GLOBAL CHANGE

IGBP

REPORT No. 16

Report from the IGBP Regional Meeting for South America

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

Stockholm, 1991

GLOBAL CHANGE

IGBP

REPORT No. 16

Report from the IGBP Regional Meeting for South America

São José dos Campos, SP, Brazil
5-9 March, 1990

Arranged under the auspices of

The International Geosphere-Biosphere Programme:
A Study of Global Change (IGBP)
The Brazilian National Committee for the IGBP
Instituto de Pesquisas Espaciais (INPE)
United National Educational, Scientific and Cultural Organization (Unesco)
Organization of American States (OAS)
Third World Academy of Sciences (TWAS)

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

Stockholm, 1991

The international planning and coordination of the IGBP is supported by ICSU, IGBP National Committees, UNEP, Unesco, Shell Netherlands and the Dutch Electricity Generating Board. Additional financial support for the South American meeting was received from Unesco, OAS, and TWAS. This support is gratefully acknowledged.

Layout and type setting by: Lisa Wanrooy-Cronqvist
Cover photograph taken by: Sven Erik Sjöberg, Pressens Bild AB

Graphic Systems AB, Göteborg 1991

 ISSN 0284-8015

TABLE OF CONTENTS

Preface

In 1986, the International Council of Scientific Unions decided to launch the International Geosphere-Biosphere Programme: A Study of Global Change (IGBP). National IGBP committees have now been established in almost 50 countries.

It is essential that IGBP research is conducted in all parts of the globe in order to collect the necessary data to evaluate the present state and future fate of the Earth system. Thus, researchers in developed and developing countries must all join in this major research undertaking.

In order to ensure that scientists from all parts of the globe are involved in the planning for, as well as the execution of, the IGBP research projects, the Special Committee for the IGBP has initiated a number of regional IGBP meetings. The first meeting was convened in Swaziland (December 1988), for the Southern Hemisphere (IGBP Report 9, 1989).

A second regional IGBP workshop was convened at the Instituto de Pesquisas Espaciais (INPE) in São José dos Campos, Brazil from 5 to 10 March 1990. The meeting was arranged by the IGBP and co-sponsored by the Brazilian National Committee for the IGBP, INPE, Unesco, the Third World Academy of Sciences, and the Organization of American States.

The objectives of the workshop were to:

- Present global change scientific issues in relation to South American ecosystems and processes.
- Discuss research needs in particular priority areas.
- Review proposals for IGBP Core Projects and the interest of the South American scientific community in participating in the projects.
- Review the concept of Global Change Regional Research Centers in a South American context.
- Propose further measures to stimulate regional collaboration in the IGBP and with other relevant international research programmes (e.g., Unesco: MAB, IOC, IHP, IGCP).

The meeting was attended by 34 participants from nine countries in South and Central America. This report contains the conclusions from the workshop and the reports from the discussion groups convened during the meeting. The full proceedings from the workshop will be published in Revista Geofisica Vol. 32.

We are very grateful to Unesco, TWAS and OAS for financial support for the meeting. We are also grateful to the INPE staff for all the practical arrangements before and during the meeting.

SUMMARY RECOMMENDATIONS

The first regional IGBP meeting for South America recommended that:

- Global change research must receive increased funding. In order to secure additional financial resources from nations and organizations outside the region, it is essential that global change research is considered a priority by funding agencies and the research communities in nations within the region. National Committees should ensure that the importance of the IGBP is recognized at the national level.

- The National Committees and groups of scientists should take the lead in developing regional projects in close consultation with the IGBP Core Project Offices. The National Committees should take proper action to ensure increased coordination within the region.

- The initiative to establish Global Change Regional Research Centers was endorsed. A first IGBP Regional Research Center in South America should be established in the Amazonian region with subsequent centers in other parts of the continent. The importance of an RRC as an information center was also stressed and the need to establish a directory of directories of data holdings of importance for global change research.

- In order to ensure an efficient participation of South American scientists in the IGBP and other global change related research activities, there is an urgent need to improve communications systems both within the region and with the science community outside the region. The frequent lack of access to modern communication systems hampers the strong involvement of South American scientists in global change research. The national committees and the IGBP Secretariat should consider ways of improving communication flow.

- In view of the lack of sophisticated analytical equipment, computers, etc., in many laboratories in the region, there is a need for the development of strong technological cooperation both within the region as well as with centers outside South America. The Core Projects and National Committees should identify such needs and take appropriate action to remedy the deficiencies.

- Scenarios for climate change in South America should be developed and distributed in the region.

- The National Committees should consider the establishment of a regional Newsletter.

- A second regional meeting should be held in 1992 and comprising Latin America and the Caribbean. An offer to arrange this in Costa Rica was gratefully accepted.

1. PAST GLOBAL CHANGES

1.1 Introduction

Not all members of the Working Group had time to read the entire 50-page, very detailed and exhaustive, draft report on the PAGES project carefully. This certainly impeded a thorough discussion of this extensive report and, perhaps, forced the members to overlook parts of it which could be relevant to the South American continent. However, a few notes were taken and these are presented in the following sections.

Most South American scientists active in the disciplines related to Past Global Changes are presently facing one or more, if not all, of the following constraints:

- lack of research funds to start new research projects or continue with existing ones;
- lack of graduate students, collaborators, technicians, etc.;
- over commitment in these research projects or other related teaching, professional and/or administrative duties;
- lack of confidence on the final destination of the results of their research, if they are merged with the worldwide information that will be assimilated into PAGES;
- unstable political, labour or research conditions.

Thus, it is extremely important to stimulate the participation of these scientists. This could be achieved by means of:

- research grants;
- travel grants;
- personnel and equipment for the research activities;
- scholarships for graduate students;
- access to research centers, data banks, working groups, etc.;
- specific, short-term research contracts.

This being a Brazilian-organized meeting the absence of Brazilian scientists in the working group was surprising. Possibly, this fact could be attributed to a lack of information to distinguished Brazilian geologists, geographers, paleoclimatologists and paleoenvironmentalists, who are mainly (more than 400) associated with the Brazilian Quaternary Association (ABEQUA) and the Brazilian IGBP Committee. It

is suggested that these organizations are consulted as soon as possible. Copies of this report should be addressed to them and their future input taken into consideration.

INQUA and IGCP have been active in disciplines related to PAGES in the South American continent for a long time. IGCP-201 ("Quaternary of South America") was active between 1982 and 1987, whereas IGCP-281 ("Paleoclimates of South America") has been very active since 1988 under the leadership of Jaime Argollo, Bolivia. IGCP-200 ("Late Quaternary Sea Level Changes") was also active during the period of 1982-1987, with a global scope but with strong, particularly east South American, involvement. A new project, IGCP-274 ("Quaternary Coastal Evolution"), is under way since 1988 with the participation of South American scientists.

The INQUA Commission on the Quaternary of South America (SUDAMQUA), was created in 1987 and it will be ongoing at least until the XIII INQUA Congress (Beijing, 1991), with a good chance of extending through another inter-congress period. (Jorge Rabassa, Argentina, is presently the President of SUDAMQUA.) It is therefore suggested that special efforts should be made to coordinate PAGES activities with those organizations mentioned above, for future developments.

Jorge Rabassa, editor of the journal "Quaternary of South America and Antarctic Peninsula", offered this yearly publication for publishing scientific contributions to forthcoming meetings or symposia at the regional level.

1.2 Special Relevance of PAGES for South America

There are many reasons why the topics addressed by PAGES are relevant to the South American Continent:

- The magnitude and the expected impact of global changes in South America, as forecasted in the current climate models, can only be recognized and fully understood through the correct knowledge and interpretation of global changes in the past, i.e., chronology, cyclicity and/or recurrence and the impacts on the South American paleoenvironments of the past, most of which are as unique and complex as the present ones.

- The poor resolution and poor reliability of the current climatological models for South America, essentially due to the lack of available data, make it imperative to search for complementary information in the paleoclimatic and

paleoenvironmental sequences of the geological, paleontological and archeological records.

- It is important to discriminate between man-induced, anthropogenic and natural global changes. This can only be done through the study of the past, to distinguish the natural changes that have taken place in recent millennia and are still operating, from those generated by human activities. In other words, which natural changes are showing up in the present climate evolution. Thus, predictive models could be established, which may forecast impact on the natural resources of the South American continent, where the present economy is mainly based on the exploitation of natural resources, often with limited technology and close to the limits of economic sustainability.

- It is highly relevant for South America to search the geological and archeological records for analogies to the environmental consequences that the current models have predicted, i.e., consequences which cannot be identified on the basis of the present conditions.

- The prevention and mitigation of natural disasters, such as those which may occur if the current predictions for South America are correct, are extremely important in developing countries. It is the pre-technological societies that are highly vulnerable to these events, both in the unplanned urban sectors and in suburban or rural areas with scarce resources and limited technology.

- In South America, we have extremely important geological, paleontological and archeological records, in very different paleoenvironmental and/or paleoclimatic conditions, along the Andes. The coastal areas, the loessic plains, etc. These records extend over a long period, e.g., the Bogota Savanna lacustrine sections are older than 2.7 Myr. Others have a good temporal resolution, e.g., the peat-bog sections in the Central Andes of Bolivia, Southern Chile and Tierra del Fuego, usually around a century, for the last 15 000 - 20 000 years. Tree-ring chronologies, with annual and sometimes seasonal resolution, extend over almost the last 2000 years for the Southern Patagonian forest.

- The geographical location of South America is highly suitable for obtaining information about the paleo-oceanographic characteristics and climates of the Atlantic, Pacific, Antarctic Ocean, and the Caribbean Sea.

- The study of the South American records could provide a unique opportunity to correlate paleoclimatic events in the Southern Hemisphere with equivalent episodes in the Northern Hemisphere, thus corroborating their global significance and simultaneity. The cooling episodes during the late glacial ("Older" and "Younger Dryas") could be good examples of such events.

- South America is one of the largest intertropical areas of the world, thus enabling us to understand and interpret the magnitude and characteristics of past global changes in these equatorial regions.

1.3 Do the Core Project Descriptions Take Due Note of Processes and Problems in South America?

The PAGES project has two major research streams; the Earth history during the past 2000 years and the Glacial-Interglacial cycles in the late Quaternary, with several activities listed in both of them.

From a general point of view, these projects take note of processes and problems in South America. Local projects directly related to both streams have been identified as well as scientists who are carrying out research in the proposed areas of research throughout most of the South American continent (Argentina, Bolivia, Brazil, Chile, Colombia, Peru). However, PAGES does not take into consideration the fact that the Andean range, which crosses the entire continent, is a "young" and unstable range. We propose that the study of the Andean neo-tectonic history and current neo-tectonic influence on the environment, if any, be included as a part of PAGES studies.

1.4 List of Researchers in South America

The following is a preliminary List of Scientists Involved in Paleoresearch in South America. The Brazilian National IGBP Committee or the Brazilian Association for the Quaternary (ABEQUA) should complement this list for Brazil.

Argentina

CONICET			
(i)	CADIC Ushuaia	J. Rabassa	Glaciology

(ii)	CRICYT Mendoza	A. Aristarian	Ice cores
		J. Boninsegna	Dendrochronology
		D. Cobos	Dendrochronology
		L. Espizua	Glaciology
(iii)	CENPAT Puerto Madryn	M. Haller	Glaciology
		D. Trombotto	Glaciology
		H. del Valle	Pedology

Universidad de Buenos Aires
Facultad de Ciencias Exactas y Naturales

	A. Bertels	Micropaleontology
	J. Codignotto	Marine Quaternary
	E. Malagnino	Quaternary geology
	E. Romero	Palynology
	Paleomagnetism Lab., INGEIS	Isotope geology - ^{14}C

Universidad Nacional de la Plata
Facultad de Ciencias Naturales y Museo

F. Fidalgo	Quaternary geology
M. Hernandez	Hydrology
M. Morbelli	Palynology
E. Schnack	Marine Quaternary
E. Tomni	Vertebrate paleoont.
Paleontology Division	
Archeology Division	

Universidad Nacional del Sur

G. Arbanesi	Land use - geography
A. Borromei	Palynology
M. Bustos Cara	Land use - geography
M. Quatrocchio	Palynology

Universidad Nacional de Mar del Plata
Centro de Geologia de Costas y del Cuaternario

J. Fasano	Hydrology
F. Isla	Marine Quaternary
A. Prieto	Palynology
M. Zarate	Quaternary geology

Universidad Nacional de Catamarca

A. Ahumada	Glaciology

Universidad Nacional de Tucuman

J. Sayago	Remote sensing

Universidad Nacional de Salta

J. Igarzabal	Deserts
F. Rivelli	Deserts

Universidad Nacional del Litoral

M. Iriondo	Geomorphology

Universidad Nacional de Rio Cuarto

M. Cantu	Soils

Universidad Nacional de San Luis

R. Costa	Neotectonics

Universidad Nacional de San Juan

G. Suvires	Geomorphology
H. Bastias	Neotectonics

Instituto Nacional de Tecnologia Agropecuaria

C. Scoppa	Soils

Museo Bernardino Rivadavia, Bs. As.

P. Nabel	Paleomagnetism

Archeology
Several institutions in the country

Servicio de Hidrografia Naval

G. Parker	Marine Quaternary

Bolivia

Universidad San Andres
Instituto de Geologia

J. Argollo	Quaternary geology
J. Ando	Geology
M. Blanco	Geology
C. Chavez	Geology
E. Soria	Geology
C. Vargas	Geology
G. Vizcarra	Geology

Instituto de Ecologia

M. Lieberman	Ecology
A. Lorini	Climatology

Instituto Nacional de Arqueologia

O. Rivera	Archeology
L. Ticlla	Archeology

Geobol	E. Saavedra	Palynology

Museo de Arqueologia y Antropologia - UMSS

R. Cespedes	Archeology

Instituto Nacional de Meteorologia

J. Diaz	Meteorology

Chile

Universidad de Chile
Facultad de Ciencias

P. Aceituno	Climatology
H. Fuenzalida	Climatology
C. Villagran	Palynology
J. Varela	Geology

Universidad de Magallanes

M. Martinic	Archeology
X. Prieto	Glaciology
J. Santana	Glaciology

Colombia

Universidad Nacional de Colombia, Bogota
Instituto de Ciencias Naturales

G. Correa	Archeology
O. Rangel	Palynology
C. Parada	Micropaleontology
F. Pineros	Palynology

Instituto Geografico Agustin Codazzi, CIAF

J. Wobzi	Glacial geomorphology
K. Robertson	id.

Ingeominas	H. Duque	Paleontology

Universidad Nacional de Medellin

M. Hermelin	Quaternary geology
G. Toro	id.

Academia de Ciencias

J. Carrisoza	Ecology
H. Duenas	Palynology

Ecuador

Instituto Geofisico de Los Andes

J. Garcia Doltz	Geology

Guyanne Francaise

ORSTOM	M. T. Prost	Quaternary geology

Peru

Instituto Geofisico del Peru

J. Macharé	Quaternary geology
R. Woodman	Paleoclimatology

Universidad Nacional de San Marcos
Escuela de Geologia

J. Guevara	Quaternary geology
Y. Veliz	Quaternary geology

Universidad Ricardo Palma		
Facultad de Ciencias Biologicas		
	V. Alleman	Malacology
Universidad Peruana Cayetano Heredia		
	D. Bonavia	Archeology
Instituto de Investigacion de la Amazonia Peruana		
	R. Beauzeville	Programme manager
Hidrandina	B. M. Arnao	Glaciology
	A. Ames	Glaciology
	M. Zapata	Glaciology
Instituto Français de la Recherche Scientifique pour le Development en Cooperation - ORSTOM		
	L. Ortlieb	Quaternary geology
	M. Servant	Paleoclimatology
	M. Fournier	Isotopic dating
	L. Martin	Quaternary geology
	J. -F. Dumont	Quaternary geology
Geotop - Université du Quèbec à Montréal		
	C. Hillaire-Marcel	Quaternary geology
	C. Perrier	id.
Université de Paris IV - Soho		
	C. Vergnaud-Grazini	Isotopic geochemistry
	J. -F. Saliege	id.
University of Colorado, Boulder		
	B. B. Balsley	Paleoclimatology
	R. Phipps	Dendrochronology

1.5 What are the Major Limitations for Increased Participation?

The economic limitations of the region are the major cause for the lack of increased participation in the IGBP projects. For this reason, it is absolutely necessary to obtain external funds (i.e., from international organizations, private foundations, European or North American governments, Australia or Japan) to enable the South American scientists to participate in the IGBP and to generate the data needed for an understanding of global changes in South America. Funds are requested for:

- Research projects:
  Field expenses; laboratory expenses; analysis of samples, (e.g. C and O isotopes, etc.,) in countries outside the region; basic infrastructure and scientific equipment for laboratories; temporary hiring of technical personnel; computer time costs.

- Human resources identification and formation:
  Scholarships for graduate students of the region to be granted in already existing disciplines and particularly in disciplines where there is an almost complete deficit of resources; travel grants for both senior and junior scientists, within and outside of the region.

- Information and documentation:
  Scientific literature and bibliography; cartography; access to international data banks.

- Interaction of the scientists of the region:
  Organization of regional workshops and scientific meetings; regional publication of scientific papers; regional seminars and graduate courses; publication of a regional IGBP Newsletter.

Any efforts that the IGBP can make in order to promote the programme among the governments of the region would be highly appreciated. This would help scientists to obtain official recognition of the significance of the programme, and the importance of scientific activity for the planning of any local or regional development programmes. Fortunately, there are no serious linguistic or cultural barriers among the countries of the region.

The existing scientific groups in the region are highly sensitive to political and/or economic instability and have a strong tendency to disintegration due to the lack of adequate salaries and stimulation. As a consequence of recurring crises, researchers often leave the region for the more developed countries.

1.6 Specific Recommendations for Follow-up Activities

IGBP should sponsor and support the organization of regional meetings related to the programme in general, and to specific topics of the PAGES project. These meetings should be prepared simultaneously with other meetings of the disciplines related to PAGES, in order to improve participation and to maximize available resources. Forthcoming events at which PAGES meetings could be organized:

(i) May 1990 - IGCP-281 "Paleoclimates of South America", annual meeting in Medellin, Colombia.

(ii) November 1990 - INQUA Commissions on Loess and on the Quaternary of South America; International Meeting on Loess, Mar del Plata, Argentina.

(iii) November 1990 - IGCP-274 "Quaternary Coastal Evolution", annual meeting and Symposium (International), Argentina.

(iv) July 1991 - Meeting on Paleo-ENSO research, Lima, Peru.

Financial support from IGBP is requested for travel grants and accommodation expenses for ten South American scientists to enable their attendance at each of such meetings.

IGBP should sponsor and support the organization of graduate seminars, training courses and short visits of scientists and graduate students to research centers within the region. The full use of the available human resources in the region should be encouraged in these activities. A course on "Dating Techniques in the Quaternary" is suggested to be held during the July 1991 Meeting on Paleo-ENSO research, Lima, Peru. Funds to enable the participation of both lecturers and graduate students are requested.

Regarding specific research activities, this Working Group suggests that several key projects should be supported by IGBP. These projects should be chosen based on their scientific and geographical significance. The suggested projects are the following:

Paleoclimatic and paleoenvironmental study of a long terrestrial record: the Savanna of Bogota, Colombia.

The Savanna of Bogota project is the study of the sedimentary in-fill of this basin, which includes a more than 800-meter thick stratigraphic section. This in-fill is a sedimentological record, which is devoid of important stratigraphical hiatus and embraces rudiments which may range from Pliocene to Recent (at least the last four million years). This sedimentary infill is mostly clay with lesser interstratified sands, peats and volcanic ash. For these sediments only palynological determination and the dating of the volcanic ashes have been carried out. Analyses such as paleomagnetism, geochemistry, diatoms, etc., have not been done. These studies are extremely important for the control of the Savanna of Bogota itself as well for the correlation of this section with the other long sections drilled by the deep-sea drilling project, which could provide information on the control of climate changes in

the last four million years. Taking into account that the Bogota savanna section is the only complete terrestrial section, our strong suggestion is to improve the research in this area, through a coordinated regional effort.

Paleoclimatic and paleoenvironmental study of a continental record dating back from the end of the penultimate glaciation (ca 150 kyr) to present time: Lake Titicaca, Bolivia.

Lake Titicaca is located in the Bolivian-Peruvian Altiplano. It is an endorheic lake, of large dimensions, 3810 m.a.s.l. The origin of this lake dates back to the beginning of the Quaternary. It is fed by snowmelt water and seasonal precipitation. The studies conducted so far in this area, in the fields of geology, limnology, geochronology, hydrological budget, indicate that, during the last 10 000 years BP, large, severe climatic crises took place in the region. For example, sedimentological studies in cores, 6-8 m long, have enabled us to locate the lake Titicaca level 20-30 m below its present level around 7500-7000 years BP. The lake reached its present level only 1500 years ago. This necessitates drilling to deeper levels than those studied so far, until reaching the record of the last climatic glacial-interglacial cycle (the last 150 000 years). This will allow us to reconstruct the paleoclimatic and paleoenvironmental history in the region, through sedimentological, geochemical, palynological, paleontological, geomagnetic, and stratigraphic studies.

Paleoclimatic and paleoenvironmental study of pollen and tree-ring records dating back from the termination of the last glaciation (ca 15 kyr) to the present: Southern Chile and Tierra del Fuego.

Southern Chile and Tierra del Fuego (latitude 38°-56°S) have a cool, wet temperate climate that favoured the development of subantarctic forests and peat-bogs since the termination of the last glaciation, around 15 000 years ago. Known pollen records in Tierra del Fuego show pronounced climatic cooling during the late glacial, which would suggest that the Allerød - Bolling and Younger Dryas events occurred worldwide. Other climatic fluctuations shown by the records have not yet been interpreted. Vegetation zoning in time, ecological changes, fossil fires, and volcanic eruptions have been recorded as well. A similar study is proposed, covering the last 15 000 years but with emphasis in the last 2000 years by means of even more detailed sampling. Tree-ring records now cover the last 1600 years in the Subantarctic *Nothofagus* forest. A reappraisal of the already interpreted chronologies for *Fitzroya* and *Austrocedures* is encouraged, as well as new samplings in key areas. Modelling of climatic information recorded in tree-rings should be estimated.

These proposed projects are related to activities of the IGCP-253 "Termination of the Pleistocene" and several INQUA commissions.

Analysis of historical and instrumental climatic records in South America

The relatively more abundant climatic information derived from historical and instrumental records provides a basis for the understanding of the dynamics of the present climate in South America. This knowledge is considered essential to understand both past climate conditions and the patterns of regional climate anomalies expected in the near future.

Studies of Paleo-ENSO events: Study of late Quaternary abrupt global changes

ENSO is one of the clearest examples of short-term recurrent global change. Written chronicles have revealed its repeated occurrence during the past five centuries, at least. It is intended to analyze several geological and paleo-biological records of ancient strong ENSO events, in order to establish variations within their intensities and frequencies back to the Holocene or further. Sources of the possible records of this phenomenon have already been recognized:

- Coastal sediments (beach ridges) in NW Peru are considered to be formed by the sequence: Heavy rainfall - unusual erosion - sediment transport from land to sea - redistribution of sediments by coastal currents.

- Sedimentary infill of coastal and endorheic depressions in the desert of northern Peru. Core drilling of some topographic depressions could display the rainfall history of the region, and therefore of paleo-ENSOs.

- Unraveling of the tree-ring patterns of *Capparis* and other long-life species could identify the occurrence of heavy rainfalls.

- Core drilling of ice caps in the tropical Andes show short-lived periods of decreasing snow-fall. These periods characterize ENSO events as shown by comparison with the last events.

- The isotopic composition ($\delta^{18}O$, $\delta^{13}C$) of some mollusks living during the last ENSO (1987) display "anomalies" probably linked with the rising of sea-surface temperature. These anomalies could be isotopic signatures that

characterize ENSO events, and marine shells may constitute good tracers in paleo-climatic reconstructions.

Anthropological paleoecology project

A retrospective vision of the different cultural modalities through the archeological evidence allows determination of the characteristics of the interaction between man and his environment. Man has largely modelled his habitat but, to an even larger degree, has also produced cultural responses that have allowed his adaptation to a changing environment. Settlement patterns, subsistence procedures, artifacts, housing, flood-control and erosion-control techniques, management of fauna and plant resources, frequently allow us to identify not only local variations but contribute to the definition of global changes. For instance, the archeological records enable us to show that environmental changes occurred during the late Pleistocene and the Holocene. These changes are expressed in clear modifications of the fauna, flora, lithic industries and ceramic traditions, allowing the reconstruction of stages of hunters (including megamammal hunters of the late Pleistocene), hunter-gatherers and finally, agricultural groups, and agricultural ceramics groups. There are, however, some variations that were, in some cases, induced by climatic changes. It is, therefore, necessary to emphasize paleoecological studies related to the archeological record. As long as these studies permit a retrospective overview that will elucidate climate and environment changes, they will contribute to a productive vision of the management of certain environmental phenomena. Examples of immediate application of this methodological approach to prehistorical ecology include the study of the Rio San Jorge region in the northern coast of Colombia, the project on the relation of Late Pleistocene - Holocene Environments and Prehistoric Man in the Cordillera Oriental de Colombia, the Project Telarmachay in the Peruvian Siena, and the Arroyo Leco Project, Buenos Aires Province. All these projects, and other similar ones, could be utilized as potential sources of reliable information and planning new projects in selected key areas should be encouraged.

Ice coring in the Andes

Along the Andean Ranges, there are many ice caps and glaciers suitable for ice coring and paleoclimatic studies, both in tropical and temperate latitudes. Expertise has been obtained through extensive work in the Quelccaya Ice Cap, Peru, in the Patagonian Andes of Chile and in the Antarctic Peninsula. Dr. Alberto Aristarian

(Mendoza, CONICET) should be contacted on these matters, due to his long experience and his work with C. Lorius and other colleagues in Grenoble, France.

Volcanic tephras

Many areas of the Andean Cordillera were volcanically active during the Holocene and even during recent times. Volcanic ashes have been preserved in the sediments of lakes, ponds, mires and bogs and could be closely dated by ^{14}C dating of underlying and overlying organic beds. A project is proposed to determine the amount of volcanic activity during the Holocene period and the impact on the regional ecosystems.

Present state of the proposed research projects

The proposed research projects mentioned above are at different stages of development. Some of them are already in progress, sponsored by national organizations, under the auspices of, among others, INQUA and IGCP. Some of them have already reached a significant level of development through long-term contributions by South American and out-of-the-region scientists. However, there is a need for summarized versions of the projects, review papers and modelling of the paleoenvironmental data into paleoclimatic information, which could be used by other IGBP projects. Finally, other projects have not started yet and need full support to become established. The proposed research projects can be classified as follows:

Sabana de Bogotá	In progress	More drilling is needed, together with more analytical work and modelling of paleoenvironmental data
Lake Titicaca	To be started	Funding for drilling and subsequent laboratory analysis is needed
Pollen records and tree-ring data	A review paper to summarize the information is needed, together with modelling of paleoenvironmental data	Synthesis will perhaps suggest the need for further coring in geographical areas poorly represented, or re-studying certain sites or particular periods in detail

Historical and instrumental climatic records	Significant published and unpublished information, but no synthesis efforts done as yet at the continental level	Modelling is badly needed, using the already existing data
Paleo-ENSO	Just starting	Needing full support to coordinate the different efforts to be undertaken
Anthropological paleoecology	Many scientific contributions already done on the continent	A general summary and synthesis process of the information is necessary
Ice coring in the Andes	Only two areas (Peru and Southern Chile) have been investigated	An entirely new drilling project in a selected key area is encouraged
Volcanic tephrochronology	An outstanding volcanic record is available in the published literature. A synthesis effort is needed	Further research in key areas should be proposed after the synthesis process

Detailed proposals, with specific objectives and references for each proposed project, personnel, methodology, expected results, budget and chronograms will be presented later, if requested.

1.7 Data and Information Needs

The lack of communication among South American scientists and between them and other research centers in the world is one of the major constraints for scientific development. Therefore, we propose:

- The establishment of a telemail network between South American research centers. For that purpose, a special committee should be nominated to propose the procedure and suggest the budget (modem purchasing, telemail systems, fees).

- The creation of a Center for Information and Documentation for Past Global Changes in South America. This Center should include general bibliography, specific literature, archives of published and unpublished reports, papers, maps, etc. It should be accessible for all South American scientists through an efficient fax system or other adequate system. Funds could be requested

from TWAS and Unesco. It is proposed that the Center is established in Peru or Bolivia.

- Arrangements to enable access of South American scientists to the Center for Aerial Photo Interpretation and Satellite Imagery (CIAF) in Bogota, Colombia, or other similar centers.

1.8 Modelling Efforts

Computer simulation of past atmospheric and oceanic circulation is considered essential in order to put the results from a variety of paleoclimatic studies at individual sites in a common continental perspective. This activity, although important, cannot be developed in the region at the present time due to lack of adequate computing facilities. A special project on "Modelling of climatic data out of the existing regional palynological and dendrochronological information" is strongly encouraged. It is hoped that the installation of a super computer at INPE, Brazil will provide opportunities for South American atmospheric scientists to develop research in climate modelling both for prediction purposes and analysis of past conditions.

1.9 Conclusions

The following conclusions may be drawn from the discussions:

- The South American Continent is clearly a key region for the study of Past Global Changes within the scope of IGBP.

- Existing research groups have been identified in almost every country of the region. The potential for developing other groups is very high, provided that encouragement and support are given.

- Several research projects have been proposed in different time spans and disciplines, according to PAGES Streams I and II and the activities described in them.

- Regional research should be stimulated by improving communication among scientists, and by the development of new human resources.

- Financial support is absolutely necessary together with technological cooperation from developed nations.

- In addition to the research projects, several academic activities have been proposed.

- The South American Continent is a unique paleoenvironmental and paleoclimatic data reservoir for the Southern Hemisphere.

2. EFFECTS OF CLIMATE CHANGE ON TERRESTRIAL ECOSYSTEMS

2.1 Special Relevance of GCTE for South America

South America has a unique and rich biota associated with its various ecosystems: tropical, subtropical, temperate, mountainous, dry lands, etc. There is a need to assess the importance of this biodiversity for humanity and to evaluate its conservation possibilities for the future.

South America is triangular in shape, with a sharp southern tip, and is predominantly tropical. The geography imposes constraints on the eventual relocation of the regions large biodiversity. It might also involve severe constraints on the movement of human populations. These facts make South America a sensitive continent in relation to response to climate change.

People in South America still depend, to a large extent, on natural resources, making them particularly vulnerable to the effects of climate change, i.e., changes that may affect primary production or decrease economic returns from production activities.

All these factors are at work on a continent that already has high population growth rate, low scientific, economic and technological capacities, and where environmental crises may occur even in the absence of global climate change. Adding these factors to the social inequalities and high social expectancies of the majority of poor and little educated people living in societies with weak political institutions, the situation could become very explosive and the risks of over-exploiting (degrading) the natural resources of the region are high. Not only the need to satisfy the increasing food requirements of a demanding population in a subsistence economy, but the additional high foreign debt burden, imply high risks for the people, resources, and biodiversity of the continent.

2.2 Do the Core Project Descriptions Take Due Note of Processes and Problems in South America?

The GCTE core project appears to cover the major processes and problems that we have identified for the South American region.

The effect of global change on ecological complexity (GCEC) is a potential IGBP core project the overall objective of which is to develop a capability to predict the effect

of global change (changes in land-use, the atmosphere and climate) upon the complexity of ecosystems. Since tropical ecosystems in South America have a unique biodiversity, which is maintained through very fragile dynamic equilibria, global change is expected to affect both the structure and function of these ecosystems. This enhances the significance of conducting a project focusing on these issues in the South American region.

2.3 List of Researchers in South America

The list could be extensive, since most ecologists could contribute from their own field. To contact prospective researchers who could contribute to the global programme, the projects might be presented in scientific journals. Unfortunately, there is no easy way to reach the majority of the scientists in this region with information. However, there are Scientific Councils in most Latin American countries, which already have an extensive list of researchers. These Councils could be requested to announce the IGBP and to stimulate prospective contributors.

2.4 What are the Major Limitations for Increased Participation?

Lack of financial resources to support IGBP research certainly limits participation. The resources required to foster participation should cover equipment, expenses, and scholarships for training new scientists or more senior scientists in new concepts or techniques.

Inadequate communication among scientists in the region with scientists outside the region limits participation, because many scientists ignore the aim and scope of IGBP.

The lack of an appropriate mechanisms to recognize creative contributions may prevent some scientists from contributing novel ideas to a project with the IGBP scope. Hypotheses and new ideas are the most important resources in science; therefore scientists may hesitate to contribute ideas in the absence of a clear mechanism to show how their contributions will be recognized.

Poor recognition of the IGBP at the national level may limit participation of some scientists; especially those in institutes with a rigid research agenda.

2.5 Specific Recommendations for Follow-up Activities

We propose to develop a few regional research projects to study the effects of climate change upon one or two of the major ecosystems of the region. These projects will include scientists from at least two countries. The principal investigators will try to obtain funds for the project from local as well as from international sources. Besides the scientific contribution to IGBP goals, the projects will be very useful in stimulating other scientists and in generating the intellectual excitement necessary to foster participation. Examples of possible titles for these projects are: (i) effects of climate change on tropical forests increasingly used by humans and; (ii) effect of global change upon ecosystems limited by the length of the dry season. We also suggest development, or completion of the development, of a network of PCs with the objective of solving the communication limitations. The network will support E-mail and a regional bulletin board for IGBP issues.

The development of new versions of current GCMs, which take into account the Andes mountain range, will provide better estimates of changes on climate (see Section 5). These estimates are important in observing the impact on terrestrial ecosystems.

2.6 Data and Information Needs

- Two or three information centers that will provide information on where existing data are available and how it can be obtained.
- Regional libraries with periodicals and books.
- The preparation and maintenance of a description of the status of major ecosystems on the continent. A need to enrich reference collections for animals and plants of the regions.
- Standardization of measurements that will make results comparable.

2.7 Modelling Efforts

- Improve the quality of climate models to the point that specific, well accepted scenarios, can be used as a basis for research proposals to investigate the consequences of climate change on terrestrial ecosystems.

- Develop mechanistic models relating ecosystem variables (such as species types, nutrient fluxes, productivity, and decomposition rates) to changes in temperature, CO_2 and rainfall.

- Develop conceptual and simulation models that allow for the separation of climate change from the human disturbance signals in field data.

3. THE ROLE OF OCEAN PROCESSES IN GLOBAL CHANGE

3.1 Special Relevance for South America

Global changes that may affect the ocean environment, and therefore fisheries and other coastal natural resources, are critical for the countries of the region. In particular, ENSO and anti-ENSO events have a large impact on the interannual variability of climate in several regions of South America. A change in the frequency and intensity of these events will have a major impact.

The ocean off the west coast of South America is the most productive in the world. Therefore, influence of expected climate changes in the up-welling regime is extremely important. The up-welling areas constitute hot spots in terms of bioproductivity and CO_2 and DMS exchanges at the air-sea interface.

The circum-Antarctic ocean current and air-sea interaction processes in the boundary ice water are key factors influencing the South American weather and climate.

Sea-level changes are seen also as a very critical factor, in particular along the Atlantic coast, the Caribbean region and insular southern Chile.

3.2 Do the Core Project Descriptions Take Due Note of Processes and Problems in South America?

Concerning JGOFS planned activities for the Atlantic and Pacific oceans, relevant observations, both in the oligotrophic central gyres and within the highly productive coastal zones around the continent, are contemplated. However, a special effort should be made in order to ensure the participation of South American scientists in the detailed implementation plans.

In relation to LOICZ, we see a better coverage of the regional problems related to the coastal area of the Humboldt and Brazil-Malvinas currents, and we would expect that scientists from the area be involved in the planning process.

In terms of PAGES planning, it is important to recover information from past ENSO events, particularly their frequency and intensities. It is suggested that analysis of anoxic basin sediments, carbonate sediments and other techniques, such as Cd/Ca relationships, etc., should be considered.

3.3 Ongoing Research

Brazil

A complete programme for IGBP has been established at the University of São Paulo. It consists of a programme for monitoring sea level through a net of tide gauges along the coast. Pelagic gauges will also measure sea level at 100 to 200 meters depth on the shelf. Hydrographic sections from Santos to the SE, on at least a yearly basis, will contribute with data on SST, salinity, primary productivity, nutrients, dissolved oxygen, CO_2 and sediments. Currents and meteorological measurements will be performed from a fixed station in the South Atlantic.

At INPE, oceanic modelling efforts are being carried out. A study on the influence of sea ice around Antarctica, particularly in the Weddell Sea area, in the storm tracks that reach Brazil, is also under way. In addition, 3-D Atlantic ocean circulation modelling using integral equations is being used to relate ice volume and sea-level fluctuations. Other programmes in Brazil are: (i) map of ancient shore faces at 20 m depth by satellite and study of cores; (ii) mapping of algal cover to 40 m depth by satellite in north east Brazil and; (iii) coastal sediment transport (TOPSUB/INPE).

Peru

Peru is actively participating in the TOGA programme by means of deploying drifting buoys and measuring meteorological and oceanographic parameters along the coast with DCPs. The research activities are focused on the understanding of ocean processes and marine productivity to support fishing activities. Peru will also participate in the NASA Global Tropospheric Experiment (GTE) programme for measuring atmospheric gases in the upwelling regions.

Chile

Chile is doing research work on air-sea interaction processes and primary production in upwelling areas where the phenomena appear in the form of pulses. This research aims to estimate the actual potential of the resource base in order to understand the underlying physical mechanisms that could change due to the expected global warming. Rainfall events in central Chile in connection with ENSO atmospheric circulation anomalies are also being studied.

There is general agreement about the lack of knowledge of ocean currents in the Humboldt system, except for restricted coastal areas. This issue has to receive attention in the future. Chilean oceanographers and meteorologists participate in a working group on Dynamics of Oceans and Atmosphere within the National Oceanographic Committee. Their current responsibility is to organize the Chilean participation in the World Ocean Circulation Experiment (WOCE) through a programme consisting of drifting-buoy displays, current meter arrays and a yearly oceanographic section in the area where the west wind-drift meets the continent.

3.4 What are the Major Limitations for Increased Participation?

The most critical limitation for carrying out scientific research on oceanic processes in the region is the lack of adequate funding at national levels. This situation severely limits the operation of ships and other seagoing platforms, as well as appropriate laboratories and instruments.

An incipient level of coordination among scientists from the countries of the region was recognized. This situation must be improved, if a significant contribution from the region is to be achieved.

The need to improve the modelling capabilities in different disciplines, particularly in the field of global climatic change, geophysical fluid dynamics and bioproduction in the upper ocean was recognized.

Although the IGAC Science Plan includes aspects of relevance for the region, there is an insufficient number of specialists in atmospheric chemistry in Latin America.

The lack of scientific planning at the regional level was also identified as a strong limitation. Steps toward improving this situation should be considered within the IGBP.

3.5 Specific Recommendations for Follow-up Activities

Recommendations:

- To coordinate efforts by scientists and institutions conducting repeated ocean observations, especially hydrographic cruises, by standardizing their timing, measurement techniques and periodicity. Ongoing or planned experiments by countries in the region could greatly benefit from such coordination.

- Tide gauge data exchange among scientists, and sea level cooperative research, in both the east and west coast of South America, should be encouraged.

- Institutions conducting repeated ocean observations in the coastal zone (time-series), should expand their protocols to include some biological measurement of the ecosystems response, such as chlorophyll-*a*, at a weekly frequency.

- Efforts to improve coordination of regional participation in WOCE should continue, and regional meetings, timing, joint ship-time planning and coordination should be strongly encouraged by WCRP and IGBP.

- JGOFS and WOCE projects extend their activities to the coastal areas in the Chile-Peru Current System, and in the Brazil and Malvinas Current areas. Large international efforts, where regional participation is contemplated, should not ignore the importance of the boundary between oceanic and coastal zones.

- Latin American scientists to participate in future planning of the proposed IGBP project on Land-Ocean Interaction, in the Coastal Zone.

- IGAC should identify and contact centers of excellence in chemistry in the region, with the purpose of initiating a sustained effort for training specialists in atmospheric chemistry.

- To prepare workshops on the region in topics such as: Ocean monitoring, global changes in tropical areas, variability of tropic benthic ecosystems, etc.

- Countries maintaining Antarctic Research Programmes should be encouraged to interact with each other, to share scientific resources and to give priority to projects related to global change, based on the large potential impact of predicted changes in the Antarctic continent. An appropriate avenue for this purpose could be the upcoming meeting "Primera Conferencia Latinoamericana sobre Geofísica, Geodesia e Investigación Espacial Antárticas" to be held in Buenos Aires from 30 July to 4 August 1990.

- Electronic mail usage by individual scientists should be encouraged and facilitated. Accordingly, it is requested that the IGBP explores alternatives to

implement a system of electronic mail among National IGBP Committees including the establishment of a Bulletin Board within the system.

3.6 Data and Information Needs

Although the world oceans play a dominant role in global change, the number of physical and biological observations taken regularly are three orders of magnitude less than those available for the atmosphere. To understand the processes that regulate global change in the next 50 years, a completely new mode of monitoring the oceans will have to be developed and implemented. In particular, this monitoring is needed to discriminate the early signals of global oceanic changes against the background of natural variability. Despite the fact that remote sensing does represent an improvement with respect to spatial coverage, it is still limited because of the presence of clouds and does not represent an alternative to the crucial direct observations that are needed to understand the processes that regulate ocean-atmosphere-biosphere interactions. Furthermore, it is important to note that direct observations show discrepancies in the remotely sensed information.

For the purpose of data exchange, it would be convenient to identify selected coastal stations (at least one per country), where measurements of physical and biological parameters of the water column are taken. With the data collected in this network one can build up time series of relevant variables to assess local and regional variability. The network should also include atmospheric observations. Five-day means, or pentads, of the data collected should be exchanged and distributed monthly as a table or graphs.

To strengthen cooperation, it is suggested that whenever possible the writing of trans-national, multi-author papers should be encouraged as a general strategy. This goal could be promoted by National IGBP Committees.

The precarious level of planning of the scientific sector in the region was also identified as a strong limitation, and so far it prevents longer term sustained efforts. Improving scientific planning at the national level was considered as a requirement to strengthen regional cooperation.

3.7 Modelling Efforts

The main modelling efforts have been concentrated in Argentina (CIMA) and Brazil (INPE). It seems absolutely necessary to support the continuity of these groups, and to stimulate regional exchange and training.

Efforts should be made by IGBP-related projects to understand the conditions of the sea ice around the Antarctic continent. This is necessary because the lack of data, especially in the oceanic areas covered by ice, causes extrapolation problems. These areas can cover up to 7.5 % of the Southern Hemisphere, and the total range of annual average variability is of the order of 2 000 000 km^2.

Specific problems related to ocean modelling in the region are:

- Lack of adequate data to verify, initiate, and establish the boundary conditions in the models.

- Need for a close coordination mechanism between observing and modelling groups during the planning phase of observations.

Finally, efforts in bio-oceanographic modelling are viewed with special interest, since models of the ecological system in the upper ocean layer are very relevant to the highly productive areas of South America. Hopefully these efforts will be extended to other trophic levels.

4. LAND TRANSFORMATION AND GLOBAL CHANGE PROCESSES

4.1 Special Relevance for South America

The importance of this topic for South America is obvious, as land transformation processes are occurring at alarming rates in this area of the world. Land-transformation processes that should be considered, irrespective of importance to global changes are: Deforestation (tropical and others), desertification, vegetation burning, drainage of wetlands, erosion and sedimentation of mountainous areas, conversion of forests and grasslands to pasture or croplands, urbanization, and large-scale forestation or reforestation.

No major global-change related alterations are occurring in the temperate regions of South America. Most changes have occurred already. However, the present conditions are not static. Since no information is available for some of the major processes, e.g., trace-gas exchange, it is not possible to set priorities for the region, and research projects to evaluate the present situation should be undertaken. In addition, in several areas of South America, given the population pressure, the potential for severe land transformation activities is high. The necessary studies may be lacking because of funds are not made available.

In South America, the Amazonian basin and the deforestation process occurring there, is of most significance for global-change effects in the region. Research indicates the importance of South American Amazonia as a regulator of global climate.

Theoretical and modelling studies suggest that profound changes in all branches of the soil and atmospheric hydrological cycles might result from extensive deforestation in Amazonia. There have been almost no experiments aimed at verifying/validating model results relating to possible hydrological cycle changes.

The most important changes envisioned when converting from forest to pasture or intensive agriculture are listed below:

At the soil level

Increased compaction and loss of soil structure result in marked reduction of hydraulic conductivity. Measurements for forest and pasture soils in Para, Brazil, show reduction of infiltration rates as high as a factor of ten for soils under pasture

compared to forest soils. Root depth and density is lower for grass or crops than for forest. Due to decreases in organic matter content, water availability is reduced in the root zone of soils under pasture. During intense storms, surface runoff and erosion are more severe on pasture than on forest soils.

At the canopy level

Energy balance at the canopy level is quite different in model simulations for forest compared to grass. As a result of reduced available radiative energy at the canopy plus an increased stomatal resistance to the transfer of water from the soil to the atmosphere through transpiration, the total evapo-transportation of grass cover is less than the evapo-transportation of forest cover. The Bowen Ratio (sensible heat/latent heat) is about 0.3 for forest and about 0.6 or larger for grass. Therefore, a larger proportion of the available radiative energy goes into heating the air near the surface. In modelling calculations the daily average surface temperature is 2 to 3°C warmer for grass cover compared to forest cover.

The large-scale

Modelling results indicate that for extensive deforestation in Amazonia and replacement by short-grass vegetation, regional rainfall would decrease somewhat and there would be a lengthening of the dry season. Also, these climate simulations indicate an overall reduction of runoff on an annual basis.

Another problem that is worth mentioning is the transformation of savannas in Venezuela and Brazil, in particular when this is related to changes in agricultural use. This might lead to the disruption of the trace-gas cycles. In addition, the use of intensive irrigation, e.g., in the east of central Brazil and the São Francisco river valley, is hazardous for the hydrological cycle of the region.

Problems like the aridization of areas in Northern Chile due to intensive sheep grazing, and the alarming deforestation levels should not be neglected.

4.2 Do the Core Project Descriptions Take Due Note of Processes and Problems in South America?

The core projects were not studied in detail due to lack of time. The summary Global Change NewsLetter descriptions of core projects however, show that even though tropical South America is fairly well covered, there are warm and temperate

areas that are not covered by the projects; e.g. the Andean region and the South Cone. In the subproject of IGAC on acidification and trace gases, only tropical South East Asia is taken into account and nothing is mentioned about industrialized South Eastern South America. In addition, some important processes are taking place which, despite their apparent small size, within in a short time period might generate important regional alterations, capable of reaching global impact levels, e.g., charcoal mining and burning.

4.3 Ongoing Research and List of Researchers in South America

The following ongoing projects are of relevance in this context:

Amazonian Surface Climate Experiment

- This is a four-year project to study the changes in surface climate and soil hydrology in converting tropical forest into pasture in Brazilian Amazonia. Three sites will be selected for the experiments: a deforested site 80 km north of Manaus (WWF plots), two paired sites (forest/pasture), one in eastern Amazonia and the other in western Amazonia.

Start:	September 1990
End:	1994
Institutions:	I.H. (UK), INPE, INPA, CENA-Piracicaba, Federal University of Para.
Contact person:	Carlos Nobre, Brazil Jim Shuttleworth, UK

South American Regional Atmospheric Experiment

- This experiment consists of launching four radio-soundings a day to study the troposphere and lower stratosphere during a 15-day period in late 1990 in southern South America, including southern Brazil, Paraguay, Uruguay, central and northern Argentina and southern Bolivia. The goal is to understand details of the diurnal cycle of the tropospheric circulation in subtropical South America east of the Andes.

Period:	September 1990
Contact person:	Jan and Julia Paegle, University of Utah, USA Pedro Dias, CPTEC/INPE, Brazil

Amazonia Deforestation and Climate Change

- Modelling and observational studies to understand climate change due to Amazonia deforestation and to detect regional climate change.

Period: 1990 - 1993
Institution: INPE
Contact person: Carlos Nobre, INPE, Brazil

Monitoring of Biomass Burning in South America

- Detection of biomass burning on near real time utilizing NOAA Satellite's AVHRR sensor.

Status: Ongoing operation project
Institution: INPE, Brazil
Contact person: Alberto Setzer, INPE, Brazil

Lands at Amazonia Deforestation Assessment

- Annual assessment of Brazilian Amazonia deforestation using Landsat imagery.

Status: Ongoing operational project
Institution: INPE
Contact person: Roberto P. da Cunha, INPE, Brazil

Preliminary list of research/researchers. Any omission in this list is only due to lack of information at the time of writing.

Argentina

Centro de Zoología Aplicada
Dr. Marcelo Doucet
Universidad de Córdoba
Casilla de Correos 122
Córdoba 5000

Centro de Ecología y Recursos Naturales (CERNAR)
Dr. Ricardo Luti
Universidad de Córdoba
Cordoba 5000

Instituto Argentino de Zonas Aridas (IADIZA)
Mr Ricardo Ojeda
Casilla de Correos 507
Mendoza

Centro de Investigaciones Ecológicas del Chaco
Ing. Carlos Saravia Toledo
Del Milagro 106
Salta 4400

Instituto Miguel Lillo
Dr. Abraham Williak
Miguel Lillo 205
Tucumán

Instituto Argentino de Limnología (INALI)
Prof. Adolfo Beltzer
José Macia 1933
Santo Tome (Santa Fe)

Brazil

CENA, INPE, INPA, EMBRAPA, UW, WHRC, UFPa, CTA, UFRJ, USP, NCSU
Key persons: C. Nobre, G. Batista, J. Richey, R. Victoria, P. Fearnside, K. Kawashite.
Projects involved: CAMREX, EOS Regional Amazon Model, Amazonia - IAEA Bra/0/010, ABRACOS, SAMUEL H.P.D., Burnings, Land Transformation in Amazonia, Amazon estuary, Geochronology

Colombia

Universidad Nacional de Colombia
Facultad de Ingeniería — Consuelo Dias
Departamento de Biología — German E. Marques / Silvio Euluaga
Facultad de Ciencias Humanas — Joaquín Molano
Instituto de Ciencias Naturales — Clara Ines Orozco
Agronomía — Luis Jorge Mesa / Henry Corredor

Ingeominas: Instituto geológico minero
Inderena: Instituto de Recursos Naturales
CIAF: Centro Internacional de Aerofotogrametría
HIMAT: Centro de Meteorología y adecuación de tierras
ICA: Instituto Colombiano Agropecuario

Peru

Instituto Geofísico del Perú — Pablo Lagos / José Macharé
Universidad de Piura — Ramón Mugica
Universidad Nacional Agraria La Molina (UNAM) — Carlos A. Llerena
Oficina Nacional de Investigación Agraria — Walter Sánchez
NCSU, Yurimaguas — Dale Bandy
Centro de Datos parala Conservación de la Naturaleza — Manuel Ríos
Centro Internacional de Zonas Aridas — Carlos López-Ocane
Instituto de Investigaciones de la Amazonia Peruana — Jose Lopez-Parodi
Proyecto Utilización de Bosques Secundarios (UNALM) — Anibal Cheenz
Proyecto Dantos (UNALM) — Daniel Marmillod

4.4 What are the Major Limitations to Increased Participation?

Funds are the main limitation. There is also a lack of scientists and technicians, especially in some specific fields (e.g., atmospheric chemistry, nuclear physics techniques), and an absence of adequate training programmes in environmental science at universities and technical schools. No communication or communication difficulties among colleagues at the regional level, and internationally is a limiting factor. This is mainly related to scarce computing power. Insufficient library resources constitute another important limitation, as well as problems of acquisition, maintenance, and technology transfer of state-of-the-art equipment and instrumentation that is badly needed for improving data collection and processing.

4.5 Specific Recommendations for Follow-up Activities

A regional workshop on land transformation is urgently needed in order to obtain direct information on land transformation statistics (reliable and definite ones), processes, and studies ongoing in the region. This event will provide the baseline information, generate a strong position paper on this matter at the regional level, and orientate the related core projects. A network of people involved in IGBP projects related to land transformation is also needed in order to improve communication and share data. E-mail is strongly recommended as a handy tool in this regard. Also fax and conventional mail should be activated.

In the same way, the group consider that support to ongoing projects already producing results and data must be strengthened. Efforts to use older and successful projects as models to be reproduced in neighbour countries or states, and, if possible, standardization of methodologies and regional transfer of technology should be considered.

4.6 Data and Information Needs

Basic information and data on land transformation and related processes will be obtained at the workshop indicated above; in the same way improved communication will make it possible to keep information and data flowing freely between scientists and institutions. At present, there are several national institutions in South America gathering hydro-meteorological data that share common problems, i.e., poor data, not enough prepared people, lack of funding. Since these data are fundamental for studying land transformation consequences for global change, data collection must be drastically improved or generated when

lacking. Information on soils, geology, wildlife and vegetation must also be included in this consideration. Remote-sensing monitoring and use of GIS must be used and promoted into the South American region, again trying to standardize procedures if possible.

4.7 Modelling Efforts

There are several models being developed and used in the region, some of them might not even be properly employed. Generally speaking, lack of data hinders new development of an adequate model for all land transformation processes and their consequences. However, information and basic data generated by the regional workshop proposed in this report, will make it possible to prepare a conceptual model of the actual situation and to estimate more reliable projections of its consequences.

5. IMPORTANCE OF THE ANDES FOR GENERAL CIRCULATION MODELS

On the continental scale the Andes is a most important feature of the region. To a large extent, this area determines the climate distribution in South America and coastal up-welling in the Pacific Ocean. Climate features are as important as rainfall distribution and arid zones are known to be linked to this narrow orographic barrier. However, some of the processes involved need to be understood to be able to tackle the impacts of global change.

From a global perspective, the Andean Altiplano hosts one of the two summer convection centers of the tropical regions, i.e., places where transfers between the troposphere and stratosphere are considered to be most active. Very little information is presently available in this regard.

Snow and ice fields provide a natural regulation system for water resources, where dry and wet seasons alternate throughout the year. The area involved in the water storage is profoundly affected by temperature fluctuations; a global warming of the magnitude predicted can substantially decrease the accumulation of surface water in the semi-arid regions of Argentina and Chile. This will result in floods in the wet season and drier conditions during summer.

Present GCMs cannot adequately consider the knife slope of the Andes due to their spatial resolutions. This adds an important uncertainty factor to their products. For South America, it is of paramount importance to construct climate scenarios at a regional scale to alleviate this insufficiency.

Fortunately, a powerful computing facility is to be installed within the region, at INPE, Brazil, and the Director General and the Director of Meteorology of INPE have expressed an interest in receiving visiting scientists from the region to do climate research. This is to be added to the Trieste facility for Third World countries and the offer made by Australian scientists in Swaziland in 1988 (IGBP Report 9, 1989).

Because upgraded GCMs will be the most suitable tool for studying global change, it is necessary to consider how to utilize their products in the region.

To foster the improvement of present deficiencies in GCMs, particularly in relation to South America, and remembering that the only large computing facility will be at INPE it is desirable to:

- Strengthen the regional collaboration in GCM research through visiting scientists to INPE and to provide fellowships for talented post-graduate students.

- Have regional meetings with some periodicity where updating surveys are offered by leading scientists.

Because many scientists from disciplines other than meteorology and oceanography are not familiar with the shortcomings of GCMs products and their perception of the capabilities of such models it is recommended to:

- Set up a short training course on general features of GCMs, the products provided by them, and their limitations.

6. REGIONAL RESEARCH CENTERS

The national committees of South American countries considered it highly desirable to establish one or more RRCs in the region. These Centers will foster cooperation among scientists and provide facilities for interdisciplinary work. South American countries do not possess the resources to attack the problems of global change individually and cooperation among them is thus absolutely essential. Synthesis of the activities in the region will be carried out at these centers, and modelling will be one of the many tools utilized.

South America encompasses tropical and temperate regions. Amazonia is the most extensive region of the world where deforestation is taking place at a rapid rate. The consequences of this deforestation will have a profound influence on the global climate. Therefore, it is clear that it is of high priority to establish a RRC in Amazonia.

Temperate ecosystems represent a large fraction of South America and they account for a substantial proportion of the crop and beef production not only of the region but also of the world. The southern tip of the continent reaches latitudes as high as 52°S, where GCMs predict that the winter temperature increase will be the largest. This region therefore becomes ideal to monitor temperature changes.

The climate in temperate zones responds to different driving mechanisms than climate in tropical zones. Ecosystems are also very different between tropical and temperate regions. All of which suggests that scientists of southern South America face different problems in relation to global change than do scientists in the tropics. This justifies the location of a second RRC in the temperate zone of South America. Whereas the Amazonian RRC will focus on the problems of land transformation, the temperate RRC will emphasize the monitoring of climate change and its consequences for ecosystems of high economic value.

APPENDICES

1. Workshop Programme
2. Workshop Participants

1. WORKSHOP PROGRAMME

Monday 5 March 1990

09.00	Opening Ceremony	J. M. Albuquerque
Forman		Brazilian National Committee for the IGBP
		M. N. Barbosa, INPE Director General
		T. Rosswall, IGBP
Session I:	*Chairman: J. M. Albuquerque Forman (Brazil)*	
09.30 - 10.00	Global change: A research challenge for the future	T. Rosswall (IGBP)
10.00 - 10.30	Climate change in South America: The use of general circulation models	M. Nuñez (Argentina)
10.30 - 11.00	Coffee	
11.00 - 11.30	Amazon deforestation and regional climate change	C. Nobre (Brazil)
11.30 - 12.00	Climate change effects on agricultural crops	J. Burgos (Argentina)
12.00 - 12.30	The use of generic models to estimate the effect of climate change on crop production	E. Cabrera (Venezuela)
12.30 - 14.30	Lunch	
Session II:	*Chairman: C. Nobre (Brazil)*	
14.30 - 15.00	The role of the Amazonian forest in the hydrological cycle	L. C. Molion (Brazil)
15.00 - 15.30	South American ecosystems as sources of nitrogen oxides	E. Sanhueza (Venezuela)
15.30 - 16.00	Coffee	
16.00 - 16.30	South American ecosystems as sources of methane	R. L. Victoria (Brazil)

Tuesday 6 March

Session III:	*Chairman: M. Nuñez (Argentina)*	
09.00 - 09.30	Sensibility of the Piura area to detect El Niño phenomena	R. Mugica (Peru)
09.30 - 10.00	El Niño - Southern oscillation phenomena and global change	P. Aceituno (Chile) / P. Bernal (Chile) J. Ruttlant (Chile)
10.00 - 10.30	Paleo - ENSO studies in Peru	J. Macharé (Peru)
10.30 - 11.00	Coffee	
11.00 - 11.30	Impact assessment of El Niño forecasts in Peru	P. Lagos (Peru)
11.30 - 12.00	Springtime ozone depletion over Antarctica	H. Fuenzalida (Chile)
12.00 - 12.30	Effects of sea-level changes on South American coastal systems	E. J. Schnack (Argentina)
12.30 - 14.00	Lunch	

Session IV:	*Chairman: E. Sanhueza (Venezuela)*	
14.00 - 14.30	Climate change effects on natural and man-made ecosystems	E. Bucher (Argentina) / J. Morello (Argentina) / E. Fuentes (Chile)
14.30 - 15.00	Geochronological studies in South America	J. Rabassa (Argentina)
15.00 - 15.30		G. Correal (Colombia)
15.30 - 16.00	Coffee	
16.00 - 16.30	Environmental change in Bogota over the past 10,000 years	H. Duenas (Colombia)
16.30 - 17.00	The use of remote sensing for fire monitoring	A. Setzer (Brazil)

Wednesday 7 March

09.00 - 12.30 Parallel working group sessions:
- Land Transformation and Global Change Processes
  Chairman: R. Victoria (Brazil)
- The Role of Ocean Processes in Global Change
  Chairman: P. Bernal (Chile)
- Global Changes in the Past
  Chairman: J. Rabassa (Argentina)
- Regional Research Centers
  Chairman: O. Sala (Argentina)
- Effect of Climate Change on Terrestrial Ecosystems
  Chairman: O. Sala (Argentina)

12.30 - 14.00 Lunch
14.00 - 18.00 Excursion to Campos do Jordão

Thursday 8 March

09.00 - 12.00 Preliminary reports from the working groups and general discussion
12.00 - 13.30 Lunch
13.30 - 17.00 Continued working group discussions

Friday 9 March

09.00 - 12.00 Presentation of working group reports and recommendations for future collaboration
12.00 - 13.30 Lunch
13.30 - 17.00 Discussion on:
- Involvement of South America scientists in the implementation of the IGBP
- Financing of regional collaboration
- Future regional meetings
- Involvement of the scientific community in the policy process
- Data and information systems
- The role of information

17.00 End of workshop

2 WORKSHOP PARTICIPANTS

Argentina

Dr. Enrique H. Bucher
Department of Biology
Colorado State University
Fort Collins, Colorado 80523
USA
Tel: (1-303) 491 88 31
Fax: (1-303) 491 19 65

Prof. Juan J. Burgos
Centro de Investigaciones
Biometeorologicas
Caja Postal 5233
Correo Central
1000 Buenos Aires
Tel: (54-1) 855 48 58/ 85
Tlx: 9900 BTH CA AR

Dr. Mario N. Nuñez
Departamento de Meteorologia
Universidad de Buenos Aires
Pabellon 2 - Ciudad Universitaria
1428 Buenos Aires
Tel: (54-1) 782 65 28
Fax: (54-1) 311 05 16
Tlx: 18694 IBUBA AR

Dr. Jorge Rabassa
Centro Austral de Investigaciones
Cientificas - CADIC
CC92 (9410) Ushuaia
Tierra del Fuego
Tel: (54-901) 223 10/12/14/20/26
Fax: (54-901) 223 18
Tlx: 88602 CADIC AR
E-mail: ATINA! CADIC!
ATT.JRABASSA

Dr. Osvaldo E. Sala
Departamento de Ecologia
Universidad de Buenos Aires
Facultad de Agronomia
Av. San Martin 4453
Buenos Aires 1417
Tel: (54-1) 52 09 03
Fax: (54-1) 34 54 37
E-mail: DELPHI USERNAME SALA

Dr. E. J. Schnack
Laboratorio de Oceanografia
Costera
Casilla de Correo 45
1900 La Plata
Argentina
Tel: (54-21) 80 03 12 (home)

Bolivia

Dr. Jaime Argollo
Faculdad de Ciencias Geológicas
Universidad Mayor de San Andrés
Casilla de Correo 11152
La Paz
Tel: (591-2) 37 44 64
Fax: (591-2) 35 94 91
Tlx: 3438 UMSA/ 3514 ORSTOM

Brazil

Dr. Getulio Batista
INPE - DPA
Remote Sensing for Global
Resources
Caixa Postal 515
12201 São José dos Campos, SP
Tel: (55-123) 22 99 77 ext 586
Fax: (55-123) 21 87 43

Prof. Umberto G. Cordani
Instituto de Geociencias - USP
Ciudade Universitaria Armando
Salles de Oliveira
Rua do Lago 562 - 211.2847
Caixa Postal 20899 - Butantã
05508 São Paulo, SP
Tel: (55-11) 211 28 47
Fax: (55-11) 815 42 72
Tlx: 82564 UVSI BR
E-mail: UGCORDAN@BRUSP
[BITNET]

Dr. John M. Albuquerque Forman
Presidente
Industrias Núcleares do Brasil SA
Av Presidente Wilson, 231-11° Pav.
20030 Rio de Janeiro RJ
Tel: (55-21) 262 19 19
Fax: (55-21) 262 36 60
Tlx: 2123830 NUCLA BR

Prof. Afranio Rubens de Mesquita
Instituto Oceanografio - IOUSP
Universidade de São Paulo
Caixa Postal 9075
05508 São Paulo
Tel: (55-11) 813 32 22 ext 2319
Fax: (55-11) 211 44 22

Dr. Luiz Carlos B. Molion
INPE - LPAO
Caixa Postal 515
12201 São José dos Campos S.P.
Tel: (55-123) 22 99 77
Fax: (55-123) 21 87 43

Dr. Carlos Aefonso Nobre
INPE/CPTEC
Caixa Postal 515
12201 São José dos Campos S.P.
Tel: (55-123) 22 99 77 ext 507
Fax: (55-123) 21 87 43
Tlx: (38) 1233530 INPE BR

Dr. Luci Hidalgo Nuñez
Instituto Geológico, Coordenadoria da
Pesquisa de Resursos Naturais
Avenida Miguel Stefano No. 3900
CEP 04301
Agua Funda SP
Tel: (55-11) 276 82 88
Fax: (55-11) 276 85 72

Prof. Aldo Rebouças
Instituto de Geociencias - USP
Ciudade Universitaria Armando
Salles de Oliveira
Rua do Lago 562 - 211.2847
Caixa Postal 20899
CEP 05508 Butantan SP
Tel: (55-11) 210 78 44
E-mail: ADREBOU@BRUSP [BITNET]

Dr. Alberto W. Setzer
INPE/DEM
Caixa Postal 515
12201 São José dos Campos, SP
Tel: (55-123) 22 99 77 ext 347
Fax: (55-123) 21 87 43
Tlx: 1233530 INPE BR

Dr. Marcio Luiz Vianne
Department of Oceanography
INPE - Instituto de Pesquisas
Espaciais
Caixa Postal 515
12201 São José dos Campos S.P.
Tel: (55-123) 22 99 77
Fax: (55-123) 21 87 43

Dr. Reynaldo L. Victoria
USP/CENA/Isotopos Estaveis
Caixa Postal 96
13400 Piracicaba, SP
Tel: (55-27) 33 51 22 ext 27
Tlx: 191097 CENA BR
E-mail: RLVICTOR @ BRUSP

Chile

Dr. Patricio Aceituno
Departamento Geologia y Geofisica
Facultad de Ciencias Fisicas y
Matematicas
Blanco Encalada 2085
Casilla 2777
Santiago
Tel: (56-2) 696 87 90
Fax: (56-2) 71 27 99
Tlx: 244302 INGEN CL
E-mail: PACEITUN@UCNCECVM
[BITNET]

Dr Patricio Bernal
Universidad Catolica de Chile
Biotecmar
Casilla 127
Talcahuano
Tel: (56-41) 54 25 92
Fax: (56-41) 54 10 24
Tlx: 260191 PUCST CL

Dr. Tomas Fonseca
Departamento de Geofisica
Universidad de Chile
Blanco Encalada 2085
Casilla 2777
Santiago
Tel: (56-32) 21 65 70
Fax: (56-32) 21 22 05

Prof. Eduardo R. Fuentes
Department de Ecologia
Facultad de Ciencias Biológicas
Universidad Catolica de Chile
Casilla 114-D
Santiago
Tel: (56-2) 222 45 16 ext 2614
Fax: (56-2) 222 55 15
Tlx: 240395 PUCVACL

Dr. Humberto Fuenzalida
Facultad de Ciencias Fisicas y
Matematicas
Blanco Encalada 2085
Casilla 2777
Santiago
Tel: (56-2) 696 87 90
Fax: (56-2) 71 27 99
Tlx: 244302 INGEN CL
E-mail: HFUENZAL@UCHCECVM
[BITNET]

Dr. José Rutllant
Facultad de Ciencias Fisicas y
Matematicas
Blanco Encalada 2085
Casilla 2777
Santiago
Tel: (56-2) 698 20 71 ext 310
Fax: (56-2) 71 27 99
Tlx: 244302 INGEN CL
E-mail: JRUTTLAN@UCHCECVM
[BITNET]

Colombia

Dr. Gonzalo Correal
Colombian Academy of Sciences
PO Box 52514
Bogota 2, DE
Tel: (57-1) 245 00 33/285 74 59
Fax: (57-1) 285 74 78

Dr. Henry Corredor Triana
Universidad Nacional de Colombia
Faculdad de Agronomia
Departamento de Agua y Suelos
Apartado 14490
Bogota

Dr. Hernando Duenas
Colombian Academy of Sciences
PO Box 52514
Bogota 2, DE
Tel: (57-1) 245 00 33, 285 74 59
Fax: (57-1) 285 74 78

Costa Rica

Dr. Primo L. Chavarria
Vicerector de Investigacion
Universidad de Costa Rica
San José
Tel: (506) 24 70 51
Fax: (506) 24 93 67
Tlx: 2544 UNICORI

Mexico

Dr. J. Manuel Maass
Centro de Ecologia
Universidad Nacional
Autonoma de Mexico
Apartado Postal 70-275
Ciudad Universitaria
04510 UNAM Mexico
Tel: (52-5) 550 54 85
Fax: (52-5) 548 52 59
Tlx: 1760155 CICME

Peru

Dr. Pablo Lagos
Scientific Director
Instituto Geofisico del Peru -
PIGB
Los Alamos 241
San Isidro
Lima
Tel: (51-14) 37 02 58
Fax: (51-14) 37 02 58
Tlx: 25507 PE IGP LIM
E-mail: TOGA.PERU (omnet)

Mr Carlos A. Llerena
Facultad de Ciencias Forestales
Universidad Nacional Agraria La Molina
Apartado 456
Lima
Tel: (51-14) 75 34 56 (home)
Fax: (51-14) 31 57 47

Dr. José Macharé
Instituto Geofisico del Peru - PIGB
Los Alamos 241
San Isidro
Lima
Tel: (51-14) 36 56 40
Fax: (51-14) 37 02 58
Tlx: 25507 PE IGP LIM
E-mail: TOGA.PERU (omnet)

Prof. Ramón Mugica
Universidad de Piura
Piura
Tel: (51-74) 32 38 33/32 81 71
Fax: (51-74) 32 86 45

Venezuela

Dr. Evelin Cabrera de Bisbal
CENIAP-FONAIAP
Apdo Postal 4653
Maracay 2101
Tel: (58-43) 45 30 75
Tlx: 43344 FONMA VC

Dr. Eugenio Sanhueza
Department of Airchemistry
Max-Planck-Institut for Chemistry
(Otto-Hahn-Institut)
Postfach 3060
D-6500 Mainz
GERMANY
Tel: (49-6131) 30 51
Fax: (49-6131) 30 53 88
Tlx: 4187674 MPCH D

IGBP

Prof. Thomas Rosswall
Executive Director IGBP
IGBP Secretariat
Box 50005
S-104 05 Stockholm
Sweden
Tel: (46-8) 16 64 48
Fax: (46-8) 16 64 05
Tlx: 17509 IGBP S
E-mail: T.Rosswall (omnet)

Ms Cecilia Edlund
IGBP Secretariat
Box 50005
S-104 05 Stockholm
Sweden
Tel: (46-8) 15 04 30
Fax: (46-8) 16 64 05
Tlx: 17509 IGBP S
E-mail: IGBP.Secretariat (omnet)

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 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)

No. 4. The International Geosphere-Biosphere Programme. A Study of Global Change (IGBP). A Plan for Action. A Report Prepared by the Special Committee for the IGBP for Discussion at the First Meeting of the Scientific Advisory Council for the IGBP, Stockholm, Sweden 24-28 October, 1988 (1988)

No. 5. Effects of Atmospheric and Climate Change on Terrestrial Ecosystems. Report of a Workshop Organized by the IGBP Coordinating Panel on Effects of Climate Change on Terrestrial Ecosystems at CSIRO, Division of Wildlife and Ecology, Canberra, Australia 29 February - 2 March, 1988. Compiled by B. H. Walker and R. D. Graetz (1989)

No. 6. Global Changes of the Past. Report of a Meeting of the IGBP Working Group on Techniques for Extracting Environmental Data of the Past held at the University of Berne, Switzerland 6-8 July, 1988. Compiled by H. Oeschger and J. A. Eddy (1989)

No. 7. A Report from the First Meeting of the Scientific Advisory Council for the IGBP. Volumes I and II (1989)

No. 8. Pilot Studies for Remote Sensing and Data Management. Report from Working Group Workshop held in Geneva, Switzerland 11-13 January 1989. Edited by S. I. Rasool and D. S. Ojima (1989)

No. 9. Southern Hemisphere Perspectives of Global Change. Scientific Issues, Research Needs and Proposed Activities. Report from a Workshop held in Mbabane, Swaziland 11-16 December, 1988. Edited by B. H. Walker and R. G. Dickson (1989)

No. 10. The Land-Atmosphere Interface. Report on a Combined Modelling Workshop of IGBP Coordinating Panels 3, 4, and 5. Brussels, Belgium, 8-11 June, 1989. Edited by S. J. Turner and B. H. Walker (1990)

No. 11. Proceedings of the Workshops of the Coordinating Panel on Effects of Global Change on Terrestrial Ecosystems. I. A Framework for Modelling the Effects of Climate and Atmospheric Change on Terrestrial Ecosystems, Woods Hole, USA, 15-17 April, 1989. II. Non-Modelling Research Requirements for Understanding, Predicting, and Monitoring Global Change, Canberra, 29-31 August 1989. III. The Impact of Global Change on Agriculture and Forestry, Yaoundé, 27 November-1 December, 1989. Edited by B. H. Walker, S. J. Turner, R. T. Prinsley, D. M. Stafford Smith, H. A. Nix and B. H. Walker (1990)

No. 12. The International Geosphere-Biosphere Programme: A Study of Global Change (IGBP). The Initial Core Projects. (1990)

No. 13. Terrestrial Biosphere Exchange with Global Atmospheric Chemistry. Terrestrial Biosphere Perspective of the IGAC Project: Companion to the Dookie Report. Report on the Recommendations from the SCOPE/IGBP Workshop on Trace-Gas Exchange in a Global Perspective. Sigtuna, Sweden, 19-23 February, 1990. Edited by P. A. Matson and D. S. Ojima (1990)

No. 14. Coastal Ocean Fluxes and Resources. Report of a CP2 *Ad Hoc* Workshop, Tokyo, Japan, 19-22 September 1989. Edited by P. Holligan (1990)

No. 15. Global Change System for Analysis, Research and Training (START). Report of the Bellagio Meeting (1991)

No. 16. Report of the IGBP Regional Workshop for South America, São José dos Campos, SP Brazil, 5-9 March 1990. (1991)

IGBP Secretariat, Royal Swedish Academy of Sciences
Box 50005, S-10405 Stockholm, Sweden.