Scientific challenges for the conservation of forests and ecosystem services in the "three basins"

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The "three basins" account for the majority of the world's humid tropical forests. These include vast forests in South America (Amazon and Guiana Shield) and Central Africa (Congo and Atlantic basins). In Asia, high conservation value cloud forests range from the Western Ghats in India all the way to Papua New Guinea.

Humid tropical forests and deforestation

The three conventions resulting from Rio 1992 recognize the crucial importance of the humid tropical forests, and the issues concerning them run through most of the SDGs. Covering only 12% of land masses, these forests are home to more than half of all known terrestrial plant and animal species (two thirds of flowering plants). Around 350 million people depend directly on their resources (wood, non-wood forest products, medicinal plants, etc.). Many more people in the global South benefit from their ecosystem services (water regulation and quality, soil protection, etc.). Finally, their environmental services related to the climate, carbon sequestration and the regulation of major rivers are of global significance.

In the last 30 years (1990-2020), the world's humid tropical forests have lost in the order of 220 million hectares, almost equivalent to the total forested area of the Congo Basin. Forest degradation represents an estimated area of at least 100 million hectares. Degradation results in particular in the loss of tree biomass – and thus of carbon stocks – and the disappearance of species of plants and animals, including some of the most emblematic (known as "umbrella" species). **Degradation and deforestation are very often associated**, with the former preceding the latter, or forming a "halo" around deforested zones.

Agriculture is the main direct cause of tropical forest loss. In South America, the establishment of pastures and large industrial plantations for export play a key role. In Africa, clearing is primarily due to family farming. Asia has a range of different situations, presenting an intermediate panorama. Although the pace of deforestation appeared to slow in the 2000s, it has begun to increase again. Central Africa, which was relatively unaffected until now, is showing an acceleration in countries with a growing rural population[1].

The commitment of states is indispensable to restrict deforestation/degradation, the scale of which can vary with political changes, as seen in Brazil. **The involvement of indigenous or local communities and the recognition of their rights is also essential**, in particular in states with limited resources and poor governance, which have little effective presence in the field. **New international ambitions were announced** during COP27 (UNFCCC) and COP15 (CBD), along with new financial instruments (PCP). This dynamic is aimed at **building on the science to ensure the credibility and relevance of actions, in tropical contexts that are insufficiently studied** in comparison with the countries of the North.

[1] For more details: Note sur les forêts d'Afrique centrale et leurs enjeux (Couteron & Karsenty, 17/02/23)

The state of scientific research in the three basins

Science, whether basic or applied, could be a powerful tool for development in the countries of the global South that have humid tropical forests. However, most of these countries can only dedicate limited resources to this science**. Often, the critical mass or the permanence of local research teams are not guaranteed. Direct "South-South" collaborations between the basins are very rare, and sometimes insufficient between neighbouring countries**. Cooperation from the global North does not invest enough in building local scientific capacities. The academic system presents varying levels of weakness depending on the country or the region within a given country. It has been shown to be particularly weak in the Congo basin[2]. **The French higher education and research system has been active for a long time in many of the countries of the three basins**, through **original partnership structures and dedicated institutions**. It could therefore be a driving force for new dynamics.

Scientific challenges for the conservation of tropical forests

The complexity of tropical forests and of deforestation processes necessarily entails a very wide range of scientific disciplines, through inter- or trans-disciplinary approaches.

Better understanding interactions between the climate, forests and the carbon cycle

The crucial role forests play in regulating rainfall, water resources (groundwater, rivers, wetlands), **cloud cover and temperatures is acknowledged**. It has been documented and modelled in the Amazon (through the Large-scale Biosphere-Atmosphere experiment[3]), but is less well known elsewhere, especially in the Congo Basin[1,2]. It is important to better identify the meteorological determinants of large wildfires, which particularly threaten degraded forests, such as the ones occurring in the Amazon and in Borneo.

Challenges linked to the carbon cycle, associated with specific financial instruments**, call for a focus on the points of quantification that present the greatest uncertainties**:

- **For stocks**: root and soil compartments, wetlands, peatlands, mangroves;
- **For fluxes**: land use change and degradation[4], followed in the long term by **tree growth and post logging absorption** faced with climate change, the scale of **re-emissions linked to tree mortality** (natural or human-induced, drought-induced, sensitivity to fire), the level of **re-emissions after transfer to water systems** of greenhouse gases (CO_2, CH_4, N_2O).

Going further with the inventory of biodiversity and biodiscovery

Knowledge of the biodiversity of tropical forests is still only very partial, and many species have not yet been described. The level of the inventory varies between countries and regions, and some vast territories have barely been explored. This calls for:

- **Consolidating taxonomic expertise in the global South** and the invaluable collections associated with it (herbaria, etc.), building on the most recent methodologies (environmental DNA, etc.);

[2] See article White L.J.T. et al., 2021, Nature. [3] Large-scale Biosphere-Atmosphere Experiment in Amazonia (LBA). [4] See One Forest Vision (OFV)

- **Developing participatory science to associate local communities** with the inventory of their resources, using NICT (for data aggregation and dissemination) and **AI for species determination systems** through visual content on smartphones[5].

Anticipating deforestation/degradation and fostering territorial planning

Although the general drivers of deforestation/degradation are well known, many regional and local variations of the problem exist, which calls for further research to address the diversity of contexts and to propose adapted solutions. The research issues are:

- **Anticipating the risks of deforestation, by better contextualising deforestation models** in order to increase their spatial resolution and their accuracy;
- **Ensuring near real-time monitoring to improve warning systems**, in particular for the implementation of the EU regulation on imported deforestation;
- **Qualifying territories according to their combined values for carbon and biodiversity** (based on the two previous points), which is central to the PCP approach.

The goal is to **identify the territories that are the most exposed in the short or medium term** (through risk modelling), and **in particular the most "vital", to prioritize research and action resources**, which are very limited in tropical contexts. This should contribute to:

- **Fostering territorial planning** through action research at the interface between digital, agricultural/forestry and human sciences (stakeholder approaches, provision of meaningful maps, etc.). The overall objective is **to reduce the inconsistencies and conflicts between agricultural, forestry and conservation policies** that are noted all too often.

- More specifically supporting **the implementation of national policies for the management and restoration of forest resources**, which are needed to cover the future needs of the most populous countries, by conserving natural forests that are threatened by urban demand for wood (lumber, timber, fuelwood, etc.). This calls for research to **identify relevant zones and techniques for the restoration of degraded forests** and the implementation of methods to predict total potential wood production (from plantations, agroforests, natural forests) **at the national and regional levels**.

Co-developing sustainable solutions with local stakeholders

Numerous studies conducted in the three basins have shown that **indigenous or local communities can contribute to conservation**, manage their forest resources and propose sustainable agricultural and agroforestry practices. Going beyond the case studies, research needs to **identify the conditions that have enabled these successes and build on them to design socially acceptable solutions that are adapted to other contexts**. This implies:

- **Integrating in-depth knowledge of local environments, economies and cultures**, through research efforts and investments by financial partners that are sufficiently targeted (see previous point) and long-term;
- **Designing locally adapted technical solutions** for the ecological intensification of agriculture and the creation of new resources that reduce pressure on wildlife and forests: breeding small species for hunting, planting native species for timber/lumber;
- **Developing innovative approaches at the interface between IT and anthropology** to foster consultation between stakeholders (inhabitants, technical managers, etc.), giving them access to knowledge on their environment through meaningful tools.

[5] For example Pl@ntNet (https://fr.wikipedia.org/wiki/Pl@ntNet, https://plantnet.org/)