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LBA FOLHA AMAZÔNICA

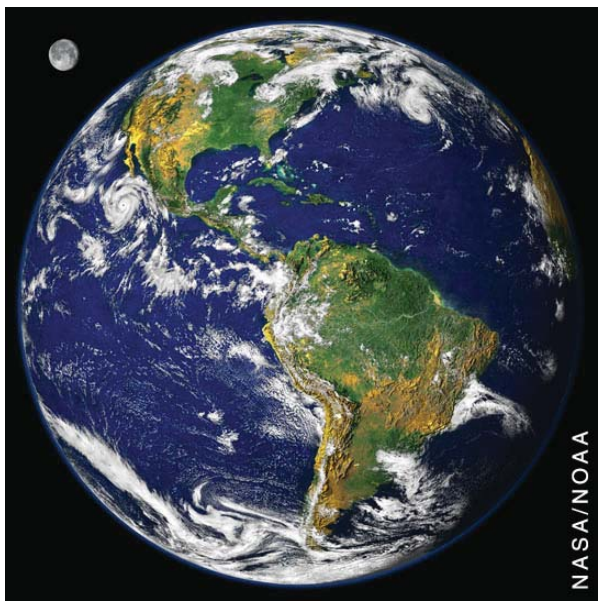
Newsletter of the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA)

In this Issue:

The LBA Project: Understanding complex biosphere-atmosphere interactions in Amazonia

Flávio Luizão - INPA

This edition of the Folha Amazonica was prepared especially for the III LBA Scientific Conference, taking place in Brasilia, 27-29 July 2004. With more than 600 scientific papers accepted, the Conference is a milestone that attests to the success and maturity of the largest tropical environmental research program ever. With the objective of deepening our understanding of the role of Amazonia and of land use changes in the Earth's climate system, and also, of the influence of global changes on the functioning of Amazonian ecosystems, the Large-scale Biosphere-Atmosphere Experiment in Amazonia (LBA), formed out of various large collaborative national and international scientific projects done previously, deals with seven major research themes which are treated in a multi- and interdisciplinary manner. This special edition presents a brief synthesis of the results of research from the seven science themes of LBA, as well as presenting information about the activities of its Training & Education Committee.



An extensive and integrated approach, with seven major interacting scientific themes (some, such as Land Use and Land Cover Change and Human Dimensions permeate throughout), has brought together the information necessary to respond to the major scientific questions relevant to the sustainable development of a region as complex as the Amazon. This integration demand studies at different temporal and spacial scales, using a variety of methodologies and instruments: from local process measurements, across great transects crossing the region, using a network of observations of gas and energy fluxes, taken by sensors on metal flux towers, boats, balloons, various aircraft and satellites.

Results have been remarkable and suffice to explain complex mechanisms such as the formation of clouds and rain in the Amazon: trees emit volatile organic compounds- VOCs (Biochemistry domain); in the atmosphere above the forest during the wet season, VOC molecules form tiny crystals or aerosols (Atmospheric Chemistry); in the absence of other aerosols, these crystals serve as nuclei for condensation of clouds, attracting water vapor (Physical Climate) and forming large, heavy raindrops that soon fall to earth in the same region where they were formed, in a rapid and efficient mechanism.

Combined with good science, we believe that a strong investment in the education of hundreds of young Amazonian scientists provides the guarantee of continuity of research in LBA themes (principally through local institutions) and a solid basis for the rational development of the region.

Editorial

The Third LBA Science Conference, which is being held on July 27-29, in Brasilia, demonstrates the success and maturity of LBA. The new scientific findings of LBA are very important to the understanding of the processes that regulate the functioning of Amazonian ecosystems. Understanding climate processes; carbon and nutrient cycling; biogeochemistry of waters; and many other aspects of the ecology and human dimensions of land use in the Amazon, will help subsidize sustainable public policies for the region. The Conference is being held in Brasilia- the political center of the country- to allow wide participation of those who make and implement public policy for the Amazon.

LBA has grown enormously over the course of its existence. One indication of its growth and dynamism can be deduced from the numbers of presentations at the LBA Science Conferences. When the first LBA Science Conference was held in Belem, Para, in July 2000, 282 abstracts were presented. In this Third Science Conference: 611 presentations. Undoubtedly, this is the largest scientific meeting to consider exclusively the scientific knowledge of the Amazon region. LBA has grown and matured. Knowledge generated by LBA is providing subsidies for public policies for sustainable management of the vast natural resources of Amazonia. Hundreds of students trained in LBA programs will contribute to the continuity of research in the future, to technological development, and to formulation of public policies for use of its natural resources. The interdisciplinary nature of LBA research is moving at full speed, as you can see from the high number of papers crossing thematic disciplines.

The general coordination of LBA, under the Ministry of Science and Technology (MCT), initially through the National Institute for Space Research (INPE) and, in the last two years, by the National Institute for Research in the Amazon (INPA), has played a key role in the success of the experiment. The great number of universities and research institutions, Brazilian and foreign, attest to the interest of the scientific community in LBA, and the hard work that, throughout these so many years, has been producing high quality science, attested by a number of papers in prestigious journals such as Science and Nature. Recent editions devoted to LBA in specialty areas, such as Journal of Geophysical Research, Global Change Biology, Oecologia, Remote Sensing of the Environment and others, demonstrate the dynamism of LBA research. Support from Brazilian funding agencies such as CNPq, CAPES, FINEP, and FAPESP has been key to LBA's success. Outside Brazil, LBA has significant support from a number of agencies such as National Aeronautics and Space Administration (NASA), United States Department of Agriculture (USDA), United States Forest Service (USFS), National Science Foundation (NSF) and many others. The European Commission and various national European funding agencies have also contributed substantially to LBA research, as has the Inter-American Institute for Global Change Research (IAI).

The Third LBA Science Conference will be a milestone in environmental research in Brazil, attesting to the maturity and success of LBA. We look forward to your active participation in this Conference.

Paulo Artaxo
Mercedes Bustamante
Michael Keller
Flávio Luizão

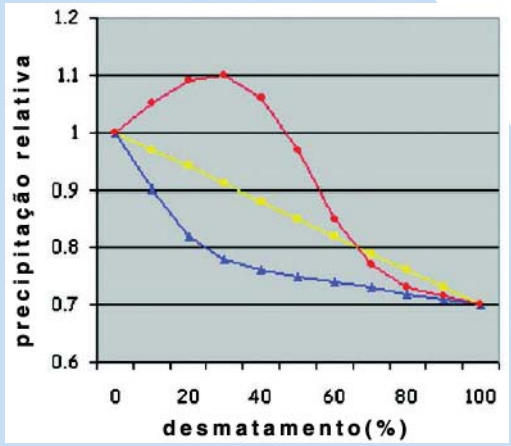
Third LBA Science Conference Co-Chairs

The Amazonian climate and its interaction with the biosphere

Maria Assunção F. da Silva Dias - USP

The Amazon evokes images of forest and rain, of a humid tropical climate in an ecosystem characterized by biodiversity and immense trees. The balance between the ecosystem and climate occurs mainly through humidity provided by the vegetation to the atmosphere, which forms clouds that rain and return water to the forest. Vegetation also releases volatile organic compounds that facilitate the formation of small drops in clouds, encouraging more precipitation. In this way, forest and climate are maintained in balance. However, this balance can be altered by several natural factors and by human activity as well.

Natural variability of climate occurs in response to variations in oceanic circulation and in the inclination of the Earth's rotational axis. In the Amazon, variations occur with a period of 10 to 20 years, with rain in successive years occurring below or above the annual average. During an El Niño year, there is less rainfall mainly in the eastern part of the Amazon. These variations do not affect the balance between climate and forest in a significant way because they are not permanent changes but just oscillations around an equilibrium. Paleoclimatological data, however, show that there were periods in the remote past when the forest area decreased, suggesting that there were long dry periods when native vegetation suffered from lack of rain and was replaced by a vegetation resistant to dryness, typical of the "cerrado" (savannah).



Three lines indicate the possible effects of deforestation on Amazon rainfall. The red line – an LBA result – is markedly different from the others and indicates deforestation increases rainfall for a limited period of time. After a certain threshold, deforestation inevitably causes a reduction in rainfall.

For the last three decades, humans have intensively increased their activity in the Amazon, cutting trees and burning vegetation to form pastures and plantations. A drastic effect of total deforestation of the native Amazon, which would replace native vegetation for pastures or agriculture, had already been an object of research well before the beginning of LBA. Numeric computer simulations indicated an increase in temperature and a decrease in rainfall. This result was expected, since native vegetation – with deep roots – is responsible for maintaining humidity in the air even during the less rainy season of the year.

In reality, the Amazon has been deforested from its borders inwards, mainly in the south and east and in various corridors that are advancing gradually. One of the results of this regional deforestation is, in fact, very unexpected: rainfall in the regions that include deforestation is more abundant during the rainy season and less abundant in the dry season, which makes the precipita-

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The climate and the interaction...
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tion regime similar to the cerrado's, south of the Amazon. The total annual final result shows an increase in rainfall. The figure on the previous page shows three lines which indicate the possible effects of deforestation on Amazon rainfall. The red line – an LBA result – is markedly different from the others and indicates deforestation increases rainfall for a limited period of time. After a certain threshold, deforestation inevitably causes a reduction in rainfall.

Burning, in addition to its association with deforestation, produces smoke, soot particles and gases that are initially taken upwards by heat from burning and then transported by winds to distances that can reach thousands of kilometers from the origin. Burning induces the transportation of organic matter and gases to far-off places, breaking the local exchange process between forest and atmosphere. Moreover, the particles produced by burning – the so-called aerosols – interfere with the process of cloud formation and, as a consequence, with precipitation.

At the end of the dry season, the presence of aerosols significantly increases the number of cloud condensation nuclei, increasing the number of water droplets, and due to competition among droplets for the humidity available in the atmosphere, keeping the droplets very small and not heavy enough to fall to the ground. The first effect of this is the inhibition of rain at this time of the year. Clouds very often dissipate without rain or sometimes end up becoming storm clouds with strong winds, ice and lightning, but little rain.

In summary, human interventions have caused unexpected alterations in the hydrological cycle of the Amazon, stressing the sustainability of its balance and indicating possible permanent changes. The concern becomes even greater when scientists observe that changes have been occurring in an extremely reduced time interval compared to the natural changes that occurred in the past.

Unraveling the mysteries of carbon in Amazonia: LBA moves forward, but stumbles on complexities of ecosystems

Antonio Donato Nobre - INPA

The LBA project has managed in a few years to install and consolidate the best and largest network of environmental study sites that Amazonia has ever seen, comparable to existing networks in developed countries. With a great number of studies developed on flux towers, in forest stands, in monitored watersheds and in comparative transects, the LBA community had hoped to obtain over a few years massive and convincing evidence for the magnitudes, the destiny and the processing of the carbon exchanged with the atmosphere by Amazonian ecosystems. However, the more the contrasting ecosystems dispersed through the region are studied, the more the multiple-scale wealth and complexity of these ecosystems is realized, then the greater the need for deepening and broadening of the approach is verified.

In a useful comparison, consider that the more we investigate the mysteries of the human body, the more we discover about the microscopic and paradoxically gigantic complexity of this organism, a single species. Imagine, in Amazonia, the magnitude of complexity that LBA researchers and students encounter in ecosystems with millions of species, millions of square kilometers, everything interconnected with the environment in a myriad of links, forming magnificent webs...

Carbon is nothing but the primary element of matter of these multidimensional live constructions. To understand carbon stocks, flows and controls, we now know there is the need to better understand the biological logic behind carbon fixation, consumption, allocation, the relationship with the water and nutrient cycles, the processes of stabilizing selection versus destabilizing effects in communities affected by environmental alteration, among so many other factors.

Even so, LBA has made important strides, revealing some of these complexities, or at least indicating pathways for further investigation. The discovery of the importance of emission of volatile compounds of carbon by plants in the generation in the atmosphere of cloud condensation particles (called aerosols), associated with the revelation of the importance of these aerosols in the dynamics of cloud and rain formation, possess enough impact to revolutionize what was known about the relationships of the forest with the rain. This biological control of droplet generation in clouds and, therefore, of rain, triggered by plant compounds emitted in very small amounts and in little-known rhythms, might be related to plant internal processes, and therefore not easily detectable with simple measurements. In turn, when the amount or distribution of rain on a forest area is altered, the capacity of this ecosystem to capture and keep carbon is also altered.

Other studies at several sites in Amazonia have related biomass growth and distribution with some simple parameters of soil type and fertility, and are revealing the existence of surprisingly rich ecological patterns at regional scales, perhaps indicating the non-disturbed forests of Amazonia as a whole may be functioning as a small sink for excess CO_2 from the atmosphere. Studies in a watershed associating hydrological controls with vegetation cover revealed that even at local scales there is great variability and wealth of ecosystems, each one with its own and diversified metabolism.

How then can reliable numbers be generated for the exchanges of this amazing and immensely diverse biome with the atmosphere? Flux tower studies present important results for daytime exchanges, with the advantage of allowing integration at local scales of all exchanges mediated by wind. However, the well-known inability of flux towers to measure nighttime fluxes in a reliable manner has been hindering the application of tower data to inferences on long-term total exchanges. Complementary new LBA studies on the continental distribution of tenuous fluctuations of atmospheric CO_2 concentrations promise to expand greatly our capacity to monitor the integrated behavior of exchanges across the whole Amazonian biome.

However, even if we successfully measure and describe with confidence how the atmosphere presently interacts with ecosystems in Amazonia, we will still be far away from being able to affirm with conviction the reasons why, unless we deepen our ecophysiological and biological studies. Without knowing the reasons why, it will be very difficult to anticipate the responses of this biome to global climate change. As can be seen, the LBA project, despite its enormous impact and vast discoveries, has just begun to uncover the "tip of the iceberg" of Amazonian complexity.

Antonio Nobre

Some results of biogeochemistry in LBA

Eric A. Davidson WHRC (EUA)

Nutrients such as nitrogen, phosphorus, and potassium are essential for plant and animal life, as well as for human nutrition. The study of movement of these nutrients among soils, plants, animals, groundwater, streams, and the atmosphere is called *biogeochemistry*. The Large-scale Biosphere-Atmosphere Experiment in Amazonia (LBA) includes a significant research focus on biogeochemistry to address the critical role that these nutrients play in plant growth, forest health, agricultural productivity, and water and air quality. The objectives are to improve our understanding of how these nutrient cycles are affected by land management and how management of nutrient cycles can be included in sustainable development strategies.

Studies of biogeochemistry generally include measurements of stocks of nutrients (how much nitrogen is present in leaves, tree trunks, soils, etc., at any given point in time) and the flows of those nutrients (how much nitrogen is falling from the leaves to the soil per year, leaching from the soil to the groundwater with each rainfall event, or being exported from the ecosystem via the streams and rivers during each season). A variety of collectors are employed for these studies, ranging from simple screened baskets placed in the forest to collect leaves falling from the trees, to sophisticated automated river water sampling machines.

One of the advances made by LBA researchers is an improved understanding of why some cattle pastures become "degraded" fairly rapidly while others remain productive much longer. When cattle pastures become degraded, bushes and forbes that ranchers consider "weeds" start to grow more vigorously than the planted pasture grasses. The ranchers often use fire to control these weeds, but eventually, even repeated fire fails to keep the weeds down, and the pastures are often abandoned. LBA researchers have shown that, in many cases, nitrogen and phosphorus become limiting to plant growth in these degraded cattle pastures. Nitrogen is lost as gases and wind-blown ash during fires, which affects regional air quality as well as local soil fertility. Some phosphorus is also lost in the ash, and it is also "locked up" in accumulating organic matter from dead grasses and native plants. The native weeds have an advantage over the exotic grasses in degraded pastures because the native plants are better adapted to these nutrient poor conditions. This nutrient limitation has been observed most often in the highly weathered soils that are very common in Pará state. While similar soils are also found in the western Amazonian states of Rondônia and Acre, more fertile soils are also common in those regions, so that pasture degradation is often a more gradual process there. Interestingly, the streams and rivers demonstrate a similar pattern, with more nutrients naturally leaching from the richer soils of the western Amazon region.

These results help explain why the use of fertilizers in pasture management is more common in the eastern Amazon compared to the western Amazon and where cattle pasture management might be more or less favorable. The results also have important implications for rates of regrowth of secondary forests following pasture abandonment and for managing the quality of water draining from agricultural and forested ecosystems.

Land use change and its implications for surface water chemistry

Alex V. Krusche CENA-USP
Javier Tomasela INPE

The well-known images from the Landsat satellite show how deforestation evolved in the state of Rondônia, along a central axis formed by highway BR-364 and various perpendicular secondary roads. Human actions during this process of occupation have affected the water courses in the region. Because this type of land occupation has not taken into consideration natural characteristics such as topographic relief, availability of water, or soil type, one can expect that some farm lands will prosper while others are fated to be abandoned.

The river basin of the Ji-Paraná, which is cut by highway BR-364 in its southern and central regions, is an example of how this process takes place. In the basin, the pastures that have persisted are found intimately related with soils rich in nutrients, suited to agro-pastoral use, and at the same time, the composition of the soils shows a strict relationship with the chemistry of the waters. Regions with sandier, less alkaline soils have rivers with lower ion concentrations in their waters than those where the soils are more alkaline, and where we find a greater concentration of cations and anions in the rivers.

Thus, studies about the effects of land use changes on the surface water chemistry of Rondônia carried out in the basin of the Ji-Paraná River present a certain ambiguity resulting from the correlation between a natural characteristic – the types of geological substrata and the resultant soils – and an anthropogenic one, which is the more intensive presence of pastures on richer soils. Probably the most direct effect of conversion of forests into pastures may be the amplification of export of material from the terrestrial system to the aquatic system due to soil compaction in pastures. Nevertheless, the differences observed in water chemistry of this basin could also originate from pre-existing natural variability. On the other hand, following a more detailed analysis of these processes, comparing small rivers – the "igarapés"- with coverage exclusively by either forests or pastures, one observes drastic alterations in the structure and function of these ecosystems.

At the "New Life Ranch"- Fazenda Nova Vida, Ariquemes, RO- after the conversion of the forest into pasture, the *igarapés* were invaded by the native grass *Paspallum*, which was no longer growth limited by coverage by the forest canopy. Along some stretches, the flow of water disappeared under the dense growth of this grass, which added a large quantity of organic material to the aquatic system. With this, the previous aerobic conditions in the forest become semi-anaerobic (due to decomposition of organic material and/or root respiration), altering the nutrient cycle and biodiversity of these rivers. Because of the oxygen deficit, communities which are not strictly aerobic came to predominate, and CO_2 emissions to the atmosphere were tripled.

Because this pathway of carbon cycling in Amazonia was also recently identified as very important in large rivers, the potential impact of these changes is extremely significant. Other nutrients, such as nitrogen and phosphorus, also have their cycles modified, something which can be observed even in somewhat larger rivers, such as the Urupá and Roim de Moura, tributaries of the Ji-Paraná River. Hence it follows that anthropogenic actions in the Amazon region, despite being imperceptible in the waters of the great rivers like the Solimões or Negro, already have made a mark on

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Composition of Amazonian atmosphere and its implication for climate

Paulo Artaxo - USP

The Atmospheric Chemistry theme in LBA deals with the processes that regulate the concentrations of gases and of aerosol particles in the Amazonian atmosphere. Among the more reactive gaseous components, the most important trace gases are volatile organic compounds (VOC), ozone (O_3), carbon monoxide (CO), and nitrogen oxides (NO and NO_2). VOCs are naturally released by vegetation and form a family of compounds where isoprene and terpenes are most important from the point of view of biosphere-atmosphere interactions in Amazonia. Some VOCs participate actively in chemical reactions in the atmosphere, regulating the concentration of ozone, hydroxyl radical and other chemical species that affect the functioning of the ecosystem as a whole. Recent studies indicate significant differences in isoprene emissions between LBA tower sites; we still do not know the emission pattern of this important trace gas across Amazonia. High concentrations of ozone, comparable to the values measured in the center of the city of São Paulo, were observed in areas around Manaus during the wet season and in regions in Rondonia during the "epoch of fires" in the dry season. Interactions between VOCs and nitrogen oxides- not just in burning areas but also in the "urban plume" of pollutants downwind of Manaus- can be responsible for the high ozone concentrations observed. Ozone in the atmosphere near the earth's surface damages plants and people because it is a strong oxidant that can damage delicate lung tissue and plant leaves. Aerosol particles are critically important for their role in the formation of clouds and for their effect on the solar radiation balance over the Amazon. Vegetation releases particles to the atmosphere through direct emission of primary biogenic particles and through the emission of VOCs, some of which are transformed into particles. Some of these aerosol particles act as "Cloud Condensation Nuclei" (CCN), thus being responsible for the production of cloud droplets and, ultimately, for precipitation in the Amazon region.

Aerial view of fire in the Amazon. Photo Credit: M.O. Andreae, Max-Planck Institute, Germany.

Recent LBA research shows that high emissions of aerosol particles from biomass burning produce substantial changes in cloud formation mechanisms. This was observed with *in-situ* measurements as well as with remote sensing tools. A strong suppression of formation of low clouds in the presence of high amounts of aerosol particles from burning was observed. The suppression of low cloud formation has the power to inhibit precipitation in large areas affected by burning emissions that could be hundreds or thousands of kilometers away from burning areas. Effects from burning can even reach the central and southern regions of Brazil in months when burning emissions are significant (August to November).

One of the new important aspects of LBA was the measurement of nitrogen deposition by rainfall in some locations such as Balbina, to the north of Manaus, and Rondonia. We have always expected Amazon forest growth to be limited by phosphorus availability, but recently it has been demonstrated that in secondary forests, nitrogen deposition helps the recovery of certain degraded areas. In Rondonia, an Amazonian region with important changes in land use, the composition of rainwater in terms of nitrogen compounds is dominated by nitrate instead of ammonia, as is the case in remote regions in the Amazon. Changes in the atmospheric deposition of nitrogen could cause difficult-to-estimate-yet-important impacts on nutrient cycling. The nitrogen deposition in Rondonia - most of it in the form of nitrates - is reaching levels similar to the levels found in the industrialized part of the state of São Paulo, which can start acidification problems in parts of Amazonia.

The atmospheric chemistry component of LBA is revealing important aspects of the functioning of the Amazonian ecosystem that will be crucial for the establishment of strategies for the sustainable development of the Amazon.

Land use change and its implications for surface water...
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rivers of lesser size, significantly modifying the structure and function of these ecosystems.

Other LBA studies associated with projects in INPA's Cuieiras Reserve (Manaus-AM) are being developed to obtain observations of the dynamics of transfer and storage of water among the various compartments of soil, vegetation, and atmosphere, such as precipitation and evapotranspiration, interception of precipitation by vegetation, and depth and movement of groundwater.

Because water is a principal component in the regulation of the fixation of carbon by plants, and in the process of allocation of particulate and dissolved carbon in soils and runoff, these studies must include the determination of chemical compounds transported by water among compartments, as well as including a strong component of hydrological and micrometeorological modeling devoted to the determination of carbon sequestration by the biosphere.

These studies demonstrate that connections among terrestrial and aquatic systems are important components of the functioning of rivers in the Amazon. The forms and rates of carbon exchange among these systems still need to be better quantified as a function of variability of soil types and in the hydrological and biogeochemical characteristics present in the region, as well as because of the impact of anthropogenic actions on these systems.

Science and frontier governance in the Amazon

Daniel Nepstad - WHRC (EUA), IPAM and NAEA

In an ideal world, the great forests would be opened to free enterprise through carefully planned strategies that seek to build sustainable economies of natural resource management while minimizing the social and ecological costs of frontier expansion. This ideal has, unfortunately, rarely been achieved by human societies. Instead, forest regions that are suddenly made accessible to colonization and commerce through investments in transportation infrastructure undergo a predictable sequence of natural resource liquidation that is wasteful, chaotic, and violent. The rapid exploitation of timber, wildlife, minerals, soils, and other natural resources causes "booms" of economic activity that go "bust" as natural resources are depleted, leaving impoverished ecosystems and people in its wake. The natural wealth of forested landscapes that could have been used to capitalize sustainable systems of land management is squandered in a temporary pulse of wealth that accumulates in the hands of the most powerful frontier actors.

The Amazon may become the first major exception to this worldwide legacy of poorly planned frontier expansion into forest regions. Through the combined influences of an organized civil society, responsive government, increasingly transparent commerce, and policy-relevant science, it has become clear since the inception of LBA that frontier governance could become a reality in the Amazon. It is now clear that new investments in highway paving into remote forest regions will not proceed without a process of regional planning that addresses the aspirations of the forest residents who already live in these regions, that addresses the fragility of the ecosystems and climate of each region, and that implements the power of law over the power of violence and economic wealth. These planning processes are well-advanced for the Santarém-Cuiabá highway (BR-163) and for the highway to the Pacific from Assis Brasil to Puno, Peru. But these remarkable planning processes,

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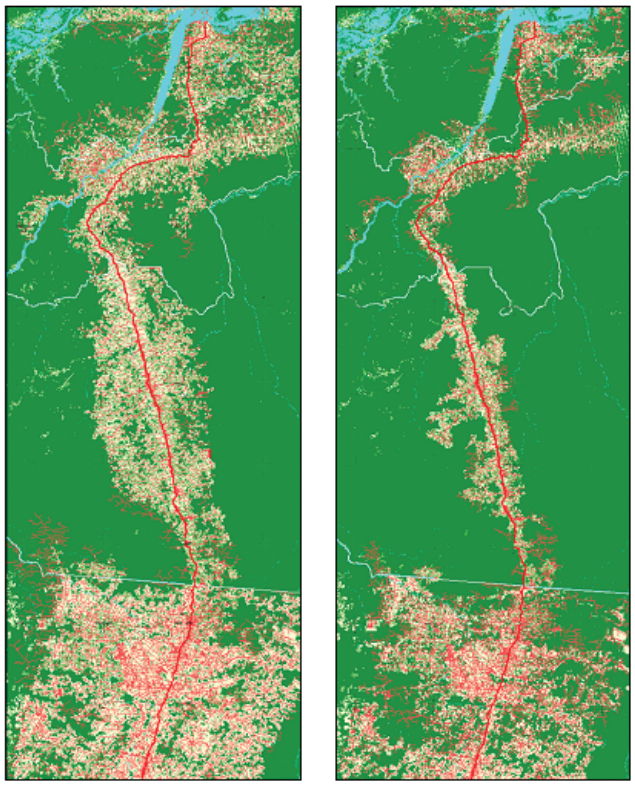

Business as usual scenario *Governance scenario*

Simulated land cover along the BR-163 highway in 2026 under scenarios of "business-as-usual" and "governance". The maps provide compelling reminders to social movements, NGOs, local governments, and national governments that paving into remote forest regions does not necessarily lead to runaway deforestation. Source: Soares Filho et al. 2004.

The Human Dimensions of LBA

Bertha K. Becker - UFRJ; Diógenes S. Alves - INPE; Mateus Batistella - Embrapa; Eustáquio J. Reis - IPEA/DIMA

LBA addresses two fundamental questions so as to understand how the Amazon functions as a regional system and how changes in land use and climate can affect the functioning of this system. The underlying concept of LBA is concerned with recognizing patterns and processes of change in land cover and land use and to formulate scenarios that incorporate the diversity and complexity of changes in land use so as to improve the definition of the conditions under which Amazonian systems should operate. At the same time, climate and environmental changes have effects on the sustainable use of resources and, in a general form, on populations. It is in this context that Human Dimensions comes into the picture: to investigate how different human factors can influence the processes of transformation in Amazonia; and to understand how man can suffer from or adapt to the impacts of changes in climate and in ecosystems.

These questions have become ever more important in environmental change studies, as demonstrated by the IHDP (International Human Dimensions Program), the IGBP (International Geosphere-Biosphere Program) and the WCRP (World Climate Research Program). To address these questions requires an integrated approach, including Human, Social and Natural Sciences, developed in common studies through complex exercises focusing either on the epistemological or the organizational point of view of the research, or even on the consequences of research to society.

In the case of LBA, the challenge of the exploration of the new, or in some cases, the unusual, which distinguished the natural sciences since the beginning of the experiment, became still more complex and intricate when the time came to include the human element. The way encountered to deal with this challenge was to carry out three exercises that would bring into question the human aspects that are present in several disciplines: in the first phase, a survey of scientific products in the human and social fields during the 1990s; in a second effort, three important questions about the Amazon were more deeply discussed; and finally, based on these studies and contributions from specialists in various areas, some gaps in understanding of Human Dimensions were identified and a prioritized research agenda was formulated.

The survey of scientific products for 1900-2002 included the themes "Cities and Networks", "Populations, Ethno-Cultural Representations and Society", "Recent Dynamics of Cattle Farmers and Extractivists", and "Expansion and

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Science and frontier...
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which attract hundreds of participants to their periodic meetings—federal ministers, local governments, social movements, non-governmental organizations—will only realize their full potential through an expanded foundation of policy-relevant science.

How can science foster frontier governance? The most important contribution that science can make to strengthen the regional planning processes underway in the Amazon is to provide clear, accessible analyses of the economic, social, ecological and climatological implications of each regional development trajectory that is under consideration. Science has the potential to map the potential profitability and job creation of competing land-uses for the entire region, it should identify regions of potential runaway fire regimes, it should call attention to sensitive watersheds, and to the potential changes in rainfall that might accompany each trajectory. Science can provide tools with which the complex interactions among economic, ecological, and climatic systems that are stimulated by each development scenario are simulated and expressed in compelling graphics and figures. In sum, science can improve the quality of regional planning if it is successful in providing compelling, rigorous, and accessible information.

A simulation model of future deforestation of the BR-163 highway under (no action taken) and "governance" (with intervention) scenarios (Soares Filho et al. 2004) demonstrates the potential influence of scientific results expressed in the form of maps. The first map simulates the future trajectory of deforestation along the Cuiabá-Santarém assuming that deforestation patterns of the past will continue into the future. The second map assumes that several measures for restricting "unproductive" deforestation, for supporting forest-based economic activities, and for implementing the law, will be realized, avoiding the most wasteful forms of forest clearing. The resulting maps were presented in meetings of BR-163 stakeholders, before several Ministers, and were featured in Veja magazine. And, yet, this model is just a small example of what science could offer to support the regional development planning processes underway.

LBA-DIS: The data and information system for collaborative science

The LBA DIS (Data and Information System) is a window that allows you to look into the world of scientific research in the Amazon provided by this large Experiment. All data collected during the LBA project are being collected into one place so that scientists, teachers, students and society in general can access this immense collection of LBA data and information sets.

INPE (the first institution to manage LBA) and NASA were responsible for the development of LBA-DIS. The core of LBA-DIS – its archive and distribution – is maintained at INPE/CPTEC and managed by the LBA Central Office, currently at INPA, in Manaus. The core of LBA-DIS has mirror sites and supporting nodes at INPA, USP and in the USA.

The LBA-DIS contains data sets organized according to the specific information described in the metadata files: who collected the data, where, what methods, instruments and models were used; in short, a number of details and information that allow the data to be categorized.

The system provides two on-line tools, the LME (LBA Metadata Editor), used by investigators to create and edit descriptions of their datasets, and "Beija-flor", which searches the metadata created by the LME and allows the user to find and download data of interest.

The LBA DIS does not merely consist of the data collected by Brazilian researchers and their foreign counterparts. The collection includes data from meteorological stations from around the world, subset to feature data from regions studied by LBA. At this time, the LBA DIS stores data relevant to climate, atmosphere and forests; fields and pastures; soils; surface waters (rivers, streams, and wetlands); land cover and use; biomass and vegetation.

The LBA DIS makes it possible that this valuable and ample source of information may produce infinite combinations, generating firm foundations for studies in diverse areas which advance understanding of climate and environmental studies. The existence of this system, transparent to the user and easy to work with for the providers of data and information, that is, for the scientists, students and technicians of LBA, is likewise contributing to slowly change the "culture" previously prevalent among scientists of not sharing field data for many years. The new "culture" which LBA is helping to spread is to share data no more than two years after they are collected, or even sooner, to maximize the interdisciplinary work of joining together data from different disciplines so that we may advance the frontiers of understanding of the complex universe of Amazonia.

Human dimensions in LBA...
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Dynamics of Industrial Activities". The survey showed that a good number of studies are being developed in the region in mature graduate programs and with active participation of research centers that are not part of universities. This study also helped identify some important gaps in research.

Three questions were thus proposed as a result of the survey of scientific products in this field: 1) Amazonian population – a neglected theme during the 90's; 2) emergent systems of production and 3) the expansion of soy agribusiness in the Amazon, including the establishment of its logistics infrastructure.

A more specific agenda for research development was formulated in May 2004 during the "Human Dimensions and LBA" Workshop which assembled researchers from several study areas to discuss a series of fundamental issues in this field. Based on the identification of gaps in knowledge and also on discussions about the importance of several themes from the sustainable development perspective, the following themes were considered a priority: "The Agrarian Question", "Systems of Production" and "Land Cover and Land Use Change", themes which focus on socioeconomic and socioenvironmental aspects of land use; "Logistics and Regional Development" and "Population Mobility and Urbanization", understood as processes which underlie changes in land use; and "Institutions and Governability" and "Institutions and Policies in Science and Technology", considered as urgent needs for strengthening of institutions to bring about planned land management.

When dealing with Human Dimensions in LBA, we felt that the whole community was interested in contributing to reduce and mitigate the impacts of the accelerated and unplanned occupation of the Amazon. We also felt that it is necessary to search for alternatives for sustainable development for rural and urban populations that have been growing so rapidly in recent decades. This motivates us to find the best way to integrate both social and natural sciences so that society and decision makers can use and enjoy the results of our research.

New initiatives in Training and Education

Regina C. C. Luizão - INPA

The Training and Education component of LBA continues to expand its actions to increase the number of new scientists in the Amazon. This year, a new project was incorporated into LBA: PARAMA, the Project for the Advance of Regional Research Networks in the Amazon, a European cooperation with Latin American partners. The initiative will involve the participation of 70 researchers from ten Latin American and European countries. The aim will be to advance and understand the structure and functioning of the Amazon forest and provide training for local researchers and students in order to guarantee the continuation of these studies through standardized methodologies.

Training for students will be provided through Advanced Study Workshops led by European and South American scientists. Scholarships will also be granted to high-level candidates for the development of projects addressing current European Union carbon cycle and biodiversity priorities, including forest diversity and dynamics; tree biodiversity and carbon dynamics; and whole ecosystem physiology.

Another important initiative is the offer of three scholarships by the Master of Environmental Management Program at Duke University, USA. The rationale is to offer fellowships to candidates from the Amazon region for studies in the areas of Environmental Economics and Policy; Environmental Health and Security; Forest Resource Management; Global Environmental Change; Conservation Science and Policy; Ecosystem Science and Management; and Water and Air Resources.

These partnerships will help increase the remarkable educational achievement already accomplished by LBA: 249 undergraduates, 195 Masters and 196 PhDs having received formal training in programs with partner institutions.

Besides formal training, LBA will continue to offer courses and seminars in regions where LBA research sites are concentrated. So far, 19 short courses and more than 50 lectures have been organized for LBA students and technicians. These meetings, also open to local communities, students and professors of local educational and research institutions, have created a variety of experiences in the teaching and learning processes, not only by improving scientific knowledge acquisition through interaction with different research groups but also by developing communication skills in oral and written modes through the development of skills in coordinating and synthesis which are exercised in group discussions.

Since the beginning of 2004, the travelling course "Dynamic Environmental Systems Modelling" is being offered at LBA research sites using the "Portable Computing Laboratory", which includes 12 laptops. This course is coordinated by Professor Marcos Costa, from the Federal University of Viçosa, in collaboration with Wisconsin-Madison University. Young scientists of Viçosa University, Manaus and the Federal University of Mato Grosso were the first to benefit from this innovative program which aims to provide this learning opportunity to students at all LBA research sites.

For the III LBA Scientific Conference, the LBA Training and Education is providing financial support to 188 Brazilian and South American students, all of them first authors of poster sessions and oral communications. This initiative is undoubtedly the greatest support that a research program has ever provided to young scientists in Brazil.

Folha Amazônica
http://lba.inpa.gov.br/

Dr. Carlos A. Nobre, Scientific Coordinator of LBA and Chair of the International Science Steering Committee of LBA 2004, CPTEC/INPE, Brazil: nobre@cptec.inpe.br;
Dr. Diane Wickland, Terrestrial Ecological Program Manager, NASA, USA/ LBA-ECO Component;
Dr. Pavel Kabat, Coordinator of the LBA European Commission

Collaborators for this Edition:
Dr. Paulo Artaxo (USP), Dr. Michael Keller (UNH), Dr. Mercedes Bustamante (UnB), Dr. Flavio Luizão (INPA), Dr. Maria Assunção F. da Silva Dias (USP), Dr. Antonio Nobre (INPA), Dr. Erick Davidson (WHRC), Dr. Alex Krusche (CENA-USP), Dr. Javier Tomasela (INPE), Dr. Daniel Nepstad (WHRC, IPAM), Dr. Diógenes Alves (INPE), Dra. Bertha Becker (UFRJ), Dr. Mateus Batistella (Embrapa), Dr. Eustáquio Reis (IPEA), Dr. Regina Luizão (INPA), Dr. Peter Griffith (LBA-ECO), Dr. Ivani Pereira (LBA-ECO).

Support: LBA - https://lba,inpa.gov.br and LBA-ECO - http://www.lbaeco.org/

Journalist: Tânia Brandão, MTB 025/DRT-AM, INPA e MCT, Av. André Araújo, 2936, Manaus, Brazil: http://www.inpa.gov.br/

Technical review: Dr. Carlos A. Nobre and Dr. Antônio O. Manzi

Design: Beth Nelson (LBA-ECO)

Comments and suggestions: eneida@inpa.gov.br

LBA in Numbers

1998 - 2004

PROJECTS		
100% Brazilian		20
Cooperation		
Brazil + USA		77
Brazil + USA + Amazonian Countries		4
Brazil + USA + Europe		1
Brazil + Europe		16
Brazil + Europe + Amazonian Countries		2
TOTAL		**120**
PARTNER INSTITUTIONS		
Brazilian (non-Amazonian)		63
Amazonian (Brazil and Amazonian Countries)		39
Foreign		143
TOTAL		**245**
RESEARCHERS		
Brazilian	990	
Foreign	708	
TOTAL	**1698**	
STUDENTS		
Undergraduate		249
Masters		195
Doctoral		196
TOTAL		**640**
PUBLICATIONS IN SCIENTIFIC JOURNALS		
Brazilian Authors or co-authors		371
Foreign Authors		108
TOTAL		**479**
Papers in Special Editions		
Journal of Geographical Research, 2002		57
Ecological Applications, 2003		24
Remote Sensing of Environment, 2003		13
Global Change Biology, 2004		26
Intl. Journal of Theoretical & Applied Climatology, 2004		12
Acta Amazônica (submitted)		28

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