



MRI/UNESCO International Workshop on

“Global Change Research in Mountain Biosphere Reserves”

Entlebuch Biosphere Reserve, Switzerland
10 – 13 November 2003

organized by

The Mountain Research Initiative (MRI)

and

UNESCO’s Man and the Biosphere (MAB) Programme

UNESCO’s International Hydrological Programme (IHP)

Workshop Report

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1. Introduction and Workshop Objectives

Global change will have serious repercussions on fragile mountain ecosystems. The anticipated changes will not only affect the socio-economic conditions of mountain dwellers, but also downstream communities that are dependent upon the flow of goods and services from mountain regions. Mountains serve as the “water towers of the world”, with more than half of humanity depending on freshwater generated in mountains. Changing precipitation regimes, increased water run-off, reduced ice and snow storage capacities in mountains, changing frequency and magnitude of mass events (e.g. land slides and avalanches) will be some of the consequences of global change that may also increase natural disasters in mountains and – perhaps even more pronounced – in the associated lowland areas.

Moreover, rising temperatures will affect the current altitudinal location of the snow line, the vegetation line and the treeline in mountains, and will impact ecosystem properties through the effects on habitats of species, their population dynamics and distribution in high altitude areas. Mountain regions provide a number of key indicators with which the impacts of global changes can be detected, such as changes in snow line, glacier mass balance, and shifts in ecological properties (e.g. changes in the elevation of the upper limit of vascular plants). Mountain regions are distributed nearly from pole to pole, and from highly maritime to highly continental areas; therefore, comparative analyses of the impacts of global change on mountain regions are particularly rewarding.

Mountain people, often living in marginalized societies especially in developing countries, will have to cope with such drastic changes while make a living from already limited mountain resources. The severity of the anticipated changes will dictate their response strategies, which could range from adaptation in a changing environment to outright emigration to the lowlands.

These issues should be addressed in a new global network of scientists and protected area site managers using mountain biosphere reserves as study and monitoring sites within the UNESCO World Network of Biosphere Reserves. The network will operate at the interface of scientific research, protected area management and the promotion of sustainable development of mountain regions using a comparative study approach. Mountain biosphere reserves have been selected as they contain protected areas in their core zones (with little direct human disturbance) as well as economically used areas (buffer and transition zones) so that the impact of global change can be analysed both in a natural or near-natural environment, as well as in a human-used environment with similar environmental conditions.

Therefore, a workshop was organized as a joint endeavour of the Mountain Research Initiative (MRI) comprising the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Environmental Change (IHDP), and the Global Terrestrial Observing System (GTOS), as well as UNESCO’s Man and the Biosphere (MAB) Programme and the International Hydrological Programme (IHP).

The specific objectives of the workshop were

- 1 To review the state of global change research (natural, social, cultural, economic and political sciences) in a range of mountain Biosphere Reserves (MBRs) that could be used as pilot study areas for implementing the activities defined by the MRI (cf. Becker & Bugmann 2001).

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- ☐ To refine and prioritize the MRI activities to an operational level for application in MBRs.
 - ☐ To identify gaps in coverage and methodological problems with respect to Global Change research in MBRs.
 - ☐ To provide guidelines for implementing integrated Global Change research in MBRs around the world, with a view towards general applicability in mountain regions.

In order for the meeting to be a success, it was essential that all participants became familiar with the Global Change research that is ongoing in the selected Biosphere Reserves. Therefore, a significant fraction of the workshop was devoted to presentations from MBR representatives.

2. Workshop Agenda

Monday, 10 November 2003

Workshop opening: Overview of workshop structure and objectives

Chairperson: Harald Bugmann, President of Mountain Research Initiative (MRI)

- Opening of the workshop – Harald Bugmann
- The Mountain Research Initiative – Mel Reasoner
- UNESCO-MAB and the World Network of Biosphere Reserves – Thomas Schaaf
- UNESCO's International Hydrological Programme (IHP) – Lalji Mandalia
- Entlebuch Biosphere Reserve – Engelbert Ruoss

Session 1: Presentation of mountain biosphere reserves in Latin America

Chairperson: Thomas Schaaf

- Marcela Canon (Colombia): Cinturon Andino Biosphere Reserve
- Marco Zapata/ Jorge Recharte (Peru): Huascaran Biosphere Reserve

Session 2: Presentation of mountain biosphere reserves and GLORIA sites in Europe and Northern America

Chairperson: Bruno Messerli

- Christer Jonasson (Sweden): Lake Torne Biosphere Reserve
- Thomas Scheurer (Switzerland): Swiss National Park Biosphere Reserve and GLORIA site Biosphere Reserve
- Roland Psenner (Austria): Gossenköller See Biosphere Reserve
- Dan Fagre (USA): Glacier National Park Biosphere Reserve and GLORIA site
- Glen Jamieson (Canada): Mt. Arrowsmith Biosphere Reserve

Session 3: Presentation of mountain biosphere reserves in Africa

Chairperson: Daniel Maselli

- Francis Ojany (Kenya): Mount Kenya Biosphere Reserve
- Driss Fassi (Morocco): Oasis du Sud & Tassili Biosphere Reserves

Poster Session

- Michael Vogel (Germany): Berchtesgaden Alps Biosphere Reserve

Tuesday, 11 November 2003

Session 4: Presentation of mountain biosphere reserves in the Asia-Pacific region

Chairperson: P.S. Ramakrishnan

- Li Yang (China): Changbaishan Biosphere Reserve
- Erkinbek Kojekov (Kyrgyzstan): Issyk-Kul Biosphere Reserve
- Bayarsaikhan Bayarmagnai (Mongolia): Uvs Nuur Basin Biosphere Reserve
- Z.A. Viktorovich/Yuri Badenkov (Russian Federation): Katunsky Biosphere Reserve in the Altai
- Ken Green (Australia): Kosciuszko Biosphere Reserve

Field trip to Entlebuch Biosphere Reserve, including Workshop Dinner

Wednesday, 12 November 2003

Session 5: Perspectives and comments from the point of view of global change-related scientific programmes

Chairperson: Mel Reasoner (Switzerland)

(a) Long-Term Monitoring

- Alpine Vegetation (GLORIA) – Georg Grabherr (Austria)
- Cryosphere (WGMS) – Wilfried Haeberli (Switzerland)
- Land Use/Land Cover – George Malanson (USA)
- Climate – Ray Bradley & Douglas Hardy (USA)

(b) Integrated Modelling

- Integrated ecosystem modelling – Harald Bugmann (Switzerland)
- Regional Atmospheric models – Marco Verdecchia (Italy)

(c) Process Studies

- Biodiversity and Ecosystem Function (GMBA) - Christian Körner (Switzerland)
- Biogeochemistry (INSTAAR-MRS) - William Bowman (USA)

(d) Sustainable Development

- Sustainable Water Use (NCCR North-South) – Daniel Maselli (Switzerland)
- Agriculture and Traditional Knowledge (GIAHS) – P.S. Ramakrishnan (India)
- Globalisation in Mountain Contexts (ICIMOD) – N.S. Jodha (Nepal)

Examples of integrated global change programmes

Chairperson: Thomas Schaaf

- Himalayan-Andean Watershed Project – Hans Schreier (Canada)
- The GLORIA Master Station concept – Georg Grabherr (Austria)

Breakout group discussions: Selection of Programmes, Definition of Priorities

- Long-term Monitoring – Chair: Georg Grabherr (Austria)
- Integrated Modelling – Chair: Dan Fagre (USA)
- Process Studies – Chair: Bill Bowman (USA)
- Sustainable Development – Chair: Jörg Stadelbauer (Germany)

Thursday, 13 November 2003

Breakout groups report to plenary

Chairperson: Mel Reasoner

- Long-term monitoring – Georg Grabherr
- Integrated Modelling – Dan Fagre
- Process Studies – Bill Bowman
- Sustainable Development - Jörg Stadelbauer

Open Forum: discussion on next steps and workplans for collaboration

Chairperson: Bruno Messerli

Close of the Workshop (at noon)

3. Brief Summaries of the Sessions

3.1 *Presentations on Mountain Biosphere Reserves (Sessions 1-4)*

The 16 oral presentations from the selected Mountain Biosphere Reserves (MBRs) around the world were essential for the success of the workshop. They were very informative in portraying the general situation of the MBRs in socio-economic and political terms as well as serving to inform of their research infrastructure while recognizing the opportunities that Biosphere reserves provide for Global Change research activities. Unfortunately however, five of the MBRs that had initially been selected by the Programme Committee for presentation at the workshop were unable to send a delegate. They include Araucarias and Torres del Paine Biosphere Reserves in Chile; Kruger to Canyons Biosphere Reserve in South Africa; Tassili N'Ajjer Biosphere Reserve in Algeria, and Sierra Nevada Biosphere Reserve in Spain. Nanda Devi Biosphere Reserve in India has since been selected to become part of the study. It is hoped that a representative from these biosphere reserves will be able to attend the forthcoming thematic workshop. Nevertheless, MBRs from all continents were represented at the workshop.

Even though the extent of ongoing Global Change research activities varied widely among the biosphere reserves and also between continents, all the MBR representatives expressed their strong interest to participate in the new MRI/UNESCO-MAB "Global Change Research in Mountain Biosphere Reserves" initiative or even to start small national to continental networks of mountain researchers and reserve managers, along the lines suggested by the MRI at the global scale. Many of the MBR representatives, essentially from developing countries, expressed the need for financial assistance. Despite the fact that all the MBRs possess the necessary infrastructure to at least carry out the most basic measurements, indicators that can be measured at relatively low cost with basic technological infrastructure, many of the MBRs from developing countries lack the advanced technology at the intermediate level of global change indicators. Ideally, assistance should be provided to these MBRs so that they can meet this intermediate level.

The range of research activities presented at the workshop were impressive and covered all aspects outlined in the Implementation Plan of the Mountain Research Initiative, from monitoring activities (e.g., glacier dynamics, climate, hydrology) through to process studies and modeling, which are on-going in several MBRs, to research programmes geared towards defining sustainable land use practices.

A more extensive description of the state of Global Change research in individual MBRs is available from the Proceedings of the Entlebuch kick-off workshop, which is currently being compiled by UNESCO-MAB.

3.2 *Commentaries from the point of view of global change programmes (Session 5)*

A number of scientists involved in international Global Change Programmes had the opportunity to briefly present (10 minutes) perspectives for Global Change Research in MBRs. A common thread throughout these presentations was that this new initiative is very welcome from both a research as well as a development perspective, but that we should be careful not to re-invent the wheel, particularly in the context of environmental monitoring. Notably, a large number of protocols are available and have been in use in some cases for

many decades, and therefore it would be advantageous to make use of them for implementing Global Change research activities in MBRs. Examples include the ongoing GLORIA (Global Observation Research initiative in Alpine Environments) initiative for monitoring climatic and vegetation changes on mountain summits or the World Glacier Monitoring Service that has been in operation for many decades. As regards the GLORIA approach, whose principal aim is the implementation of a long-term observation network to obtain standardized data in alpine environments, it was proposed that the actual European-wide network be extended worldwide and that the MRI/UNESCO initiative would provide the ideal platform to achieve this.

The contributions on land use/land cover change research, integrated ecosystem modeling and regional atmospheric modeling suggests that such activities despite their importance would be rather less straightforward to implement in MBRs and their environs, for a number of reasons, but are largely linked to financial constraints, this is particularly true for MBRs in developing countries. Nevertheless, these activities are important to keep in mind at least for the longer-term goals of the MRI/UNESCO initiative, and the inputs provided by the respective scientists were useful in providing a wider perspective.

Finally, the contributions on the relationship between biodiversity and ecosystem function and mountain biogeochemistry clearly showed the importance of the link between land use practices and fundamental ecological research. Judicious land use cannot be achieved without a profound knowledge of its associated ecological processes, be it through traditional or formal knowledge systems, nor is it possible to conduct ecological research without taking into account land use history and practices applied in the area under investigation. It has become clear that for pure methodological reasons we need a standard protocol for such research investigations otherwise results from the different studies will remain difficult to compare. .

In the context of climate monitoring, it was suggested that it would be quite appropriate to submit a GEF proposal for the establishment of a network of reference quality, high elevation climate observation system, an integrated global set of monitoring stations that are relayed by satellite, so that the data can be accessed worldwide. The idea of a “GLOBAL MOUNTAIN ENVIRONET” was welcomed by the workshop participants, and it was suggested that other aspects of Global Change Research in MBRs might be added to such a GEF effort.

3.3 Results from the Breakout Groups

Breakout Group “Monitoring Environmental Change in MBRs” (rapporteur: G. Grabherr)

For each environmental parameter to be monitored, it will be necessary to define such details as the method of data collection as well as the temporal and spatial considerations of data collection. In order to address the minimum set of required data, the initiative must evaluate and balance the cost of obtaining the data, the ease at which the data is obtained and the importance of the data. Furthermore, the programme must take into consideration the capacity of the biosphere reserves to carry out measurements and thus its availability to implement the collection of data.

The success of the initiative will largely depend on the data available as well as the collection of high quality and comparable data. Consequently, although high-quality monitoring systems

will be expensive, they will be necessary for ensuring that data are consistent. Moreover, the collection of high-quality information will likely be more attractive to funding agencies.

In order to effectively implement the monitoring programme, capacity building will be necessary and we should explore the development of training courses that would be specifically tailored to this programme. The training of personnel will facilitate the implementation of the initiative, and at the same time, serve to increase the skills of local people involved in the project and train them in the initiative thereby providing a sense of ownership in the process. The importance of the proceedings and other publications stemming from the thematic workshops and their diffusion among the Biosphere Reserve and science communities on the subject of global change should be highlighted. Other communication tools that would help in capacity building would include the creation of thematic websites and a discussion forum or bulletin board.

Monitoring activities in biosphere reserves are being carried out under the BRIM programme (Biosphere Reserve Integrated Monitoring), which places an important emphasis on the social dimensions of monitoring. As a precondition, monitoring should only be established if it adds to already existing observation networks or those that are in *status nascendi*. This is particularly valid for establishing stations for climate observations at high elevations and glacier mass balance monitoring. The core zone may provide perfect sites for looking at climate change effects on vegetation. However, other indicators such as birds should be included. Most of these mentioned observation activities could make use of the already existing standardised approaches in the different fields. Where possible, paleo studies should be taken into consideration. Exceptional events such as floods, fires, etc. should be protocolled in all BRs.

Further comments:

- a) Existing hydrological stations should be used and new ones established in collaboration with FRIEND and HELP projects of the UNESCO International Hydrological Programme (IHP).
- b) Climate change (sophisticated set of indicators): High elevation stations; calibration; indicators measured as precisely as possible; comparable and standardised equipment should be used at all sites to ensure consistency in data collection.
- c) Wherever possible, historical records of events in each BR should be established (e.g. paleo data; floods or droughts).

Breakout Group “Process Studies in MBRs” (rapporteur: W. Bowman)

The discussions in this breakout group focused on environmental forcing factors and the study of their impacts on ecological and hydrological processes; however, it was undisputed that economic driving factors are probably of equal or even greater importance in mountain regions, at least in the short- to medium term (i.e., over the coming few decades).

Process studies are important to better understand the consequences of global change on Mountain Biosphere Reserves (MBRs). Accurate predictions of future changes in pertinent resources (including ecosystem services, aesthetics) requires an understanding of how specific environmental forcing factors (e.g. climate change, land use) will change the component ecosystems. The goals of the process level studies are 1) to increase understanding of the

mechanisms that lead to environmental change, including the exceedance of thresholds that can initiate undesirable environmental conditions; 2) to provide future scenarios for biosphere reserve managers and the people who live in and use the reserve, and 3) to provide data for modeling studies in order to assist the MBR in its likely response to global change. The products provided by the process studies should include feedback to and from the MBR managers with a view to adaptive resource management so as to mitigate undesirable effects of global environmental change.

The resources of interest and the relative importance of environmental forcing factors will vary considerably among the Mountain Biosphere Reserves. Therefore rather than propose a set of universal experiments among the MBRs (and we recognize that there are many potential experiments that could be done in all or many of the set of selected reserves), we suggest the following strategy. First, stakeholders within the MBRs, including people using and living in the MBR, as well as managers and scientists, should provide input on the factors that are of concern. Secondly, existing studies, and proxies of paleoenvironmental change should be used where appropriate to help determine the possible range of variability for parameters of interest. This is particularly true where extreme events (e.g. floods, fires) are a concern. This cumulative information should be used to determine what variables should be measured, at what frequency, and what factors are experimentally manipulated.

Examples of process studies that could be performed in MBRs include:

- ❖ The influence of land use (e.g. grazing) on water yield and water quality
- ❖ The role of plant and soil biodiversity on ecosystem processes, particularly production, water yield and quality, nitrogen sequestration, and resilience to disturbances
- ❖ The influence of nitrogen deposition on ecosystem services

Process studies should include a replicated range of intensities or treatment levels along with appropriate control treatments, in order to evaluate system thresholds, i.e. the level at which an ecosystem is impacted before detrimental effects occur. As water quantity and quality are viewed as critical response variables in nearly all of the MBRs, catchment level studies are encouraged. Some treatments may not be appropriate in some MBRs (e.g. only one catchment, manipulative experiments not permitted), and thus variation in pre-existing conditions (e.g. variation in grazing intensities, variation in geomorphic disturbance) may be used as a surrogate for experimental procedure. This approach however is less desirable for statistical and interpretive reasons. New or existing management activities should be viewed as experiments that provide information on the processes that influence MBR resources, and should be coupled closely with monitoring activities to evaluate their influences.

It is hoped that networks of MBRs will develop process level experiments to address the comparative responses to global change. Such networks may be within a similar physiognomic region and constitute a “virtual Mountain Biosphere Reserve,” emphasizing sites where long-term environmental records and experimental sites exist. These networks should utilize existing protocols where available. An example of such protocols includes the GCTE “Network of Removal Experiments on the Role of Biodiversity in Ecosystem Functioning” (<http://gcte.org/Diaz.pdf>). Collaborations between developed and developing countries (e.g. US LTER and ILTER) to accomplish comparative process level studies are encouraged.

Breakout Group “Integrated Modeling for MBRs” (rapporteur: D. Fagre)

a) Values and Uses of Modeling

Models are not magic. Models structure existing information in ways that allow us to develop new ideas and pose new questions. Models summarize how we think an ecosystem works and how it will respond to drivers, forcing functions, or stressors but cannot be given much weight until validated by real world data. Models are simply hypotheses to be tested and improved. Models can fill in gaps where measurements or experiments cannot be performed. Models can provide common outputs for comparing mountain systems with mismatched datasets. Models are tools, not end products.

We determined that modeling is a very useful tool for Biosphere Managers because it provides information not currently available from monitoring or process studies alone. Modeling can shape a MBR manager’s views of potential future conditions to make more informed decisions in the present. Modeling can help managers better understand the underlying dynamics of ongoing change, possibly identifying thresholds of irreversible change or other unexpected consequences of land use and climatic change.

Models must be implemented or developed with inputs from, and linkages to, MBR managers to make sure that relevant questions are answered. Modeling provides explicit forecasting value but, like weather forecasts for the coming week, should be used cautiously.

b) Examples and range of models

Models can be conceptual, empirical or statistical, spatially or temporally extrapolative, scale independent, biogeographic (geospatial), deterministic, mechanistic, first principal-based, process-oriented, nested, integrative and simulation-based or combinations thereof but they all seek to improve our understanding of system behavior so that we can better “anticipate” the future.

c) Suggested Modeling Activities for MBRs

There is a need for a complete inventory of available data at each MBR. The data that modelers can access will determine which models can be used, the spatial and temporal scales that can be addressed, and the priority for acquiring new data. The goal is to have a minimum common dataset to support modeling and to standardize the model (and its application) being used to answer basic questions. This step will facilitate direct comparisons between MBRs (where possible).

We decided that a series of ecosystem processes were important to model for management of MBRs in the face of global change and to clarify the value of MBRs to society (e.g. ecosystem services). These are:

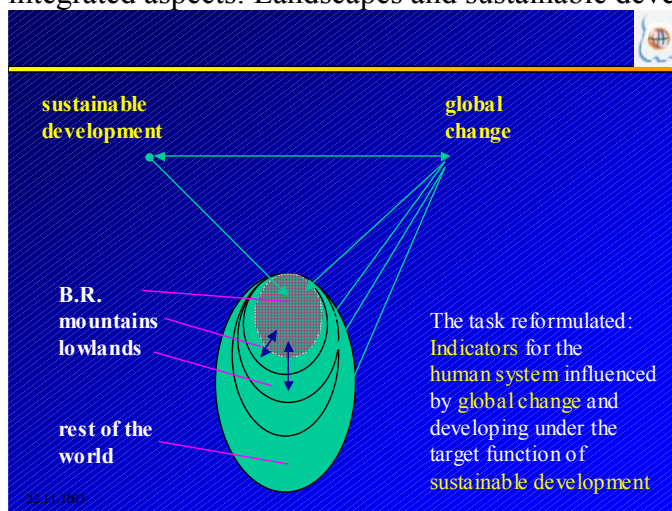
- Hydrology – the change in quantity and timing of the MBR water output
- Land Cover – a proxy for productivity, structure and function
- Carbon flux – impacts of changes in climate, grazing and logging on carbon stocks (balance), rates of fixation (growth, Net Primary Productivity)
- Nitrogen – critical to ecosystem dynamics
- Disturbance role – ecosystem sensitivity to perturbation, future range of variability

Three different levels of intensity of the possible modeling activities were distinguished by this Breakout Group, with recommendations for each level. A complete account of the discussion results can be found in the Proceedings of the Entlebuch workshop.

Breakout Group “Sustainable Development in MBRs” (rapporteur: J. Stadelbauer)

a) Defining the task, the aim and the conditions of the search

The task concerns the human system integrated into biosphere reserves. Monitoring of social, cultural, economic and political variables in the context of ecological issues. Land-use, water, integrated aspects: Landscapes and sustainable development



More precisely:

- Identification of indicators for a system of continuous monitoring
- Indicators of sustainability
- Evaluation of practicability of the indicators
- Suggestions for the creation of a differentiated system for socio-economic monitoring of sustainable development

Main problems

- awareness of the task: specific indicators of sustainability
- practicability of the indicators (availability of data)
- systemic interference of the indicators
- difference and lack of comparability of the MBRs

Therefore, two leading questions can be formulated:

- 1 How many indicators or parameters are necessary in order to describe the effects of sustainability in a mountain biosphere reserve under the conditions of globalisation? Do we need a large „shopping list“ of indicators or can we see a real reduction of parameters?
- 2 Is there an order of indicators? Which ones are the key/core indicators, which ones those for advanced surveys, which ones those for more sophisticated research?

Furthermore, the conditions of living in MBRs have to be taken into account:

- It is necessary to take into account the vulnerability and the continuous coping of the population with uncertainties.
- We may not neglect the dependence of biosphere reserves on state subsidies

b) Identifying the indicators

A list was developed during the discussion session that contains the indicators that were identified as being relevant in describing the development of MBRs. The impact of globalisation is a secondary one; its relation to the development of MBRs depends on hypotheses on the influence of globalisation on economy and society. Thus, local population dynamics are regarded as being relevant if we assume that sustainability needs a continuous composition of all age groups, a balance of male and female population, that global change means a decreasing population in the post-industrial societies and a further increase of population in low income countries. The balance of immigration and emigration is interconnected to the local population dynamics because this indicator regards the out-migrating and immigrating groups (people in the working age leaving the MBR region? Old people immigrating for recreation and permanent residence?). The full set of indicators (including a list of key priorities) can be found in the Workshop Proceedings volume.

c) Summary

A small number of (normally) easily available variables should be used as key indicators:

- Local population dynamics. Immigration/emigration – reasons: economic, political reasons, disasters: why? Ethnic composition of the population
- Institutions and rules
- Seasonal water availability and quality. Energy supply and consumption
- Earning opportunities. Food securityInvestment and subsidies
- Governance. Tensions and conflicts. However, in reality it may often be quite difficult to reach the aim of collecting a few relevant indicators:
 - A large system of hypotheses and related indicators is necessary
 - The search for relevant indicators should be regarded as a chance for more sophisticated socio-economic research on a balance between ecological demands, conditions of global change, economic strategies and political realisation.

3.3 Results of the Final Session

During the Final Plenary Session, many participants expressed their interest to be involved in the future development of this new initiative. Global Change processes are often judged as being of high relevance for the future sustainable use of land in MBRs (and elsewhere), and hence the MRI/UNESCO initiative we welcomed as being useful and timely. Also, it was generally found that the present workshop had been a good start for putting things into practice. It was emphasized by many participants that training aspects are quite important, so that research activities can be conducted locally, without long-term dependencies on scientists from abroad.

UNESCO-MAB informed the workshop participants about their plans to get endorsement for the MRI/UNESCO initiative from the International UNESCO-MAB Secretariat for those MBRs that expressed their desire to be involved in the initiative.

A number of participants informed the audience about their plans for regional workshops or similar events to carry the new initiative a step further. These include (1) a national Russian network to foster the implementation of the MRI activities at the national scale; (2) the western climate science initiative in North America, which has already produced a white paper, and will hold a larger workshop (100 participants) in May 2004; (3) an IHP workshop in 2004

to discuss the state of the Andean glaciers and the associated research efforts; and (4) a regional meeting in South America in early 2004 that will discuss the implementation of MRI Activities in South American MBRs.

The participants agreed that one important next step would be to perform a survey of the indicator variables that are being collected in the MBRs, so as to define the next practical steps. Also, the workshop participants were informed that the European Union has agreed to fund through its 6th Framework Programme an initiative that serves to define the implementation of Global Change Research Activities in MBRs at an operational level. To this end, a series of four workshops culminating in an Open Science Conference is foreseen, to be taking place within the coming 24 months. These events will be coordinated through the MRI Office. The first workshop, entitled “Global Environmental and Social Monitoring”, has been scheduled to take place from 9-11 May 2004 in Vienna, under the guidance of Prof. Georg Grabherr. Further workshops on Process Studies, Integrated Modeling and Sustainable Development will follow in Fall 2004, Spring 2005 and Summer 2005, respectively, culminating with the Open Science Conference to follow, possibly in late 2005.

4. Workshop Products

The workshop participants agreed that two major products would be sought from this event, the first in the short term, whereas the second has a medium-term perspective, as follows:

- 1) A written compilation of the state of research in the MBRs that were selected for the workshop. It is anticipated that the compilations will be published in “synthesis” form as a proceedings volume by UNESCO-MAB. This will include, through the outcome of the discussion reports from the Breakout Groups, recommendations about *which* research activities should be implemented in MBRs, and *how*, including a review of possible conceptual, technical and technological limitations.
- 2) A handbook or manual (to be completed after the workshop, based on inputs from workshop participants plus additional efforts to be conducted in the future) describing the technical details of these measurements and activities. Notably, the series of workshops to be held during the coming 2 years will be instrumental for addressing these questions in detail.

5. Workshop Conclusions

The UNESCO/MRI Workshop held 10-13 November 2003 in Entlebuch Biosphere Reserve had originally been planned as a small gathering of perhaps 20-30 persons. The organizers were overwhelmed by the expressions of interest to participate that came from both managers of biosphere reserves as well as from scientists involved in Global Change research activities. Hence, the size and the fruitful discussions of the Entlebuch workshop clearly demonstrate the strong interest in and the concern about Global Change impacts and the associated research activities from the point of view of the managers of Mountain Biosphere Reserves, but also from the point of view of the scientific research community.

The participants welcomed this new UNESCO/MRI initiative and expressed their interest to stay involved in the future development of this endeavour. Particularly, the following recommendations emerge from the deliberations in the plenary discussions as well as during the Breakout Group session at the Entlebuch workshop:

- 1) The workshop was judged to be a success, both from the perspective of the MBRs as well as from a scientific point of view. It is clear that scientific research cannot and should not be restricted to the subset of questions that is of immediate relevance for MBR managers. However, it was agreed that there exists a considerable overlap in the interests of MBR managers and Global Change scientists, and the new initiative should aim to build upon these potential synergies.
- 2) The present workshop can only be considered as the first in a series that will need to be held to define the MRI activities to an operational level in the context of MBRs and their regional needs. It is appreciated that significant funding is available from the 6th Framework Programme of the European Commission, and it was also welcomed that UNESCO is likely to be able to contribute some additional funding to this endeavour.
- 3) The MRI Coordination Office should take the lead for carrying this initiative further, in close collaboration with the UNESCO-MAB Secretariat in Paris.

Overall, the workshop participants are convinced that this workshop has been the first step in an exciting new collaboration that has the potential to be for the mutual benefit of both Biosphere Reserve Managers as well as the global scientific community interested in the impacts and feedbacks of global change processes in fragile mountain environments.

Appendix

List of Participants

Mountain Biosphere Reserves

Australia: Kosciuskko BR

Dr. Ken Green
Alpine Ecologist
Snowy Mountains Region
NSW National Parks and Wildlife
PO Box 2228
Jindabyne 2627
Australia
Tel: (02) 6450 5538
Fax (02) 6456 2291
E-mail: ken.green@npws.nsw.gov.au

Austria: Gossenköller See

Prof. Dr. Roland Psenner
Institute of Zoology and Limnology
University of Innsbruck
Technikerstr. 25 A-6020 Innsbruck
Tel: 0043/512-507-6130
Fax: (43 512) 507 29 30
E-mail: roland.psenner@uibk.ac.at

Canada: Arrowsmith BR

Dr. Glen Jamieson
Pacific Biological Station
Fisheries and Oceans Canada
Nanaimo, BC, V9T 6N7
Canada
Tel: (1 250) 756 7223
Fax: (1 250) 756 7138
E-mail: jamiesong@pac.dfo-mpo.gc.ca

China: Changbaishan BR

Mr Li Yang
Changbaishan Natural Reserve
Erdao town 133613
Antu County
Jilin Province
People's Republic of China
Tel: 86-433-5710248(office)
Tel: 86-433-5710739(home)
Fax: 0086-433-5714099
Mobile ph: 13844736687
E-mail: liyang065@sina.com

Colombia: Cinturón Andino BR

Marcela Cañón
Unidad Administrativa Especial del Sistema de
Parques Nacionales Naturales
Ministerio de Ambiente, Vivienda y Desarrollo
Bogotá, D.C.
Colombia

Tel: (57 1) 2865869
Fax: (57 1) 3410676 /3412218
E-mail: mcanon@parquesnacionales.gov.co

Germany: Berchtesgaden Alps BR

Dr. Michael Vogel
Nationalpark Berchtesgaden
Doktorberg 6
83471 Berchtesgaden
Germany
Tel: (+49-8652) 968622
Fax: (+49-8652) 968640
E-mail: m.vogel@nationalpark-berchtesgaden.de

Kenya: Mount Kenya BR

Prof Francis Ojany
Chairperson of MAB National Committee of Kenya
University of Nairobi
P.O. Box 30197
Nairobi
Kenya
Tel: (254 2) 217924
Fax: (254 2) 583568
E-mail: ojany@bidii.com

Kyrgyzstan: Issyk-Kul BR

Mr Erkinbek Kojekov
Scientific Secretary
Kyrgyzpatent International Relations Division,
National Academy of Sciences of the Kyrgyz
Republic
62, Moskovskaya Str.
Bishkek
Kyrgyzstan
Tel: (+996-312) 68 08 19
Tel/Fax: (+996-312) 68 17 03
E-mail: erkinmail@rambler.ru
erkinmail@netmail.kg

Mongolia: Uvs Nuur Basin BR

Mr. Bayarsaikhan Bayarmagnai
Chairperson
Division for Special Protected Area Management
Ministry of Nature and Environment
Government Building III, Baga Toiruu 44,
210620 Ulaanbaatar
Mongolia
Tel: (976 11) 323 273
Fax: (976 11) 323 273
E-mail: bbmagnai@yahoo.com

Morocco: Oasis du Sud BR

Mr Driss Fassi
Secrétaire

Institut Agronomique et Vétérinaire Hassan II
B.P. 6202
Rabat
Morocco
Tel/Fax: (212.37) 68 13 58 (office)
Tel/Fax: (212.37) 60 19 88 (home)
E-mail: Idrissfassi@yahoo.fr

Peru: Huascarán BR

Mr Marco Zapata
Specialist of Glaciology Department
INRENA – Huaraz
Av. Confraternidad Internacional Oeste 167. Huaraz
Peru
Tel: (+51-43) 72-1601
E-mail: glaciologiahuaraz@terra.com.pe

Mr Jorge Recharte
Director of The Mountain Institute
The Mountain Institute, Andean Programme
Pasaje Ricardo Palma 100
Soledad – Huaraz
Peru
Tel: (+51-43) 72-3446
TMI Peru Lima Office = (51-1) 4218942 (telefax)
TMI Peru Huaraz Office = (51-44) 726610 (fax)
E-mail: jrecharte@mountain.org

Russian Federation: Katunsky BR (Altai)

Mr. Alexander Viktorovich Zateev
P.O. Box 24
Zapovednaya St. 1
v. Ust-Koksa 649490
Altai Republic
Russian Federation
Tel/Fax: + 7 (38848)22946
E-mail: katunskiy@mail.ru

Dr. Yuri P. Badenkov
Institute of Geography
Russian Academy of Science
29, Staromonetny
119017 Moscow Russia
Tel: +7 (095) 418 55 32
Fax: +7 (095) 959 00 33
E-mail: yubaden@mail.ru

Vladimir N. Bolshakov
Director Institute of Plants and Animals Ecology
Russian Academy of Science Ural Branch
Tel: +7 (3432) 74 49 68
Fax: +7 (095) 938 22 11
E-mail: vladimir.bolshakov@ipae.uran.ru
kharitonova@ural.ras.ru (Moscow office)

Sweden: Lake Torne BR

Mr Christer Jonasson
Deputy Director
Associate Professor

Abisko Scientific Research Station
981 07 Abisko
Tel: (+46-980) 401 79
Fax: (+46-980) 401 71
E-mail: christer.jonasson@ans.kiruna.se

Switzerland: Entlebuch BR

Dr. Engelbert Ruoss
Chlosterbuel 28
CH-6170 Schüpfheim
Switzerland
Tel: (+41-41) 485-8852
Fax: (+41-41) 485-8801
E-mail: e.ruoss@biosphaere.ch

Switzerland: Swiss National Park

Dr. Thomas Scheurer
Coordinator of the Research Committee of the
Swiss National Park
Oberdorfstrasse 83
CH-3053 Münchenbuchsee
E-mail: icas@sanw.unibe.ch

USA: Glacier National Park BR; Niwot Ridge BR; Alaska: Denali BR; Olympic BR

Daniel B. Fagre, Ph.D.
USGS Science Center
Glacier National Park
West Glacier, MT 59936
USA
Tel: 406-888-7922
Fax: 406-888-7990
dan_fagre@usgs.gov
<http://nrmssc.usgs.gov>

Scientific Participants (MRI, MAB, IHP)

Dr. Jill Baron
Natural Resource Ecology Laboratory
Natural and Environmental Sciences Building,
Room B225
Colorado State University
Fort Collins, Colorado 80523
USA
Tel: (970) 491-1968
Fax: (970) 491-1965
Home: (970) 221-4879
E-Mail: jill@nrel.colostate.edu

Dr. Neil Bayfield
CEH Banchory
AB314BY
Kincardineshire
Great Britain
Tel: (44 1) 330 826345
(44 1) 330 823303
E-mail: nb@ceh.ac.uk

Prof. Alfred Becker

Potsdam Institute for Climate Impact Research
PO Box 601203
144412 Potsdam
Germany
E-mail: becker@pik-potsdam.de

Dr. Astrid Björnsen Gurung
The Mountain Research Initiative
Bärenplatz 2
3011 Bern
Switzerland
Tel: (41 31) 328 23 31
Fax: (41 31) 328 23 20
E-mail: bjoernsen@sanw.unibe.ch

Ms. Bettina Büchler
The Mountain Research Initiative
Bärenplatz 2
3011 Bern
Switzerland
Tel: (41 31) 328 23 31
Fax: (41 31) 328 23 20
E-mail: buechler@sanw.unibe.ch

Prof. Harald Bugmann
Departement Forstwissenschaften
Gebirgswaldökologie
ETH Zürich
Zentrum
8092 Zürich
Switzerland
Tel: (41 1) 632 32 39 or (41 1) 632 32 36
Fax: (41 1) 632 11 46
E-mail: bugmann@fowi.ethz.ch

Dr. William D. Bowman
University of Colorado
INSTAAR
Environmental, Population and Organismic Biology
80309 Boulder, CO
USA
Tel: (1 303) 492 25 57
Fax: (1 303) 492 86 99
E-mail: bowman@spot.colorado.edu

Prof. Raymond S. Bradley
Department of Geosciences
University of Massachusetts
Morrill Science Center, 611 North Pleasant Street
Amherst, MA, 01003-9297
United States of America
Tel: (1 413) 545 2120
Fax: (1 413) 545 1200
E-mail: rbradley@geo.umass.edu

Dr. Jean-Jacques Brun
CEMAGREF
La Recherche pour L'Ingénierie de l'Agriculture et
de l'Environnement
Equipe Ecologie Spatiale et Fonctionnelle

U.R. Ecosystèmes et Paysages Montagnards
2, rue de la papeterie, Domaine Universitaire - BP
76
38402 Saint Martin d'Hères
France
Tel: (33 4) 76 76 27 79
Fax: (33 4) 76 51 38 03
E-mail: jean-jacques.brun@grenoble.cemagref.fr

Prof. Bernard Debarbieux
Dépt. de Géographie
Université de Genève
102, Bd. Carl-Vogt
1211 Genève 4
Tel: +41 (0) 22 379 83 38/32
Fax: +41 (0) 22 379 83 53
E-mail: debarbieux@geo.unige.ch
<http://www.unige.ch/ses/geo/>

Dr. Jean-Pierre Dedieu
UJF / CNRS
Laboratoire de Glaciologie et Géophysique de
l'Environnement
54, rue Molière
38402 Saint Martin d'Hères Cedex
France
Tel: (33 4) 76 82 42 00 / 74
Fax: (33 4) 76 82 42 01
E-mail: dedieu@lgge.obs.ujf-grenoble.fr

Prof. Dr. Georg Grabherr
Institut für Ökologie und Naturschutz der
Universität Wien
Althanstrasse 14
A-1090 Wien
Austria
Tel: (43 1) 4277 543 70
Fax: (43 1) 313 36 776/(43 22) 73 2
E-mail: georg.grabherr@univie.ac.at
grab@pflaphy.pph.univie.ac.at

Mr. Gurung Ghana S.
Geographisches Institut - Human Geography
Universität Zürich
Winterthurerstr. 190 - Irchel
8057 Zürich
Tel: (41 1) 635 51 86/78 ; +41 (0) 1 635 51 11
Fax: (41 1) 635 51 68 07
E-mail: ghanag@geo-unizh.ch
<http://www.geo.unizh.ch/human>

Prof. Wilfried Haeberli
Director
Physical Geography
Geographisches Institut
Universität Zürich
Winterthurerstr. 190 - Irchel
805 Zürich
Switzerland
Tel: (41 1) 635 51 20

Tel 2: (41 1) 635 51 21
Fax: (41 1) 635 68 48
E-mail: haeberli@geo.unizh.ch

Dr. Douglas Hardy
Department of Geosciences
Morrill Science Center
Univ. of Massachusetts
Amherst MA, 01003-9297
United States of America
Tel: (1 802) 649 1829 ; (1 413) 545 0659
Fax: 413 545 1200 / 802 649 1829
E-mail: dhardy@geo.umass.edu

Ms. Daniela Hohenwallner
Institut für Ökologie und Naturschutz der
Universität Wien
Althanstrasse 14
A-1090 Wien
Austria
Tel: (43 1) 4277 54 383
E-mail: hohenw@pflaphy.pph.univie.ac.at

Dr. Narpat Jodha
Agricultural and Rural Income Diversification
Programme
ICIMOD
P.O. Box 3226
Kathmandu
Nepal
Tel: (977 1) 5525313
Fax: (977 1) 5524509
E-mail: njodha@icimod.org.np

Dr. Georg Kaser
Institut für Geographie
Universität Innsbruck
Innrain 52
6020 Innsbruck
Austria
Tel: (43 512) 507 5407
Fax: (43 512) 507 2895
E-mail: georg.kaser@uibk.ac.at

Prof. Christian Körner
Botanisches Institut - Pflanzenökologie
Schönbeinstrasse 6
4056
Basel
Tel: (41 61) 267 35 10
Tel 2: (41 61) 267 35 00
Fax: (41 61) 267 35 04
E-mail: ch.koerner@unibas.ch

Ms. Cathy Lee
Division of Ecological Sciences
UNESCO
1, rue Miollis
FR-75732 Paris Cedex 15
France

Tel: (33 1) 45 68 41 73
Fax: (33 1) 45 68 58 04
E-mail: c.lee@unesco.org

Prof. George Malanson
Department of Geography
University of Iowa
316 Jessup Hall
Iowa City, IA, Iowa 52242
United States of America
Tel: (1 319) 335 0540
Fax: (1 319) 335 2725
E-mail: george-malanson@uiowa.edu

Dr. Lalji Mandalia
UNESCO
International Hydrological Programme (IHP)
Division of Water Sciences
1, rue Miollis
75732 Paris Cedex 15
France
Tel: (+33-1) 45.68.40.54
Fax: (+33-1) 45.68.58.11
E-mail: l.mandalia@unesco.org

Dr. Daniel Maselli
Geographisches Institut - Centre for Development
and Environment (CDE)
Universität Bern
Steigerhubelstrasse 3
3008 Bern
Tel: +41 (0) 31 631 52 81 ; +41 (0) 31 631 52 72
Fax: +41 (0) 31 631 85 44
E-mail: daniel.maselli@giub.unibe.ch

Prof. Bruno Messerli
Geographisches Institut
Universität Bern
Hallerstrasse 12
3012 Bern
Switzerland
Tel: (41 31) 819 33 81
Fax: (41 31) 819 76 81
E-mail: bmesserli@bluewin.ch

Dr. Constance I. Millar
PSW Research Station
USDA Forest Service
800 Buchanan St
94710 Albany, CA
USA
Tel: (1 510) 559 6435
Fax: (1 510) 559 6499
E-mail: cmillar@fs.fed.us

Dr. Harald Pauli
Institut für Ökologie und Naturschutz
Universität Wien
Althanstr. 14
1090 Wien

Austria
Tel: (43 1) 42 77 54 383
E-mail: pauli@pflaphy.pph.univie.ac.at

Prof. Martin F. Price
Dr. Martin F. Price
Centre for Mountain Studies
UHI Millennium Institute
Crieff Road
Perth PH1 2NX
Great Britain
Tel: (44) 1738 877 217
Fax: (44) 1738 877 018
E-mail: martin.price@perth.uhi.ac.uk
<http://www.cms.uhi.ac.uk>

Dr. Yannis Raftoyannis
Laboratory of Forest Protection
Department of Forestry
TEI Lamias
GR-36100 Karpenisi
Greece
Tel: (30) 22370 25063
Fax: (30) 22370 24035
E-mail: rafto@teilam.gr

Prof. P.S. Ramakrishnan
UGC Emeritus Professor

School of Environmental Sciences
Jawaharlal Nehru University
New Delhi, 110067
India
Tel: 0091 11 26704326
Fax: 0091 11 26162276
E-mail: psrama2001@yahoo.com

Dr. Mel Reasoner
MRI The Mountain Research Initiative
Bärenplatz 2
3011 Bern
Switzerland
Tel: (41 31) 328 23 30 / 31
Fax: (41 31) 328 23 20
E-mail: reasoner@sanw.unibe.ch

(as far as I gather - he didn't attend)

Dr. Thomas Schaaf
UNESCO
Man and the Biosphere (MAB) Programme
Division of Ecological Sciences
1, rue Miollis
75732 Paris Cedex 15
France
Tel: (+33-1) 45 68 40 65
Fax: (+33-1) 45 68 58 32
E-mail: t.schaaf@unesco.org

Ms. Annette Schmid

Geographisches Institut - Economic Geography
Universität Zürich
Winterthurerstr. 190
8057 Zürich, ZH
Tel: +41 (0) 1 635 52 45 / 51 11
Fax: +41 (0) 1 635 68 48
E-mail: a.schmid@geo.unizh.ch
<http://www.geo.unizh.ch/~a.schmid>

Prof. Hans Schreier
Institute for Resources and Environment
2206 East Mall
Vancouver, B.C. V6T 1Z3
Canada
Tel: (604)-822-4401
Fax: (604)-822-9250
E-mail: star@interchange.ubc.ca
Website: <http://www.ire.ubc.ca/hans/>

Dr. Joerg Stadelbauer
Department of Cultural Geography
University of Freiburg
Werderring 4
79085 Freiburg
Germany
Tel: (49761) 203 3577
Fax: (49761) 203 3575
E-mail: joerg.stadelbauer@geographie.uni-freiburg.de

Mrs. Ursula Schüpbach
Managementzentrum
UNESCO Weltnaturerbe Jungfrau-Aletsch-
Bietschorn
Jungfraustrasse 38
3800 Interlaken
Tel: +41 (0) 33 821 61 76 ; +41 (0) 79 418 23 31
Fax: +41 (0) 33 821 08 67
E-mail: ursula.schuepbach@weltnaturerbe.ch

Mr. Marco Verdecchia
Dipartimento di Fisica
Universita degli Studi dell'Aquila
Via Vetoio
IT-67010 Coppito
Italy
Fax: +39 862 433089
E-mail: marco.verdecchia@aquila.infn.it