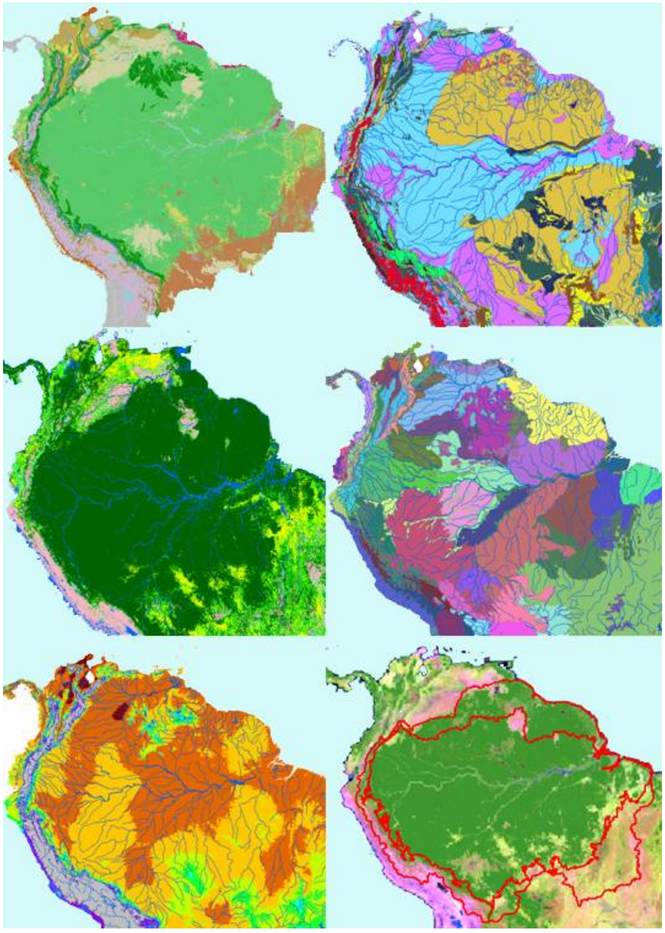
A PROPOSAL FOR DEFINING THE GEOGRAPHICAL BOUNDARIES OF AMAZONIA



Synthesis of the results from an Expert Consultation Workshop organized by the European Commission in collaboration with the Amazon Cooperation Treaty Organization - JRC Ispra, 7-8 June 2005

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A PROPOSAL FOR DEFINING THE GEOGRAPHICAL BOUNDARIES OF AMAZONIA

Synthesis of the results from an Expert Consultation Workshop organized by the European Commission in collaboration with the Amazon Cooperation Treaty Organization - JRC Ispra, 7-8 June 2005

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and with forewords by

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Figure 1: The proposed delimitation – Amazonia *sensu latissimo* (in red) – consisting of a core subregion Amazonia *sensu stricto* (dotted line) and four peripheral subregions, Andes, Planalto, Guiana and Gurupí.

Executive summary

At the end of 2004 Mrs. Rosalía Arteaga Serrano, Secretary-General of the Amazon Cooperation Treaty Organization (ACTO), asked the President of the European Commission for the scientific and technical support of the Commission's Joint Research Centre (JRC) in ***defining the geographical boundaries of Amazonia.***

The European Commission responded positively to the request from ACTO through a letter of JRC Acting Director General Roland Schenkel dated 22nd December 2004, offering the expertise of the Joint Research Centre.

The task is being coordinated by the JRC's Institute for Environment and Sustainability (IES) in Ispra (Italy). IES staff have been consulting with Latin American scientists and collecting available map and satellite data to support the work.

As part of the process, IES organised a two day workshop of selected European experts on Amazonia, held at the JRC Ispra site on the 7th and 8th of June, 2005. The experts came together to present current thinking on the geographical borders of Amazonia from different scientific perspectives, such as climate, hydrology, flora, fauna, ecology and biogeography.

The invited experts represented a range of geographic areas and major research initiatives on Amazonia and included a number of former and current directors of major institutions active in the region.

ACTO Secretary-General Rosalía Arteaga Serrano and ACTO Executive Director Francisco Ruiz attended the first day of the meeting.

It was stressed by Commission staff that the workshop was part of a supportive effort for ACTO, not to determine the outcome, but to provide possible solutions, or input to solutions, for discussion with Latin American experts. The effort is also a scientific exercise, based on biophysical rather than political criteria.

After a series of oral and illustrated presentations made by each of the 16 experts and by Commission staff, an overview of the proposed criteria for the definition of the area of Amazonia was elaborated. On the second day a final proposal was unanimously made and was agreed upon by the Expert Group. A physical description and a map were produced.

The scientific basis for the proposal to delimit the Amazon region, was derived from Article II of the Amazon Cooperation Treaty itself.

"ARTICLE II. This Treaty shall be in force in the territories of the Contracting Parties in the Amazon River Basin as well as in any territory of a Contracting Party which, by virtue of its geographical, ecological or economic characteristics, is considered closely connected with that Basin."

It was agreed upon to use essentially the following three criteria:

1) an **hydrographical** criterion, based on the total extent of the Amazon Basin (including the Amazon and Tocantins river systems) which forms the central constituent of the definition.
2) an **ecological** criterion, subdividing the Amazon Basin (as defined above) in various subregions, which are belonging to different ecoregions, but still exercise strong direct or indirect influences on the lowland Amazon region.
3) a **biogeographical** criterion, complementing the formerly defined area of the Amazon Basin by using as an indicator the known historical extent of the Amazon lowland rainforest biome in northern South America (taken or inferred from the TREES map of 1999; with south and eastern borders delimited according to Soares, 1953).

The result is shown in Figure 1, where an Amazonia *sensu latissimo* (in red) gives the full extent of the delimitation. However, accepting the wide biogeographic and geomorphological differences, the region is divided into five subregions: one core subregion (Amazonia *sensu stricto*) and four peripheral: Andes, Planalto, Guiana and Gurupí. The **Amazonia** *sensu stricto* subregion is defined by the limit of the Amazon Basin in the north, the 700 m contour in the west and the lowland Amazon rainforest biome (before exploitation) in the south and south-east. The **Andes** subregion is from the 700 m altitudinal zone up to the watershed of the Amazon Basin. The **Planalto** subregion is the area between the Amazon lowland rainforest boundary and the limits of the Amazon/Tocantins headwaters in Bolivia and southern Brazil. The **Guiana** subregion is bound in the north by the Atlantic coast and the Orinoco and Vichada rivers, whereas the southern limit is formed by the watershed with the Amazon River Basin. The **Gurupí** subregion is located to the east, outside of the Amazon/Tocantins river basins, but is covered by the Amazon lowland rainforest, with limits defined by Soares (1953).

The use of these five subregions (Amazonia *sensu stricto*, Andes, Planalto, Guiana and Gurupí) allows a flexibility that would be impossible with one sole region.

It was stressed that this does not need to be the definitive solution, but a proposition which can serve as a basis for discussion with scientists and stakeholders in the ACTO Member States.

Foreword by

Rosalía Arteaga Serrano
Secretary-General
Amazon Cooperation Treaty Organization

Ever since the governments of Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela honoured me with the task of becoming Secretary-General of the recently created Amazon Cooperation Treaty Organization (ACTO), to contribute in a joint effort to the sustainable development of this strategic region of the planet and heart of the South American subcontinent, we have seen ourselves hindered by situations where it is essential to start with a key question: what is 'Amazonia', its limits, its outreaches and, of course, its challenges?

It is not in vain that the specialists talk about the heterogeneity and multiplicity of the Amazonias, making reference not only to the eight countries and the French territory of Guiana which share this extraordinary biome, but also to the ecological, landscape, biological and cultural variety enclosed.

Already in 1992, the book "Amazonia Without Myths" (published by the then *pro-tempore* Secretary of the Amazon Cooperation Treaty with the support of the Inter-American Development Bank and the UNDP), which has become an important bibliographic reference on the region, pointed to the enormous difficulties in the attempt to define Amazonia, considering the diverse conceptual possibilities and applicable criteria: vegetation cover, altitudinal zones, river basin, political-administrative borders and, consequently, the inaccuracy of calculations on its geographical extension.

Of course, this is not only a formal question or an issue of pure academic interest. Building a consensus about the possible definitions will allow us to enhance our understanding of the current political, social, economic and ecological processes and their spatial expression (such as deforestation, land use, protected natural areas, etc.), as well as contribute to the development of better tools for sustainable land management.

For these reasons, we set ourselves the task of carrying out an exercise that revises and proposes our regional limits, with full respect for the territorial, political-administrative or any other delimitation which each Member State of the Amazon Cooperation Treaty Organization (ACTO) has done in sovereignty, in line with its constitutional and legal norms.

To achieve this goal, we started a discussion process with the Institute for Environment and Sustainability (IES), which forms part of the Joint Research Centre of the European Commission (JRC), taking advantage of its inherent technical capacities in global environmental monitoring, based on high-resolution satellite images. We agreed that the first phase of the process, whose outcome is the present technical report, should be concluded by gathering the most relevant European experts on Amazonia to embark on this discussion in a workshop, which indeed took place on the 6th and 7th June 2005.

The experience of the workshop made possible by the JRC, which is located in the lovely town of Ispra (Italy) at the shores of Lago Maggiore, cannot be erased from the minds of those of us who were present. The working group was made up of scientists from different European nationalities, all of them counting on a vast experience and studies carried out in Amazonia, in one or more countries of the region.

The participation of these experts, each of them belonging to a different area of knowledge, has been a privilege which will allow us, after carrying out a similar meeting, this time with scientists native to the Amazon region, to define Amazonia based on their particular academic perspectives and study experiences in the region.

In this way, geologists, geographers, hydrologists, pollen analysts, botanists, all gathered debating in loud voice about Amazonia, offered us during the two day workshop, and now through this publication, their knowledge, their wisdom, which allows us to understand better this region in which we have the opportunity to work. Equally, it allows us to get a more complete, more scientific view, of the complex reality of this region that hosts the largest biodiversity of the planet, this Amazonia that constitutes the biggest tropical rainforest of the Earth, that contains about 20% of the freshwater resources, and contributes to the regulation of the world's climate, just to mention some of the most relevant aspects that can be said about this region.

We received these reflections with open minds, and we hope that they will be studied in the same spirit and openness by all those who are interested in Amazonia, by those who love her, feel passion for her and take care of her conservation.

With the valuable input contained herein, we will invite as soon as possible the highest esteemed Amazon specialists from the ACTO Member States, as well as the relevant national research institutions, to complete the exercise, in order to enable us to build a consensus about the criteria and definitions that correspond to our regional reality, based on the best scientific practice available.

I wish to thank Mr. José Manuel Barroso, President of the European Commission, for his immediate attention to the cooperation request of the Organization, the personal engagement of the European Commissioner for Research Mr. Janez Potočnik, the Acting Director General of the JRC Mr. Roland Schenkel, the Director of IES Mr. Manfred Grasserbauer, as well as all researchers and specialists of the JRC and the universities, research centres and European institutions that generously offered their knowledge and experience to the success of this initiative. Especially, I want to express my acknowledgement to Hugh Eva and Otto Huber, coordinators of the project, and to Jan Marco Müller for his untiring effort to build a lasting relationship of cooperation between the EU and ACTO.

Foreword by

Manfred Grasserbauer
Director of the Institute for Environment and Sustainability
European Commission, Joint Research Centre

At first glance, defining Amazonia seems to be an easy task. However, when the Institute for Environment and Sustainability received through European Commission President José Manuel Barroso the request from the Amazon Cooperation Treaty Organization (ACTO) to support the development of a definition for the geographical delimitation of Amazonia, this proved to be a scientifically highly challenging exercise. The reason for this is the fact that the Amazon ecoregion is not necessarily identical with the Amazon river basin, both of them being areas facing permanent natural and man-made change.

Despite these difficulties, defining the geographical extension of Amazonia is of highest relevance for a large number of political issues, starting with a simple question like indicating the population of Amazonia, and ending up in complex problems such as estimating the carbon balance of the Amazon Basin as a key factor for global climate change. In fact, Amazonia is a set of ecosystems of truly global impact and thus its sustainable development is of highest importance not only for the countries involved, but for the entire international community, including the European Union. For this reason, the Joint Research Centre of the European Commission (JRC) has made the effort to support the Amazon Cooperation Treaty Organization as the only inter-governmental body with the mandate to strive for a sustainable development of Amazonia.

As a first product of this support to ACTO, it is my great pleasure to present this report which is the result of a consensus-building process among highly esteemed European experts for Amazonia, coordinated and facilitated by the JRC. It should be noted that the report does not reflect any official position of the European Commission, but is to be regarded as an independent opinion of leading European Amazon experts. Of course, the results need now to be discussed and validated with our colleagues from South America with the aim to come up with a common definition to be used as a reference whenever talking about Amazonia.

The Joint Research Centre feels honoured to be part of this process and this report is envisaged to be just a first step in a lasting collaboration with the Amazon Cooperation Treaty Organization. I would like to express my sincere thanks to Mrs Rosalía Arteaga Serrano, Secretary-General of ACTO, for the trust and confidence she placed into the expertise and coordination capacities of the JRC's Institute for Environment and Sustainability.

Finally, I would like to thank all experts who provided their high-level expertise in developing this proposal for a common definition of the area to be considered as Amazonia. A particular thanks goes to Hugh Eva and Otto Huber for being the technical coordinators of the report, our colleagues in the Spanish and Portuguese sections of the Directorate-General for Translation (DGT) and Mrs. Maria Helena Domingues Ramos for additional translations and finally to Jan Marco Müller for serving as the main point of interaction with the Amazon Cooperation Treaty Organization.

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1. Introduction

1.1. Objectives of the project

At the end of 2004 Mrs. Rosalía Arteaga Serrano, Secretary-General of the Amazon Cooperation Treaty Organization (ACTO), asked the President of the European Commission for the scientific and technical support of the Commission's Joint Research Centre (JRC) in ***defining the geographical boundaries of Amazonia.***

The Amazon Cooperation Treaty is a legal instrument signed in 1978 by Brazil, Bolivia, Peru, Ecuador, Colombia, Venezuela, Guyana and Suriname with the aim of fostering an integrated and sustainable development of the Amazon Region through multilateral or joint activities among the countries involved. Among the Treaty's objectives, particular importance is assigned to ensure a better environmental protection, the rational use of natural resources, and improve the living standards of Amazon populations.

Through an amendment to this Treaty in 1998, the signatory states agreed to set up the Amazon Cooperation Treaty Organization (ACTO) with its Permanent Secretariat in Brasilia as a mechanism for institutionally improving and strengthening the process of cooperation among the signatory countries and for enforcing the implementation of the Treaty. In 2003, the Permanent Secretariat became fully operational, developing the Strategic Plan 2004-2012, which was agreed by the Foreign Ministers of the ACTO Member States in September 2004.

The Strategic Plan is used as navigation chart, which contains ACTO's mandates that satisfy the various strategic axes and programmatic themes such as: Water; Forests, Soils and Protected Areas; Biological Diversity, Bio-Technology and Biotrade; Spatial Planning, Human Settlements and Indigenous Affairs; Social Infrastructure, Health and Education; Transportation, Electric Power and Communication Infrastructure. At present, however, the lack of an accepted definition of 'Amazonia' hampers the implementation of this programme.

The European Commission responded positively to the request from ACTO through a letter of JRC Acting Director General Roland Schenkel dated 22nd December 2004, offering the expertise of the Joint Research Centre. To effect this, the delineation of Amazonia has been incorporated into the Work Programme of the JRC's Institute for Environment and Sustainability, with the aim of providing a proposal, or set of proposals, to ACTO before September 2005.

1.2. Current problem posed by a lack of an agreed definition of Amazonia

Currently the contracting parties to the Amazon Cooperation Treaty Organization, the Republics of Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela, all use their own national definitions of Amazonia. These definitions can then be assembled to make up the territory for which the treaty is valid. Nations use different criteria to define their 'Amazonian' regions (Table 1). Some of these criteria are physical (*e.g.* a water basin or forest cover) and some are not (*i.e.* they are administrative). Even when countries use the same criteria, they may use different thresholds (*e.g.* altitudinal zones for differentiating between Andean and Amazonian regions).

While at a national level this poses no problem, and indeed is quite logical, at the regional level it can create difficulties in assembling data and statistics which are meaningful both in their content and in their spatial extent. In Venezuela, for example, three definitions of the Amazon Region could be made: that part of the country that drains to the Amazon River (53,280 km^2), the state of Amazonas (180,145 km^2) or the whole Guiana region (453,950 km^2). Another example of this is provided by the MAPAZ project (Projeto Meio Ambiente, População e Desenvolvimento da Amazônia) which aims to collect and harmonise population data on Amazonia. The recent publication 'Populações da Pan-Amazônia' (Aragon 2005) points to the difficulties of assembling and comparing such data due to a lack of a clear definition of the Amazon region. For the implementation of the ACTO Strategic Plan and for future planning, such data are essential.

Country	**Area included in the ACT (km^2)**	**Percentage (%)**	**Territory included**
Bolivia	600,000	7.9	River basin and forest
Brazil	5,144,800	76.8	Legal Amazon
Colombia	419,346	5.5	Legal Amazon
Ecuador	131,000	1.7	River basin and forest
Guyana	215,000	2.8	Forest
Peru	756,992	10.0	River basin and forest
Suriname	142,800	1.9	Forest
Venezuela	180,145	2.4	State of Amazonas
Total	**7,590,083**	**100.0**	

Table 1: Territories defined by each country as part of the Amazon Cooperation Treaty (ACT) and their respective areas, (Source: Gutiérrez, Acosta and Salazar 2004).

It should be noted that, for the purposes of this scientific study French Guiana has been included in the discussions, despite not being a member state of ACTO. Within this work, we use the term "Guiana" throughout for the designation of the physiographic region of northern South America centred on the Precambrian Guiana Shield and including much of southern Venezuela, Guyana, Suriname, French Guiana and a portion of southeastern Colombia and northern Brazil.

Figure 2: The territory covered by the Amazon Cooperation Treaty as defined by national entities (Source: derived from Aragón 2005 and Gutiérrez et. al 2004). Note: French Guiana is not an ACTO member state.

1.3. Proposed approach

The work programme proposed by the Joint Research Centre to respond to the ACTO request has three aspects: data collection, expert consultation and data generation and analysis.

The data collection consists of reviewing the current national definitions of 'Amazonia' along with ACTO's strategic document and published scientific and technical literature. At the same time existing map material and digital data were collected (a list is provided in the Annex).

Expert consultation is to be carried out at two levels, one scientific and the other more technical / managerial. These consultations should be carried out with different groups of experts: European scientists, Latin American scientists, national and international agencies involved in environmental management. The separation of European and Latin American experts has been undertaken for two reasons; i) the request from ACTO was for an independent view which can be furnished by the European experts, ii) for logistical reasons workshops bringing together trans-Atlantic groups are difficult and costly. The approach, approved by ACTO, is therefore to have the European experts propose a solution, the results being discussed and if the concept is accepted, fine-tuned at a second workshop of Latin American experts.

To support these activities, the Joint Research Centre is providing new remotely sensed data. The Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) for the year 2004 as derived from MODIS (Moderate Resolution Imaging Spectroradiometer) data is being analyzed to determine to what extent this parameter varies between different regions of the humid tropical forest biome in South America. For topography and hydrology, data from the Shuttle Radar Topography Mission (SRTM) are being exploited. This mission obtained elevation data on a near-global scale to generate a complete digital topographic database of Earth (http://srtm.usgs.gov/). It is hoped that the integration of these activities will support the goal of providing ACTO with options for defining the extent of the Amazon region.

2. European expert consultation workshop

2.1. Requirements

To establish a proposition for delineating the Amazon region, a group of high level European experts was solicited to come to Ispra and present the current thinking from a range of disciplines on Amazonian. The selection of the group was guided by a number of factors.

A small group was required to maintain discussion and focus. Established experts representing a range of disciplines from ecology, climate, phytogeography, zoogeography, geology etc. were requested to participate. It was felt necessary to have expertise that covered the full geographical extent of the Amazon region. We also targeted those European experts who have worked extensively in Amazonia and who have high scientific reputations there. A number of the invited experts are members of scientific committees in Latin America and some have received prestigious honours from ACTO Member States. It was also felt necessary to have representation of two major scientific projects LBA (*The Large Scale Biosphere Atmosphere Experiment*) and ABRACOS (*The Anglo-Brazilian Climate Observation Study*) present at the meeting.

The workshop was carried out over two days; on day one the experts gave a series of presentations relating to their discipline in the Amazon; on day two the workshop was led by Prof. Otto Huber in a consensus building session to arrive at a definition on Amazonia. Prof. Huber had previously led a similar activity in addressing conservation priorities in the Guiana Shield (Huber and Foster, 2003).

2.2. Expert group

The expert group covered seven broad areas of competence (Table 2). Two experts were unable to attend in person, but sent depositions.

The services of the European Commission were represented by:

- *Prof. M. Grasserbauer, IES Director, DG JRC*
- *Dr. A.S. Belward, DG JRC*
- *Dr. J.M. Müller, DG JRC*

The Amazon Cooperation Treaty Organization was represented by:

- *Mrs. R. Arteaga Serrano, Secretary General, ACTO*
- *Dr. F.J. Ruiz, Executive Director, ACTO*

Dr. G. Simon of the German cooperation agency *Gesellschaft für Technische Zusammenarbeit* (GTZ) also attended the meeting.

The list of presentations, the specific discipline of each expert, their current affiliation and their geographical area of expertise are given in Table 3. Biosketches are given in the Annex.

Flora and Phytogeography • *Prof. O. Huber* • *Prof. Sir G. Prance* • *Prof. S. Beck* • *Prof. A. Cleef* • *Prof. H. Balslev*	Geomorphology and Hydrology • *Dr. J. Duivenvoorden* • *Prof. W. Junk* • *Prof. J. Salo* • *Dr. J. Roberts*
Zoogeography • *Dr. M.S. Hoogmoed* • *Dr. C. Peres*	Climate • *Dr. B. Kruijt* • *Prof. P. Kabat** • *Dr. Y. Malhi*
Remote sensing and land cover mapping • *Prof. J.M. Periera* • *Dr. H.D. Eva* • *Dr. F. Achard*	Anthropology • *Dr. M. Colchester** Paleogeography • *Dr. H. Behling* * Deposition presented

Table 2: Experts and their broad fields of competence.

2.3. Options and methods for defining a region

The delineation of a region can be undertaken in a number of ways. The workshop's aim was to discuss potential approaches and if possible arrive at a biophysical definition which would not only satisfy scientific rigour, but also the programmatic issues ACTO is facing. The concept of defining an 'ecoregion' is not new. The World Wildlife Fund's full definition of an ecoregion is the following (Olson et al. 2001):

"A large area of land or water that contains a geographically distinct assemblage of natural communities that
(a) share a large majority of their species and ecological dynamics;
(b) share similar environmental conditions, and;
(c) interact ecologically in ways that are critical for their long-term persistence."

However at the same time, ACTO's strategic plan needs to be kept in mind. From this plan (ACTO 2004) one can identify three key issues:

a) The goal is for a sustainable development of the Amazon region;
b) There are a number of important cross cutting issues: forests; soils; water; protected areas; biological diversity, biotechnology and biotrade; human settlements and indigenous affairs; social infrastructure, health and education; transport, power and communication infrastructure.
c) The Treaty is there to help the parties find solutions to common problems that cut across national boundaries and which arise from sharing a common environment / ecoregion taking into consideration interfaces, included ecosystems and anthropic disturbances.

Expert	**Discipline**	**Geographical area**	**Affiliation**	**Presentation**
Frédéric Achard	*Carbon estimates*	**Tropics**	European Commission, JRC, Ispra, Italy	***The TREES project work in Amazonia***
Henrik Balslev	*Flora, Phytogeography*	**Ecuadorian Amazon**	Inst. of Biological Sciences, University of Aarhus, Denmark	***Palms and the delimitation of the Amazon region***
Stephan Beck	*Flora, Phytogeography*	**Bolivian Amazon**	National Herbarium, La Paz, Bolivia	***A perspective of Amazonia from Bolivia***
Hermann Behling	*Paleogeography*	**Brazilian Amazon**	Dept. of Geosciences, University of Bremen, Germany	***Late Quaternary Amazonian vegetation in space and time***
Antoine Cleef	*Andean Flora, Phytogeography*	**Colombian Amazon/Guianas**	Inst. for Biodiversity and Ecosystem Dynamics, University of Amsterdam, The Netherlands	***Amazonia versus Andes and Orinoquia***
Marcus Colchester	*Anthropology*	**Guianas**	Forest Peoples Program, UK	***Forest Peoples and the Amazon***
Joost Duivenvoorden	*Geomorphology, Ecology*	**Colombian Amazon**	Inst. for Biodiversity and Ecosystem Dynamics, University of Amsterdam, The Netherlands	***Landscape heterogeneity in Colombian Amazonia***
Hugh Eva	*Mapping Land cover and Fire*	**Tropical South America**	European Commission, JRC, Ispra, Italy	***Landcover mapping in tropical South America***
Marinus Hoogmoed	*Herpetology, Zoogeography*	**Guianas/Brazilian Amazon**	Museu Paraense Emilio Goeldi/CZO, Belém, Brazil	***Amazonia from the viewpoint of a herpetologist***
Otto Huber	*Phytogeography, Ecology*	**Venezuelan Amazon/Guianas**	Botanical Institute of Caracas, Venezuela	***Methods for defining Amazonia***
Wolfgang Junk	*Hydrology, Aquatic ecology*	**Brazilian Amazon**	Max-Planck-Institute for Limnology, Plön, Germany	***Amazonia: Delineation from a hydrological point of view***
Bart Kruijt & Pavel Kabat	*Climate, Hydrology*	**Brazilian Amazon**	Alterra, Green World Research, Wageningen Research Centre, The Netherlands	***A functional definition of Amazonia?***
Yadvidner Malhi	*Geography, Environment*	**Brazilian Amazon**	School of Geography and the Environment, University of Oxford, UK	***The deep time history of South American rainforests***
José Pereira	*Mapping Land cover and Fire*	**Amazonia**	Technical University of Lisbon, Portugal	***Landcover mapping in tropical South America***
Carlos Peres	*Mastozoology, Ecology*	**Brazilian Amazon**	School of Environmental Sciences, University of East Anglia, UK	***Vertebrate assemblage structure in Amazonian forests***
Sir Ghillean Prance	*Flora, Phytogeography*	**Brazilian Amazon**	School of Plant Sciences, University of Reading, UK	***Amazonia as defined by plant species distributions***
John Roberts	*Eco-Hydrology*	**Brazilian Amazon**	Centre for Ecology and Hydrology, Wallingford, UK	***Evaporation processes in tropical rainforest - Are the forests of Amazonia different?***
Jukka Salo	*Geomorphology, Hydrology*	**Peruvian & Ecuadorian Amazon**	Proyecto Biodamaz, Amazon Research Institute of Peru, Iquitos	***Geological evolution and forest heterogeneity of the Western Amazon***

Table 3: Experts and their respective disciplines, affiliations and presentations.

From a methodological point of view a region can be defined using a single discipline (*e.g.* hydrology) or a combination of disciplines (*e.g.* hydrology and land cover). We can identify a number of disciplines as potential candidates for defining a region (Table 4).

Biogeography, Phytogeography, Zoogeography and Paleogeography: *A definition based on the present and past distributions of fauna and flora*
Land cover / Vegetation*:* *The area dominated by the same land cover (e.g. dense evergreen humid forests)*
Hydrology: *A definition based on the water basin system and / or properties (white- / black-water)*
Geography: *An area defined with common geographical / geological characteristics*
Climatology: *An area defined on climatic variables*
Biophysics: *A region defined with the same biophysical (remote sensing) properties (e.g. FAPAR / surface temperature / 'roughness')*

Table 4: Examples of disciplines which could be used to define a region.

Once a discipline or set of disciplines has been chosen, we need to select what criteria and the limits of these criteria that define our region (Table 5).

Which discipline / disciplines?
Which criteria do we select within the chosen discipline(s)?
Which limits of these criteria are required to define our area?
How do we measure these limits?
Do we have the data to do this?

Table 5: Steps in defining a region.

If for example, we were to decide on the definition of a region as "humid lowland evergreen forests of the Amazon Basin" (Figure 3), we then need to agree on what measure, threshold and data source is used for each criterion. Even if the initial definition is agreed upon, subsequent thresholds and data sources may pose problems, especially when in the case of the Amazon region one is dealing with different ecosystems and national definitions. The problem of data sources should not be underestimated when dealing with such a large area.

2.4. Methodological problems

In defining a region, a number of methodological problems arise. How do we deal with included areas, both natural and anthropic? How can a border be drawn when vegetation cover has been modified or the boundary is blurred in an ecotone? Some critical limits differ between nations (*e.g.* lowland forest altitudinal limits < 200 m or < 500 m).

For some criteria continental spatial data are not available – *e.g.* certain species distributions. For animal species we do have a good idea about their general distribution and our knowledge is constantly increasing. For floristic distributions our knowledge is less complete. If data are available, they may be in different formats and different definitions due to their (national) sources.

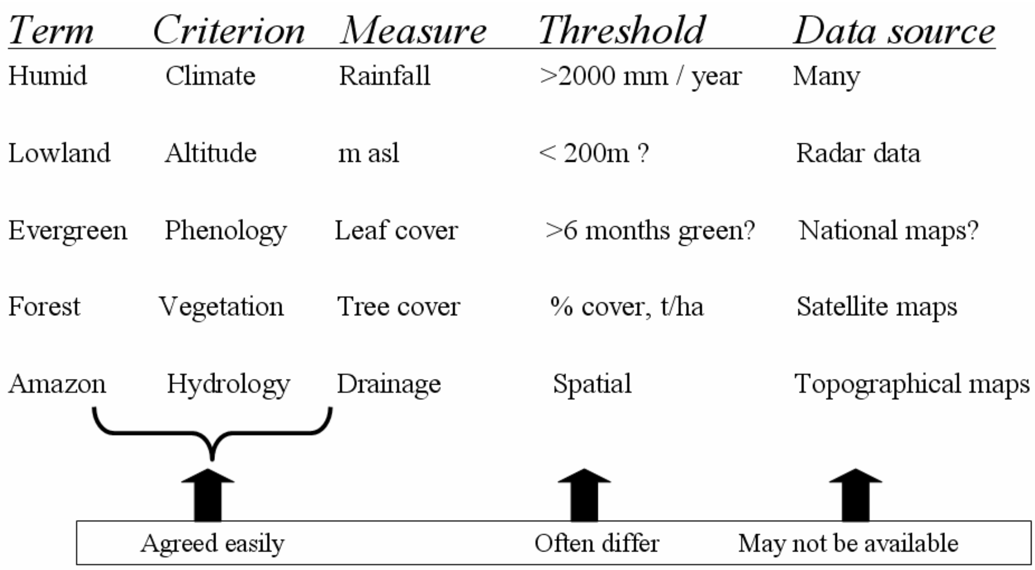


Figure 3: An example of terms and criteria used in the scientific definition of a region (m asl = metres above mean sea level).

It is also of interest to note that without cartographic implementation seemingly reasonable scientific definitions give surprising results. In implementing the criteria outlined in Figure 3 (*i.e.* humid lowland evergreen forests of the Amazon) with the thresholds indicated for rainfall, altitudinal zone, vegetation and hydrology, we obtain a rather unexpected result (Figure 4) with a major discontinuity in the region.

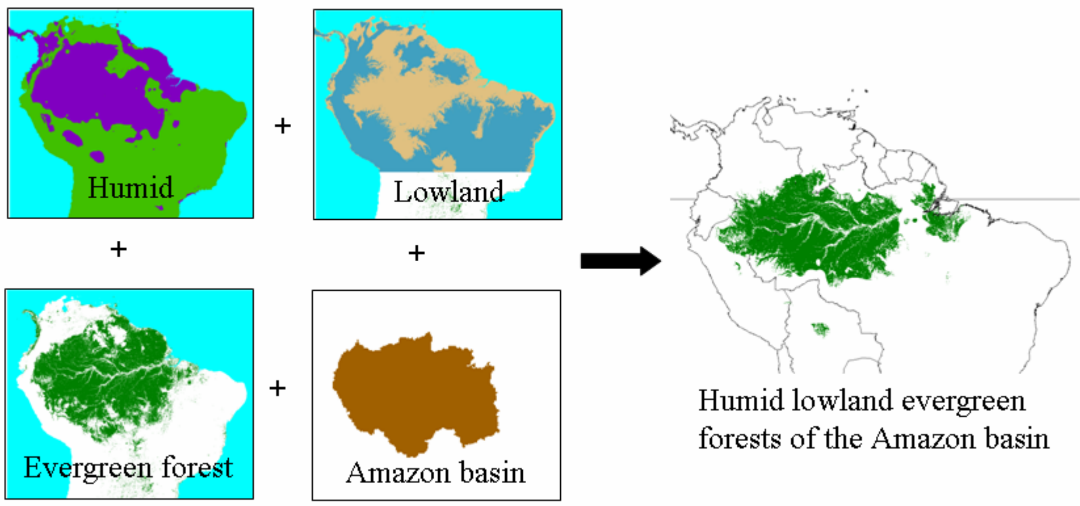


Figure 4: Cartographic representation of criteria used in Figure 3. Note the discontinuity in the forest (green) to the east of the Amazon basin.

This result points to the importance of using Geographic Information Systems (GIS) when defining ecoregions. For the expert workshop three GIS specialists were available.

3. Results of the expert consultation

3.1. Key messages from the experts

In the workshop a set of oral presentations was made on day one. On day two the workshop held an open session in which the discussions were focused on how to define Amazonia, *i.e.* what disciplines and criteria and limits should be adopted.

During the presentations and in the following discussions several key concepts emerged, such as:

- The importance of using the entire Amazon Basin up to the headwaters; such a hydrologically defined unit however is not satisfactory in meeting many aspects of Amazonian biogeography;

- since the evergreen lowland forest biota of the Amazon are similar in several important aspects to those of the Guiana Region, that region must also be considered in the definition process;

- Andean high mountain biota are generally not directly related with the Amazon lowland biota, but they are ecologically and hydrologically strongly linked to each other;

- likewise, the slopes of the Brazilian Planalto draining into the Amazon and Tocantins river basins, although having different biotic and geographic characteristics, are ecologically and hydrologically linked to lowland Amazonia;

- in terms of climate the Amazon region cannot be considered totally separate from the rest of the continent or indeed the world.

3.2. Finding guidelines

A crucial step in moving forward with the definition was a review of the Treaty itself in which Article II deals with the geographical extension:

"ARTICLE II. This Treaty shall be in force in the territories of the Contracting Parties in the Amazon River Basin as well as in any territory of a Contracting Party which, by virtue of its geographical, ecological or economic characteristics, is considered closely connected with that Basin."

Two clear guidelines can be taken from this:

i) the territories of the Contracting Parties in the *Amazon River Basin;*

ii) any territory, by *virtue of its geographical, ecological* or economic characteristics which is considered closely connected with that Basin.

These two guidelines were then used by the experts to come to a consensus view of the regional definition. It must be noted that economic characteristics were not taken into consideration, as being outside the competences and brief of the workshop.

3.3. Definition of the areas

The definition of the area of Amazonia was elaborated and it was agreed upon to use essentially the following three criteria:

1) an **hydrographical** criterion, based on the total extent of the Amazon Basin (including the Amazon and Tocantins river systems) which forms the central constituent of the definition;

2) an **ecological** criterion, subdividing the Amazon Basin (as defined above) in three subregions, which are linked together by strong ecological and functional connections, although belonging to three different ecoregions;

3) a **biogeographical** criterion, complementing the formerly defined area by using as an indicator the known historical extent of the Amazon lowland rainforest biome in northern South America (taken or inferred from TREES map 1999; S and E borders delimited according to Soares, 1953).

As a result, the delimitation of the Amazon Region made by the European group of experts has been accomplished in the following three steps:

1st step: Definition of a strictly hydrographically delimited Amazon Basin:

I - Amazon Basin, this includes the entire drainage basin formed by the river network of the Amazon and the Tocantins river basins, extending in Bolivia, Brazil, Colombia, Ecuador, Peru and Venezuela, from all the watersheds down to the outer mouth of the river delta (incl. the brackish water ecosystems).

2nd step: Definition of three ecologically and biogeographically based subregions (Amazonia, Andes, Planalto) within the first unit I:

Ia - Amazonia *sensu stricto*, the area of the Amazon and Tocantins river basins dominated by the Amazon lowland rainforest biome (including also minor other, forest and non-forest vegetation types and their associated fauna);

Ib - Andes, extending along the eastern slopes of the Andean Cordillera between Bolivia in the south and Colombia in the north, from 700 m asl upwards to the actual watershed;

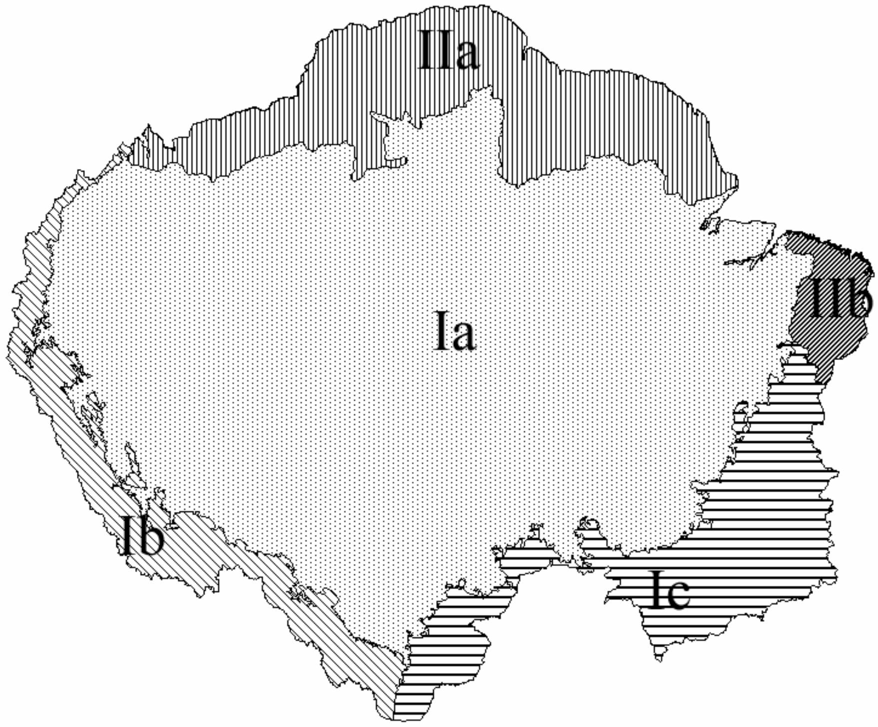
Ic - Planalto, located on the northern slopes of the Brazilian Shield and of the Bolivian central plains of Santa Cruz; this subregion extends along the southern Amazon rainforest limit and the southernmost watershed limits of the Amazon and Tocantins river network and meets eastwards the upper Mearím River in Maranhão.

3rd step: A biogeographically based definition (cover of Amazon lowland rainforest biome) of two additional subregions (Guiana and Gurupí), external to unit I:

IIa - Guiana, comprising the Guiana region of Venezuela, parts of Colombian Amazonia, the three Guianas and the northern part of the state of Amapá in Brazil, including the sandstone and granite mountains of the Guiana up- and highlands and the enclosed area north of Guri;

IIb - Gurupí, including the river basins between the lower Tocantins and the Mearím/Pindare rivers draining into the Atlantic Ocean in Brazilian northeastern Pará and western Maranhão.

Note that regardless of the criterion used to select a region, for practical purposes wherever possible we use rivers and their basins for cartographic delimitation.



UNIT **I** = Amazon and Tocantins river basins [“*Amazon Basin*” or “*Hydrographical Amazonia*”]

Ia = Lowland rainforest biota of the Amazon and Tocantins River basins [“*Lowland Amazon Basin rainforest*” or “*Amazonia sensu stricto*”]
Ib = Andes (non-lowland biota of the Andean Amazon Basin, > 700 m asl)
Ic = Planalto (non-lowland biota of the southern Amazon Basin)

UNIT **II** = Amazon lowland rainforest types outside Unit I

IIa = Guiana
IIb = Gurupí

Ia + IIa + IIb = Entire Amazon lowland rainforest biome [“*Hylaea*” or “*Amazonia sensu lato*”]

I + II = Amazon and Tocantins river basins + Amazon lowland rainforest biome outside the basin [“*Amazonia sensu latissimo*”]

Figure 5: Subregions of Amazonia elaborated by the expert group. Note terms in square brackets are suggested names.

The approximate geographical coordinates of this widest delimitation of Amazonia are as follows:

in the N:	60° 20’ long W	08° 40’ lat N
in the W:	79° 40’ long W	05° 44’ lat S
in the S:	63° 30’ long W	20° 30’ lat S
in the E:	44° 20’ long W	02° 20’ lat S

3.4. Cartographic data sets

To produce an initial cartographic representation of the limits set out by the experts, continental scale data sets were used. Whilst they may be less reliable than the national data sets, being readily available and homogeneous, they enable us to give a ‘first pass’ 1:5 million product.

Figure 6: The northern limits (lines as Figure 1)**.**

Figure 7: The southern/eastern limits.

Figure 8: The western limits.

The following datasets were used in producing the map:

- *River network:* ArcWorld 1:3 million (ESRI 1992).
- *Water basins:* derived from the Shuttle Radar (SRTM) digital elevation data set.
- *Altitudinal zones*: also derived from the SRTM digital elevation data set.
- *Forest map:* derived from the TREES 1:5 million vegetation map (Eva et al. 1999) and the GLC 2000 map (Eva et al. 2002), supplemented by the vegetation maps of Hueck and Seibert (1972), UNESCO (1981) and IBGE (1993).

3.5. Resulting data

Several results can be immediately extracted from the new database. The areas of the five component regions are shown in Table 6, where we see that the total area of the newly defined region is larger than that currently covered by the Amazon Cooperation Treaty (Table 1). In terms of the land cover the region is nearly 80% forested and includes 97% of the continent's lowland rainforests (left outside are the Orinoco delta and the Chocó forests) and 83% of the flooded forests, highlighting the Amazon forest domain.

Subregion	Area (km^2)	Percentage (%)
Amazonia Ia	5,569,174	68
Andes Ib	555,564	7
Planalto Ic	864,951	11
Guiana IIa	970,161	12
Gurupí IIb	161,463	2
Total	**8,121,313**	**100**

Table 6: Areas of the subregions.

	Subregion						
	Ia	**Ib**	**Ic**	**IIa**	**IIb**	**Total area**	**Percentage**
Land cover types	(km^2)	(km^2)	(km^2)	(km^2)	(km^2)	(km^2)	(%)
Humid forests	4,586,909	237,013	34,976	805,007	56,418	5,720,323	70.4
Dry tropical forests	82,282	58,966	171,263	11,305	1,819	325,635	4.0
Flooded tropical forests	189,983	244	2,132	37,134	5,017	234,510	2.9
Agriculture	406,995	56,593	352,728	27,129	94,025	937,470	11.5
Grass and shrub lands	235,344	196,562	299,629	81,308	3,064	815,907	10.0
Little or sparse vegetation	67,660	4,826	4,222	8,279	1,120	86,108	1.1
Water bodies	-	1,360	-	-	-	1,360	0.0
							0.0
Subregion area (km^2)	5,569,174	555,564	864,951	970,161	161,463	8,121,313	100.0
Subregion percentage (%)	68.6	6.8	10.7	11.9	2.0	100.0	

Table 7: Land cover distribution by subregion.

3.6. Differences between the current national definitions of Amazonia and the expert proposition

Geographic differences between the current national definitions of Amazonia and the expert proposition are shown in Figure 9.

The main areas which now fall outside the expert proposition are:

- a small section of central Maranhão (Brazil) ,
- a section of the Llanos Orientales in the Vichada department of Colombia,
- the northern Pantanal of Mato Grosso (Brazil).

Areas now included are:

- the state of Bolívar (Venezuela),
- the headwaters of the Amazon in the Andes of Bolivia, Perú, Ecuador and Colombia,
- the region to the southeast of Santa Cruz (Bolivia),
- the northern part of Goiás state (Brazil).

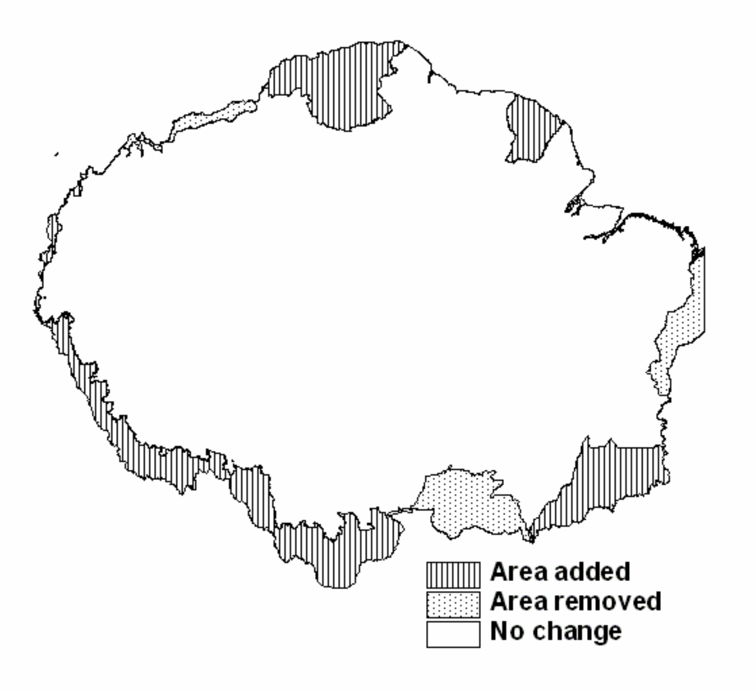


Figure 9: The differences between the current national definitions of Amazonia and the region proposed by the experts.

4. Detailed description of the subregions of Amazonia

4.1. I - Amazon Basin

This is the natural region located in tropical South America comprising the entire Amazon river basin, from all and each of its uppermost headwaters in the surrounding mountain systems (Guiana Highlands and Pakaraima Mountains to the N, Serras Acaraí and Tumucumaque to the NE, Andean Cordillera to the W and the Brazilian Shield or Planalto to the S) down to the easternmost extension of the mouth (Amazon delta). In addition to the Amazon river basin proper, this region also comprises all of the Tocantins river basin of Brazil. Also herewith included is the brackish water belt occupying the transition from the river delta into the Atlantic Ocean. This hydrographical region extends in the following South American nations: Bolivia, Brazil, Colombia, Ecuador, Guyana, Perú, Venezuela.

The Amazon river basin consists in the first place of the main stem of the Amazon River Valley, made up of the Brazilian Rio Amazonas, from the mouth into the Atlantic Ocean to the confluence with the Rio Negro, and of the Rio Solimões, from its confluence with the Rio Negro in Brazil upstream to Iquitos in Peru and further to the confluence of the Ucayali and Marañón rivers; and in the second place by all the individual river basins draining into this first order fluvial axis.

There are three groups of main affluents to the Amazon river:
- the northern tributaries draining the southern and southwestern sections of the Guiana Shield (*e.g.* the Jarí, the Parú, the Trombetas, the Jatapú, and part of the Negro rivers)
- the western tributaries draining the eastern slopes and piedmont hills of the Andes Cordillera (*e.g.* the Caquetá, the Putumayo, the Napo, the Marañón, the Ucayali, the Juruá, the Purus, and part of the Madeira rivers)
- the southern tributaries draining the northern slopes of the Brazilian Shield (*e.g.* the Tapajós and the Xingú rivers).

All the mountainous area above 700 m asl, located within the Amazon river basin in the Casiquiare-Rio Negro drainage in northern Brazil and southern Venezuela (including the Pantepui Province of the Brazilian/Venezuelan Serra da Neblina/Serranía de la Neblina, Serra Tapirapecó with Pico Tamaquari and the summit region of Serra Aracá in the northern Amazonas state of Brazil) and in the *Amazonía Colombiana* (mainly Sierra de Chiribiquete in the departments of Guaviare and Caquetá) is also included herewith, although it is recognized that the upper and high mountain ecosystems of this area belong typically to the Pantepui Province of the Guiana biogeogeographic region (Huber 1994, Berry et al. 1995).

4.2. Ia - Amazonia [Amazonia sensu stricto]

The main criterion for the spatial delimitation of this subunit is the overall presence of the typical Amazon lowland rainforest biome extending within the hydrographical limits of the Amazon Basin (Unit I); in some places, however, the plant cover includes also non-forest vegetation, such as (Amazon) savannas, white-sand scrub, *campina-rana*, *campina*, etc., as well as flooded forest vegetation, such as *várzea*, *igapó* and other riparian vegetation types.

The typical **"Amazon lowland rainforest**" (also known as the *Hylaea*) is defined as:
- all natural forest types growing in the macrothermic lowlands [mean annual temperature (MAT) >24 °C] of the Amazon river basin and on sub-montane slopes and hill-lands of the piedmont belonging to the surrounding mountain systems up to an elevation of 700 m asl (MAT ≈ 20 °C);
- forests of evergreen to sub-evergreen phenology growing under medium to high rainfall regimes [ombrophilous, mean annual precipitation (MAP) >1.400 mm], therefore often called "rainforest";

- forests growing on a wide variety of tropical soil types with different chemical and physical properties, on both flooded or non-flooded terrain, including the riparian habitats of *várzea* and *igapó*.

Herewith included are also the coastal forests (mangroves) and swamps along the Atlantic Ocean, as well as the adjacent oceanic brackish water ecosystems.

The area included here in the concept of Amazonia also comprises the extensions of recently cleared forest lands, *i.e.* areas covered by forest during historic times and identifiable as such on earlier maps of Hueck & Seibert (1972) and of Projeto RADAM (1974-1986).

The extension of this tropical rainforest biome in Amazonia also coincides with the area of the corresponding regional and local rainforest faunal assemblages.

The reference map for this definition of Amazonia is the TREES "*Vegetation map of Tropical America*" at scale 1: 5 million, published by the JRC in 1999 (Eva et al. 1999).

4.3. Ib – Andes

Since a major part of the waters of the Amazon River originate in the Andean Cordillera, it is necessary to take into account the physical and biotic characteristics of that large natural region. The direct and indirect influences of the Andean orography and its associated biota on the hydrological balance of the lowland Amazon basin cannot be underestimated. The mere presence of such a huge physical barrier like the Andes, an up to 6000 m high mountain chain along the entire western margin of the Amazon basin, determines the global and regional climate regimes of the central South American continent. Also the geochemical balance of the Amazon lowlands is primarily influenced by the continuous deposition, transport and re-allocation of sediments derived from the weathering processes along the Andean slopes. If one considers that the sediment load - originated mainly in the Andes and then released into the Atlantic Ocean by means of the Amazon River - can still be observed on satellite images as far as the island of Trinidad or farther (*i.e.*, more than 5000 km away from the headwaters!), the importance and sheer magnitude of the erosional processes taking place in the eastern Andes and their impact on the hydrography of the lowlands can easily be recognized.

Obviously, Amazonia and Andes are two very different natural regions, the former consisting of relatively flat lowland plains, the latter formed by some of the steepest and tallest mountain ranges on earth, including numerous active volcanoes. Hot tropical lowlands near sea level versus freezing cold tropical high mountain peaks at up to 6 km elevation, nowhere in the world are such dramatic environmental contrasts lying closer together! Naturally, each of these two realms is subject to different, but in many aspects interrelated, sets of physical, geochemical and biologic parameters.

A biologically very significant aspect of the Guiana Shield and the Andes massifs lies in their radically different evolutionary histories: whereas the Guiana Shield has been firmly established in its near-equatorial position since Precambrian times (*i.e.*, at least 500 million years ago), the Andean orogeny only took place during the Tertiary. But the direct impact of the Andean upheaval on the regions lying to the east was dramatic: the Proto-Amazon river, then draining from east to west into the Pacific Ocean, was forced by the steadily uprising barrier of the early Andean chain to invert its direction of flow from west to east. This also caused the temporary formation of one or more large continental lakes in the Amazon depression during parts of the late Tertiary and early Quaternary. The relatively "young age" of the lowland Amazon valley biota with its present depositional landforms, compared to the much older, typically erosional landscapes of the adjacent upland and highland systems (Guiana, Brazilian shields), is another important characteristic of that region. At the same time, with the uplifting of the originally lowland biota into increasingly higher montane levels during the Andean orogenetic process, these were forced to adapt to the continuously changing environmental parameters, giving rise to a whole set of new ecosystems previously unknown in the Amazon region, such as the high mountain *páramos*, *puna*, montane cloud forests, *yungas*, etc. Their taxonomic and ecologic *in situ* differentiation has further been emphasized by the immigration, from the north and from the south, of nearctic and subantarctic elements and their subsequent local speciation.

The transition from lowland to montane up- and highland biota is always subject to the concurrence of a number of different factors (mainly of orographic, thermic, and ecologic nature). Although every mountain on earth - and especially tropical mountains - exhibit a more or less clearly recognizable altitudinal zonation of biota along their slopes, it is not always easy to find the lowermost inversion point, *i.e.* the level where a significant number of lowland elements is being replaced by typically montane elements. The *massenerhebungseffekt* on one side, the intensity of the decline of the thermic altitudinal gradient, the exposition and/or slope angle on the other may all be responsible for the appearance of that belt separating the *basi*-montane from the *sub*-montane zone.

Considering all these details, it was generally agreed by the workshop participants that in the case of the contiguous Andes/Amazonia realms, this limit should be located at the contour line of 700 m asl. In this way also the numerous premontane hills and low mountain chains, particularily frequent in the Peruvian Amazon, remain included within the first subunit (Amazonia *sensu stricto*). It must be emphasized, however, that the delimitation along the 700 m asl line must not be taken as an absolute value, but that it may require minor adaptations - above and below that line - to situations with local deviations, which is understandable if we consider that the Amazonas/Andean interface is not less than 3000 km long!

For the cartographic delimitation of the subregion Andes in the present context of Amazonia, the following criteria have been applied:

- upper altitudinal limit: the actual divide between the Amazon/Pacific or Amazon/endorrheic basins, from the headwaters of the Río Ariari in Colombia in the N to the headwaters of the Río Parapetí in Bolivia in the S;
- lower altitudinal limit: the 700 m asl contour line, from its intersection with the Río Ariari in Colombia to the intersection with the Río Parapetí in Bolivia.

The Andean subregion includes therefore all submontane, montane and high-andean (alpine) ecosystems, such as montane rain forests, montane cloud forests, *yungas, páramos, punas, jalcas, chirivitales*, etc. and their corresponding faunal assemblages, living on the eastern slopes of the Andean Cordillera, from Colombia in the north through Ecuador and Peru to Bolivia in the south.

4.4. Ic - Planalto

The finding of the southern limits of the Amazon region has long been difficult, mainly due to the inaccessible terrain conditions and the scanty geographical information available on this extensive transition zone between the Amazon lowland plains to the north and the intricate pattern of slopes and valleys descending from the Brazilian Planalto (Brazilian Shield) in the south. Only the detailed geographical study of Soares (1953) and later the set of maps produced by the Projeto RADAM (1974–1986) have set the ground for a precise delimitation between the large Amazon rainforest biome and the essentially open savanna (*"campo cerrado"*) landscape typical of the southern mountain massif. Also the establishment of a legally defined area and borders for the entire Amazon region in Brazil (*"Amazônia Legal"* 1966) has stimulated further geographical research along its extensive southern borderline.

The southern border of the Amazon region is characterized by a steady transition from an essentially forested landscape (the Amazon lowland rainforest) to a mainly non-forested landscape, in which open vegetation types predominate, such as savannas (*campos cerrados* and alluvial flooded savannas), savanna woodlands (*cerradão*) and other mainly scrubby vegetation types. These changes in the vegetation are due in the first place to a significant decrease of the rainfall, both in absolute amount, as well as in length of the dry season; second to the transition from a hot (macrothermic) equatorial lowland to a cooler (mesothermic) upland climate at 1000 to 1500 m asl; and third, to dramatic changes in the edaphic conditions, especially with reference to soil fertility and drainage dynamics.

It is generally assumed that the age of the southern Brazilian Shield is equal to that of the northern Guiana Shield, *i.e.* of Proterozoic origin: therefore, the weathering products of these old bedrocks consist, in both cases, mainly of highly mineralized, extremely nutrient-poor substrates. The *cerrado* biome with its lower biomass and nutrient reserves compared to the rainforest biome is considered to be one of the prime indicators of that natural region bordering the Amazon valley to the south.

For the cartographic delimitation of the subregion Planalto in the present context of Amazonia, the following criteria have been applied:

- the subregion extends somewhat irregularily from the southeastern Andean piedmont in Bolivia eastwards to the city of Brasilia on the Brazilian Planalto and then northwards until reaching the upper course of the Río Mearím/Pindaré in the state of Maranhão;
- in Bolivia, the SW border is formed by the headwaters of the Mamoré River (Río Parapetí) of mainly Andean origins, and the Guaporé (Iteñez) river, which drains the northwestern slopes of the Brazilian Shield;
- in Brazil, the southern border is formed by the southern watershed of the Madeira, Tapajós, Xingú and Araguaia-Tocantins rivers draining the northern and northeastern slopes of the Planalto;
- The northern limits of this subunit will follow precisely the limits of the *campo cerrado* biome as indicated by the TREES vegetation map (Eva et al.1999), with justifications elaborated by Soares (1953).

The subunit thus delimited contains a considerable portion of tree (*cerradão*) and shrub savanna (*cerrado*), which are characteristic landscape elements of the central Brazilian Planalto. However, the subunit also contains a variable belt of dry forests, bamboo forests and liana forests, which form the transition from the Amazon rainforests in the lowlands to the more open forests and woodlands of the hills of the Brazilian Shield. In the eastern Bolivian lowlands, this subunit consists of an extensive mosaic of evergreen forests, dryer forest patches alternating with flooded savannas and palm swamps, which are then limited to the south by the dry forests of the Chiquitania and the Chaco formations.

4.5. IIa - Guiana

To the north of the Amazon valley the extremely ancient landmass of the Guiana Shield is located occupying an area of approx. 1 million km^2. It consists of an igneous-metamorphic Archean-Proterozoic basement, which was later covered by extensive layers of sandy quartzitic materials during a long-lasting sedimentary period until nearly the end of the Precambric time; since then, most of the resulting quartzite and sandstone cover has been eroded away and today only remnants of the once much more widespread high plains are visible in the form of approx. 50 more or less isolated table mountains locally called "*tepuis*". These impressive, usually flat topped mountains reach elevations between 1200 and 3000 m, the largest number of *tepuis* is found in southern Venezuela, but a few are also found in adjacent Brazil and Guyana, together with some lower outliers in Suriname and Colombia.

The mountains of the Guiana massif are mostly surrounded by extensive forelands (*glacís*) which are the result of the continuous accumulation of weathering products from the *tepui* summits and slopes and their subsequent translocation towards the lower lying river system. Only the southern and southwestern section of the Guiana massif are draining into the Amazon River; the northwest and northern sections drain into the Orinoco river, whereas the rivers coming from the three Guianas drain directly into the North Atlantic Ocean.

It is also worth mentioning that there exists no evidence (geologic or palaeontologic) that the plateau of the Guiana Shield has ever suffered submersion caused by marine transgressions since Palaeozoic times, whereas both valleys located to the south (Amazon) and north of it (Orinoco) have repeatedly been covered by water during more or less prolonged periods up to the Quaternary times.

The group of experts is of the opinion that the lowland forest cover of the area of the Guiana Shield is generally comparable to that of the lowland rainforest mosaic of Amazonia (see Unit Ia), including the coastal (mangroves) and the sub-montane forests growing along the lower talus slopes of the Guiana mountains up to an elevation of approximately 700 m asl and as such forms a continuation of the Amazon *Hylaea.*

For the cartographic delimitation of the subunit IIa - Guiana (excluding the part of the Guiana Shield that hydrologically is part of the Amazon basin proper) in the present context of Amazonia, the following criteria have been applied:

- all the area located to the N of the Amazon river watershed extending in (from E to W) northeastern Amapá of Brazil, French Guiana, Suriname and Guyana, up to the North Atlantic Ocean;
- all the area drained by the southern and southeastern affluents of the Orinoco river in Venezuela, comprising the political entities of the states Delta Amacuro (southern portion), Bolívar and Amazonas;
- the area extending between the southern border of the Llanos savannas along the watershed between the Vichada and Guaviare rivers south to the Orinoco/Amazonas watershed between the Inírida and the Vaupés rivers; the northern limit runs from the intersection of the Río Ariari with the 700 m asl contour line along the eastern Andean slopes down to Puerto La Concordia and from there following northeastwards the southern shore of the Río Vichada until its junction with the Orinoco river in the E;
- the base of the Serranía de la Macarena (< 700 m asl) belongs to the Guiana subunit in Colombia.

4.6. IIb - Gurupí

The small Subregion IIb – Gurupí located in the northeastern part of the Brazilian state of Pará and the western half of the state of Maranhão south of the delta of the Amazonas/Tocantins rivers has been added to the present definition of the wider Amazonia region for three reasons:

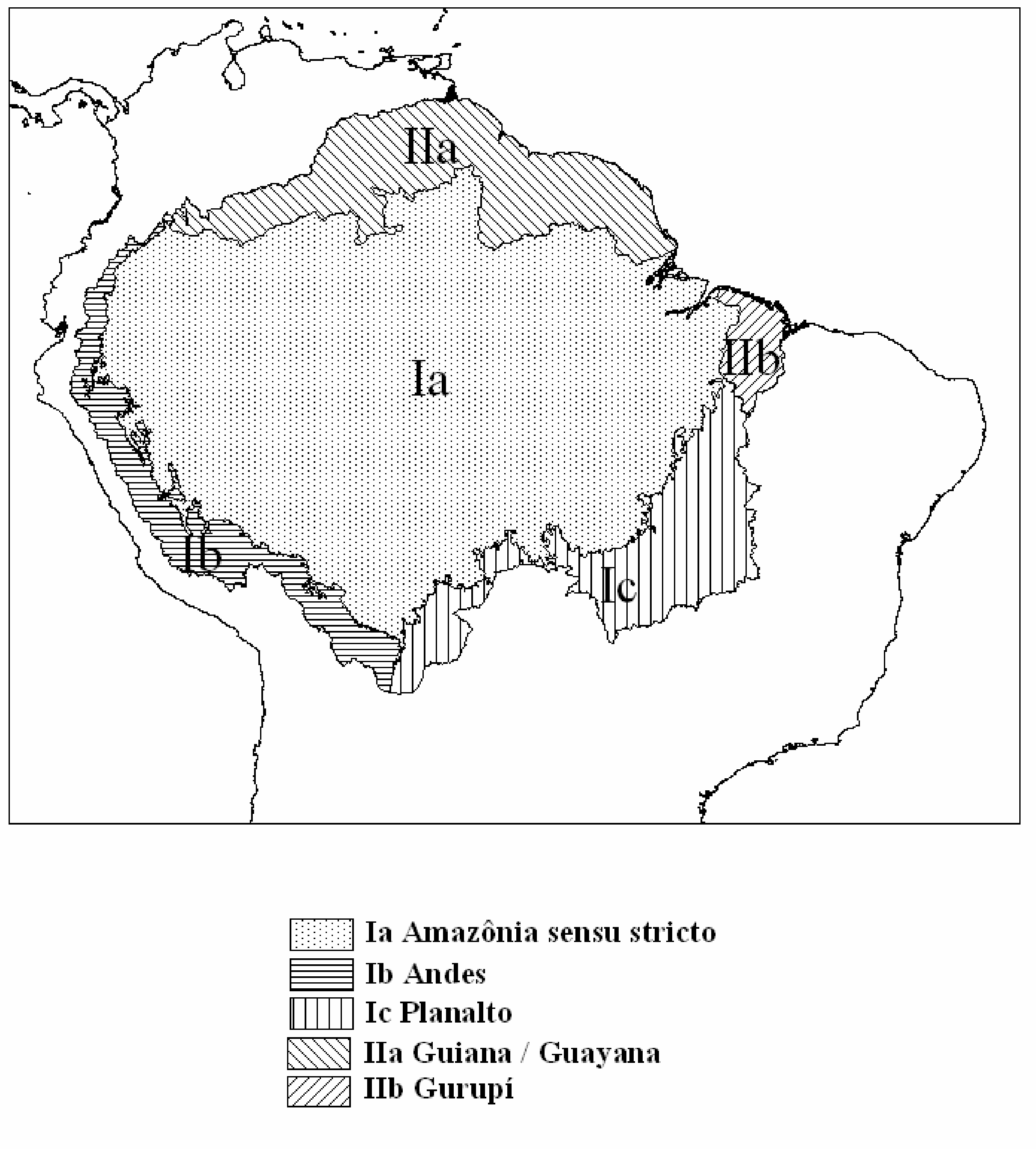
1. It is consistently indicated as a part of the Amazon *Hylaea* by all authors reviewed by Soares (1953); in the same paper of Soares (l.c.) it is also included in his own delimitation of the southern and eastern limits of the Amazon rainforest region;
2. nearly the same area has also been included in the delimitation of the “*Amazônia Legal*” by the Brazilian government;
3. on the vegetation map of TREES (Eva et al. 1999) the originally predominant Amazon rainforest cover is still clearly recognizable, despite of the ongoing process of recent deforestation. Along the coast, mangroves predominate and to the southeast, transition vegetation types, such as *babaçu* palm forests, are common.

For the cartographic delimitation of the subunit IIb – Gurupí, the following geographic criteria have been used:

It includes the basins of the following rivers draining directly either into the Baía de Marajó or into the

Atlantic Ocean to the east of the Tocantins river: the Moju/Acará, the Capim, the Gurupí, the Turiaçú and the Pindaré rivers; the Pindaré river following up to the headwaters of the Mearím river and then until reaching the divide with the Tocantins river in the Serra do Gado Bravo in the state of Maranhão.

Amazonia *sensu latissimo*



5. Conclusions and recommendations

In line with Article IX[1] of the Amazon Cooperation Treaty, an international organization, the European Commission, has brought together a group of scientists to carry out a study on the definition of Amazonia. Having reached a consensus view, we now submit this proposition to the Amazon Cooperation Treaty Organization and the appropriate national institutions for their considered opinions.

The group of experts has provided a scientific basis for delineating the Amazon region based on consensus among disciplines ranging from local scale species distributions to global climate scale roles.

Geographically, the proposal has two key elements; the entire hydrological Amazon and Tocantins river basin and two additional areas located outside of it, *i.e.* the Guiana and Gurupí regions.

The use of the entire hydrological Amazon Basin brings some areas/biomes into the region that are usually not considered of as Amazonian (*i.e.* Andean and Cerrado). Nevertheless, they play essential roles in the functioning of the Amazon hydrological system as they contain the headwaters of the basin's rivers. To distinguish these two areas from the core forested lowland areas, the expert group created subregions within this zone, resulting in three distinct units which collectively make up the Amazon River Basin: the Amazon lowland rainforest region proper (Amazonia *sensu stricto*), the Andean subregion including the area from the 700 m altitude line to the headwaters of the basin, and the Planalto subregion including the non-forest ecosystems along the southern border of the basin.

In addition, the group of experts decided to include two external areas into a wider definition of Amazonia, since these are mostly covered by Amazon rainforest types similar to those found in the core area of the basin. The two additional areas are the Guiana region stretching north to the Vichada and Orinoco rivers in Colombia, Venezuela and the three Guianas, and the Gurupí region, consisting of the northeastern part of the state of Pará and the western part of the state of Maranhão in Brazil, south of the delta of the Amazonas/Tocantins rivers.

The use of these five subregions (Amazonia *sensu stricto*, Andes, Planalto, Guiana and Gurupí) allows a flexibility that would be impossible with one sole region. The main elements of what a layman's view of Amazonia should be is found in the inclusion of almost all the lowland rainforest biome. The insistence by hydrologists that for ecosystem management all the watershed should be included, is respected and those that cannot reconcile 'Andean' with 'Amazonian'or upland *cerrados* with Amazon basin *várzeas* also have their distinct sub-regions; whereas those who insist on the biotic and geomorphic differences between the Guiana Shield region and the Amazon region are accommodated.

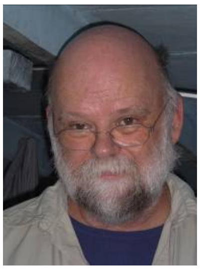
The experts hope that this proposal provides the Amazon Cooperation Treaty Organization with the basis of a sufficiently flexible and manageable set of tools, helping to fulfill its mandate of striving for a sustainable development of Amazonia.

[1] "The Contracting Parties, whenever they deem it necessary and convenient, may request the participation of international agencies in the execution of studies, programs and projects resulting from the forms of technical and scientific cooperation defined in Paragraph One of this Article." Paragraph 2 of Article IX.

6. Annexes

6.1. Biosketches of the expert group

Frédéric Achard completed his studies as an "ingénieur polytechnicien" in 1984 and graduated with a Masters degree in image processing from Strasbourg University in 1986, a PhD in tropical ecology and remote sensing from Toulouse University in 1989, and a "Habilitation à diriger des recherches" from the latter university in 1997. Having first worked in optical remote sensing at the Institute for the International Vegetation Map (CNRS/University) in Toulouse, he later became a seconded national expert from the French Ministry of Agriculture and Forest to the JRC in Ispra. Here he started a research activity over Southeast Asia in the framework of the "TRopical Ecosystem Environment observations by Space" (TREES) project. Having joined the JRC in 1992, his current research interests include development of Earth observation techniques for global and regional forest assessments and monitoring, and assessment of the implications of forest cover changes in the Tropics and boreal Eurasia on the global carbon budget.



Henrik Balslev is professor at the University of Aarhus in Denmark where he is head of the Department of Systematic Botany. He received his MSc from the University of Aarhus and his PhD from the City University of New York, based on research carried out at The New York Botanical Garden. His initial research interest was in plant taxonomy and he has subsequently broadened this to include ethnobotany and vegetation studies, and currently he is particularly interested in processes governing the spatial distribution of biodiversity in South America. He has worked on both the Andean and the Amazon floras and has focussed his field work in the western Amazon basin and in the Andes of Ecuador, Peru and Bolivia. He has lived and worked in South America, for extended periods particularly in Ecuador where he directed the herbarium and taught botany at the Pontificia Universidad Católica del Ecuador in Quito.

Stephan G. Beck is the founder and current director of the Herbario Nacional de Bolivia, which is part of the Instituto de Ecología of the Universidad Mayor de San Andrés (UMSA). He was born and educated in Germany, and has lived and worked in Bolivia since 1978. He is professor at the biological faculty of the UMSA. His fields are botany, agrobiology, ecology, biodiversity. He has worked and assisted students in environmental assessment, sustainable use of natural resources, and inventory of natural forests, medicinal plants, underexploited tropical plants with promising economic value and in tropical grassland husbandry.

Hermann Behling is biologist with a specialisation in palynology and paleoecology. His main research interest is the reconstrution of natural and anthropogenic paleoenvironmental changes in the tropics during the late Quaternary. Dr. Behling successfully participated and performed numerous research projects during the last 15 years in Central and South America. He focused his research on late Quaternary vegetation and climate dynamics in Amazonia. Hermann Behling is "Privatdozent" at the University of Bremen and teaching in biology. He performed also several courses in palynology at different universities in Switzerland and Brazil. In October 2005 he will start the Professorship on Palynology and Climate Dynamics at the University of Göttingen in Germany.

Alan Belward's research interests focus on monitoring land surface processes using data from Earth observing satellites and he has published more than 100 scientific articles in the domain. He received the BSc degree in Plant Biology from the University of Newcastle upon Tyne in 1981, and MPhil and PhD degrees in remote sensing studies of vegetation, both from Cranfield University 1986 and 1993 respectively. He co-chaired the International Geosphere-Biosphere Programme's Land Cover Working Group during its work to create the first satellite derived global land cover data set in the 1990s and was Chairperson of the G7 Committee for Earth Observing Satellites Working Group on Calibration and Validation from 1996 to 2000. He has been Vice Chairperson of the UN sponsored Global Terrestrial Observing System's science panel dealing with Global Observations of Forest Cover since its creation in 2000 and has chaired the UN Global Climate Observing System's Terrestrial Observing Panel for Climate since January 2001.

René Beuchle is a researcher at the European Commission's Joint Research Centre at Ispra, Italy. He has studied Cartography in Karlsruhe and Sydney; he made his Masters Degree at the University of Applied Sciences at Karlsruhe, Germany in 1991. Since then he has worked for 10 years in private companies in the fields of remote sensing and GIS. He has specialised in digital cartography, GIS and remote sensing in the context of land cover / land cover change. Since 2003 he is working at the JRC.

Antoine M. Cleef. Ecologist and botanist of the Universities of Amsterdam and Wageningen. Since 1971 he has carried out research on the flora and vegetation of Colombian paramos, collecting more than 10,000 plant species. He participated in the ECOANDES Project between 1977 and 1983, for the inventory of forests and paramos of the Sierra Nevada di Santa Marta and the three 'cordilleras' of Colombia (1980-1983). Academic Coordinator of Tropenbos-Colombia since 1987. Member of the directive council of NWO-WOTRO. He has supervised more than 25 PhDs. Evaluator for the European Commission (INCO-DV) NWO-WOTRO and DFG (Germany) and for many scientific organizations in Europe, Mexico and Colombia. Author of more than 100 refereed articles in national and international journals, he is a member of the editorial board of journals in Germany, Spain, Mexico, the USA and Colombia, and is a member of the "Academia de Ciencias Exactas, Físicas y Naturales de Colombia". He received the Körber European Science prize in 1996.

Joost F. Duivenvoorden is landscape ecologist and staff member at the Institute for Biodiversity and Ecosystem Dynamics (IBED) of the University of Amsterdam. Among his main research interests are the biodiversity and ecology of the forests in NW Amazonia and the nearby Andes.

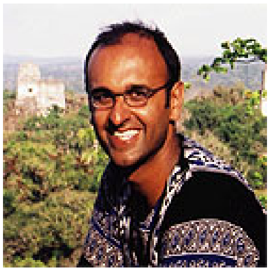
Hugh Eva is a research officer at the European Commission's Joint Research Centre, Ispra. He received his BSc from Manchester University, MSc from Cranfield University and PhD from the Catholic University of Louvain-la-Neuve. He specialises in the use of remotely sensed data for mapping fires and forests in tropical ecosystems and has published two land cover maps of South America derived from satellite imagery. He has been the Latin America co-ordinator of the TREES (the TRopical Ecosystem Environment observation by Satellite) project, which was set up to monitor and measure changes in the tropical forest belt, using remote sensing.

Marinus Steven Hoogmoed, Dutch nationality. Studied biology at Leiden University, Netherlands (1960-1966), specialising in taxonomy and zoogeography of reptiles and amphibians. He was curator of reptiles and amphibians at the National Museum of Natural History in Leiden from 1966 to 2004, when he took early retirement. After retiring he moved to Belém, where he is a guest researcher at the Museu Paraense Emilio Goeldi and where he continues his studies on Amazonian herpetofauna in cooperation with Brazilian colleagues. From 1975 on he has been involved in the Convention on International Trade in Endangered Species of Fauna and Flora (CITES) in several capacities, as a representative of the Dutch Government. He was a European representative on the CITES Animals Committee 1997-2002, and chaired this committee from 2000-2002. From 1997 to 2004 he also was co-chair of the CITES Nomenclatural Committee.

Otto Huber has a degree in Biology from the University of Rome (Italy, 1971) and a PhD in Botany and Geography from the University of Innsbruck (Austria, 1976). During more than 30 years he made botanical and ecological field research in Venezuela, concentrating on savannas, cloud forests and non-forest ecosystems of the Venezuelan Guayana region; his expertise lies in phytogeography, vegetation science and cartography of the Neotropics. Formerly Director of Research of the Fundación Instituto Botánico de Venezuela, Caracas, and Scientific coordinator with the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) in the co-operative MARNR/GTZ project *Centro Amazónico de Investigaciones Ambientales* "Humboldt" he was the founder and Director of the Neotropical Laboratory on Vegetation Mapping and Chorology "Alexander von Humboldt", adscribed to the Centro Internacional de Ecología Tropical (CIET) at the Instituto Venezolano de Investigaciones Científicas (IVIC), in Caracas. He has been involved in over 80 scientific expeditions in Latin America, and has over 100 refereed publications. In 1991 he received both the Orden Henri Pittier and the Orden Andrés Bello from Venezuela.

Bart Kruijt is a research scientist with about 15 years experience in micrometeorology, plant physiology, modelling land-atmosphere exchange and development of eddy-correlation technology. He has extensive experience with working in the tropics. Before joining Alterra in 1999, he worked at the University of Edinburgh, UK for 7 years, leading work in Scotland, England and Brazil. He is involved in carbon cycle research within CarboEurope and FLUXNET, but has led projects of a wider scope, including on the sustainability of carbon sinks in forests, eddy correlation methodology development, drought sensitivity of Mediterranean ecosystems and CO2 measurements. Recently he started an initiative to investigate aspects of resilience and vulnerability of the Amazon in ecohydrological, meteorological and socio-economical terms. He is a member of the Scientific Steering Committee of the Large-Scale Biosphere-Atmosphere experiment in Amazonia.

Wolfgang Johannes Junk, studied zoology, botany, marine sciences and limnology at the Universities of Bonn, Freiburg and Kiel. In 1967/68, he made the field work for his doctoral thesis on floating meadows and colonizing aquatic invertebrates at the National Amazon Research Institute (INPA) in Manaus. After his PhD in 1970, he studied wetlands in Thailand and returned in 1974 to the Amazon. For 5 years he build up at INPA the Department of Fisheries and Aquatic Sciences and a post-graduate course. In 1980, he accepted the leadership of the Working Group of Tropical Ecology at the Max-Planck-Institute for Limnology in Plön. He established with scientists of INPA a long-term research program on the Amazon River floodplain. In 1990, the cooperation was extended to the University of Cuiabá to study the Pantanal of Mato Grosso. Since 1990, Dr. Junk is Professor at the University of Hamburg. His scientific interests concentrate on the ecology of floodplains with emphasis on nutrient fluxes, primary production and decomposition, biodiversity and sustainable management. Prof. Junk has published about 200 articles in scientific journals. He is corresponding member of the Brazilian Academy of Sciences and received several honours, among others the Gran Cruz of the Brazilian Government and the International Fellow Award of the Society of Wetland Scientists.



Yadvinder Malhi is a Royal Society University Research Fellow at the Oxford University Centre for the Environment. His research focuses on how the physiology, structure, biomass and dynamics of Amazonian forests is controlled by climate and soils, and how these features of the forest may respond to ongoing global atmospheric change. He is co-founder of the RAINFOR project, which has conducted systematic field research of Amazonian forests in Brazil, Bolivia, Peru, Ecuador, Colombia, Venezuela and French Guiana, and co-ordinator of the EU-funded training programme PAN-AMAZONIA (Project for the Advancement of Networked Science in Amazonia). He is co-editor of the book Tropical Forests and Global Atmospheric Change (Y. Malhi and O.L. Phillips, Oxford University Press, published July 2004).

Jan Marco Müller studied Geography, Hispanistics and Media Sciences at the University of Marburg (Germany). Diploma 1996, PhD 2000 with a thesis on the transport system of Colombia. Lecturer of courses on urban geography and regional development in Latin America at the Universidad Nacional de Colombia (Bogotá) and the University of Leipzig. 2000-2004 Assistant of the Scientific Director of the UFZ-Centre for Environmental Research Leipzig-Halle, 2001-2004 Secretary of the PEER Network of European Environmental Research Centres. Since 2004 Science Strategy Manager of the Institute for Environment and Sustainability, Joint Research Centre of the European Commission. Coordinates the collaboration between the Joint Research Centre and the Amazon Cooperation Treaty Organization. Honorary engagements include President of the Latin American Society of Leipzig (2001-2004) and Vice-President of the Association for German-Colombian Friendship (since 2005).

José M.C. Pereira has an undergraduate degree in forestry from the Technical University of Lisbon (1983) and a PhD in Renewable Natural Resources Studies from the University of Arizona (1989). He is Associate Professor and vice-president of the Department of Forestry, Technical University of Lisbon, and national chair of the IGBP Global Land Project. His regional scale research focuses on the application of remote sensing to burned area mapping, fire risk mapping, and landscape ecology of wildfires. He is also involved in the application of remote sensing to the estimation of global biomass burning, and has been involved in field campaigns dealing with this topic, in Africa, South America and Australia.

Carlos Peres was born in Belém, Brazil and so was exposed to Amazonian natural history from early childhood, and his father's ranch in eastern Pará, consisting largely of primary forest, became his playground. For the last 20 years he has been studying wildlife community ecology in Amazonian forests, their responses to varying scales of forest disturbance, and the biological criteria for designing nature reserves to set aside representative complements of Amazonian biodiversity. He currently co-directs two research programs on the ecology of key timber and non-timber forest resources at the Uauaçú Reserve of the lower Purús river and the Kayapó Indian Reserve of southeastern Amazonia. He has published over 120 papers on neotropical forest ecology and conservation at scales ranging from populations to entire regional landscapes. In 1995 he received a "Biodiversity Conservation Leadership Award" and in 2000 was elected an "Environmentalist Leader for the New Millennium" by Time Magazine. He is currently a Reader in Tropical Ecology at the University of East Anglia, UK, and divides his time between Norwich and fieldwork in the Brazilian Amazon.

Professor Sir Ghillean Prance was born in Suffolk in 1937 and was educated at Malvern College and Keble College Oxford where he obtained a BA in Botany and a DPhil. His career began at the New York Botanical Garden in 1963 as a research assistant and subsequently B A Krukoff Curator of Amazonian Botany, Director and Vice-President of Research and finally Senior Vice President for Science. His exploration of Amazonia included 15 expeditions in which he collected over 350 new species of plants. He was Director of the Royal Botanic Gardens, Kew from 1988 to 1999. He was McBryde Professor at the National Tropical Botanical Garden in Hawaii 2001-02 and is Scientific Director of the Eden Project in Cornwall and Visiting Professor at Reading University. He is author of nineteen books and has published over 450 scientific and general papers in taxonomy, ethnobotany, economic botany, conservation and ecology. He holds fifteen honorary doctorates and in 1993 received the International COSMOS Prize and was elected a Fellow of the Royal Society. He was knighted in July 1995 and received the Victoria Medal of Honour in 1999. In 2000 he was made a Commander of the Order of the Southern Cross by the President of Brazil.

Dr John Roberts was born in 1945 in Wales. He gained a BSc, PhD and DSc from the University of Wales. Research career involves physiological controls of transpiration from vegetation, especially forests. After his PhD John worked as a post-doctoral research assistant to Professor AJ Rutter at Imperial College, London. He joined the Institute of Hydrology (now Centre for Ecology and Hydrology, CEH) Wallingford in 1974 and remained until retirement in 2005. Now a fellow at CEH Wallingford. Responsible for plant physiology and soil water studies in two projects (ARME, Amazonian Regional Micrometeorological Experiment and ABRACOS, Anglo-Brazilian Regional Climate Observation Study) in Brazil. He is the co-editor of the book "Amazonian deforestation and climate".

Jukka Salo is Professor of Environmental Sciences and Biodiversity and Head of University of Turku Environmental Center, Turku, Finland. Currently he is leading the BIODAMAZ Project in Peru which is seeking new ways and means to conserve and use the biodiversity resources of Peruvian Amazon. Since 1980 he has directed several research projects and programmes in the Amazon and Andean Region. These programmes have been oriented towards landscape ecology, forest regeneration and ecosystem classification of the Western Amazon lowlands. The projects have published so far more than 150 papers, including scientific articles, books, project documents and technical reports. Since 1993 Mr. Salo has participated in the implementation of the United Nation's Framework Convention on Biological Diversity, CBD, the preparation of work programmes and the design of the agreement's economical sector. In 1993 he acted as a member of the UNEP Expert Panel III, which drafted the outlines of economical relations between Global Environment Facility (GEF) and the agreement. He held the chairmanship of the workgroup that drafted the Work Programme on Forest Biological Diversity under the CBD in 1997.

6.2. Abstracts

Palms and the delimitation of the Amazon region

Henrik Balslev, Stine Bjorholm & Jens-Christian Svenning
University of Aarhus - Institute of Biological Sciences

Palms are the quintessence of tropical latitudes and are abundant in the forests of the Amazon region. They make up important elements in the ecosystem as keystone species for many animals. They are also a uniquely important plant resource to the people living in the region providing construction materials for houses, food, and a wealth of other products such as fibres, utensils, weapons, etc. In the Americas there are about 550 species of palms; areas particularly diverse in palms include southern Mesoamerica, the Chocó (with up to 80 species per degree square), and the western and eastern Amazon basin. The species occurring in the core Amazon basin tend to have wide distributions and its palm flora includes some 150 species; along the northern (Guiana) and western (Andes) edges of the Amazon there are a number of additional species with more narrow distributions, whereas the southern (Cerrado) edge tend to have a impoverished palm flora without many additional species. There is a pronounced latitudinal palm species richness gradient even close to the equatorial line. GIS based analysis of environmental and spatial variation components show that their richness patterns are influenced by both current ecological conditions, especially humidity, and spatial determinants that may reflect historical processes related to changing boundaries of paleoecological zones.

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A perspective of Amazonia from Bolivia

Stephan G. Beck
National Herbarium, UMSA, La Paz – Bolivia

In Bolivia are sited three hydrographic basins: the Altiplano-Titicaca Basin without drainage, the La Plata and the Amazon Basins. By far the Amazon represents the greatest extension with about two thirds of the country. My topic concerns phytogeography, flora, vegetation and some ecology of Bolivian Amazon, using geology, soil and climate data. In Bolivia there are different opinions concerning Amazonia. According to Ibisch et al. (2003) Bolivian Amazon includes the following regions:

The Humid Forests of the SW of Amazonia (Acre-Madre de Dios)

- Inundated forests, Subandean forests, Preandean forests, Tropical Forests of Pando, Tropical Forests of the Beni and Santa Cruz

The following units present ecotones of Amazonia:

- Temporary inundated Savannas of the Llanos de Moxos; Cerrado vegetation: Cerrado Beniano, Cerrado Chiquitano, the dry forest of the Chiquitano.

Navarro (2002) only considers the phytogeographic province Acre-Madre de Dios with the following biogeographic sectors:

- Madre de Dios, including biogeographic districts of Madre de Dios and Pampa del Heath
- Amazonian of the Andean piedemont with biogeographic districts of the Alto Madidi, Alto Beni and Chapare

Results of recent expeditions suggest that the Madeira-Tapajoz biogeographic province reaches Bolivia in the far north of Pando and Beni, too.

Definitely not Amazonian are:

- Andean high montane forests (above 2000 m?), subalpine, cloud forests, paramo, puna
- Chaco vegetation…

The criteria used to characterize regions are:

Altitudinal zones, precipitation, temperature, relief, geomorphology, water basins, flooding, and mainly physiognomic characters of the vegetation.

Accepted thresholds within these criteria are:

The altitudinal range is not well defined: 900-1200 m or up to 1500-2000 m?

Limits to the Cerrado-Dry forest or of the biogeographic region Brasileno-Paranense, (63° W, distribution of *Bertholletia excelsa* ?)

Mosaic of different phytogeographic elements of the Pantanal

Mosaic of vegetation types of the savannas (forest islands, gallery forest…)

Can you delimit 'Amazonian' and 'non-Amazonian' at the regional and continental scales?

Lowland and premontane regions with their watershed draining to the north in the Amazon basin with

mostly evergreen forest.
Bolivian Amazonian Basin corresponds to the sub basin (headwaters) of the Madeira composed by the five large streams Guaporé (Iteñez), Mamoré, Beni, Madre de Dios and Orthon. Delimitation on a popular scale considers the hot lowland area as Amazonian.

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Late Quaternary Amazonian vegetation in space and time

Hermann Behling
Department of Geosciences, University of Bremen

Several late Quaternary pollen records from the Amazon rain forest and bordering savanna regions north and south of the equator provide insight on past vegetation dynamics. During glacial times environmental changes in forest and savannas are spatially complex. Some pollen records show either stable grassland where forest exists today, and some records show signs of a repeated alternation between forest and savanna. For instance, new pollen data of a lacustrine sediment core from Lagoa Grande of Serra Norte region in eastern Amazonia (Carajás, Pará State) document marked changes between rain forest and savanna during several glacial and interglacial periods. During the last full glacial period neotropical savannas, both north and south of the equator, covered large areas due to markedly drier conditions. The Amazon rain forest area must have been reduced. Results from Lagoa da Confusão in southeastern Amazonia (Tocantins State) show that during glacial and early Holocene times the landscape was grass savanna and savanna woodland. The region was more forested by the stronger presence of gallery forest and Amazon forest trees during mid and late Holocene times. During the early Holocene in general the distribution of savanna was much larger than during late Holocene periods, reflecting drier conditions in most of the tropical South American regions than today. There is in different regions a marked expansion of rain forests after about 6000, 3500/3000 and 1000 14C yr BP. For instance, records from the Colombian lowland in northwestern Amazonia show a marked Amazon rain forest expansion into the Colombian savannas of the Llanos Orientales, starting at 6000 14C yr B.P.

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Amazonia versus Andes and Orinoquia

Antoine Cleef
Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam

My view on Amazonia is mainly from the equatorial Andes and my geobotanical experience in Amazonia is mainly from the Middle Caquetá region of Colombia and the Carajás lakes area in Pará, Brasil. Vegetation ecology (including phytosociology) with phytogeography and paleo-ecological interpretation are my main subjects of study. In Amazonia I have studied open vegetation: savanna-like and cerrado and allied successional and edaphic series.

The Amazon river basin is determined by the drainage system: the Amazon river and in my study area with all its tributaries up to the watershed of the easternmost Andean Cordillera and the Orinoco watershed. The Amazon basin contains a widely varied series of zonal and azonal vegetation types: rain forests, shrub, open and closed herb vegetation, growth on rock, flooded vegetation (forests, shrub, savanna-like), aquatic communities of running water and lakes, swamps and peat. This diversity of vegetation types reflects geographical and physiographic position in the basin, but also differences in climate, substrate and Neogene history. Also a number of man-induced vegetation types have been documented.

The Andes is an almost closed climatic barrier determined by permanent low temperatures and with frost events in the higher reaches. The *páramo*, *puna* and the Upper Montane Rain Forest (UMRF) are basically tropical high Andean ecosystems. Climatic and environmental constraints are reflected in ecology, in plant composition and in phytogeographic spectrum (family, genus and species levels).
Amazonian species seem absent at the species level and only some genera are in common with the Amazon basin, e.g. Clusia, Epidendrum, Miconia, Palicourea, Podocarpaceae, Tillandsia. Most genera have been derived from temperate stock.
It is clear that coldness is the main climatic barrier and filter and can be located along the UMRF-LMRF borderline.
Below that border, Lower Montane Rain Forest (LMRF) contains with decreasing altitude an increasing amount of Amazonian genera, but also the first Amazonian species begin to appear.
Amazon slope LMRF shares some system-ecological characteristics with Amazon rain forests and are

basically mixed in composition. Today they have been little studied, only with more detail in Ecuador (Grubb & Whitmore 1966; and the multidiscinaplinary DFG group headed by Prof. Erwin Beck near Loja).
In contrast to the clear Andean border, the northern limit with the Orinoco drainage system is rather vague and diffuse. Amazon forests reach the Guaviare river which is an affluent to the upper Orinoco. Climatic barriers and efficient physiographic borders are absent. It seems that Amazon forests spread into the Orinoco river system.
Also the Guianas (Guyana, Surinam, Guyane Française) mainly belong to the Amazon floral realm in my perception.
I see most difficulties for a meaningful delimitation in the area of the Orinoco drainage basin and in the three Guiana countries.
Ice age thermal conditions were for the remaining Amazon forest refuges like today in premontane and the lowermost LMRF.

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Forest Peoples and the Amazon

Marcus Colchester
Forest Peoples Program, Moreton-in-Marsh, UK

According to the briefing the workshop will only look at the 'natural properties' of the Amazon Basin, which may be interpreted as excluding social and cultural aspects, although arguable these could be included under (Social) Geography, (Social and Human) Ecology.

Assuming, however, that the workshop does want to consider social and cultural aspects, especially of the region's indigenous peoples, I make the following points:

1. The Amazon Basin, in its strict sense of a watershed, does not correspond to any cultural or social unity.

2. Many of the broad linguistic and cultural groups found in Amazonia (sensu stricto) are also found in neighbouring areas with similar ecology such as in the Orinoco basin, the Guianas and some of the Southern parts of Brazil, SE Bolivia and Northern Paraguay. These include for example peoples from the Quichua, Carib, Arawak, Tupi-Guarani, Tukanoan, Yanomami and Ge linguistic families, as well as a number of independent linguistic groups.

3. Indeed many of the individual ethnic groups found in Amazonia have territories that overlap into neighbouring zones. For example, just along the Venezuela-Guyana border with Brazil we find the following groups whose territories are in Amazona sensu stricto and also overlap into neighbouring areas: Piaroa, Piapoco, Hiwi, Bare, Kurrim, Yekuana, Yanomami, Sanema, Ninam, Pemon, Makushi (also Pemon speaking), Kapon (Akawaio and Patamona), Wapishana, Wai Wai, Trio, Oyampi (Wayapi).

4. In the same way as language groupings and ethnic groups overlap into neighbouring areas, so do customary forms of subsistence, social organization and relationship terminologies also overlap into the neighbouring zones. Projects dealing with disease ecology, development challenges and conservation likewise face similar issues in Amazonia sensu stricto and these neighbouring areas.

5. Recognising that the cultural area is much broader than the Amazon basin sensu stricto, cultural anthropologists tend to talk about 'Lowland South America' (which they distinguish from the highland regions where social forms were historically developed into proto-state formations and had more hierarchical forms of social order). Within 'Lowland South America', less clearly defined sub-regions can also be identified such as the Guianas, the North-West Amazon (in the broad sense), South Central (the Ge and dry forest zones southwards in Brazil down to Uruguay) and the Chaco (South-eastern Bolivia, Paraguay and northern Argentina). The 'Southern Cone' (Argentina and Chile) tends to be treated as a separate area in cultural terms.

6. Based on these considerations and given the political membership of the Amazon Cooperation Treaty, it would seem logical to consider the Amazon Region to include: all of the territories of the Andean member countries east of the Andes and below 1,500 metres, all of the Orinoco basin, the Guianas and Brazil to include the legal territory of the Greater Amazon. Drawn this way, the region would exclude the Chaco.

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Landscape heterogeneity in Colombian Amazonia

Joost Duivenvoorden
Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam

One way to define the limits of Amazonia is to look for strong changes in landscape (including climate, geology, terrain form, soil, and forest) along its border areas. In my analysis I will highlight such changes at the northern and eastern boundaries of Colombian Amazonia, and compare these with the heterogeneity in landscapes found inside the Amazon basin in Colombia.

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Amazonia from the viewpoint of a herpetologist

Marinus S. Hoogmoed
Museu Paraense Emilio Goeldi/CZO, Belém, Brasil

Herpetology is the science that deals with amphibians (frogs, toads, salamanders, worm-salamanders) and reptiles (crocodiles, turtles and tortoises, tuatara, lizards, snakes and worm-lizards) in the widest sense. My fields of expertise within herpetology are taxonomy (the study of relationships between different species of amphibians and reptiles), species recognition, zoogeography and habitat requirements of species.
Reptiles and amphibians are ectothermic vertebrates, that are partly dependent on external factors (temperature and humidity) to perform their normal functions. Amphibians in principle lay un-shelled gelatinous eggs in or near water. The eggs develop into tadpoles that metamorphose into small frogs, toads and salamanders. However, there is a distinct tendency to become independent of water, and about 35 different modes of reproduction are now known among frogs, with increasing independence from water, including direct development in the egg on land in moist situations and live bearing of metamorphosed toadlets and salamanders. Amphibians have a (moist) porous skin that easily looses or absorbs water. This causes them to be rather dependent on environmental humidity, or develop special behaviour to avoid desiccation. Tropical rain forests are an ideal habitat for frogs and toads and it is there that they reach their highest diversity.
Reptiles are not that dependent on water as amphibians, as their skin is rather impermeable and relatively resistant to waterloss, their eggs have a leathery shell, through which moisture from the surroundings can be absorbed. From the eggs hatch completely developed juveniles that are miniature replicas of the adults. Some species give birth to live young. Despite this greater independence of water and humidity, still the highest diversity of reptiles is encountered in humid tropical rain forests.

For biologists “the Amazon region” generally has been rather clear cut. The area was generally related to part of the Amazon´s hydrographic basin, and in particular to the area covered with lowland tropical rainforest. A close relation between forest reptiles and amphibians with the vegetation cover always has been accepted and in general the area is considered to reach from sea level to 500 – 800 m on the Andean slopes, depending on the author. In 1977 a symposium on the South American herpetofauna dealt with the following groups of interest here: “The amphibians of the lowland tropical forests” (Lynch, 1979), “The herpetofauna of the Guianan region” (Hoogmoed, 1979) and “Origin and distribution of reptiles in lowland tropical rainforests of South America” (Dixon, 1979). The first and last of these presentations also treated the reptiles and amphibians of the Chocó and the Atlantic forests which do not interest us here. The area we want to concentrate on is the so-called central cis-andean tropical lowland forest, also known as Hylaea, an area reaching from the foot, or rather the eastern slopes, of the Andes to the Atlantic Ocean and including the three Guianas, although those three territories are not drained by the Amazon or its tributaries, but have rivers that directly empty into the Atlantic Ocean. For some time the three Guianas and small parts of Venezuela and Brazilian Amapá were considered a separate zoogeographic entity because of the fact they did not form part of the Amazon drainage and were considered to have an elevated number of endemic species [Descamps (1978) and Lescure (1977)]. Hoogmoed (1979, 1983) considered the entire area between the Atlantic Ocean, the Amazon, the Rio Negro and the Orinoco, generally known as the Guiana Shield, as an entity, because of the fact that many Guiana lowland endemics occur throughout that area and are not restricted in their distribution by the low divide between the Guianan rivers and the northern tributaries of the Amazon (Avila-Pires, 1995). Recently, because of more research it has become clear that several species formerly considered Guiana endemics, in reality have much larger distributions encompassing a large part of the Amazon Basin. The general opinion at the moment is that the Guianas form part of the Amazon area, but with a number of lowland endemic species, which are not (yet) known from outside Guiana (Duellman, 1999).
When herpetologists are talking about the herpetofauna of the Amazon Basin they are not referring to the hydrological Amazon Basin, but to the biological one, which is synonymous with the tropical lowland

rain forest that only covers the northern part of the drainage of the southern tributaries of the Amazon, the Amazon valley itself, the drainages of the northern tributaries of the Amazon and the Guianas, and which so to speak has shifted a bit north of the hydrological Amazon basin. It agrees generally with the Amazonian equatorial morphoclimatic domain as used by Ab´Saber (1977) and the Amazonia-Guiana area as used by Duellman (1999). Distributions of amphibians and reptiles mainly are determined by the distribution of vegetation types and to a much lesser extent by altitude.

The areas of cerrado and other open vegetations in Bolivia that are drained by southern affluents of the Amazon are not considered part of the Amazon Basin, they have a distinctly different herpetofauna and form a different zoogeographical region. However, the herpetofauna of savanna enclaves in the Amazon Basin, which is radically different from that in the rain forest and shows more relations with the fauna of the Llanos of Venezuela and the cerrado of Brazil, is considered part of the Amazonian fauna.

There is one region within the Guianas that is considered different from the Amazon Basin because of its different vegetation and fauna, with many localized endemics, and that is the region of the tepuis in Venezuela, Brazil and Guyana. These are elevated areas, generally above 1500 m, with a different climate and vegetation, which is reflected in the herpetofauna as well.

Thus, the Amazon region is a rather compact area with a hole (the Guiana highlands) near its northwestern border.

References:

Ab´Saber, A.N., 1977. Os domínios morfoclimaticos na América do Sul. Primeira Aproximação. – Geomorfologia 52: 1-21.

Ávila-Pires, T.c.S. de, 1995. Lizards of Brazilian Amazonia Reptilia: Squamata). – Zoologische Verhandelingen 299: 1-706.

Descamps, M., J.-P. Gasc, J. Lescure & C. Sastre, 1978. Études des écosystèmes guyanais. II. Données biogéographiques sur la partie orientale des Guyanes. – Comptes Rendues de la Societé Biogéographique 467: 55-82.

Dixon, J.R., 1979. Origin and Distribution of Reptiles in Lowland Tropical Rainforests of South America. In: W.E. Duellman (1979): The South American Herpetofauna: Its origin, evolution, and dispersal. University of Kansas Museum of Natural History Monograph 7: 217-240.

Duellman, W.E., 1999. Distribution patterns of amphibians in South America. In: W.E. Duellman: Patterns of distribution of amphibians. A global perspective: 255-328. – John Hopkins University Press, Baltimore and London.

Hoogmoed, M.S., 1979. The Herpetofauna of the Guianan Region. – In: W.E. Duellman (1979): The South American Herpetofauna: Its origin, evolution, and dispersal. University of Kansas Museum of Natural History Monograph 7: 241-279.

Hoogmoed, M.S., 1983 [1982]. Snakes of the Guianan region. – Memorias do Instituto Butantan 46: 219-254.

Lescure, J., 1986. Amphibiens et reptiles de la bande cotière en Guyane française. – Le littoral Guyanais: 111-118 (SEPANGUY-SEPANRIT).

Lynch, J.D., 1979. The Amphibians of the Lowland Tropical Forests. In: W.E. Duellman (1979): The South American Herpetofauna: Its origin, evolution, and dispersal. University of Kansas Museum of Natural History Monograph 7: 189-215.

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Amazonia: Delineation from a hydrological point of view

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The delineation of Amazonia from a hydrological point of view is relatively easy because Amazonia can be defined as the catchment area of the Amazon River. Catchment areas represent hydrological units in the landscape that reflect the impact of climate, geology, geomorphology, soils, and their interactions with the biota including the results of human activities, on amount, quality and discharge pattern of surface water and ground water.

In the case of the Amazon Basin, there are several transition areas to other catchments that are hydrological poorly defined. The Casiquiare permanently connects the Negro to the Orinoco River basin, and periodic connections may occur during the rainy season through the Roraima-Rupununi savannas between the Branco River and the Essequibo River basin. Periodic connections may also occur between the headwaters of the Tocantins and the Paraná Rivers near Brasilia and between the Paraguay River and the Guaporé River. These connections are of biogeographic interest but not important from a hydrological point of view, because they have little effect on the water budget of the respective rivers.

Quality, quantity and discharge pattern of rivers represent the sum of factors acting in their catchments. Water quality has been used to classify Amazonian rivers into 1) nutrient and sediment rich white water rivers with neutral pH that have their origin in the Andes, 2) nutrient and sediment poor, acidic black waters with high content in humic acids that drain podzolic soils in the lowlands and 3) clear water rivers with transparent greenish water of intermediate chemical status that drain the archaic shields of the Guianas and Central Brazil and latosols in the central basin. This group shows a relatively large variability in chemical parameters because of the geologic heterogeneity of the soils in their catchments.

With increasing catchment size the indicative value of river water decreases. All large white water rivers receive their hydrochemical signature in the Andes and the pre-Andean region and maintain it along their entire courses. For instance, the quality of the Amazon River water at Obidos is the result of the mixture of white water, black water and clear water of the upper catchment area, but the white water influence dominates despite the dilution by the black water and clear water tributaries. Also, the floodplains of the Amazon River and its large white water tributaries crossing the nutrient poor central Amazon basin are relatively fertile in comparison to the surrounding uplands, because of the load of dissolved and suspended material of Andean origin. Low-order rivers provide a better resolution of the local catchment conditions. This also holds true for the detection of human impacts that affect water quality directly by pollution and indirectly by change in vegetation cover and different land use activities.

The size of the catchment area also influences the discharge pattern of Amazonian rivers. Large rivers show a highly predictable, monomodal flood regime with one high water and one low water period per year, according to rainy and dry season. Small rivers show increased base flow during the rainy season, but polymodal, unpredictable flood pulses according to individual rain storms. Large scale changes in vegetation cover favour the occurrence of extreme flood and drought events in low order rivers, and hydroelectric reservoirs can modify completely the natural discharge pattern of medium sized rivers with far reaching consequences for the biota upriver and downriver of the reservoir.

The catchment area approach for the delineation of Amazonia is valuable for the hydrological and hydrochemical characterization and the indication of changes that affect these factors, respectively the monitoring of the consequences that result from changes in water quality and discharge pattern. Global climate change will modify the precipitation and evapotranspiration in different ways in the entire catchment including melting of glaciers in the High Andes. Deforestation at the slopes of the Andes will modify sediment load and discharge in a different way as in the Amazonian lowlands, but will affect the entire downriver reaches. The construction of large reservoirs will affect not only the respective tributaries, but to a certain extent also the main stem of the Amazon River. On the long run development plans for the sub-basins and the entire catchment will be necessary to permit the sustainable use of natural resources and the maintenance of biodiversity.

It could be expected that the catchment area of the Amazon River would also be a suitable unit for the characterization of aquatic flora and fauna, because it sets boundaries for their distribution. This is, however, not the case, because the large catchment does not correspond to biogeographic boundaries, nor to habitat characteristics. Differences in climate, altitude, geology, geomorphology, and vegetation cover lead to variability in habitat conditions that overlap with biogeographic and evolutionary aspects. In a preliminary approach, ichthyologists of The Nature Conservancy and WWF, for instance, differentiate between 13 ecoregions basing mostly on the fish faunas of sub-catchments or parts of catchments. This characterization draws a border along the Andes in an altitude of about 500 m and justifies it with climate changes (Petry, pers. comm.). Another important abrupt physical barrier for fishes and other large aquatic vertebrates is the line of waterfalls that separates the Amazonian lowlands from the shields of the Guianas and Central Brazil. Therefore, a future subdivision of the ecoregions can be expected. On the other hand, many species occur in several ecoregions of the Amazon basin, and some species even migrate between ecoregions, e.g., the large migrating catfishes that use as juveniles the estuary of the Amazon River for feeding and than migrate to their spawning grounds in the headwaters of the Amazon River and its large white water tributaries. Several species are also found in neighbouring catchments, such as the Pirarucú, and some larger catfishes (Pseudoplatystoma spp.). The Negro and Orinoco River basins are connected via the Casiquiare and share several fish species and many genera as shown by the Neon Tetra (Paracheirodon axelrodi) that is restricted to parts of the Negro River catchment and parts of the southwestern Orinoco system. On the other hand, many species or groups of species have very restricted distribution areas that can be explained in part by specific habitat requirements, such as some fish species of the family Loricariidae. I guess that about half of the Amazonian fish species occurs in the headwaters of the large rivers and many of them have restricted distribution, such as the species of the specious genus Corydoras.

Geomorphologic barriers are not necessarily valid for other aquatic organisms, such as aquatic invertebrates, algae, aquatic birds, aquatic macrophytes and trees of the floodplain forest that are often also found in catchments adjacent to the Amazon River basin. For instance, some aquatic wading birds occur in the flooded savannas north and south of the rainforest including the adjacent river basins because of habitat requirements. Of very restricted range are Podostemonaceae that require rocky substrate in rapids. Aquatic molluscs do not occur in black water because of low pH values and low Ca-content.

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A functional definition of Amazonia?

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Should Amazonia be defined in terms of taxonomy (biological, soils, climate) or in terms of functional traits? Aspects of function are: Carbon uptake and carbon dynamics, hydrometeorological cycles, the role of the rivers and wetlands, savanna and campina/caatinga areas:
How does the climate system ‘see’ Amazonia? How does the global hydrological cycle ‘see’ Amazonia?
- Buffer or potential ‘carbon and heat bomb’?
- Water store?
- Teleconnections?

How do socio-economic processes, land-use drivers and regional politics see Amazonia?
- Potential economic value in wood and (well managed) crops.
- A (potential) place to live.
- A region with specific problems (poverty, land conflicts, accessibility).
- A strategically important zone to protect territorial integrity against global powers.

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Landcover mapping in tropical South America

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We describe the recently produced GLC2000 map of South America, a 1 km resolution database derived from a range of Earth observing satellites. Different satellite products from the SPOT VGT, the ERS-ATSR2, the DMSP and the JERS-1 radar are used to map different South American land cover types. The resulting map provides for the first time a spatial explicit database with a high thematic content. We review upcoming satellite products and their capacities to monitor land cover in the tropics.

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Vertebrate assemblage structure in Amazonian forests

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Wildlife assemblages in Amazonian forests are highly diverse in both species composition and functional groups. Here are examined the effects of regional scale geochemistry and forest productivity on the structure of bird and mammal communities, and characterized their patterns of diversity in different forest types. Terra firme forests invariably contain richer bird and mammal species assemblages than do adjacent várzea forests, but faunal interchanges between forest types is a typical feature of the terra firme-várzea interface. There is a clear habitat-dependent positive association among vertebrate species, particularly within várzea forests, as well as marked shifts in guild structure between forest types. Species turnover between these two forest types involve primarily ground-dwelling and understory insectivores, which are usually absent from inundated forest on a seasonal basis. On the other hand, large-bodied arboreal folivores such as howler monkeys and sloths are rare in terra firme forests, but extremely abundant in annually flooded várzea and supra-annually flooded floodplain forests. This can be largely explained by the predictable flood pulse and nutrient-rich alluvial soils of young floodplains, compared to the heavily weathered terra firme soils occurring even within short distances of major white-water tributaries of the Amazon. I therefore show a reverse diversity-density pattern resulting from the lower species richness, but high overall community biomass of seasonally flooded Amazonian forests, which can now be generalized to other terrestrial vertebrate taxa.

Amazonia as defined by plant species distributions

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The distribution of plant species or genera such as Hevea (the rubber tree genus) has often been used to define the limits of Amazonia. A series of plant distribution maps of typically Amazonian species, particularly in the plant families Chrysobalanaceae, Lecythidaceae, Dichapetalaceae and Caryocaraceae will be used to define the biological limits of Amazonia with a special focus on the Brazilian part of the region. The limits are reasonably well defined, but Amazonian elements stretch well into the cerrado or savanna region of central Brazil in gallery forests and forest islands, and also into the Pantanal biome in Mato Grosso. Plant distributions should be the primary test for the definition of biological regions. The definition of Amazonia to the south is well marked by the distribution data. To the north there is little definition unless the Guianas and the Orinoco delta region are also included. When using distribution maps to define regions it is essential to have data on the habitat occupied.

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6.3. Maps consulted

Dinerstein, E. et al. 1995. *A conservation assessment of the terrestrial ecoregions of Latin America and the Caribbean.* WWF-US, World Bank, Washington D.C.

ESRI 1992. - ArcWorld 1: 3 Million digital data set. Available through the website found at: www.esri.com/data/online/index.html.

Eva, H.D., Glinni, A., Janvier, P. and Blair-Myers, C. 1999. Vegetation map of tropical South America at 1:5,000,000. *TREES Publications Series D : Thematic outputs* n° **2** : 44 p. EUR 18658 EN, European Commission, Luxembourg.

Eva, H.D., de Miranda, E.E. , Di Bella, C.M. et al. 2002. *A vegetation map of South America*. 1:8,500,000. EUR 20159 EN, European Commission, Luxembourg.

Huber, O., Gharbarran, G. and Funk, V. 1995. *Vegetation map of Guyana* (*Preliminary version*). 1:1,000,000. University of Guyana, Georgetown.

Hueck, K. and Seibert, P. 1972. *Vegetationskarte von Sudamérica / Mapa de la Vegetación de America del Sur*. 1:8,000,000. Fischer-Verlag, Stuttgart.

IBGE 1993. *Mapa de vegetação do Brasil*. 1:5,000,000. IBGE, Rio de Janeiro.

Projeto RADAMBRASIL 1974-1986. *Levamento de recursos naturais*. Ministério das Minas e Energia, Departamento Nacional da Produção Mineral, Rio de Janeiro.

UNESCO 1981. *Carte de la Végétation d'Amérique du Sud*. 1:5,000,000. UNESCO, Paris.

6.4. Literature consulted

Amazon Cooperation Treaty Organization (ACTO), 2004. *Strategic plan 2004-2012*, ACTO, Brasilia.

Achard, F., Eva, H., Stibig, H.J. et al. 2002. Determination of deforestation rates of the world's humid tropical forests. *Science* **297**: 999-1003.

Aragon, L.E. (ed.) 2005. *Populações da Pan-Amazônia*. NAEA, Belém.

Ávila-Pires, T.C.S. de 1995. Lizards of Brazilian Amazonia (Reptilia: Squamata). *Zoologische Verhandelingen* **299**: 1-706.

Balslev, H. and Luteyn, J.L. 1992. *Paramo – an Andean ecosystem under human influence*. Academic Press, London.

Behling, H. 2002a. Carbon storage increases by major forest ecosystems in tropical South America since the Last Glacial Maximum and the early Holocene. *Global and Planetary Change* **33**:107-116.

Behling, H. 2002b. Late Quaternary vegetation and climate dynamics in southeastern Amazonia interfered from Lagoa da Confusão in Tocantins State, northern Brazil. *Amazoniana* **17**: 27-39.

Behling, H. and Hooghiemstra, H. 2000. Holocene Amazon rain forest - savanna dynamics and climatic implications: high resolution pollen record Laguna Loma Linda in eastern Colombia. *Journal of Quaternary Sciences* **15**: 687-695.

Behling, H. and Hooghiemstra, H. 2001. Neotropical savanna environments in space and time: Late Quaternary interhemispheric comparisons. In: *Interhemispheric climate linkages* (V. Markgraf, ed.), pp. 307-323. Academic Press, London.

Berry, P.E., Huber, O. and Holst, B.K. 1995. Floristic analysis and phytogeography. In: *Flora of the Venezuelan Guayana* Vol. **1**: *Introduction* (P.E. Berry, B.K. Holst and K. Yatskievych, eds.), pp. 161-191. Timber Press, Portland and Missouri Botanical Garden, St. Louis.

Botero, P. (ed.) 1999. *Paisajes fisiográficos de la Orinoquia-Amazonia (ORAM), Colombia*. IGAC, Bogotá.

Carreiras, J.M.B., Pereira, J.M.C. and Shimabukuro, Y.E. [in press]. Land cover mapping in the Brazilian Amazon using SPOT-4 VEGETATION data and machine learning classification methods. *Photogrammetric Engineering & Remote Sensing*, in press.

Carreiras, J.M.B., Pereira, J.M.C., Campagnolo, M.L. and Shimabukuro, Y.E. [in press]. Supervised classification of SPOT VEGETATION data to obtain a land cover map for the Brazilian Legal Amazon. *Remote Sensing of Environment*, in press.

CDEA, 1992. *Amazonia without myths*. Comisión de Desarrollo y Medio Ambiente para la Amazonía; Commission on Development and Environment for Amazonia (CDEA). Inter-American Development Bank, United Nations Development Programme, Amazon Cooperation Treaty.

Dixon, J.R. 1979. Origin and distribution of reptiles in lowland tropical rainforests of South America. In: *The South American Herpetofauna: Its origin, evolution, and dispersal* (W.E. Duellman, ed.), *University of Kansas Museum of Natural History Monograph* **7**: 217-240.

Ducke, A. and Black, G.A. 1953. Phytogeographical notes on the Brazilian Amazon. *Anais da Academia Brasileira de Ciência* **25**: 1-46.

Duivenvoorden J.F. and Lips, J.M. 1993. *Ecología del paisaje del Medio Caquetá. Memoria explicativa de los mapas*. Tropenbos-Colombia, Bogotá.

Etter, A. 1992. Mapa ecológico general de la Amazonia Colombiana. In: *Amazonia Colombiana: diversidad y conflicto* (G.I. Andrade, A. Hurtado and R. Torres, eds.). CEGA, Bogotá.

Eva, H.D., Belward, A.S., de Miranda, E.E. et al. 2004. A land cover map of South America. *Global Change Biology* **10** (5): 732-745.

Gutiérrez Rey, F., Acosta Muñoz, L.E. and Salazar Cardona, C.A. 2004. *Perfiles urbanos en la Amazonia Colombiana*. SINCHI, Bogotá.

Holdridge, L.R., Grenke, W.C., Hatheway, W.H., Liang, T. and Tosi, J.A. 1971. *Forest environment in tropical life zones*. Pergamon Press, Oxford.

Hoogmoed, M.S., 1979. The Herpetofauna of the Guianan Region. In: *The South American Herpetofauna: Its origin, evolution, and dispersal*. (W.E. Duellman, ed.). *University of Kansas Museum of Natural History Monograph* **7**: 241-279.

Hoogmoed, M.S., 1983 [1982]. Snakes of the Guianan region. *Memorias do Instituto Butantan* **46**: 219-254.

Huber, O. 1988. Guayana highlands versus Guayana lowlands, a reappraisal. *Taxon,* **37**(3): 595-614.

Huber, O. 1994. Recent advances in the phytogeography of the Guayana region, South America. *Mémoires de la Société de Biogéographie (3. Série)* **4**: 53–63.

Huber, O. and M. Foster (eds.) 2003. *Conservation priorities for the Guayana Shield: 2002 Consensus. – Prioridades de Conservación para el Escudo de Guayana: Consenso 2000. – Prioridades de Conservação para o Escudo das Guianas: Consenso 2000. – Priorités pour la conservation du Massif des Guyanes: Consensus 2000. – Natuurbehoudsprioriteiten voor het Guiana Schild: 2002 Consensus.* Conservation International - CABS, Guiana Shield Initiative, UNDP, IUCN, Washington DC. 99 pp. (English, Portuguese), 101 p. (Dutch, Spanish) + 3 sep. fold. maps, col., 1:2,900,000 (front chart), 80 x 126.5 cm, bilingual (English/French, English/Dutch, and Spanish/Portuguese).

Hueck, K. 1965. *Die Wälder Südamerikas. Ökologie, Zusammensetzung und wirtschaftliche Bedeutung*. Gustav Fischer Verlag, Stuttgart.

IBGE 1992. *Manual técnico da vegetação brasileira: manuais técnicos em geociências no. 1*, Fundação Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro.

Junk, W.J. 1989. *Flood tolerance and tree distribution in Amazonian floodplains*. In: *Tropical forests*. (L.B. Holm-Nielsen, I.C. Nielsen and H. Balslev, eds.), pp. 47-64. Academic Press, London.

Oliveira, A. and Nelson, B. 2001. Floristic relationship of *terra firme* forests in the Brazilian Amazon. *Forest Ecology and Management* **146**: 169-179.

Olson, D.M. et al. 2001. Terrestrial ecoregions of the world: a new map of life on earth. *BioScience* **51** (11): 933-938.

Olson, D.M. and Dinerstein, E. 2002. The Global 200: priority ecoregions for global conservation. *Annals of the Missouri Botanical Garden* **89**: 199-224.

Pires, J.M. and Prance, G.T. 1985. The vegetation types of the Brazilian Amazon. In: *Key Environments Amazonia,* (G.T. Prance and T.E. Lovejoy, eds.), pp. 109-145. Pergamon Press, Oxford.

Prance, G.T. 1989. American tropical forests. In: *Ecosystems of the World,* Vol. **14B**, (H. Lieth and M.J.A. Werger, eds.), pp. 99-132. Elsevier, Amsterdam.

PRORADAM 1979. *La Amazonia Colombiana y sus recursos. Proyecto radargramétrico del Amazonas*. IGAC, Bogotá.

Ratter, J.A. 1992. Transitions between the cerrado and the forest vegetation in Brazil. In: *Nature and dynamics of forest-savanna boundaries*, (P.A. Furley, J. Proctor and J.A. Ratter, eds.), pp. 417-429. Chapman and Hall, London.

Roberts, J.M., Cabral, O.M., De Aguiar, L.F. 1990. Stomatal and boundary-layer conductances measured in a terra firme rainforest, Manaus, Brasil. *Journal of Applied Ecology* **27**: 336-353.

Seibert, P. 1998. *Guide de l'Amérique du sud, paysages et végétation*. Eugen Ulmer, Paris.

Sioli, H. (ed.) 1984. *The Amazon - Limnology and landscape ecology of a mighty tropical river and its basin*. Junk, Dordrecht.

Soares, L. de C. 1953. Limites meridionais e orientais da área de ocorrência da floresta amazônica em território brasileiro. *Revista Brasileira de Geografia* **15** (1): 3-122.

ter Steege, H., Sabatier, D., Castellanos, H., van Andel, T., Duivenvoorden, J., de Oliveira, A., Ek, E., Lilwah, R., Maas, P.J.M. and Mori, S. 2000. An analysis of the floristic composition and diversity of Amazonian forests including those of the Guiana Shield. *Journal of Tropical Ecology* **16**: 801-828.

Thery, H. 2005. Situações da Amazônia no Brasil e no continente. *Estudos Avançados* **19** (53): 37-49.

Verissimo, A., Capobianco, J.P. et al. (eds.) 2004. *Biodiversity in the Brazilian Amazon*. Instituto Socioambiental, São Paulo.

Zeng, N. 1999. Seasonal cycle and interannual variability in the Amazon hydrologic cycle. *Journal of Geophysical Research* **104**: 9097-9106.

European Commission

EUR 21808 ***A Proposal for defining the geographical boundaries of Amazonia***

H.D. Eva and O. Huber (editors)

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Abstract

A group of European experts came together for a two day workshop at the Joint Research Centre, Ispra, to discuss a proposal for defining the geographical boundaries of Amazonia. The experts represented a wide range of scientific disciplines from climate studies to phytogeography. A consensus approach was taken to developing a concept. The final proposal was reached with the agreement of all the participants. This proposal has two key elements; the entire hydrological Amazon and Tocantins river basin and two additional areas located outside of it which are dominated by Amazonian type forests.

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