as for computing and data-handling facilities. **The funding provided through the RRN should support the operation of the RRC and those activities within the RRN that directly serve approved projects and activities of the START network.** While the RRCs should not serve as "third-party" granting institutions, the RRCs, with the assistance of the START Standing Committee, should seek to develop avenues of grant support for individual principal investigator projects implemented at RRCs that serve the total programme of the RRN.

The formal establishment of an RRN will require, by necessity, formal instruments of agreement between the regional participants involved. While the legal arrangements for each RRN will vary from location to location, they will be characterized by: Memoranda of Understanding (MOU's) between the partner countries and the RRN; bilateral and

multilateral agreements; and the appointment, in some cases, of an existing legally established institution that will serve as the legal fiscal agent for the RRN, and in other cases, by the creation of a new legal entity recognized by law as an appropriate fiscal agent for the RRN. These legal entities will most likely be non-profit institutions in the host country. A comprehensive analysis of this aspect of management should be a prerequisite for establishing of an RRN. As a complement to this, and as noted elsewhere in the report, a comprehensive analysis of proposed management, administrative policies, and organizational structure should be documented for each individual RRN.

The implementation plan for an RRN should also include mechanisms to assure accountability of each RRN to its sponsors. The plan will often include provisions for Boards of Trustees, Scientific Advisory Committees, methods for periodic review, and other management strategies needed to maintain a high level of excellence and credibility.

## 5. CONCLUSION

We stand at a propitious moment. Decision makers at all levels in governmental and intergovernmental structures are requesting information from the natural and social science communities regarding future prospects for global change. At the same time the science communities are advancing their consensus positions for the research agenda that will most effectively and expeditiously generate the understanding necessary to produce a practical predictive capability for global change. Were there no anthropogenic drivers of global change, the task lying before the science community at this moment would be daunting to say the least. The climate system, including its interactive chemical and biological processes, changes naturally on a wide range of time scales. And while a full understanding of this system has long been a primary motivation in earth, atmospheric, and oceanic sciences, the recent, current, and likely future human perturbation to this system makes this quest even more difficult and more urgent.

After nearly a decade of planning, the international science community is now prepared to accept this challenge in a bold and comprehensive manner. Projects of the IGBP, WCRP, and those now evolving for HD/GEC are specifically designed to address these issues. By bringing their plans to fruition we will narrow the current uncertainties in predictions of global change.

It is important to note, however, that decision makers will in many instances be more interested in regional manifestations of global change than global change *per se*. Regional forecasts will be important for long term economic development, including planning for those aspects that relate to the production of food, fodder, fuel, and fiber. It is also clear that substantial regional changes in industrial development and land use practices can result in change of global proportions. But the necessary understanding of future regional change cannot be generated independently of the global context, and vice versa.

The START initiative proposed here would provide this critical link between regional and global scales by putting in place the infrastructure necessary to insure an effective regional dimension in the study of global change. The international science agenda cited above defines the global context for regional studies, and as such is the integrator that links the Regional Research Networks together. The flow of new scientific information through the system and back into each regional network will permit scientists within the region to prepare regional assessments of global change for decision makers within the region.

The appropriate division of the globe into coherent regions for the study of global change requires judicious assessment of the needs of science and the realities of existing regional organization. The group that met at Bellagio, as did others who had met previously to discuss IGBP regional needs, have proposed that roughly 10 to 20 regional networks will be required. In some of these, where considerable scientific infrastructure and resources already exist, an RRN could be initiated soon. In others, financial support from outside the region will be required in order to establish and maintain a regional network. We are greatly encouraged by the fact that government officials in a few nations are at this time considering such support for other regions.

Thus scientists are now ready to execute research relating to global change, the results of which are urgently needed by decision makers at all levels. This research cannot be successful without a regional perspective, and much of the interest of decision makers will be directed towards the regional interpretation of global change. START is a system that links scientific research at both global and regional levels to the needs of decision makers in all areas of the world.

END

## Appendix 1

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## Appendix 2

### ACRONYMS

|              |  |
|--------------|--|
| GAIM         | Global Analysis, Interpretation and Modelling (IGBP)   |
| GEMS         | Global Environmental Monitoring System (UNEP)  |
| GIS          | Geographic Information System  |
| GRID         | Global Resource Information Database (UNEP)  |
| HD/GEC       | Human Dimensions of Global Environmental Change Programme (ISSC)                                   |
| ICSU         | International Council of Scientific Unions   |
| IFIAS        | International Federation of Institutes of Advanced Studies   |
| IGBP         | International Geosphere-Biosphere Programme  |
| IGBP-DIS     | IGBP Data and Information System   |
| ISSC         | International Social Science Council   |
| JGOFS        | Joint Global Ocean Flux Study (SCOR/IGBP)  |
| LOICZ        | Land-Ocean Interactions in the Coastal Zone (IGBP, Proposed)                                       |
| MOU          | Memorandum of Understanding  |
| <b>RRC</b>   | <b>Regional Research Centre</b>  |
| <b>RRN</b>   | <b>Regional Research Network</b>   |
| <b>RRS</b>   | <b>Regional Research Site</b>  |
| SAC          | Scientific Advisory Council (IGBP)   |
| SC-IGBP      | Special Committee for the IGBP (supplanted in September 1990 by Scientific Committee for the IGBP) |
| SCOR         | Scientific Committee on Ocean Research   |
| <b>START</b> | <b>Global Change System for Analysis, Research and Training</b>                                    |
| SWCC         | Second World Climate Conference (1990)   |
| UN           | United Nations   |
| UNCED        | United Nations Conference on Environment and Development   |
| UNEP         | United Nations Environment Programme   |

|          |  |
|----------|--|
| UNESCO   | United Nations Educational, Scientific and Cultural Organization |
| UNU      | United Nations University  |
| WCP      | World Climate Programme  |
| WCRP     | World Climate Research Programme (WMO/ICSU)                      |
| WCRP-JSC | Joint Scientific Committee (WCRP)                                |
| WMO      | World Meteorological Organization                                |
| WOCE     | World Ocean Circulation Experiment (WCRP)                        |

### Appendix 3

#### IGBP REPORTS

- No. 1. The International Geosphere-Biosphere Programme: A Study of Global Change. Final Report of the Ad Hoc Planning Group. ICSU 21st General Assembly, Berne, Switzerland, 14–19 September, 1986 (1986)
- No. 2. A Document Prepared by the First Meeting of the Special Committee, ICSU Secretariat, Paris, France 16–19 July, 1987 (1987)
- No. 3. A Report from the Second Meeting of the Special Committee, Harvard University, Cambridge, MA, USA, 8–11 February, 1988 (1988)
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