

GLOBAL CHANGE NEWSLETTER

THE INTERNATIONAL GEOSPHERE-BIOSPHERE PROGRAMME: A STUDY OF GLOBAL CHANGE (IGBP)
OF THE INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS

IGBP - Quo Vadimus?

Chris Rapley, Executive Director

In April the IGBP will hold a Congress at which all its scientific steering committees will meet together for the first time. The objectives are to carry out an internal review of the status of the entire programme, to identify common issues for collaborative action, to identify the key research interfaces between the IGBP Programme Elements, and to catalyse essential cross-linking research and the integration and synthesis of results at the programme level.

The Congress is timely because the most advanced Core Projects are generating an increasing volume of new results, which need to be set in their broader context. The motivation arises from the IGBP's long-standing commitment to making the whole greater than the sum of the parts. The event marks the entry of the IGBP into an important new phase of its development.

The ultimate goal of the IGBP is to improve significantly mankind's knowledge and understanding of the Earth System, and to achieve a "practical predictive capability" for Global Change science. History will judge the programme's outcome not in terms of its success in satisfying human curiosity, but in terms of its role in underpinning a sustainable global society. This will require the delivery of practical information and tools to policy and decision makers. It will also require the ongoing development of international environmental law, and increases in public knowledge and awareness sufficient to change human behaviour in an environmentally positive manner.

The IGBP cannot achieve this alone. Even within the domain of basic research, it can address only part of the picture. Increasingly, the success of the enterprise will rely on effective collaboration with

the World Climate Research Programme (WCRP), the International Human Dimensions Programme (IHDP), DIVERSITAS, and a wide variety of related activities. Moves have already been initiated to align more closely the research agendas of the major international programmes, and to ensure that necessary integration and synthesis at the inter-programme level will take place.

Beyond research, a "practical predictive capability" will rely on the existence of an operational global observing system, and a wide array of modelling activities. Unfortunately, the development of the former is currently stalled, and urgently needs appropriate governmental commitment.

However, even an adequately funded combination of research, observation and modelling would be of limited practical benefit without new initiatives in the application of basic science results and in the

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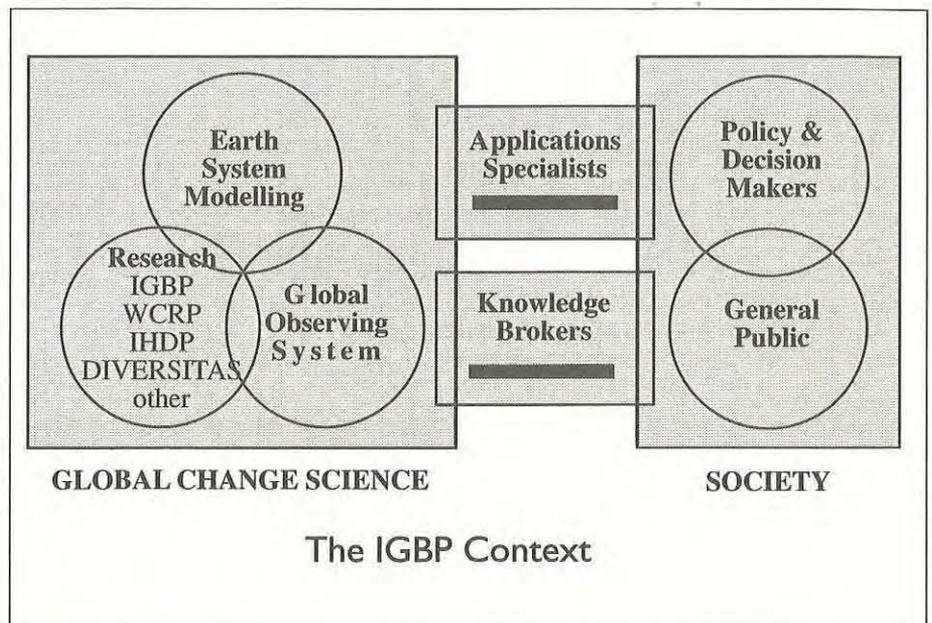
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effective interchange of information between the community of global change scientists, policy and decision makers, and society at large (figure). These crucial links will depend on the creation of a new breed of applications specialists and knowledge brokers, and on new communication mechanisms, of which the IPCC process (see below) represents an early but important example.

A journey is made one step at a time. The Congress represents a stride along a demanding and uncertain road. It provides an excellent example of the value that the IGBP can add to nationally funded Earth science. We look forward to its success and to a wide recognition of its significance.

(The IGBP Congress will take place in Bad Münstereifel, Germany. The IGBP gratefully acknowledges the generous financial contribution and organisational support provided by the German Government for this event.)



Intergovernmental Panel on Climate Change: Science-Policy Interface

by Robert Watson and Richard Moss

Since its inception, the IGBP has been deeply involved in the Intergovernmental Panel on Climate Change (IPCC). The Chairman of the IPCC, Professor Bert Bolin, was also one of the earliest leaders of the IGBP, with his chairmanship of the ad hoc planning committee for the IGBP (1984-86) and subsequent leadership on the Special Committee and its successor, the Scientific Committee for the IGBP. Many other members of the IGBP community also have contributed to the IPCC's work. Most importantly, research conducted within the IGBP framework has been an important foundation for elements of IPCC assessments. This note provides an overview of the most recent IPCC report; it highlights key uncertainties and priority topics for research.

Since its inception in 1988, the Intergovernmental Panel on Climate Change (IPCC) has documented the evolving state of scientific understanding of climate change in a series of reports. These reports have been designed to assist governments, industries, environmental organisations, and others in assessing the likelihood of change, its consequences, and potential measures for adapting to changes and reducing greenhouse gas (GHG) emissions. The reports include the comprehensive three volume assessment of climate change

published in 1990, a supplementary review of additional literature prepared for the U.N. Conference on Environment and Development in 1992, a 1994 special report on radiative forcing of climate - with special attention to trace gas cycles - and the comprehensive 1995 Second Assessment Report (SAR). The SAR received final approval from governments in Rome in December 1995 and will be published by Cambridge University Press in April/May 1996.

The SAR was produced by three Working Groups and includes nearly 60 chapters. Working Group I's contribution assesses critical topics such as the effects of emissions of GHGs and aerosols on radiative forcing; evaluation of climate models and projections of changes in climate variables and sea level; detection of climate change; and feedbacks on the climate system from changes in terrestrial and marine biotic systems. Working Group II's contribution to the SAR addresses such issues as the sensitivity and vulnerability of natural ecosystems (e.g., forests, grasslands, wetlands, and marine ecosystems), socio-economic sectors (food, fisheries, freshwater resources, human communities and infrastructure), and human health to climate change: it also assesses, options to reduce

or sequester GHG emissions through management of energy supply and demand and the forestry and agricultural sectors. Working Group III discussed decision-making frameworks, equity, economic efficiency, the applicability of cost-benefit analysis, and assessments of the damages from climate change and the likely costs of measures to reduce emissions.

In addition to these reports, the IPCC also has produced a synthesis report of information in the SAR related to interpretation of the objective of the United Nations Framework Convention on Climate Change (UNFCCC). This objective is defined in Article 2 of the Convention as "...stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system ... within a time frame sufficient to: (i) allow ecosystems to adapt naturally to climate change; (ii) ensure that food production is not threatened; and (iii) enable economic development to proceed in a sustainable manner."

Finally, the IPCC has also produced a series of methodologies for inventorying GHG emissions, assessing impacts, and evaluating applicability of mitigation measures.

IPCC process

The IPCC provides a mechanism for governments to tap the expertise of the scientific community. Because decision-makers lack the time to familiarise themselves with all of the research relevant to any particular issue - let alone to understand the nuances of different researchers' data, theories, methods, and conclusions - the policy community values a coordinated assessment of the relevant literature in which leading researchers reconcile competing views where possible, characterise alternative perspectives and viewpoints when consensus is not achievable, and analyse the potential implications of uncertainties.

Because it is an intergovernmental organisation, the IPCC must be responsive to governments; however, as a scientific and technical assessment body, the IPCC sees itself as an agent of and hence responsible to the scientific community. While the topics addressed in IPCC reports are determined by government representatives, the detailed chapters of the reports are prepared by scientists and technical experts drawn from universities, government and private-sector research facilities, and non-governmental organisations - usually in their "free-time" and without additional compensation. Many of these scientists also participate in the drafting and reviewing of the Summaries for Policymakers (SPMs), which highlight the policy-relevant portions of the detailed underlying reports. The participation of researchers in drafting the SPMs is essential, as it ensures that the Summaries accurately reflect the conclusions of the underlying chapters. The governmental role in approving the SPMs on a line-by-line basis has also proven to be essential, as the participation of government experts and policy makers helps to ensure that scientific concepts are translated into appropriate policy-relevant language. Striking an appropriate and widely-agreed upon balance which conveys a sense of the range of opinion about what we know and where there are key uncertainties has been a challenging aspect of the preparation of the Summaries. Most participants in the process feel that this challenge has been met successfully up to now, and that ideological perspectives have not biased key conclusions.

Because IPCC reports provide detailed assessments of the state of knowledge and analysis of remaining uncertainties, they not only assist decision-makers but also serve a review and research-planning function by identifying climate change issues that deserve the priority attention of the research community.

Results of the Second Assessment Report

While a number of key scientific uncertainties remain, and there is need for further research to reduce these uncertainties, the SAR concludes that based on multiple lines of inquiry, "the balance of evidence suggests a discernible human influence on the climate system." The report projects a global mean temperature increase of between 0.8 and 3.5 degrees Centigrade by 2100 given plausible projections of emissions of GHGs and aerosols, a rate of change greater than any experienced during the last 10,000 years. This projected rate and magnitude of change may have numerous adverse consequences for ecological systems (especially forests), socio-economic sectors (e.g., regional production of food), and human health (especially vector-borne diseases such as malaria, dengue fever, and yellow fever). The significance of these changes needs to be assessed in the context of other changes such as loss of biodiversity and stresses such as land-cover change, population growth and urbanisation, and intensification of natural resource exploitation.

Implications for Future Research

Governments participating in the IPCC and the UNFCCC process are clearly indicating their wish to have high confidence, quantitative conclusions that will assist them in implementing the objective of the Convention. Based on the results and uncertainties highlighted in the SAR, there are a number of priorities. The research framework provided by the IGBP and its partner global change research programs, the World Climate Research Program (WCRP) and the International Human Dimensions Program (IHDP), already offer a structure for addressing many of these critical uncertainties. Priorities include:

- * developing more accurate projections, by sector and region, of future net emissions of greenhouse gases and aerosols;

- * improving our understanding of the carbon and other trace gas cycles, including how changes in climate will affect trace gas fluxes;

- * refining our quantitative understanding of the response of the climate system, regionally and globally, to additional radiative forcing;

- * developing more reliable transient ocean-land-atmosphere climate models to project regional changes in climate for use in impacts assessment and modelling;

- * improving our understanding of the response of ecosystems (composition, distribution, and function) to changes in climate parameters;

- * examining how increased levels of carbon dioxide in the atmosphere - which have been shown to increase growth of some plant species under laboratory conditions - affect ecosystems and agricultural productivity in the field over long periods of time;

- * quantifying how the hydrological cycle and water resources will be affected by changes in climate;

- * improving our understanding of how changes in climate will affect human health, in particular how the range of vector- and non-vector-borne diseases will change in response to changes in climatic variables; and,

- * assessing the potential efficacy and costs of reducing emissions and increasing storage of carbon in grasslands and in the agriculture and forestry sectors.

In addition to these traditional areas of global change research, more emphasis needs to be placed on research in the social sciences on a variety of topics which are increasingly important in understanding the implications of global change and in developing effective responses, including:

- * improving our understanding of social and economic factors which affect society's vulnerability to climate variability and change;

- * examining the ability of our social and economic institutions to adapt to change;

- * developing new approaches for incorporating the non-market value of resources in economic accounting and pricing; and

- * identifying barriers to the diffusion of emerging technologies and possible strategies for overcoming them.

One challenge for the coming decade will be to continue to make progress on core research areas in the IGBP framework while increasing attention to research on ecological and socio-economic consequences and potential response options. An even greater challenge is the integration of the natural and social sciences and development of a variety of interdisciplinary approaches, including integrated assessment models, to synthesise information on forcing, changes in climate, potential impacts, and the environmental and socio-economic consequences of potential response options.

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Land Use and Land Cover Change: an Analysis

by David Skole

The joint IGBP/IHDP Core Project on land use and land cover change (LUCC) has recently published its science plan. It covers complex issues that are not always easy to analyse. The Chair of the LUCC Scientific Steering Committee presents an overview.

LUCC in the context of global change research

Over the coming decades, the global effects of land use and cover change (LUCC) may be as significant, or more so, than those associated with climate change. Moreover, land use and cover change are known and undisputed aspects of global change; it is an important human-caused global environmental change that is with us now. In addition to their central role in affecting climate, many facets of human health and welfare are directly connected with LUCC, including biological diversity, food production, and the origin and spread of infectious disease. Yet, we don't know enough about these important human-caused agents of global change. It is a testament to this paucity of knowledge that an accurate global map of agricultural activity does not now exist, nor do we have

good measurements of agricultural expansion and the concomitant loss of natural ecosystems, particularly forests.

Classically, the empiricism of observation and measurement is the core of good science. An improved understanding of LUCC must begin with documenting the rate and extent of major changes worldwide. However, it is equally important to move the science from the assessment of pattern to the analysis of process. Hence, furthering our understanding of the complexities and dynamics of LUCC will require a comprehensive, interdisciplinary examination of its underlying causes. LUCC is sufficiently complex that research must include a wide range of scientific and scholarly disciplines, including demography, economics, political science, systems ecology, and other related fields.

The importance of an interdisciplinary perspective was recognised early in the development of the LUCC Core Project, and is manifested in its joint sponsorship by the IGBP and the IHDP. From inception, the planning and implementation of the project has actively engaged both the natural and social science communities, and

this will continue to be an important *modus operandum* in the future.

However, it is not prudent to engage these two communities separately. Rather, we should entrain the intellectual contribution of the interdisciplinary LUCC community itself — those scientists and scholars who are actively involved in the study of LUCC in its global change context. In this way, we will not only engage research teams comprised of members from both of C. P. Snow's "two cultures", but we will also engage those individuals who bridge the two cultures in their own research: the demographer who uses remote sensing to help elucidate the spatial orientation of settlement over time, or the systems ecologist who uses socio-demographic models to help elucidate the process of habitat fragmentation (as two simple examples).

LUCC as an agent of change

The contemporary state of the world's land cover is a constantly changing mosaic of cover types determined by both the physical environment and human activities. These changes in land cover can have

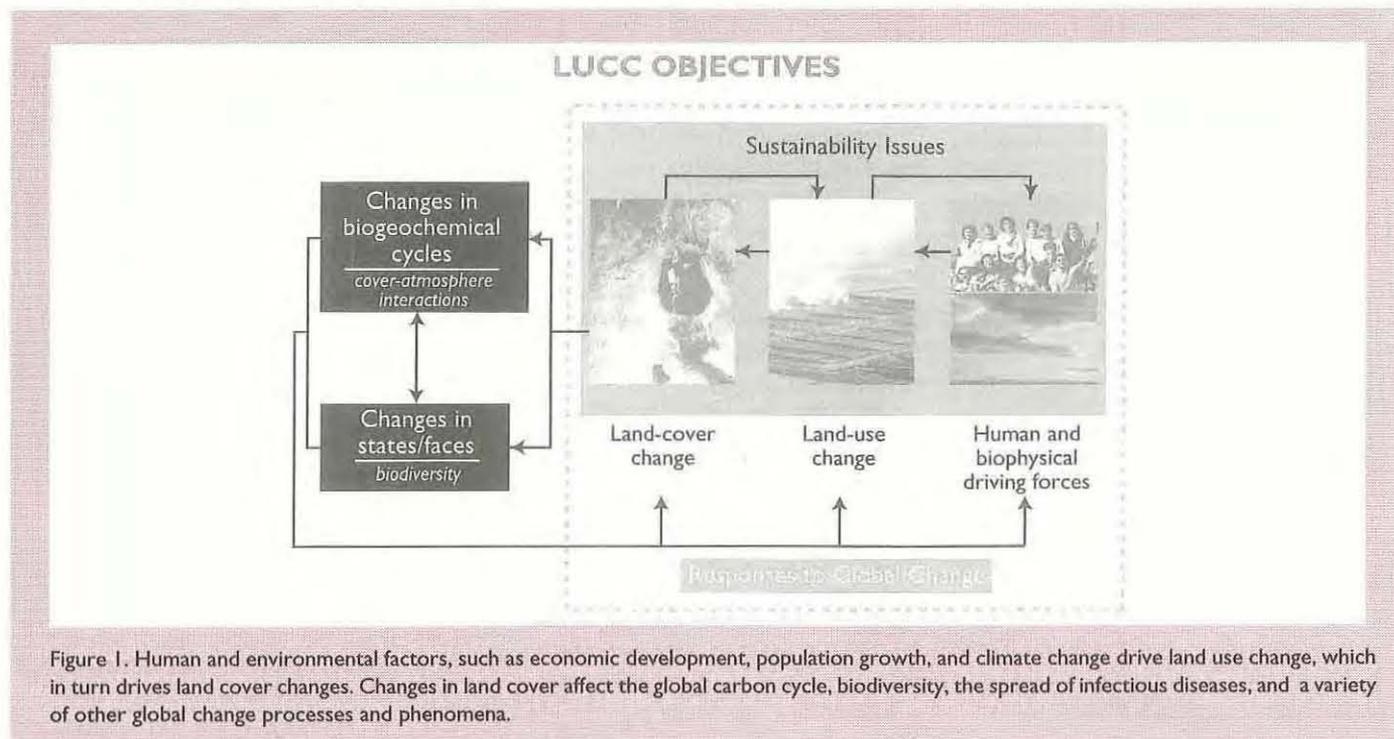


Figure 1. Human and environmental factors, such as economic development, population growth, and climate change drive land use change, which in turn drives land cover changes. Changes in land cover affect the global carbon cycle, biodiversity, the spread of infectious diseases, and a variety of other global change processes and phenomena.

profound global consequences. Here I will illustrate the various dimensions of LUC as an agent of global change through three examples: the global carbon cycle, biological diversity, and infectious disease.

The Global Carbon Cycle

Understanding the global carbon cycle is central to our understanding of global change. The increase in atmospheric carbon dioxide is attributed to two anthropogenic sources: fossil fuel combustion and land cover conversion. Although the current net flux of carbon is dominated by the fossil fuel source term, biogenic net sources contribute approximately 25%-30% of the total. However, over the last two hundred years the contribution from land cover conversion has been approximately equal to that of fossil fuel combustion. Reconstruction of the last two hundred years of land cover change will be an important part of carbon cycle research. There are two ways to provide this long term historical view. The first is to document land cover changes directly using historical reconstruction of changes in land use, particularly agricultural expansion. This would require the interdisciplinary efforts of historians and biogeographers. An example of this kind of work is the reconstruction of land cover change in South and Southeast Asia by John Richards and his colleagues and worldwide by Richard Houghton and his colleagues. Because of the nature of the data, reconstructions are usually spatially and temporally aggregated. Commonly time steps are a decade or more and data are compiled at the country or province level.

The second approach is to use models to "backcast" the history of land cover change from current distributions of land cover. The current distribution could be obtained from satellite remote sensing data, such as the global 1 km AVHRR land cover dataset being compiled by the IGBP-DIS. Integrated models, which utilize socio-demographic and economic information as forcing functions, could be used in conjunction with rule-based models and synoptic historical data at various intervals to derive spatially and temporally disaggregated analyses. In essence, such an approach which integrates actual observations, either for the current time period using satellite data or back in time using historical documents, with model-based estimates would be similar to the assimilation techniques which climate and meteorological models often utilize.

While extremely valuable as a way to build the long-term datasets on land cover transformation, such an approach falls short

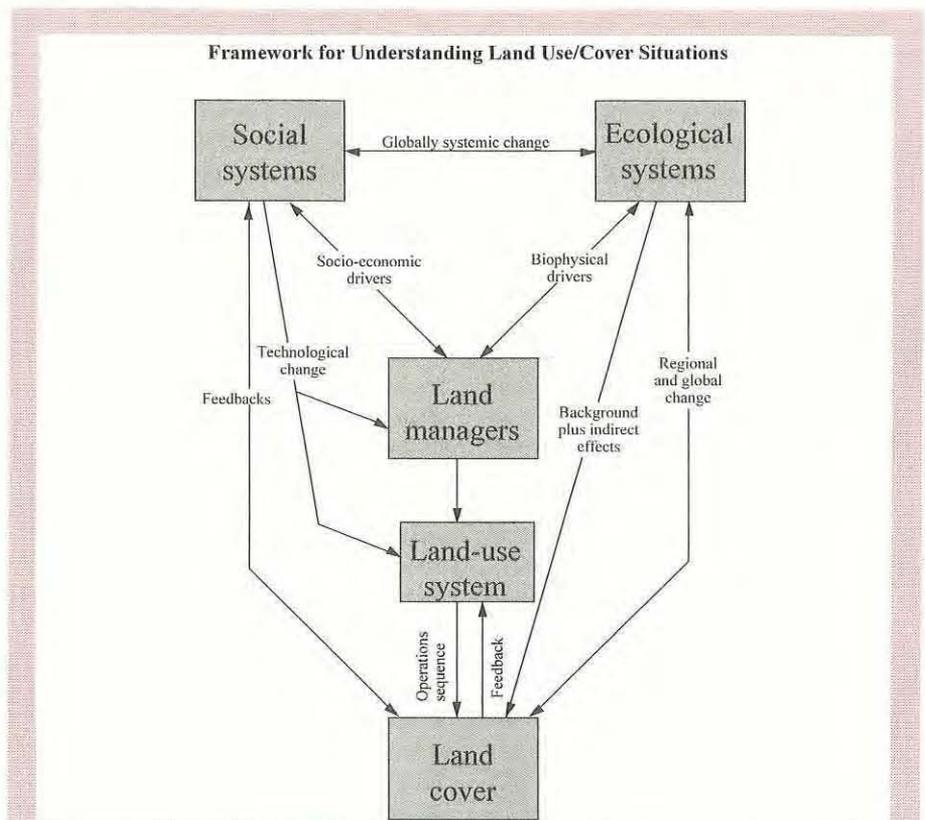


Figure 2. This diagram shows the fundamental structure of land use and cover change. Land managers (the farmers, loggers, etc.) are influenced by both the social and ecological systems in which they operate. Their activities, such as clearing forests, burning savannahs, or building terraced paddies, constitute a specific land use system, which in turn changes natural land cover.

of providing a robust and dynamic understanding of the interrelationship between land use and land cover as it is occurring today. Dynamic Vegetation Models (DVMs), in which land use change and land cover change are interrelated in terms of processes and feedbacks offer an advanced approach to coupling the human driving variables with ecosystem response functions, hydrological dynamics, atmospheric conditions, and edaphic (fire related) factors. The development of LUC-driven DVMs will require a truly interdisciplinary analysis and integrative modeling involving most of the IGBP Programme Elements.

Such models could, for instance, account for the role of transient states of secondary succession following disturbance. New evidence from satellite monitoring in tropical forests suggests that a large fraction of disturbed areas are secondary growth. In the Amazon, approximately one-third of the deforested area is in secondary succession following abandonment of agricultural fields.

Detailed multi-temporal analyses of satellite data shows that deforestation is a highly dynamic process of clearing, abandonment and re-clearing, and the rates at which land is cleared or abandoned is rela-

ted to the land use and management system the forest farmers employ. In one study I conducted with Brazilian colleagues from 1986 to 1993, approximately 35% of disturbed sites were in active agriculture every year through 1993; these are sites in which the land use system is maintaining them as pastures or crops. Another 9% of the sites persisted every year as secondary growth, representing sites where long-term abandonment was occurring due to out-migration and severe losses of site fertility. But approximately 56% of the sites rotated between secondary growth and active agriculture throughout the period of observation, representing sites where the use and rotation of secondary growth is an explicit land use strategy. In some cases, deforestation and secondary succession exist in tandem as a tightly coupled system in which secondary growth is continually recycled back into farmland. In other cases active land management maintains the land in agriculture, or the lack of active land management or population displacement results in long-term succession.

Thus, in the Amazon and elsewhere, land use change influences land cover change and is integrated with dynamics of ecosystem structure, function, and response. Within a focused research pro-

gramme on LUCC it will be important to frame such questions as: what human land-use and land management strategies are employed in different situations around the world and how do they control, or interact with, the dynamics of ecosystem response to disturbance? Because deforestation and abandonment have opposite effects on atmospheric carbon dioxide (*e.g.* uptake *vs.* release), we can restate the aforementioned general question in terms specific to the carbon cycle: over time, what land use strategies determine the abundance and spatial distribution of secondary growth, how do they determine the balance between clearing and regrowth rates, and how are these land use strategies in turn influenced by ecological conditions?

Finally it is worth noting that the current global carbon budget is not balanced. There are good reasons to suspect that there is an unaccounted "missing sink" in undisturbed forests of the world, and hence some importance is placed on emphasising research on global ecosystem metabolism. However, a net uptake of approximately 1.5×10^{15} gC yr⁻¹ spread over large undisturbed forested ecosystems would

be difficult to measure or detect in the field at the hectare scale. Thus, models which predict such sinks must infer the magnitude of the sink as a residual calculation from estimates of fluxes associated with land cover change.

Again turning to the Amazon as an example, the rate of deforestation appears to have increased from the early 1970s to the late 1980s, reaching a peak and then declining quite dramatically through the early 1990s. At the same time, but probably lagged by several years, the rate of abandonment to secondary growth has likely increased as well, but just out of phase. Such asynchronicities in two related, but non-linear and phased pulses of land cover change have interesting consequences for atmospheric carbon dioxide and global carbon budgets. Is it possible that while the rate of deforestation is declining, the rate of reforestation is increasing, causing the net flux of carbon to be unusually low, at least temporarily? Over the long-term, what socio-economic factors are controlling the relative balance between deforestation and abandonment? How will they persist into the next century? Are these socio-economic factors influenced by in-

ter-annual and long-term climate changes?

Biological Diversity

Typically, species/area curves are used to estimate the relative loss in species due to habitat loss. A simple approach would be to use rates of deforestation to estimate the change in forest habitat area. New research, however, is elucidating a fascinating new role for land use and cover change. This work points to three factors: (a) spatial geometry of ecosystem disturbance through habitat fragmentation and its relationship to land use practices, (b) the time-varying "matrix" of areas in agriculture or selective logging and secondary succession over time, and (c) historical changes in land use within "natural" ecosystems.

It is not enough to know only aggregate rates of forest loss since it is the spatial geometry of deforestation that is critically important to understanding forest fragmentation. Deforestation affects biological diversity in three ways: the destruction of habitat, isolation of fragments of formerly contiguous habitat, and edge effects within a boundary zone between forest and deforested areas. When one considers the spatial geometry of land cover change and calculates this total effect, the impact is much larger than if one used deforestation rates alone. In my own research with C.J. Tucker we found the total affected habitat to be twice as large as the deforested area.

It is not possible to predict the spatial geometry, and hence the total effect on habitat, from aggregate information on deforested areas alone. Also, within a landscape of various land uses, the dynamics of disturbance and succession create a changing matrix of vegetation types and habitats which are more complex than simply forest *vs.* non-forest. The spatial relationship between primary forest, deforested land, and secondary forest imposed by different land uses creates a specific spatial topology which cannot be determined by aggregate figures alone. Detailed measurements need to be made, considering, for example, regions where disturbance patterns are small and dispersed *vs.* large and clustered

Information on land use can provide insights into the cause and characteristics of forest fragmentation. The size and shape of clearings are often related to the land use system being employed, whether they are large commercial farms or small-holder sites. The spatial orientation is influenced by transportation corridors, population nodes, historical foci of settlement, and

Multiscale Driving Forces in Land Use/Land Cover Change

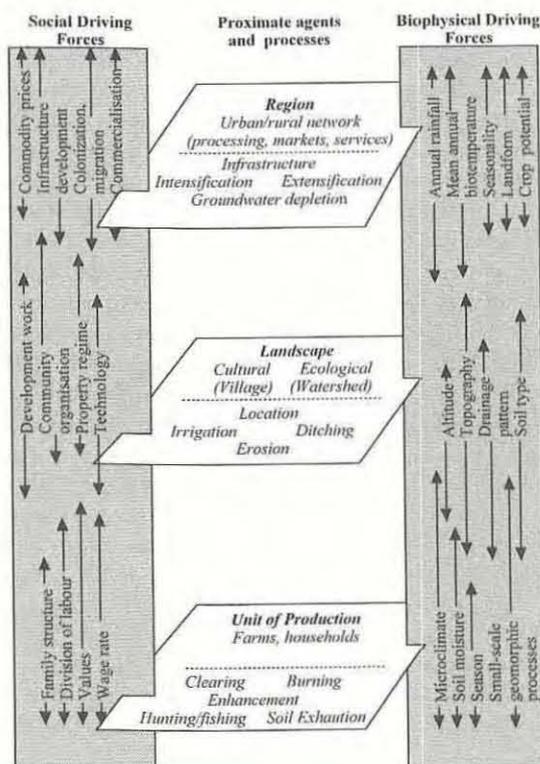


Figure 3. While Figure 2 shows the basic scheme for land use and cover change at the level of the land manager, the complex and dynamic processes of LUCC operate through strata of forces at different scales — from the unit of production, through the landscape, and large regions. Both social and biophysical factors influence, and are influenced by, LUCC at various scales.

local environmental conditions such as slope, soils, and rivers. Moreover, as mentioned above in the discussion of the carbon cycle, land use strategies are coupled closely to the dynamics of secondary growth. Some fundamental LUCC questions begin to emerge from this view: within a given landscape how do land use, tenure, and management influence the spatial topology of primary and secondary land covers and biological diversity?

Peter Vitousek and colleagues have estimated that as much as 40% of global net primary productivity has already been utilized by human activities. A large component of this appropriation of NPP occurs when human land uses directly disturb natural ecosystems, such as clearing forests for agriculture or logging. The work of anthropologists, ethnobotanists, and ecologists suggest the biological diversity of large areas of so-called "natural" ecosystems can also be directly affected by human use. In what he refers to as the Empty Forest, Kent Redford and others have shown an important influence of the customary use of natural ecosystems, where humans exploit the flora and fauna of intact forests to a significant degree, particularly those in close proximity to disturbed areas.

If our concept of global change rests solely on the issue of climate change, we would likely ignore intact forests, since their influence on carbon dioxide, sensible and latent heat flux, and the atmosphere are relatively unchanged compared to logged areas and croplands. But as Redford states, "We must not let a forest full of trees fool us into believing all is well." This leads to interesting land use and human dimensions questions to be asked if we want to look beyond climate change: How do changing patterns of consumption and human population density affect biological diversity, even in intact ecosystems? How does the spatial orientation of land use and its affect intact ecosystems?

Infectious Disease

There are very good data relating the incidence of certain human diseases with changes in land cover. Malaria rates (per thousand individuals) increased fivefold in the Amazon between 1975 and 1990 as deforestation rates increased dramatically over the same period. Regions of most rapid deforestation had the highest infection rates. The epidemiology of disease is complex, multivariate, and not linearly related to disturbance rates, but the link between changes in cover/habitat and disease is becoming an important area of research. The case of Oropouche disease

reported by Robert Shope and his colleagues in the Amazon in the 1960s is indicative. The construction of the Belem to Brasilia highway resulted in an outbreak of a flu-like epidemic which was later attributed to a virus from a biting midge. The midge population grew explosively when settlers cleared the land, and certain crop harvesting practices associated with the land use in the region provided an ideal breeding ground.

The work of Paul Epstein at the Harvard School of Public Health shows the relationship between deforestation in Honduras, where cases of malaria rose from 20,000 to 90,000 from 1987 to 1993. But he also notes that in addition to ecological effects from road building and deforestation, it is the *interaction* between land cover change and climate that is important.

Along with an emphasis on these kinds of established diseases, there is increasing speculation on the relationship between land cover change and the origin of new disease. There is considerable work to be done in this area, but like no other example the case of infectious disease illustrates the direct link between global change, LUCC, and human health.

LUCC as an IGBP Programme Element

The global effects of land use and cover change is an emerging and important area of research. Over the past four years an international community of scientists has been making the case for its inclusion into the IGBP framework, first under the auspices of an ad hoc working group (IGBP Report #24/HDP Report #5), then under the auspices of a formal core project planning committee (IGBP Report #35/HDP Report #7). There have been a number of special conferences and symposia which have also helped focus the discussion, including the 1991 Global Institute in Snowmass, Colorado, USA (published by Cambridge University Press, 1994), the 1992 Ecological Society of America Symposium on Global Impact of Land Cover Change (published as a special issue of *BioScience*, May 1994), and the LUCC Open Science Meeting in Amsterdam, The Netherlands in 1996.

The development of a Core Project on LUCC comes at an important moment in the evolution of the IGBP. Other Core Projects, such as GCTE, BAHG, LOICZ, and JGAC urgently need to incorporate LUCC dynamics in their research. The global synthesis and integrated models provided by GAIM will now need to include the transient states caused by LUCC. The 1 km AVHRR/Global

Land Cover dataset being developed by IGBP-DIS will soon be ready for widespread distribution. At this stage of IGBP development it is becoming increasingly evident that the research community which the LUCC Core Project joins will be pressured in two important ways: (i) to produce timely scientific results and policy-relevant information — in my own view through focused research campaigns or projects, such as the Large Scale Amazon Basin Experiment (LBA) or the IGBP Transects, and (ii) to strengthen the inter-program-element nature of our research, linking across rather than within the Core Projects and Framework Activities.

LUCC should be a critical nexus for this kind of IGBP research. At the same time, LUCC should provide a bridge between the human dimensions and the geophysical/biophysical dimensions of global change. Moreover, LUCC can provide direct links to policy, as it relates to climate, biodiversity, agriculture, and human health.

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LUCC marches on

The Open Science Meeting

The First Open Science Meeting was held on January 29-31 in Amsterdam, The Netherlands. Hosted at the Royal Netherlands Academy of Arts and Sciences, over 160 scientists from around the world participated in discussions of the LUCC Science Plan and worked to identify the next steps toward an implementation plan.

Core Project Office Established

The Core Project Office for LUCC will be established at the Institut Cartografic de Catalunya (ICC). The ICC currently supports advanced cartographic projects including major work on developing land use and cover datasets. Located in Barcelona, the office will officially open in the summer of 1996.

Officer for New Core Project Office Identified

A Core Project Executive Officer has been named for LUCC. Cai Puigdefabregas, who served as the former Co-ordinator of Environmental Research for the Government of Catalunya, received his Ph.D. in 1975 at the Universitat de Barcelona.

LUCC plays major role in Bi-lateral Agreement

LUCC is the main theme of a recent workshop and communiqué between the governments of Japan and the US. as part of a Bi-lateral Agreement for Cooperation on Global Change Research.

Interactions between the Biospheric Aspects of the Hydrological Cycle and Land Use/Cover Change

by Isamu Kayane

Isamu Kayane is a member of the Scientific Steering Committee for BAHC, and Chair of the National Japanese Committee for the IGBP. This article was written as a position paper for the upcoming Open IGBP/BAHC-LUCC Joint Inter-Core Project Symposium on Interactions between the Hydrological Cycle and Land Use/Cover Change in Kyoto, Japan, from 4-7 November 1996. Interested scientists are welcome to attend.

Global climate system

The global climate system redistributes energy from lower to higher latitudes. The energy surplus in the lower latitudes, whose boundary corresponds roughly to 35° latitude North and South, results from the latitudinal gradient of the Earth's energy budget. The total energy distributed by ocean currents is larger than that distributed by the atmosphere.

The mean time during which a water molecule passes through a hydrological system (a lake, the Pacific Ocean, the troposphere, etc.) is termed the mean hydrological residence time. The "memory" of a hydrological system increases with a longer residence time (Table 1). Global climate history can be understood by analysing the oxygen isotope ratio in ice cores sampled from continental glaciers and ice sheets. The atmosphere has a very short memory compared with the longer memory of the ocean. Were we able to stop the energy supply to the atmosphere, its motion would cease within a month, but the ocean would continue its circulation for a longer period following such an energy cut-off.

The total heat stored in hydrological

systems should be taken into account in assessing the future evolution of the global environment. A short memory is synonymous with a small heat capacity. Thus the atmosphere contains insufficient heat to act as the source for future dynamic changes in the global climate. It can only respond to changes in forcing such as changes in solar irradiation or heat supply from the ocean. Future atmospheric behaviour depends not only on increases in greenhouse gas concentrations and earth orbital changes, but also depends heavily on changes in sea surface temperature, global ocean circulation, and the increased atmospheric turbidity.

The stability of the global climate system is another issue to be considered. Three million years of Earth climate history revealed by the oxygen isotope ratio of a deep ocean sediment core, indicate that the glacial and interglacial cycle started around 0.8 Ma BP, when unknown feedback mechanisms began to operate (Figure 1). The amplitude of climate variation with time during the past three million years has been increasing. A possible explanation might be that this is a result from increased regional differences in both continental-scale relief caused by crustal movement, and land surface wetness due to land use/cover change.

Results from cores also reveal that the length of glacial periods is longer than that of interglacial periods. The last interglacial period, at around 130 ka BP, lasted only for 15 ka but the last glacial period lasted for 100 ka. Thus the global climate system seems to be more stable when the Earth has a huge volume of water locked in ice sheets in polar regions than under the

present condition with ice sheets existing only on Antarctica and Greenland. It is therefore possible that the present global warming may act as the trigger of the next glaciation. If the interglacial is indeed a brief, unstable period for Earth, then we should be very careful not to risk triggering the shift to the next glacial period through anthropogenic activities.

Effects of global warming on the global water cycle

The record from the polar ice cores clearly shows that the increase in greenhouse gas concentrations in the Earth's atmosphere started with the Industrial Revolution in the 18th century, though rates of increase accelerated after the middle of the twentieth century, resulting in an increase of sea surface temperatures. The average rate of the sea surface temperature increase for the whole ocean is 0.9°C/100y, which is larger than the rate of the global air temperature increase.

An important fact worth noting is that the rates of decrease of sea surface temperatures in the northern North Pacific Ocean from 30°N to the pole, where the abyssal current ascends, and also in the northern North Atlantic Ocean, show seasonal variations with a minimum (i.e. largest decrease) during the boreal summer. This fact suggests that the deepwater circulation in the global ocean has been intensified by global warming.

Higher sea surface temperatures in the Indian Ocean have resulted in a considerable increase in annual rainfall along the southwest coast of Sri Lanka and a part of southwestern India, whereas the rainfall has decreased dramatically in the mountainous area in Sri Lanka. The effects of global warming on the water cycle have appeared predominantly in the tropics. The present trend of increasing sea surface temperatures in the tropical ocean will almost certainly continue in the future, and the effect of the associated intensified energy and water cycle will gradually propagate to the middle and high latitude zones. Abnormal weather events, such as severe floods and droughts, reported recently from all over the world, may well be results of global warming, although the

Table 1 Global water inventory and the hydrological residence time

	Storage (km ³)	Mean residence time
Ocean	1,350,000,000	3,000y
Glacier	24,230,000	10,000y
Groundwater	10,100,000	1,000y
Soil water	25,000	ly
Lake water	220,000	ly to 1,000y
River water	1,000	10d
Atmospheric vapour	13,000	10d

Members of the IGBP Scientific Steering Committees

As of 1 January 1996

Short characteristics

Scientific Committee for the IGBP

Officers

Peter S. Liss (Chair), School of Environmental Sciences, University of East Anglia, Norwich, UK. Specialisation in environmental chemistry, with research in ocean/atmosphere chemistry, in particular air-sea gas exchange.

Margaret Leinen (Vice-Chair), Graduate School of Oceanography, University of Rhode Island, USA. Vice-Provost for Marine Programmes; specialist in paleoceanography, with research in ocean sedimentary records, especially the North Pacific.

Jerry M. Melillo (Vice-Chair), Marine Biological Laboratory, Woods Hole, MA, USA. Co-director of The Ecosystems Center. Principal Investigator of research projects in boreal, temperate and tropical ecosystems. Research fields include biogeochemistry and ecological modelling.

Patrick Buat-Ménard (Treasurer), University of Bordeaux, France. Head of the Department of Geology and Oceanography. Research expertise covers the atmospheric cycling of trace metals and particulate carbon; and the marine biogeochemistry of trace metals, natural radionuclides and sulphur compounds.

Members

Inder Pal Abrol (Member), Deputy Director General of Resource Management, Indian Council of Agricultural Research, New Delhi, India. Research interests in soil science, specialist in basic and applied aspects of management of salt affected soils; cropping systems research, soil and water management, agrometeorology, and agroforestry.

Raymond Bradley (Chair, Scientific Steering Committee, Past Global Changes), Department of Geology and Geography, University of Massachusetts, Amherst, USA. Expertise in climate variability and palaeoclimatology, especially of the last two thousand years.

Guy P. Brasseur (Chair, Scientific Steering Committee, International Global Atmospheric Chemistry Project), National Center for Atmospheric Research, Boulder, Colorado, USA. Professor of Atmospheric Chemistry and Director of Atmospheric Chemistry Divi-

sion. Research interests include chemistry, circulation and physics of the upper atmosphere; three dimensional transport and chemistry models of the troposphere.

Eckart Ehlers (Ex-Officio Member, IHDP), Department of Geography, University of Bonn, Germany. Professor of Geography and Chairman of IHDP. Special research interests include rural development, social structure and organisation of rural societies, urban problems focused on the Middle East.

John Field (Chair, Scientific Steering Committee, Joint Global Ocean Flux Study), Zoology Department, University of Cape Town, Rondebosch, South Africa. Research interests in the functioning of marine ecosystems, roles of physical factors, modelling.

Congbin Fu (Member), Chinese Academy, Beijing, China. Professor of Meteorology and Director of the Climate Research Laboratory at the Institute of Atmospheric Physics. Research in the fields of physical and dynamic climatology, climate change, air-sea interaction and climate-vegetation interaction.

Lawrence W. Gates (Ex-Officio Member, WCRP), Lawrence Livermore National Laboratories, Livermore, California, USA. Director of the Program for Climate Model Diagnosis and Intercomparison. Research interests include climate dynamics, climate modelling and ocean-atmosphere interaction.

Edgardo D. Gomez (Chair, Scientific Steering Committee, Land-Ocean Interactions in the Coastal Zone). Marine Science Institute, University of the Philippines, Quezon City, Philippines. Professor of Marine Biology and Director of the Marine Science Institute. Research interests include coral reef ecology, coastal zone management, and invertebrate mariculture.

Ann Henderson-Sellers (Member), Deputy Vice-Chancellor (Research and Development), Royal Melbourne Institute of Technology, Bundoora, Victoria, Australia. Research interests include climatology, numerical modelling and monitoring at a global scale of the atmosphere, hydrosphere, cryosphere, land surfaces and the biosphere.

Dunxin Hu (Member), Vice-Director of the Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China. Research interests include shelf circulation; ocean-atmosphere interaction; upwelling and sedimentation.

Pavel Kabat (Chair, Scientific Steering Committee, Biospheric Aspects of the Hydrological Cycle). Winand Staring Center, Wageningen, Netherlands. Expertise in soil-vegetation-atmosphere relation from patch to regional scales, and soil and ground water hydrology; also involved in several large scale land surface experiments.

Stephan Kempe (Member), Geological-Paleontological Institute, Darmstadt, Germany. Research interests include the carbonate system of the ocean, carbon cycle in coastal seas, biogeochemistry of rivers, evolution of ocean chemistry and formation of microbialites.

Isao Koike (Member), Ocean Research Institute, University of Tokyo, Japan. Research interests include process-oriented studies regarding the interaction between biological activities and the cycling of carbon and nitrogen in the system.

J.W. Maurits la Rivière (Ex-Officio Member, ICSU-ACE). Professor Emeritus of Environmental Microbiology at the University of Delft, Netherlands, and specialist in environmental engineering, biogeochemical cycles, microbial metabolism and ecology, and biological waste treatment and utilisation.

Berrien Moore III (Chair, Task Force, Global Analysis, Interpretation and Modelling). University of New Hampshire, USA. Professor of Systems Research at the Institute for the Study of Earth, Oceans and Space (EOS), Mathematician; with advanced research in modelling of the global carbon cycle and the role of the ocean as a sink for CO₂.

Eric O. Odada (Member), NAFCOM Secretariat, Ghana Academy of Arts and Sciences, Accra, Ghana; leader of the International Decade of East African Lakes (IDEAL) project. Marine geochemist, with special interest in past climate change in lacustrine and oceanic environments.

W. Richard Peltier (Member), Department of Physics, University of Toronto, Ontario, Canada. Research in geophysical fluid dynamics on problems involving non-linear hydrodynamic waves and wave/mean-flow interaction in the atmosphere and oceans, and the dynamics and evolution of the planetary interior and surface, especially mantle convection and paleoclimatic change.

Oswaldo Sala (Member), Department of Ecology, Faculty of Agronomy, University of Buenos Aires, Argentina. Expertise on the links between ecosystem structure/composition and system function. Research on vegetation dynamics in arid and semi-arid regions, and carbon budgets of temperate grasslands and their responses to global change.

David Skole (Chair, Scientific Steering Committee, Land-Use/Land-Cover Change), University of New Hampshire, Durham, USA. Professor of Natural Resources, Institute for the Study of Earth, Oceans & Space. Expertise in remote sensing monitoring and numerical modelling of land cover change and its relationship to global terrestrial carbon cycle and biodiversity, with a special emphasis on tropical forests.

Bernard Tinker (Member), Department of Plant Sciences, University of Oxford, UK. Research on plant nutrition and root function, particularly for tropical crops and trees, with special emphasis on responses of agricultural systems to global change.

John Townshend (Chair, Scientific Steering Committee, IGBP Data and Information System). Department of Geography, University of Maryland, USA. Advanced research in remote sensing data application to Earth science.

Peter Tyson (Chair, Standing Committee, Global Change System for Analysis, Research and Training), University of Witwatersrand, Johannesburg, South Africa. Former Deputy Vice-Chancellor and Director of Climatology Research Group. Research interests include meteorology and climatology.

Brian H. Walker (Chair, Scientific Steering Committee, Global Change and Terrestrial Ecosystems). Commonwealth Scientific and Industrial Research Organization (CSIRO), Canberra, Australia. Chief of the Division of Wildlife and Ecology; with expertise in ecosystem dynamics, ecosystem function and biodiversity, with emphasis on savannah systems.

George Zavarzin (Member), Institute of Microbiology, Member of the Academy of Natural Sciences, Moscow, Russia. Corresponding member of the Russian Academy of Sciences. Microbiologist, specialising in the study of microbial production of methane. Research interests include ecology and geochemistry, soil aspects of land use, and microbial biodiversity.

Scientific Steering Committee Biospheric Aspects of the Hydrological Cycle (BAHC)

Pavel Kabat (Chair),
(see SC-IGBP)

Alfred Becker (Vice-Chair), Potsdam Institute for Climate Impact Research, Potsdam, Germany. Research interests in hydrological research and modelling at different scales with special emphasis on the drainage basin approach; biospheric aspects of modelling and impacts of climate change on the environment and societies, in particular on hydrology and water resources.

Brad Bass, Environmental Adaptation Research Group, Canadian Climatic Centre, Toronto, Canada. Experienced in working with downscaling applications, complex systems and incorporating uncertainty into decision making. He contributes to work in integrated assessment, ecological engineering and the understanding of adaptive systems.

Moustafa T. Chahine (Ex-Officio member GEWEX), Jet Propulsion Laboratory, Pasadena, California, USA. Research interest in all fields related to water and energy cycles around the earth.

Reinder A. Feddes, Department of Water Resources, Agricultural University Wageningen, The Netherlands. Experimental and modelling studies on heat and moisture fluxes at the land-surface, and hydrology of the unsaturated and saturated zone from patch to regional scale; remote sensing approaches to modelling of soil-water vegetation-atmosphere processes, in particular to estimate land-surface characteristics.

Christopher Field, Carnegie Institution of Washington, Stanford, California, USA. Ecologist, with extensive experience in small-scale ecological studies and experiments, advanced work on large-scale ecological and ecohydrological issues, influential in the development of global ecology.

Paul G. Jarvis, Institute of Ecology and Resource Management, University of Edinburgh, UK. Ecologist; with experience in Soil-Vegetation-Atmosphere Transfer (SVAT) experimental and modelling studies; whole-plant or ecosystem physiologist. Expertise in the role of forests in regional water balance, and canopy flux studies.

Isamu Kayane, Institute of Geoscience, University of Tsukuba, Japan. Expertise in hydrological processes, soil and groundwater hydrology, and global water balance; research and modelling of land-surface-atmosphere interface processes.

Alexander N. Krenke, Institute of Geography, Russian Academy of Sciences, Moscow, Russia. Experienced in land-surface climatology and hydrology research; involvement in the preparation and implementation of large-scale experiments in central Russia.

Carlos A. Nobre, National Space Research Institute (INPE), São José dos Campos, Brazil. Expertise in field and modelling studies of land-surface climatic interaction at larger scales (meso- to macroscale), especially in tropical regions; climate impact studies with GCMs in particular on the role of tropical deforestation.

Lekan Oyebande, Department of Geography and Planning, University of Lagos, Nigeria. Expertise in hydrology and water resources, with special emphasis on its interaction with climate and the biosphere.

Michael R. Raupach, Centre for Environmental Mechanics, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Canberra, Australia. Leading scientist in modelling planetary boundary layer processes and their interaction with land-surfaces of different types and structures.

Steve W. Running, University of Montana, Missoula, Montana, USA. Ecologist, with expertise in developing large-scale integrated hydroecological models, and modelling of ecological processes in large area models (landscape, river basin, regional and continental scales).

Ernst-Detlef Schulze, Lehrstuhl für Pflanzenökologie, University of Bayreuth, Germany. Leading ecologist, with a broad understanding of ecophysiology, who has contributed to the improved understanding and modelling of ecosystem control of moisture, carbon, and other fluxes from vegetation cover to the atmosphere.

Piers Sellers (Ex-Officio member ISLSCP), National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland, USA. Expertise in modelling energy and water fluxes at the land-surface atmosphere interface, in particular in global circulation models, and the application of satellite data to characterise and quantify land surface features and exchange processes.

William J. Shuttleworth, University of Arizona, Tucson, Arizona, USA. Expertise in land-surface processes experimentation and modelling on different scales; initiator of experimental campaigns in the tropics, and other large-scale experiments on land-surface atmosphere interaction.

Riccardo Valentini, University of Tuscia, Viterbo, Italy. Specialist in the area of eddy correlation in natural ecosystems. Experienced in forest ecological research, in particular in CO₂ and water flux investigations; initiator of a worldwide network for carbon fluxes.

Charles J. Vörösmarty, University of New Hampshire, Durham, USA. Expertise in large-scale modelling of land-surface processes, with particular reference to biogeochemical cycles and ecosystems; research in the drainage basin approach towards the investigation and solution of global change processes and problems on different scales.

Scientific Steering Committee Global Change and Terrestrial Ecosystems (GCTE)

Brian H. Walker (Chair),
(see SC-IGBP)

Harold A. Mooney (Vice-Chair), Department of Biological Sciences, Stanford University, California, USA. Expertise in ecophysiology, with broad knowledge in many other aspects of ecology, particularly biodiversity and its functional significance.

F. Stewart Chapin, III, University of California, Berkeley, USA. Professor at the Department of Integrative Biology. Expertise in ecosystem function, experimental work on biological diversity and ecosystem function.

Jan Goudriaan, Wageningen Agricultural University, Netherlands. Expertise in crop system modelling, and in the terrestrial carbon cycle.

Peter Gregory, Head of the Department of Soil Science, University of Reading, UK. Research interests include soil physics, environmental biology and crop management.

Yoh Iwasa, Department of Biology, Faculty of Science, Kyushu University, Fukuoka, Japan. Theoretical ecologist in modelling the impact of environmental factors on biodiversity.

Sune Linder, Department of Ecology and Environmental Research. Swedish University for Agricultural Sciences, Uppsala, Sweden. Experience in experimental and modelling studies of tree physiology and forest productivity.

Jean-Claude Menaut, Ecole Normale Supérieure, Laboratory of Ecology, Paris, France. Ecologist, with expertise in monitoring and detection of global change.

Ian Noble, Research School of Biological Sciences, Australian National University, Canberra, Australia. Professor in Global Change Science. Expertise in ecosystem dynamics modelling, with an interest in landscape process and in human-driven change to ecosystem structure.

P. S. Ramakrishnan, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, India. Multidisciplinary interests linking ecology with social sciences. Research on the relationship between human-driven change to ecosystem composition and the resulting impacts on ecosystem function.

Oswaldo E. Sala,
(see SC-IGBP)

Robert J. Scholes, Commonwealth for Scientific and Industrial Research, Division of Forest Science and Technology, Pretoria, South Africa. Research experience in experimental and modelling aspects of biogeochemistry, especially in tropical savannahs, forests and grasslands.

Ernst-Detlef Schulze,
(see BAHG)

Herman H. Shugart, Department of Environmental Sciences, University of Virginia, Charlottesville, USA. W.W. Corcoran Professor. Expertise in ecosystem dynamics modelling, from patch to global scales; development of successful forest gap-phase models.

Robert W. Sutherst, Division of Entomology, University of Queensland, Brisbane, Australia. Research interests include parasitology of ticks and distribution and dynamics of pests and diseases.

Michael J. Swift, UNESCO Regional Office for Science and Technology for Africa, Nairobi, Kenya. Director of the Tropical Soil Biology and Fertility Programme. Research in soil biology, tropical agriculture and multi-species agroecosystems.

F. Ian Woodward, School of Biological Sciences, University of Sheffield, UK. Professor at the Department of Animal and Plant Sciences. Expertise in both ecophysiology and global ecosystems modelling, with the development of a mechanistically based global vegetation redistribution model. Research on linkages of vegetation models to GCMs.

Zhang Xin-shi, Laboratory of Quantitative Vegetation Ecology, Chinese Academy of Sciences, Beijing, China. Director of the Institute of Botany. Plant and ecosystem ecologist, with excellent knowledge of global change issues in general.

Scientific Steering Committee International Global Atmospheric Chemistry Project (IGAC)

Guy P. Brasseur, (Chair)
(see SC-IGBP)

Paul J. Crutzen (Vice-Chair), Max Planck Institute for Chemistry, Mainz, Germany. Main research interest is atmospheric chemistry and its role in biogeochemical cycles and climate, especially work on the role of NO_x in chemistry of the stratosphere, and on modelling of atmospheric photochemical processes.

Pamela A. Matson (Vice-Chair), Department of Environmental Science, Policy and Management, University of California, Berkeley, USA. Research has focused on the effects of natural and anthropogenic disturbances on biogeochemical cycling and trace gas exchange in tropical ecosystems.

Hajime Akimoto, Research Center for Advanced Science and Technology, University of Tokyo, Japan. Research interests include atmospheric chemistry of reactive species, particularly photochemical reaction mechanism in the troposphere and related atmospheric measurements.

Paulo Artaxo, Applied Physics Department, Institute of Physics, University of São Paulo, Brazil. Research interests include distribution and transportation of aerosol particles and trace elements.

Ralf Conrad, Max-Planck Institute for Terrestrial Microbiology, Marburg, Germany. Director of the Department of Biogeochemistry. Research interests focus on the microbiology and biogeochemistry of atmospheric trace gases, and on the microbial ecology of paddy soil.

Robert J. Delmas, Laboratory of Glaciology and Geophysics of the Environment, St Martin d'Hères, France. Expertise in the chemistry of glacial ice and polar sheets with emphasis on the atmospheric chemistry of polar regions.

Ian E. Galbally, Division of Atmospheric Research, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Mordialloc, Victoria, Australia. Expertise in the measurement of trace gas fluxes between the atmosphere and terrestrial ecosystems, especially N gases.

Jost Heintzenberg, Director of the Institute for Tropospheric Research, Leipzig, Germany. Research interests include aerosols, air chemistry and cloud physics.

Peter V. Hobbs, Atmospheric Sciences Department, University of Washington, Seattle, USA. Principal research interests in cloud and precipitation physics, mesoscale meteorology, atmospheric chemistry and air pollution.

Barry J. Huebert, Department of Oceanography, University of Hawaii, Honolulu, USA. Research interests include the development of methods for measuring fluxes of materials between regions of the atmosphere.

Vyacheslav U. Khattatov, Deputy Director of the Central Aerological Observatory, Moscow, Russia. Research interests include ozone, aerosols, PSC's and water vapor in the stratosphere and ozone, methane, carbon dioxide and other greenhouse gases in the troposphere.

Patricia A. Matrai, Bigelow Laboratory for Ocean Sciences, USA. Biological oceanographer, specialised in marine phytoplankton biology and biochemistry, and their role in key global biogeochemical cycles.

Heinz-Ulrich Neue, Division of Soil and Water Sciences, International Rice Research Institute, Manila, Philippines. Research has focused on biogeochemistry of wetland soils, plant nutrition, soil stress tolerance of rice, organic matter dynamics in tropical wetlands, and trace gas emissions from rice fields.

Nicholas J.P. Owens, Department of Marine Sciences, University of Newcastle, UK. Expertise in nitrogen cycling processes in diverse marine ecosystems. Research is focused on production and consumption of bio-gases (methane and nitrous oxide) in the sea.

Stuart A. Penkett, School of Environmental Sciences, University of East Anglia, Norwich, UK. Researcher into chemical processes in the atmosphere; present research with the quantification of processes leading to ozone production and destruction in the background troposphere, and chemical phenomena in the real atmosphere.

Henning Rodhe, Department of Meteorology, Stockholm University, Stockholm, Sweden. Main research interests are the atmospheric parts of the biogeochemical cycles of sulphur, nitrogen and carbon, including the environmental effects of the anthropogenic perturbations of these cycles: acidification, eutrophication and climate change.

Wang Ming-xing, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China. Research results in atmospheric aerosols, acid rain, and climate changes due to the increase of atmospheric trace gases.

Scientific Steering Committee Joint Global Ocean Flux Study (JGOFS)

John G. Field, (Chair)
(See SC-IGBP)

Liliane Merlivat (Vice-Chair), Université Pierre et Marie Curie, Paris, France. Director of the Laboratoire d'Océanographie Dynamique et de Climatologie. Research fields include air-sea gas exchange with emphasis on the distribution of carbon dioxide exchanges at the ocean surface.

Alex Bychkov, Climate Chemistry Laboratory, Pacific Oceanological Institute, Vladivostok, Russia. Research interests in ocean circulation and its effect on the global patterns of carbon dioxide air-sea exchange.

Hugh Ducklow, Virginia Institute of Marine Sciences, The College of William and Mary, Gloucester Point, Virginia, USA. Research interests in marine microbial ecology, with emphasis on bacterioplankton carbon fluxes in estuarine, coastal and oceanic systems, and modelling of plankton dynamics.

Julie Hall, National Institute for Water Research, Hamilton, New Zealand. Co-programme co-ordinator, West Coast Ecosystems Programme. Specialisation in microbial foodweb dynamics and grazing relationships.

S. Krishnaswami, Physical Research Laboratory, Ahmedabad, India. Professor at the Earth Sciences Division. Specialisation in geochemistry with research in the fields of weathering and transport; scavenging processes in the ocean, and sedimentary records.

Kon-Kee Liu, Institute of Oceanography, National Taiwan University, Taipei, Taiwan. Professor of Oceanography with research interests in the significance of continental margins in the carbon cycle of the world's oceans.

Karin Lochte, Institut für Ostseeforschung, Rostock-Warnemünde, Germany. Research interests in marine microbial ecology, with emphasis on protozoa and their role in carbon cycling in marine systems.

James McCarthy, Harvard University, Cambridge, Massachusetts, USA. Professor of Biological Oceanography, Director of the Museum of Comparative Zoology, Harvard University. Research interests include nutrient cycles in the sea, and processes that regulate marine production.

Robert M. Moore, Dalhousie University, Halifax, Nova Scotia, Canada. Professor of Chemical Oceanography, Department of Oceanography. Research interests include marine production of volatile organohalogenes and their ocean-atmosphere fluxes; Arctic oceanography and air-sea interaction.

André Morel, Laboratoire de Physique et Chimie, Université Pierre et Marie Curie, Villefranche-sur-Mer, France. Research interests in process influencing the export of particles from surface waters to deep ocean settlements and remote sensing.

Jim Murray, School of Oceanography, University of Washington, Seattle, USA. Professor of Chemical Oceanography with research interests in the export of particulate organic carbon that is produced in surface waters and buried in deep ocean basins.

Egil Sakshaug, University of Trondheim and Trondheim Biological Station, Norway. Professor of Marine Botany. Specialisation in marine phytoplankton ecology and ocean carbon flux, experimentation and modelling of photo-biological aspects.

Graham Schimmiel, Dunstaffnage Marine Laboratory, Oban, Argyll, Scotland, UK. Research interests in the processes that transform and recycle sedimentary materials, the effects of these processes on the sedimentary record, and the rates of carbon accumulation and related biogenic processes over paleoceanographic and paleoclimatic changes.

Taro Takahashi, Columbia University, Palisades, New York, USA. Professor of Chemical Oceanography. Research interests in the exchange of carbon dioxide through the air-sea interface, modelling biological effects on CO₂ in the ocean.

Bronte Tilbrook, CSIRO, Division Of Oceanography, Hobart, Tasmania, Australia. Research interests in CO₂ flux with particular interests in the Southern Ocean.

Jürgen Willebrand, University of Kiel, Germany. Professor of Physical Oceanography, Institut für Meereskunde. Research interests in ocean circulation dynamics and ocean climate interactions.

Scientific Steering Committee Land-Ocean Interactions in the Coastal Zone (LOICZ)

Edgardo D. Gomez (Chair),
(See SC-IGBP)

Larry F. Awosika, Nigerian Institute for Oceanographic and Marine Research, Lagos, Nigeria. Research interests include marine geology and geophysics, coastal geomorphology and ocean dynamics; coastal zone management, climate change and sea level rise.

Robert W. Buddemeier, Kansas Geological Survey, USA. Senior Scientist and Courtesy Professor in the Geography Department, also Chairman of SCOR-WG104 (Coral reef responses to global change: the role of adaptation). Research interests include system-level investigations of interactions between climate, surface water, groundwater and geological characteristics; studies of corals, coral reefs, and calcification.

Viatcheslav V. Gordeev, Institute of Oceanology, Russian Academy of Sciences, Moscow. Senior research scientist with specialisation in estuarine and marine geochemistry, including chemistry of hydrothermal fluids and plumes.

Donald C. Gordon Jr., Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada. Research interests include: cycling of organic matter in marine and coastal ecosystems, ecosystem modelling and environmental impact assessment.

Patrick Holligan, Department of Oceanography, University of Southampton. Professor of Oceanography with interests in phytoplankton ecology and biogeochemistry, remote sensing of the oceans and biological feedback systems.

Dunxin Hu,
(see SC-IGBP)

Silvia Ibarra-Obando, Centro de Investigación Científica y de Educación Superior de Ensenada, Ensenada, Baja California, Mexico. Research interests in coastal wetlands including saltmarsh systems, factors affecting growth of submerged macrophytes and coastal primary production.

Stephan Kempe,
(see SC-IGBP)

Han J. Lindeboom, Netherlands Institute for Sea Research, Texel, the Netherlands. Head of the department of Applied Marine Ecology, with research interests in eutrophication, (micro)pollution and effects of fisheries.

Jeffrey E. Richey, University of Washington, School of Oceanography, Seattle, USA. Senior research scientist with interest in catchment basin dynamics and river discharge.

Stephen V. Smith, School of Oceanography, University of Hawaii, USA. Professor in Oceanography with research interests in coastal carbon and nutrient budgeting and modelling, coral reefs and calcification.

Kerry Turner, CSERGE, School of Environmental Sciences, University of East Anglia, Norwich, UK. Professor of Environmental Economics, with research interests in environmental economics.

Fred Wulff, Department of Systems Ecology, Stockholm University, Sweden. Research interests include biogeochemical process and system modelling.

Jahara Yahaya, Universiti Sains Malaysia, Kuala Lumpur, Malaysia. Professor of Economics. Research interests include socio-economics of fisheries, environmental impact assessments, natural resource accounting.

Tetsuo Yanagi, Ehime University, Matsuyama, Japan. Professor of Coastal Oceanography, at the Department of Civil and Ocean Engineering, Faculty of Engineering. Research fields are material transport in the coastal sea and numerical modelling of ecological systems.

**Scientific Steering Committee
Land-Use/Land Cover Change
(LUCC)**

David Skole (Chair),
(See SC-IGBP)

Günter Fisher, International Institute for Applied System Analysis, Laxenburg, Austria. Expertise in numerical analysis, computer science, and mathematical modelling, with an emphasis on agricultural systems. Research priority is to develop a GIS-based modelling framework for land resources assessment and validation at both regional and global scale, combining economic theory with biophysical land evaluation to model spatial and dynamic aspects of land use.

Louise O. Fresco, Department of Tropical Crop Science, Wageningen Agricultural University, The Netherlands. Professor of Plant Production Systems and Chair of the Advisory Council on Nature and the Environment in the Netherlands.

Research interests in land use dynamics modelling, particularly in the tropics and subtropics.

Thelma Krug, National Institute for Space Research, São José dos Campos, Brazil. Head of Remote Sensing Division and Deputy Coordinator of Earth Observation. Field of expertise is spatial statistics, with special interest to analysis of remotely sensed data, modeling, deforestation.

Rik Leemans, Department of Terrestrial Ecology and Global Change, National Institute Public Health and Environment, Bilthoven, The Netherlands. Research interests concern biodiversity, vegetation structure and dynamics, land use and cover change, carbon cycle and global environmental data bases.

Steven E. Sanderson, Department of Political Science, University of Florida, Gainesville, USA. Expertise in rural poverty and resources, and comparative political economy, with interest in the complex human driving forces of land use and cover change, cross-scale dynamics, and the interaction of human and natural systems dynamics at the landscape scale.

Billie L. Turner II, Director of the George Perkins Marsh Institute, Clark University, Worcester, Massachusetts, USA. Higgins Chair of Environment and Society. Expertise is in cultural ecology and land-use emphasising the tropics.

**Scientific Steering Committee
Past Global Changes
(PAGES)**

Raymond Bradley (Chair),
(See SC-IGBP)

Keith Briffa, Climate Research Unit, University of East Anglia, Norwich, UK. Research is focused on instrumental records, dendroclimatology and climatic change of the late Holocene.

Zhengtang Guo, Chinese Academy of Sciences, Beijing, China. Expert in loess and paleosols. Research interests are focused on loess-based Quaternary geology and paleoclimatology, the Asian paleomonsoon and paleodata management.

Martin H. Iriondo, Comité Argentino de Investigación del Cuaternario, Paraná Entre Ríos, Argentina. Expertise in Quaternary environments and climate change of non-permanent deserts of South America with research focus on sedimentological and geomorphological analysis.

Laurent Labeyrie, Université de Paris-Sud, Orsay, France. Research interests include evolution of global climate and coupled ice-ocean-atmosphere-continental systems studies for paleoceanography.

Martin Lautenschlager, German Climate Computer Center, Max.-Planck-Institute, Hamburg, Germany. Senior Research Scientists, research is focused on modelling long-term climate changes and paleoclimate through the development of a GCM coupling of the cryosphere, ocean, biosphere and atmosphere.

Claude Lorius, Laboratory for Glaciology and Geophysics of the Environment in Saint Martin d'Hères, France. Past global changes from Polar ice cores: climate and atmospheric environment on long term and century time scales, and mass balance of the Antarctic ice sheet.

Bruno Messerli, University of Berne, Switzerland. Vice President of the International Geographical Union. Research interests are focused on global change in mountain areas with particular expertise in the Andes, Himalayas, Africa and the Alps.

Eric O. Odada,
(See SC-IGBP)

Yugo Ono, Laboratory of Geoecology, Hokkaido University, Sapporo, Japan. Research interests include paleoenvironmental and paleometeorology of Eastern Asia.

Jonathan Overpeck, Palaeoclimatology Program, National Geophysical Data Center, National Oceanic and Atmosphere Administration, Boulder, USA. Expertise in late quaternary climatic patterns and causes of decadal to millennial-scale climatic and ocean dynamics; palaeoclimate data management.

Tim C. Partridge, Climatology Research Group, Johannesburg, South Africa. Research focus on quaternary geology of the Southern Hemisphere, with expertise on the paleoclimate of Southern Africa.

Thomas F. Pedersen, Department of Oceanography, University of British Columbia, Vancouver, Canada. Expertise in quaternary palaeoceanography and paleoceanography, particularly with respect to the history of productivity and palaeonutrient fluxes, and the history of organic matter in the ocean.

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Christian Patemann, Deputy Director-General, Department for Environmental and Global Change Sciences, Environmental Technology, Marine-, Polar- and Geosciences, Federal Ministry of Education, Science, Research and Technology, Bonn, Germany, with responsibility for the respective laboratories. Background in law and economics.

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Sanga Sabhasri, past-chair, National Research Council of Thailand, Bangkok, Thailand. Chair of the Kasetsart University Council and President of the National Botanic Gardens. Specialisation in forest ecology with broad research in environment and ecology.

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IGBP Directory Update: 1996

The IGBP Directory Update: 1996 has been published by the IGBP Secretariat. The Update is to be used in combination with the 1995 edition of the IGBP Directory. The purpose of producing the 1996 edition is to keep a yearly update of the list of members of the IGBP SSCs and SCS, and ICSU liaisons (together with their contact information) for initial presentation at the IGBP Congress, to be held in Bad Münstereifel, Germany, April 1996. Publication of the next complete IGBP Directory (including National Committee Chairs and Contacts) is scheduled for 1997.

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Box 50005,
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anthropogenic contribution to the increase in sea surface temperatures remains the subject of ongoing research

Role of vegetation in the global climate system

Two roles can be distinguished for vegetation in the hydrological cycle: the transportation of energy by evapotranspiration, and the storage of water in the soil-root zone. The former process comprises a climate feedback mechanism by transporting energy and water to the atmosphere. The latter affects the hydrological residence time in drainage basins.

Before the start of the agricultural revolution in the present interglacial, the land was covered by "potential vegetation" which was determined solely by physical factors with no anthropogenic intervention. At this stage the land surface was generally wetter and the Earth transported more latent heat from the land surface to the atmosphere than it does today. An example of this is provided by plotting the difference between evapotranspiration by natural vegetation minus that by the present vegetation (Figure 2). The former were derived using the Holdridge Life Zone Classification based on present climatic data for natural vegetation, since sufficient information about paleo-vegetation was not available. Changes in land cover as a result of anthropogenic activities are particularly large on the humid Indian subcontinent and on the north China plains.

BAHC operational plan

The principal objective of BAHC is to answer the question how vegetation interacts with the physical processes of the hydrological cycle.

Since the memory of the atmosphere is short, the accuracy of long-term prediction of climate depends strongly on the accuracy of estimated boundary conditions, such as the distribution of sea surface temperatures and surface land use/cover, which determine the distribution of fluxes from Earth's surface to the atmosphere.

Inter-core project activities provide a key means to decrease the uncertainties associated with projections of future Earth conditions estimated by interpreting and combining the scientific results obtained by different groups and disciplines within the IGBP. The link between BAHC-LUCC can contribute important new insights.

Link between BAHC and LUCC

The initial land cover of the Earth before the start of the agricultural revolution was

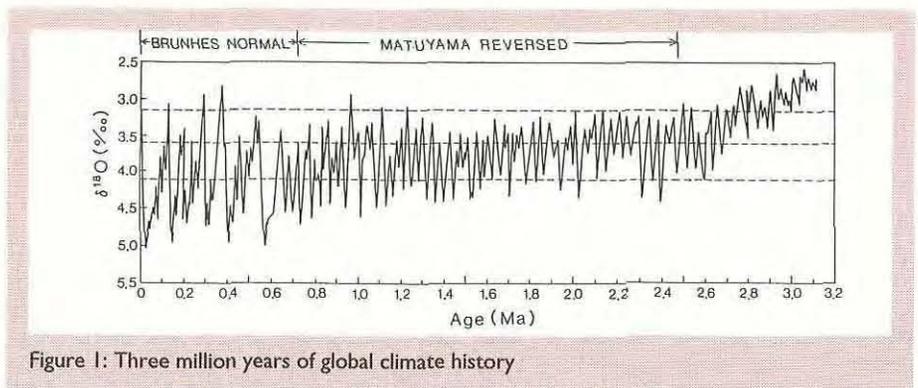


Figure 1: Three million years of global climate history

composed of potential vegetation and non-vegetated land surfaces such as water, bare rocks, ice sheets, etc. Potential vegetation has changed in response to changes in climate and/or has been affected by anthropogenic activities.

Land-use involves both the manner in which the biophysical attributes of the land are manipulated and the intent underlying that manipulation – the purpose for which the land is used.

The following issues to be studied under strong BAHC-LUCC links are of primary importance:

1. Distribution of the potential vegetation and changes in it
2. Impact of afforestation and deforestation on the global climate
3. Evaluation of changes in fluxes from the land surface due to change in land use/cover
4. Effects of urbanisation on the global climate

5. Strategy for future management of global land use/cover

Although land occupies only 29% of the Earth's surface, it is the only surface which can be influenced directly by humans in the interest of preserving the Earth system, provided that regional as well as global consensus is obtained. If changes in the land-use pattern alter feedback mechanisms affecting the global climate system, through the changes in fluxes from the land surface, then humans in their decision-making that affects the global land-use pattern, should follow criteria that will preserve, or more actively create, a global environment as appropriate as possible for mankind.

Isamu Kayane

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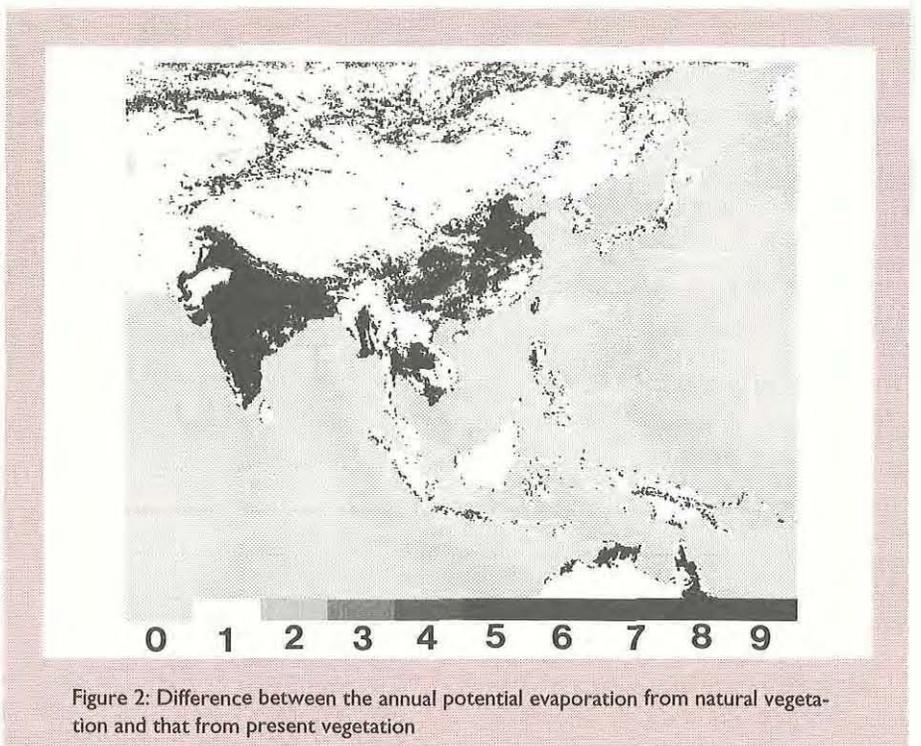


Figure 2: Difference between the annual potential evaporation from natural vegetation and that from present vegetation

Sorting Out Atmospheric Chemistry and Dynamics: The ASTEX/MAGE Experiment

by Barry J. Huebert

We've all had similar experiences: your daughter received her college diploma, but you can't even identify her in the photo because she was moving just as the shutter opened. Blurring eliminated the critical information from the picture. Exactly the same thing happens when you try to study aerosol dynamics in the atmosphere, since everything is moving. The air you want to take a picture of is advecting downwind, material is being added and removed at the surface, entrainment is mixing in different air from above, dispersion is causing horizontal mixing, and vertical wind-shear is slowing down air at the surface. How can you hope to tease out the oxidation rate of sulfur dioxide or the source strength of ammonia from such a cauldron? That's the challenge ASTEX/MAGE scientists undertook in the marine atmosphere near the Azores in 1992.

The Atlantic Stratocumulus Transition Experiment (ASTEX), one of the second series of FIRE international cloud-climatology experiments, took place in June of 1992 in the stratocumulus-capped marine boundary layer. The primary purpose of ASTEX was to study the factors influencing the formation and dissipation of marine clouds. The chemical experiment within ASTEX was organized by IGAC's *Marine Aerosol and Gas Exchange* (MAGE) Activity. Its objective was to study air-sea exchange and the formation and transformation of marine aerosols, in part by making Lagrangian observations (moving the measuring systems to stay with the same air). Chemical instrumentation was deployed on two islands, one French and two U.S. ships, and three aircraft from the U.S. and U.K. (Huebert *et al.*, The ASTEX/MAGE Experiment, *J. Geophys. Res.*, 101 (D2), 4319-4329, 1996). Although the meteorological situation was complex, chemists benefited from the observations of dozens of other groups who were studying cloud physics, boundary layer dynamics, and radiative transfer. These ASTEX scientists characterized turbulent and large-scale air motions in and above the boundary layer, thus enabling MAGE scientists to quantify the impact dynamics had on chemical concentrations.

To study marine chemical processing, we developed a Lagrangian sampling strategy for repeatedly studying the same air

parcel over a two-day period. This approach relied on the release of constant-density balloons which floated downwind with the parcel and radioed their GPS-derived locations to a relay of sampling aircraft. The balloons served as markers for the boundary layer airmass, which was continually being modified by chemical and energy fluxes at the surface, entrainment of free tropospheric air, wind shear within the boundary layer, horizontal dispersion, chemical reactions, and aerosol transformations.

Unfortunately, the balloons also served as excellent drizzle detectors, since a 0.1 mm thick layer of water deposited on their 1 m² upward facing surfaces (100 grams) was enough to drive them into the ocean. None of the balloons survived more than 7 hours in our first attempt. The second try was more successful: during the second Lagrangian (L2) one balloon (#7) remained aloft for over forty-two hours, seven research flights, and two sets of observations by ships. Incidentally, the popular hypothesis that #7's success was due to the fact that it was the only balloon with a happy face drawn on it was recently disproved in ACE-1, where three faceless "smart" balloons designed to adjust their own buoyancy were followed for 2 days by NCAR's C-130 aircraft.

While it is an oversimplification to say we studied "the same air" over a two day period, moving with the wind allowed us to see how dynamics modified a parcel of air. Conditions near the Azores made our job harder: the 2 km deep boundary layer was frequently separated into several sub-layers, each of which had to be characterized. Mixing between layers and dilution

by entrainment of free-tropospheric air were often the major causes of concentration changes. Using an entrainment velocity of 0.6 cm s⁻¹, Bretherton *et al.* computed a time scale of about 4 days for replacing the L2 boundary layer with free-tropospheric air. Chemically this usually meant that our wet, aerosol-laden boundary layer air was diluted by drier, cleaner air from above. However, late in L2 a dusty Saharan airmass passed over us, entraining large mineral aerosols into the cloud layer. This addition of large aerosols produced a noticeable modification in the microphysics and dynamics of the cloud field, creating larger droplets and increasing the likelihood of drizzle. We could not have sorted this out from Eulerian observations alone.

We were also able to derive the sea-to-air flux of ammonia (NH₃) vapor from studying the NH₃ budget during L2. Biologically, this NH₃ emission represents an unexpected loss of a limiting nutrient from the surface ocean. It is also important from an atmospheric standpoint, because the climatic and visibility impact of sulfuric acid droplets change dramatically when they are converted into ammonium salts. The ammonium/non-seasalt sulfate (NSS) ratio in this polluted European airmass increased with time, while the total NSS decreased. Several terms (all in units of micromoles (μmol) NH₃ m⁻² day⁻¹) dominated the budget (Figure 1): wet and dry deposition could have removed -4, while dilution by entrainment corresponded to a loss of -29, for a net removal flux of -33. Since the observed mixed layer concentration change (the net effect of all fluxes) was only -7, sea-to-air exchange must have provided a flux of +26 μmol NH₃ m⁻² d⁻¹.

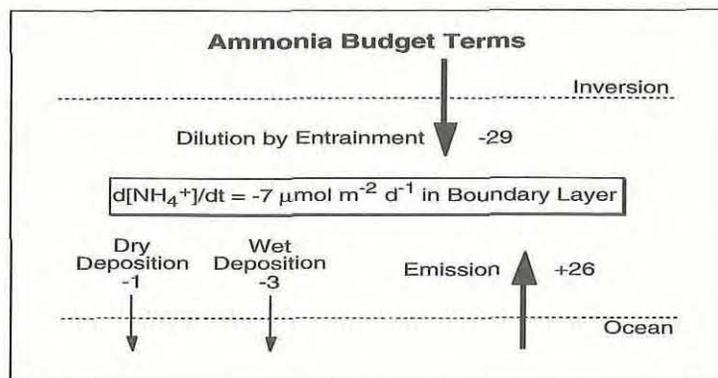


Figure 1. Schematic of the ammonia budget for the marine boundary layer during the second ASTEX/MAGE Lagrangian experiment.

Although substantial uncertainties remain, particularly in the estimation of the entrainment term, the Lagrangian strategy allowed us to measure enough of the air-motion terms to sort out a surface flux.

Chemical reaction rates were also determined by this approach. A group from the University of California at Irvine used repeated Lagrangian observations from a single flight (during which the plane was advecting with the balloons) to derive information on oxidation by free radicals. They used measurements of hydrocarbons and halocarbons versus altitude to characterise the impact that dilution by entrainment would have on concentrations. Then they employed the differing reactivity of several species to attack by hydroxyl and chlorine radicals and the observed concentration changes with time to solve for the concentrations of each radical. Significant levels of chlorine radicals could explain why several species disappear faster than expected from the marine atmosphere, but the attempts to directly measure their concentration have been controversial. Thus, this indirect observation of their importance is a big step forward. Here again, the Irvine group's ability to quantify the impact of mixing was crucial for separating out the changes caused by these oxidants.

Another group reversed the process and used aerosol measurements to derive exchange rates between the various layers of the decoupled boundary layer. They confirmed that the dynamically-derived entrainment velocity of 0.6 cm s^{-1} for the main inversion was consistent with a simple aerosol mixing model, and concluded that the surface mixed layer entrained cloud-layer air with an effective entrain-

ment velocity of 0.45 cm s^{-1} . They also identified a method whereby the ratio of volatile to nonvolatile nuclei can be used to characterise mixing between air masses with different histories. This is one of many examples in which chemical and aerosol measurements were able to constrain dynamics and provide the meteorological investigators with information they could not have derived from their usual suite of observations. Clarke's group also used the Lagrangian observations to demonstrate that no aerosol nucleation had occurred in the marine boundary layer during the course of L2.

The various platforms played complementary roles. Eleven-hour impactor samples from Santa Maria Island proved to be important for estimating particle removal rates. The aircraft were able to gather vertical profiles and keep up with the tagged air masses. The two ships made unique contributions because of their ability to move to locations of interest (like the starting and ending points of the Lagrangians), stay on station around the clock, make measurements very close to the surface, and support instruments with long sampling times. Jodwalis and Benner demonstrated that a new variance method can be used to measure air/sea sulfur fluxes, based on a fast total gaseous sulfur detector. In view of the need for ways to test the wind speed-based parameterizations of dimethylsulfide (DMS) emissions from which most submicrometer marine aerosols are derived, this is a valuable addition to our arsenal. The variance method generally found larger fluxes than estimates derived from simultaneous measurements of DMS in the water and air. From the other ship, Putaud and Nguyen used measurements

of DMS concentration gradients to estimate fluxes. These complementary approaches improve our ability to derive a consensus among flux estimation techniques.

Of course, these examples are just a small part of what was learned about aerosols and their source materials during the ASTEX/MAGE program. A collection of MAGE papers has been published in the February 1996 issue of the *Journal of Geophysical Research - Atmospheres* and is available as a compilation from this author (huebert@soest.hawaii.edu). Most of the more dynamically-oriented ASTEX papers, many containing analyses based on the Lagrangian observational strategy, are contained in the August 15, 1995 issue of the *Journal of the Atmospheric Sciences*. As with all field programs, there is still much to be learned from further analysis of the ASTEX/MAGE data set (publicly available from a database maintained by John Seinfeld at the California Institute of Technology; contact Lynn Russell, lynn@aeolus.che.caltech.edu).

Policymakers rely on models of dynamics and aerosol chemistry to make informed decisions about the costs and benefits of various emissions control strategies. Experiments like ASTEX/MAGE are essential both for properly describing the physics and chemistry of individual processes in these models and for seeing whether the models accurately predict nature's response to our emissions. Society's investment in ships, airplanes, and scientists ultimately benefits fisheries, forests, agriculture, and industry.

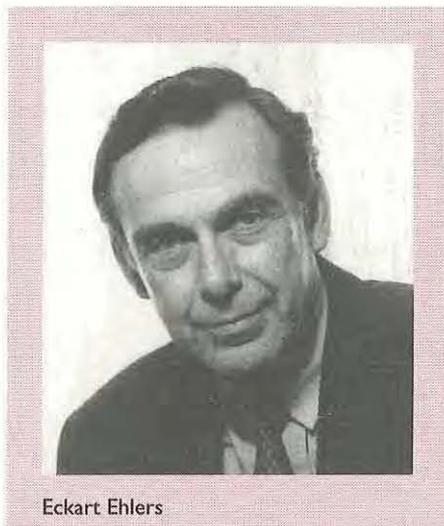
Barry J. Huebert

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The Social Sciences

New Chair for IHDP

Eckart Ehlers is the new Chairman of the International Human Dimensions Programme on Global Environmental Change (IHDP) and member of the Scientific Committee of the IGBP. Professor Ehlers obtained two Ph.D. degrees from the University of Tübingen; in agricultural geography and physical geography. He was Professor of Geography at the University of Marburg from 1972 until 1986, and is currently Professor of Geography at the University of Bonn. He was Vice-Rector of the University of Bonn from 1992 until 1996. Professor Ehlers has been Secretary General and Treasurer of the International Geographical Union (IGU) since 1992.



Eckart Ehlers

See also pull-out section.

IHDP has new sponsor

On 1 February 1996 an agreement was signed between the International Social Science Council (ISSC) and the International Council of Scientific Unions (ICSU) in Paris, France, recognising that the problems on Global Environmental Change require the attention of a wide spectrum of scientific disciplines, and that scientific research would benefit from the closer collaboration of the two programmes. Both ICSU and the ISSC agreed to co-sponsor the International Human Dimensions Programme on Global Environmental Change (IHDP).

Who's who at the IGBP Secretariat?

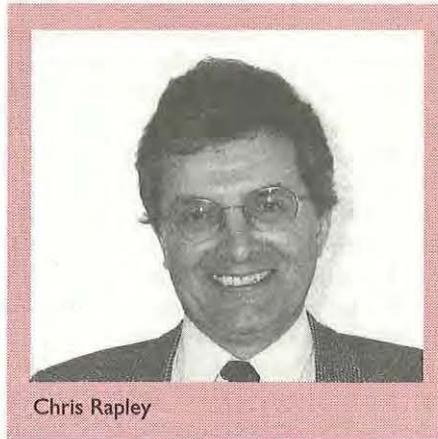
The scientific staff

Chris Rapley is the Executive Director of the IGBP. Professor Rapley is a UK citizen, with a Physics M.A. from Oxford, and a Ph.D. in Astronomy from University College London (UCL). He has followed a distinguished career in space research, especially in the field of new instrument development and new observing techniques. Before joining the IGBP, he was Deputy Director of UCL's Mullard Space Science Laboratory where he headed the Remote Sensing Group. He continues to participate in the Earth observation programmes of the European Space Agency and NASA, where he has been a Principal Investigator on a number of missions.

His role at the IGBP is to ensure the overall guidance of the programme with regard to its development and implementation, and to work with the IGBP Core Projects and Framework Activities to achieve maximum integration of the component parts. He is also active in ensuring and maintaining links with the World Climate Research Programme, the International Human Dimensions Programme for Global Environmental Change (IHDP), the United Nations environmental bodies and international funding and policy communities.

Neil Swanberg is the Deputy Executive Director. Dr. Swanberg is a U.S. citizen and has a Ph.D. from the Woods Hole Oceanographic Institution and Massachusetts Institute of Technology joint programme in oceanography. Much of his research has focused on biological questions which address issues of relevance to palaeontology, particularly aimed at using fossil evidence to interpret climatic change.

He is the primary point of contact between the Secretariat and the Joint Global



Chris Rapley

Ocean Flux Study (JGOFS), and the Global Ocean Ecosystem Dynamics (GLOBEC) Core Projects and the IGBP data and information system (IGBP-DIS). In addition acting as back-up to the Executive Director, he has planned and directed the organisation of the First IGBP Congress to be held in April 1996.

Risa Rosenberg, a U.S. citizen, is Programme Officer at the IGBP Secretariat. Before receiving her Ph.D. in Ecology and Evolutionary Biology at Cornell University, she had accumulated two bachelor degrees from Pennsylvania University: one in ecology, and the other in anthropology/psychology. Her research interests are in applied and theoretical ecology, population biology and genetics, behavioural ecology and conservation biology.

She acts as the primary point of contact between the Secretariat and the Biospheric Aspects of the Hydrological Cycle (BAHC), Global Change and Terrestrial Ecosystems (GCTE), and the International Global Atmospheric Chemistry Project (IGAC) Core Projects, and the IGBP Transects.

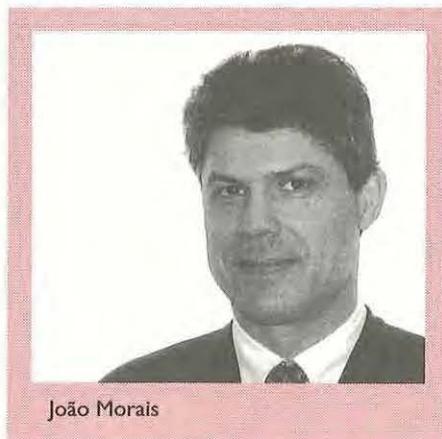
João Morais is Programme Office for Social Sciences at the IGBP Secretariat. Professor Morais is a Portuguese citizen who received his Ph.D. in Archaeology from Oxford University in the UK, after studies at Lourenço Marques University in Mozambique, where he directed the Department of Archaeology and Anthropology. He has worked as Principal Researcher at the Tropical Research Institute (ICT) and at the Universidade Lusofona de Humanidades e Tecnologias in Lisbon, Portugal. His academic interests are in African archaeology, early farming systems, past global changes and environmental archaeology, and interaction processes in natural and social sciences.

His work addresses issues on the links between the natural and social sciences in the study of global change. He acts as the primary focal point for Land-Use/Cover Change (LUCC), for Past Global Changes (PAGES), and for the Land-Ocean Interactions in the Coastal Zone (LOICZ). He provides liaison between the IGBP and IHDP, the European Network for Research in Global Change Programme of the European Community (ENRICH), and the international community of Social Scientists.

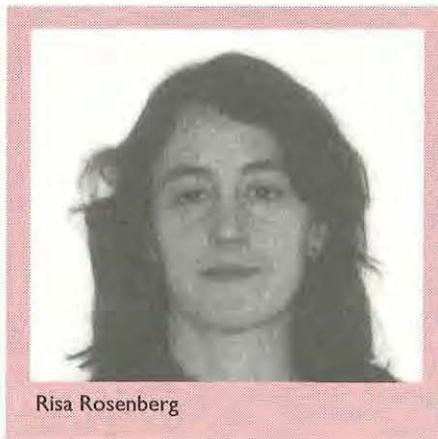
The administrative unit

Elise Wännmann is Deputy Director for Administration. She is a Swedish citizen, and worked previously in national and international economy and finance for the University of Technology.

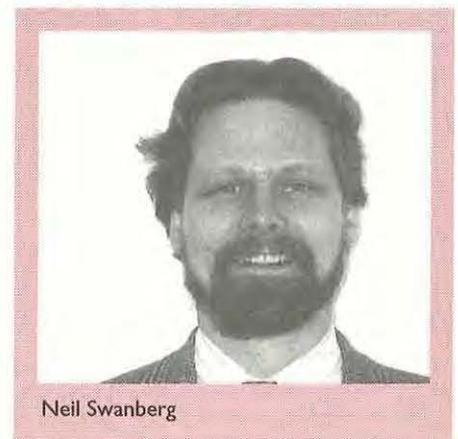
She is responsible for the day-to-day financial activities, participates in the long-term financial planning and administration, and maintains contacts with external funding agencies. She is the primary contact with the administration of the Royal



João Morais



Risa Rosenberg



Neil Swanberg



Elise Wännmann

Swedish Academy of Sciences.

June Boström is Assistant to the Executive Director. June is a UK citizen who previously did secretarial work in the UK and in Australia.

She is responsible for general office management, including the maintenance of the files and archive of Programme documents and correspondence, and for organising major meetings, including all those that are convened by the Executive Director. She manages the calendar, mail and travel of the Executive Director, and the calendar for the Secretariat. She is the person who will most often answer the phone.

Mariah Herlin, Administrative Assistant, is a Swedish citizen who came to the IGBP directly from the International Business School in Sweden. Mariah also studied language in Spain, and business administration in the UK.

Mariah is responsible for general secretarial work and substitutes for June in her absence. She also provides support to Elise Wännmann on the financial administration.

The information unit

Suzanne Nash will step down as Information Officer at the end of March when she retires. Suzanne is a U.S. citizen and has worked as a librarian in Paris, France, where



June Boström

she received a M.A. in library science. Before coming to Sweden, she headed one of the UNESCO libraries, and was librarian at the International Herald Tribune.

She has developed and edited the Global Change NewsLetter and the IGBP Directory. Her other responsibilities included keeping track of IGBP events, of publications, maintaining contact with the IGBP National Committees, organising the meetings of the Scientific Advisory Council, and answering queries about the IGBP.

Sheila Lunter is the new Information Officer. Sheila is a Dutch citizen, with an M.A. in Literary Criticism, for which she carried out research in Italy. After several years of work in Spain, she returned to the Netherlands, where she worked for the LOICZ Core Project Office in Texel as Office



Mariah Herlin

Administrator.

In addition to Suzanne's activities, she will be responsible for the contents of the IGBP Web home page, in consultation with the Programme Officer, and will serve as a focal point for the further development of communications and information.

Lisa Cronqvist is Information Coordinator/Technical Editor. Lisa is a citizen of New Zealand, where she worked as a travel consultant. In Sweden she worked for the journal AMBIO at the Royal Swedish Academy of Sciences before coming to the IGBP.

She is responsible for editing the IGBP Directory, the production of IGBP Reports, organising shipping and mailing of IGBP publications, keeping track of the membership of IGBP committees and for maintaining the database of IGBP membership and mailing.

Magdalena Kanger, Technical Editor/Graphics Designer, is a Swedish citizen with a B.A. in French and Mathematics, who worked previously in a pharmaceutical firm as Assistant Controller. She studied graphic art in Paris.

She works partly off-site, carrying out the technical editing of selected IGBP Reports and acting as the Web-Master for the IGBP Home Page on the World Wide Web. She produces artwork and diagrams for IGBP illustrative material.



Suzanne Nash



Lisa Cronqvist



Sheila Lunter



Magdalena Kanger

Open Science Conference of Global Analysis, Interpretation and Modelling

by Dork Sahagian

The First GAIM Science Conference (September 24-29 1995, Garmisch-Partenkirchen, Germany) provided a venue for the dissemination of preliminary results aimed at steering subsequent research efforts toward reliable prognostic biogeochemical models. It is apparent that models need to be developed further in order to make it possible for intergovernmental policy decisions to be based on a more thorough understanding of the biogeochemical and physical interactions between the various subsystems of the Earth System.

The Conference focused on papers in the areas of global data analysis and assessment, modelling of biogeochemical systems and their relationship to physical climate and hydrologic systems. It also addressed interpretation of current trends as indicated by global databases and model results for the extrapolation of global change. The observations and models of global change can be divided into different eras according to the resolution, time scales, and types of data.

The Paleo Era

The concern with future Earth system responses to large perturbations in atmospheric composition and climate makes it important to exploit the recent geological

record as studied by the IGBP project Past Global Changes (PAGES). The paleo record in fact provides the only means to test such models under conditions (in the past) that are as different from present as the conditions expected to apply in 50-200 years time. Paleo studies give us an understanding of the functioning of the Earth system under natural forcing, such as changes in ocean circulation and in the Earth's orbit. Glacial-interglacial variability and Dansgaard-Oeschger oscillations were among the issues discussed. Rapid climate changes have been recorded in the past, and the causes and consequences of these may shed light on the likely magnitudes and consequences of present and future anthropogenically forced climate changes.

The Historical Era

The historical era (<2,000 yrs) is the time during which human activities became a significant forcing factor in global change. The earliest influences were those of land use changes, as agriculture led to deforestation, and diversion of surface water for irrigation led to hydrologic changes on basinal scales. Steadily increasing fossil fuel emissions beginning in about 1860 are known to have caused the major fraction of the observed increase in atmos-

pheric carbon dioxide concentration. At present, however, we are unable, by accounting for other sources and the redistribution of carbon within its global cycle, to relate observed increases to estimates of past fossil fuel emissions. This questions the veracity of estimates of future carbon dioxide increase and drives a substantial effort to understand carbon cycle responses to human activities over the past several centuries. The causes of increases in other greenhouse gases such as methane and nitrous oxide since the revolution are less certain. A broad spectrum of research results was presented on terrestrial ecosystems, land use, ocean and atmospheric chemistry, and ozone.

Global Systems Integration

A special session focused on the interactions and feedbacks between biogeochemical subsystems (*e.g.* atmosphere, ocean, terrestrial ecosystems, etc.) and integration into whole-Earth models. There is considerable uncertainty in the results of models of each of the various subsystems. When these models are simple models, coupling to form Earth systems models may cause an increase in total uncertainty. However, there may be a point in the modelling of each subsystem where coupling with other subsystems reduces total uncertainty because of resulting improved dynamic constraints on subsystem boundary conditions and fluxes. This point was raised at the Science Conference, but there are still no quantitative estimates of the threshold levels for each of the subsystem models. Nevertheless, it was generally agreed that system integration through subsystem model coupling should be pursued so that the structure will be in place when subsystem modelling thresholds are identified and surpassed. Presentations were made focusing on each of several subsystem models, and preliminary approaches to system integration were addressed.

Integrating the Developing World in Global Change Modelling- A special session focused on the concerns of START and the European Network for Research in Global Change (ENRICH) recognised the

The First GAIM Science Conference 25 - 29 September 95



The organising crew in front of the Garmisch Conference Centre: Arne Spekat, Gisela Brehme, Gisela Post, Ines Lange, Clara Kustra, Dr. Sabine Lütke-meier.

importance of linking regional research programs into the global research questions on which it focuses. Moreover, there is a growing realization of the importance of tropical and subtropical regions in the study of global environmental changes and data requirements to global change issues. The success of GAIM depends on gathering expertise as well as data from the entire planet, which will heavily rely on collaboration and involvement with ongoing international modelling efforts. Many issues emerged which served to identify better the resource and other needs of scientists from developing countries. It is apparent that these needs must be fulfilled so that they can more effectively gather, assess, and integrate global change data from their regions. In many countries, leading scientists do not have even the most basic computation or communication facilities which would make involvement in international global change research programs feasible. Links between issues of local scientific interest in developing countries (e.g. land use change and sustainability) and global scientific issues, and resource requirements and funding mechanisms for enhancement of global change research in developing countries, are not always easy to reconcile.

The Contemporary Era

The Contemporary Era provides the greatest availability of data over the immediate past and the easiest task of validation over the immediate future. Further, the present is a time of rapid change, representing the most rapid change available to study over the last millennium. The period of 20 years is the shortest time scale available to look at for this decades to centuries change. A wealth of information is becoming available to model the carbon cycle, lessening, but not solving the missing sink of anthropogenic carbon dioxide emissions that cannot be accounted for, in spite of extensive studies on atmospheric, ocean and terrestrial sinks. Suggestions were made that the missing carbon dioxide may be found in terrestrial systems in the northern hemisphere. Relevant to the contemporary era are the global budgeting and modelling of the present-day state of the major biogeochemical cycles. Other issues are the effects and interpretation of atmospheric carbon dioxide variations, greenhouse gases, nitrogen and oxygen, ocean carbon, terrestrial carbon model validation, deforestation/desertification, hydrology, and atmospheric aerosols.

The Future

The capability of biogeochemical models to predict future changes in the Earth

system is dependent on the understanding of past global changes. For instance, by comparing contemporary rates of change to those of older and longer time periods, prognostic models may more accurately predict magnitudes of change in Earth systems and subsystems. While prognostic biogeochemical models are presently in a very primitive stage of development, comparison of the models will lead to better identification of data needs, shortcomings in our understanding of rates and interactions between changing subsystem components, and sensitivities of models to uncertainties in each subsystem component as well as component interactions. A whole range of future scenarios were presented at the conference, including future agricultural interactions with climate and natural ecosystems. There was a great deal of optimism at the conference about the ability to achieve a reasonable predictive capacity of decades or longer within a few years. The requirement - modelling a dynamic interactive terrestrial biosphere - is being vigorously addressed by the IGBP scientific community.

The present status of modelling reliability can be assessed by comparing different models of the same subsystem. Two classes of such subsystem model comparisons presented at the conference involve ocean carbon and terrestrial net primary productivity. In both of these subsystems, preliminary models show very contrasting results. Identification and quantification of the differences between models that emerged at the conference will expedite improvement of model parameterisation and methodology which should lead to more reliable projections of each of these subsystems in response to various aspects of global change.

Papers from the GAIM Science Conference will be published after peer review in a special issue of *Global Biogeochemical Cycles*. The conference was co-sponsored by GAIM and the German National IGBP Secretariat in Berlin, and supported by the U.S. National Science Foundation, the International Science Foundation, German National IGBP, START, ENRICH, and the German Development Foundation.

Abstracts from the GAIM Science Conference are available on the World-Wide-Web on the GAIM home page, <http://gaim.unh.edu> or can be requested from the GAIM Task Force Office:

Dork Sahagian, GAIM Office, EOS, Morse Hall, University of New Hampshire, Durham, NH 03824, USA. Tel: (+1-603) 862 3875, Fax: (+1-603) 862 0188; E-mail gaim@unh.edu

Open Science Meetings

4-6 March, 1996, Tsukuba, Japan

International Workshop on NO_x Emission from soils and its influence on atmospheric chemistry. National Institute of Agro-Environmental Sciences, co-sponsored by IGAC.

Haruo Tsuruta, National Institute of Environmental Sciences, 3-1-1 Kan-nondai, Tsukuba, Ibaraki 305, Japan. Fax: (+81) 298 38 8199, E-mail: tsuruta@nias.affrc.go.jp,

and *Arvin Mosier*, USDA/ARS, PO Box E, Fort Collins CO 80522, USA. Fax: (+1-970) 490 8213, E-mail: amosier@lamar.colostate.edu

17-21 June 1996, Washington DC, USA.

GEWEX: Second International Scientific Conference on the Global Energy and Water Cycle Experiment, at the US National Academy of Sciences. Scientific interests involve the climate feedback associated with clouds, radiation, and the hydrologic processes. **Papers invited.** Contact: GEWEX Project Office, 409 Third Street SW, Suite 203, Washington, DC, 20024, USA. E-mail: GEWEX@cais.com

27 June - 2 July, São José dos Campos, Brazil

Large scale Biosphere experiment in Amazonia (LBA) Open meeting. Contact: *Carlos A. Nobre*, Center for Weather Forecasting and Climate Research, National Space Research Institute, Rod. Presidente Dutro (Km 40), P.O. Box: 01, 12630-000 Cachoeira Paulista S.P, Brazil. Tel: (+55-125) 612 822, Fax: (+55-125) 612 835, E-mail: nobre@cptec.inpe.br

26-30 August 1996, Helsinki, Finland

Fourteenth International Conference on Nucleation and Atmospheric Aerosols. *M. Kulmala*, Department of Physics, University of Helsinki, PO Box 9, FIN-00014, Helsinki, Finland. Tel: (+358-0) 191 8308, Fax: (+358-0) 191 8680, kulmala@phcu.helsinki.fi

4-7 November, 1996, Kyoto, Japan

Open IGBP/BAHC-LUCC Joint Inter-Core Projects Symposium on Interactions Between the Hydrological Cycle and Land-Use/Cover. *Dr. M. Sugita*, Environmental Research Center, University of Tsukuba, Ibaraki 305, Japan. Tel: (+81-298) 53 2537, Fax: (+81-298) 53 2530, E-mail: bahe-lucc@erc2.suiri.tsukuba.ac.jp

2-6 December 1996, Melbourne, Australia

First SPARC General Assembly (Stratospheric Processes and their Role in Climate). *David Karoly*, SPARC 96, CRC for SH Meteorology, Bldg 70, Monash University, Clayton, vic 3168, Australia. E-mail: sparc96@vortex.shm.monash.edu.au

The editor's corner

The Global Change Newsletter is a fascinating publication to work on, for no less reason than it deals with an extraordinary programme and extraordinary people. The Newsletter could not exist without the contributions of people willing to write for it. Now that it is my turn to step down, I would like to thank warmly everyone who has helped by bringing their ideas to print, and the readers without whom there would be no publication at all.

Suzanne Nash

IGBP Publications

Programme Elements

GCTE

Terrestrial Ecosystem Interactions with Global Change (1995). *Journal of Biogeography* 22:2-3 and 22:4-5, edited by W. Steffen and J.S.I. Ingram. 600 pp. These two special issues comprise contributed papers from the First Global Change and Terrestrial Ecosystems (GCTE) Conference held in Woods Hole in May 1994.

Order from: Blackwell Science, Osney Mead, Oxford OX2 0EL, UK. (price £ 45.00).

PAGES

Global Palaeoenvironmental Data: A Report from the workshop sponsored by Past Global Changes (PAGES), August, 1993. Edited by D.M. Anderson. 114 pp. (PAGES Workshop Report Series 95-2).

PAGES Core Project Office, Bärenplatz 2, 3011 Bern, Switzerland.

START/DIS

Development of World Wide Web (WWW) Data Systems: IGBP-DIS/START Summer School on Electronic Networking and Data and Information Systems (DIS) for Global Change Research (1995) 170 pp.

International START Secretariat, Suite 200, AGU Building, 2000 Florida Avenue, NW, Washington, DC 20009, USA.

National Research

Netherlands

Dutch Social-Scientific and Economic Research on Nature and the Environment: Overview of current research and perspective for the future in an international context (1995). Ed. by S.A. Wink. RMNO Publications nr.110. Rijswijk: Advisory Council for Research on Nature and the Environment, 92 pp. RMNO Secretariat, PO Box 5306, 2280 HH Rijswijk, Netherlands.

Climate Change Research: Evaluation and Policy Implications. Proceedings of the International Climate Change Research Conference, Maastricht, Netherlands, 6-9 December 1994 (1995). Ed. by S. Zwerver *et al.* Studies in Environmental Science 65A and 65B. Amsterdam, Elsevier, 2 vols. 1463 pp. Order from: Elsevier Science, PO Box 211, 1000 AE Amsterdam, The Netherlands.

Poland

Climate Dynamics and the Global Change Perspective. Abstract from International Conference, 17-20 October 1995, Krakow, Poland. 71 pp.

Polish National Committee, Leszek Starkel, Geomorphology and Hydrology Dept., Polish Academy of Sciences, Ul. Sw. Jana 22, PL-31-018, Krakow, Poland.

Global Change: Polish Perspectives 2. (1995). Ed. by L. Starkel and M. Gutry-Korycka. Warsaw, PAN IGiPZ, 122 pp. (Geographia Polonica 65).

Polish National Committee, Leszek Starkel, Geomorphology and Hydrology Dept., Polish Academy of Sciences, Ul. Sw. Jana 22, PL-31-018, Krakow, Poland.

USA

Science, Policy and the Coast: Improving Decision-making (1995). National Research Council. Washington D.C., National Academy Press, 85 pp. National Academy Press, 2101 Constitution Avenue, NW, Box 285, Washington, DC 20055, USA.

Related Organisations

APN

APN Newsletter Vol.2, No.1, February 1996. AIRIES, 3-1-13 Shibakoen, Minato-ku, Tokyo 105, Japan.

CICSE

Cambio Global Dimensiones Humanas No.1, Enero 1996.

(CICSE) Consejo Internacional de Ciencias Sociales de España, Calle Pomaret 21, 08017 Barcelona, España.

European Commission

Global Change and Arctic Terrestrial Ecosystems: Proceedings of Papers Contributed to the International Conference, 21-26 August 1993, Oppdal, Norway (1995). Ed. by T.V. Callaghan *et al.* Luxembourg, European Commission/DG XII-D-1. (Ecosystems research reports 10).

European Commission / DG XII-D-1, Rue de la Loi 200, 1049 Brussels, Belgium

ENRICH

Proceedings of the Regional Seminar on Global Change Research: Central and Eastern Europe and New Independent States of the former Soviet Union, Budapest, 15-17 September 1994. Ed. by S. Kelecsenyi and F. Eybergen. Joint Research Centre, European Commission.

ENRICH Office, Joint Research Centre, European Commission, SDME 1/24, 8 Square de Meeûs, 1040 Brussels, Belgium.

European Environment Agency

Europe's Environment: The Dobris Assessment. (1995) Ed. by D. Stanners and P. Bourdeau. Luxembourg: Office for Official Publications of the European Communities, 712 pp.

Office for Official Publications of the European Communities, L-2985 Luxembourg (price: ECU 55)

IDEAL

IDEAL Bulletin, Bulletin of the International Decade for the East African Lakes, Autumn 1995.

Laura Lee Gance, IDEAL Program Coordinator, 2954 King James Way, #6, Madison, WI 53719, USA.

International Glaciological Society

Annals of Glaciology Vol.21: Proceedings of the International Symposium on the Role of the Cryosphere in Global Change, held at the Ohio State University, Columbus, Ohio, 7-12 August 1994 (1995) Ed. by D.A. Rothrock. 421 pp.

International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, UK.

UNESCO

A global geochemical database for environmental and resource management: recommendations for international geochemical mapping (1995). Ed. by A.G. Darnley *et al.*, UNESCO Publishing, Paris, 122 pp. (Earth Science Report 19)

UNESCO, 7 Place de Fontenoy, 75352 Paris, France

WCRP

Workshop on Cloud Microphysics Parameterizations in Global Atmospheric Circulation Models (1995). WCRP-90.

WCRP Secretariat, WMO, CP 2300, 41, Avenue Giuseppe Motta, 1211 Geneva 2, Switzerland.

The World Bank

Monitoring Environmental Progress: A Report on Work in Progress (1995). Environmentally Sustainable Development Series. The World Bank, Washington D.C., 82 pp.

The World Bank, 1818 H Street, N.W., Washington, D.C. 20433, USA.

Web Pages

IGBP Secretariat

<http://www.igbp.kva.se/>

BAHC <http://www.pik-potsdam.de/~bahc>

GCTE <http://Jasper.Stanford.EDU:80/GCTE/>

IGAC <http://web.mit.edu/igac/www/>

JGOFs <http://www1.who.edu/intlinks.html>

LOICZ <http://www.nioz.nl/loicz/>

LUCC <http://pathfinder-www.sr.unh.edu/lucc/>

PAGES <http://www.ngdc.noaa.gov/paleo/pages.html>

IGBP-DIS <http://www.meteo.fr/cnrm/igbp/>

GAIM <http://gaim.unh.edu/>

START <http://dis.start.org/>

European Science Foundation

<http://www.esf.org/>

IASC <http://www.npolar.no/iasc/>

ICSU World Data Centers

<http://www.ngdc.noaa.gov/wdc/wdemail.html>

mirror site for Europe:

<http://www.wdc.rl.ak.uk/>

IMAU, Utrecht University, Netherlands

<http://www.fys.ruu.nl/www/imau>

SCOSTEP <http://www.ngdc.noaa.gov/stp/SCOSTEP/SCOSTEP.html/>

UNESCO <http://www.unesco.org/>



GLOBAL CHANGE NEWSLETTER

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