A. P. FREIRE

Break down boundaries in climate research

Scientists wanting to implement change must collaborate between disciplines. An ambitious Amazon study shows them how, says **Paulo Artaxo**.

Tropical forests are big players in the global balance of climate and carbon, and the Amazon is the biggest of the lot. Almost 20 years ago, I was part of a group of scientists that hatched an ambitious plan to study the Amazon rainforest in a totally new way, to improve our understanding of the forest and its role in the global climate system. We wanted to build a scientific base from which to learn how the region could be developed sustainably.

I say it was ambitious, but perhaps that is an understatement. Our plan was to study the rivers and soil, use satellites to track changes in land use, monitor the atmosphere with aircraft and analyse the socio-economic factors that drive deforestation. And we wanted to install more than a dozen enormous monitoring towers deep in the remotest parts of the jungle, to measure changes in the levels of trace gases, aerosols, carbon and water vapour, among other things, and to study energy balance and plant metabolism.

At that time, environmental science in Brazil was in its infancy. But we were very optimistic, as most Brazilians are, with no reason to be sure it would work.

Today, the success of the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), as the project is known, shows that we were right to be optimistic. So, too, does the catalogue of scientific papers and results that our experiment produced over the years, which are detailed in a Review on page 321 of this issue. In fact, the LBA is a triumph for long-term cooperative research. Its success has led to calls for similar projects to be set up to monitor other tropical forests, including those in Africa and southeast Asia. So, here is how we did it.

Perhaps most fundamentally, the project encouraged cooperation between physicists, chemists, meteorologists and biologists, to tease apart the Amazon's interwoven scientific strands. The biology of the forest, for instance, drives emissions of volatile organic compounds, which affect cloud formation and development, changing how much sunlight reaches Earth and thus affecting the radiation balance. Unusually for the time, we also brought economists and social scientists into the research. We knew that this was necessary if we were to fully understand all the factors influencing such a complex system.

International cooperation has also been consistently required: each project team includes scientists and students from several countries, and every few years, the LBA holds its own scientific conference in Brazil, which attracts hundreds of scientists and students. For a single experiment, such large participation is outstanding.

The LBA was a pioneer in data sharing and access. From the beginning, policies encouraged our researchers to make information widely available, and to invite other scientists to use LBA data in their models. This helped to boost our output to more than 2,000 papers in two decades. The project has also produced 200 PhDs and nearly 300 master's degrees, and many graduates have continued to work in the Amazon region. As a result, several courses on environmental physics, ecology, climate and environment have been launched at universities in the area.

The LBA was launched with domestic and international funds (especially from NASA), and Brazilian funding agencies strongly supported scholarships to help students to participate. The project has survived several changes of government in Brazil. LBA research is now funded by the Ministry of Science and Technology and administered by the National Institute of Amazonian Research in Manaus, aided by growing awareness of regional and global environmental issues and sustainable development. In a fast-changing scientific and political field, the LBA and its leaders have been flexible. As the climate questions have become more important, we have seen that we are in a unique position to answer important questions, such as how aerosol particles emitted by burning biomass could affect cloud microphysics and precipitation, as well as how the increasing risks of fire from changes in land use and global warming interact to alter forest ecosystems. Expansion of soya farming into the Amazon was not significant when the LBA began, but when it later became so, our biophysical and socio-economic researchers altered their projects to study it.

Twenty years after it was conceived, the LBA has provided the scientific knowledge and personnel we need to help to manage the Amazon. It has provided evidence that the environmental and economic value of standing forest is significantly higher than that of degraded areas. And the large decrease in annual deforestation in Amazonia, from more than 27,000 square kilometres in 2004 to 6,200 square kilometres in 2011, shows that it is possible to implement strategies to reduce deforestation and carbon emissions in the region.

Can the LBA experience be exported to other regions? It needs to be. Research on tropical ecosystems and their role in climate change can be effective only if it is accompanied by greater integration of natural and social sciences. We need to break down the boundaries between university departments and funding agencies that cater only to broad disciplines, such as 'sciences' or 'arts'. Integrated science at the international level is certainly the way to go. This is urgent: the planet calls for action now. ■

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