Drought – Light

Monitoring forest changes for better management

The permanent plots are an important source of information (tree diameter increment, mortality rate, species abundance distribution, etc.) to monitor the dynamics of tropical forests. This information is rare in the forests of the Congo Basin. We have thus been developing a network of permanent plots in the region in the past few years, integrating the existing plots and setting up new ones as needed (e.g. in Cameroon).

These plots will be used, in particular, to quantify and monitor the biomass stored in forests and the biodiversity in the context of climate change. So far, about twenty permanent plots of one hectare each were installed in the Eastern part of Cameroon. As part of CoForChange, we are about to set up a new plot in Deng Deng National Park. A floristic survey will then be conducted to complete the project database.

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Past disturbances

New paleodata

Stable carbon isotopes $\delta^{13}C$ and trace and major elements of a sediment core (CORE 10) were studied in the Northern Republic of Congo. Results yielded new paleodata for the last seven millennia. The area remained forest covered during the period. However, some forest degradation occurred without ever reaching the savanna stage. These disturbances took place between four and two thousand years before present (ka BP). The increase in $\delta^{13}C$ is accompanied with lower iron levels, suggesting a decrease in rainfalls. These changes are concomitant with a significant increase in copper. The hypothesis that human occupation was made possible by the opening of the area is suggested. However, no copper-related activity has been reported in this region in the literature and the origin of the copper remains to be explained. The second disturbance (between 1.4 and 0.5 ka BP), characterized by high $\delta^{13}C$ and iron values, indicates human activity of iron metallurgy. In the past five centuries, the forest recovery (lower $\delta^{13}C$ and iron) suggests site abandonment.

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Soil water availability

Tree rooting

The maximum plant-available soil water reserve depends on the intrinsic properties of the soil (texture…) and on root depth. This characteristic has been little studied in tropical forests. The objective of C. Wonkam's Master-1 internship was to study the distribution of the root system of trees in two contrasted soil types of CoForChange area: sandy clay soils on quartzite sandstone (Mbaiki) vs sandy soils on Carnot sandstone (Ngotto).

At each site, two pits were opened up to 6 m or 3 m and roots counted on a 100 cm²-resolution grid. Boring augers up to 2 m deeper than the depth of the pits completed the study. Initial results showed that the roots reached at least the total depth studied: 8 m (Mbaiki) and 5 m (Ngotto). In one of the two Mbaiki pits, rooting persisted in spite of the presence of a gravelly layer and a shell, usually considered as high constraints for rooting.

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Decision-making tools

Predicting the future with LPJ-GUESS

In CoForChange, we are not only interested in studying the past and present distribution of forests, but also in projecting their future. This requires the development of modelling tools (workpackage 7) that are able to simulate the forest structure expressed in terms of phenology (evergreen/deciduous), guild (pioneer/non-pioneer, light demanding / shade-tolerant) and biomass. We are adapting the LPJ-GUESS vegetation model to our specific need to represent six tropical plant functional types (phenology crossed with guild). Field data from logging concessions will be used to select the best parameters for these plant functional types by minimizing differences between, for example, the observed and simulated above-ground biomass and basal area. The sensitivity of the model to variations in soil and rooting depth will be evaluated, and soil model parameters will be adjusted for the best fit between simulated seasonality of vegetation productivity and satellite-derived enhanced vegetation index from MODIS.

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Present-day forests

A new site in the Central African Republic

In the Central African Republic, A. Kpolita and O. Yongo completed the study on the current vegetation conducted by J.-F. Gillet in Cameroon and the Republic of Congo (see *Newsl.* No 4). Inventories have thus been carried out in Ngotto forest (3°40' – 4°20' N lat.; 16°40' – 17°30' E long.). A total of 15 plots of 50 m x 10 m (7500 m²) and 60 subplots of 4 m x 4 m (960 m²) were inventoried. In the 15 large plots, 454 woody plants (≥ 10 cm dbh) were counted, representing 94 species distributed between 33 families. The families most frequently encountered were *Lecythidaceae, Clusiaceae, Myristicaceae, Ulmaceae, Sapotaceae, Annonaceae, Mimosaceae, Bignoniaceae, Chrysobalanaceae, Combretaceae* and *Violaceae*. In the 60 small plots, 721 woody plants (< 10 cm dbh) were recorded, representing 83 species distributed between 33 families.

The first analyses show a significant floristic difference between adult and young stands. These new data will be compared to data collected in 2010 to analyze the current evolution of the various stands surveyed within CoForChange.

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PREDICTING THE EFFECTS OF GLOBAL CHANGE ON FOREST BIODIVERSITY IN THE CONGO BASIN

Converging efforts for better management of tropical forests

Integrate the results of research

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Dense forest in North Congo.

Forest management in Central Africa has undergone significant progress since the early 1990s, especially in the priority interest area of the project, the “Sangha River interval” (see *Newsl.* No 2). A crucial tool has been the implementation of very large scale forest inventories, which highly contributed to improve the knowledge on the floristic composition of the forests and their tree population structure. Forest managers have made use of these surveys to assess resources available for the industry in the medium and long term. They also helped to determine logging rules, in order to guarantee in particular satisfactory recovery of forest resources between successive cuts.

The technical methods of implemented forest management are based on these initial surveys, on the one hand, and on available knowledge resulting from forest research, in particular on ecosystems dynamics and species ecology, on the other hand. Management plans must be periodically revised. The measures taken must be regularly evaluated and adjusted. The newly acquired knowledge through scientific research will be one of the significant components that must be integrated in these revisions. Synergies between forest managers and researchers are essential, as demonstrated by the CoForChange project. This project has integrated in its work inventory data sets supplied by 11 forest concessionaires involved in the project. In return, CoForChange results will have implications on forest management measures.

The project aims, among other things, at predicting the reaction of the ecosystems to changes in environmental conditions, on which forest management has an incidence in addition to that of global change. Mapping the plant communities showed the great diversity of Central African forests: forest management rules must be adapted according to the sensitivity of forest stands to changes caused by harvesting, to the vulnerability of the ecosystems, to the endemism of the species composing them, etc. For example, dense-wooded and light-wooded forests (see *Newsl.* No 3) should be managed under different rules. Removal levels and the resulting canopy openings must be worked out according to the reaction of the ecosystems to the induced changes in environmental factors.

Beyond the results obtained by CoForChange, among forest managers' expectations with respect to research, knowledge of species dynamics parameters (growth and mortality) is a key management element: the first management plans were based on available results, which must be confirmed and further refined for the various species associations. Similarly, the regeneration conditions of the different species (fructification diameters, seeds dispersal modes and germination conditions, young trees behaviour), which are crucial for a suitable management of the stands, are still insufficiently known, as are measures which could enhance natural regeneration.

A workshop bringing together forest management players will be organized in 2012. The objective will be to translate CoForChange project results into operational management measures and to prepare future collaborations between researchers and forest managers, so as to benefit from the multidisciplinary skills implemented in the project.

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2011 International Year of Forests

... still in the news! The results obtained within the framework of CoForChange keep supplying exhibitions and conferences. The exhibition "Tropical Rainforests, the future of the planet," conducted jointly by CIRAD and IRD, is presented at the Palais de la Découverte in Paris from 28 June to 25 September 2011. This is also a traveling exhibition and a preview was presented in Brazzaville at the Heads of State and Government Summit on the Three Tropical Forest Basins (29 May – 3 June 2011). It was also presented in Bangui during the Rainforest Week (23–30 June), and O. Yongo and A. Fayolle were able to comment it live. It will then travel extensively across three continents. It is yet completed by another exhibition on the same themes, organized by CIRAD and Paris City Hall at the parc de Bagatelle, which runs from 23 May to 2 November 2011. This information and many others are available on the Internet portal created by CIRAD on the occasion of the International Year of Forests (http://forets2011.cirad.fr/).

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Focus on

The forest typology team

Lucas Bourbier is a geographer. He specializes in geomatics applied to the environment (remote sensing, geographic information systems, etc.) at Montpellier 3 University. He joined CIRAD as an intern for the CoForChange project. His job is to develop treatments that will help evaluate forest degradation from high-resolution satellite images.
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Guillaume Cornu is an engineer in scientific computer science at CIRAD (software development, scientific word processing, etc.). In CoForChange, he helps researchers recover inventory data, process field data, and present them graphically.
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Mapping tree communities and environmental factors

Mapping human impacts in forests

Assessing the recovery time of tropical forest ecosystems after logging is an aspect recently developed within the CoForChange project. For several years, the estimated degradation caused by logging has been studied by specialists in the tropics. Our work stems from the advances made in the field so as to form a chain that automatically processes satellite data to map human activities' impacts over time.

We used the LANDSAT satellite for regular and accurate monitoring over time as the archive of the United States Geological Survey (USGS) has not only been providing standard data since 1984, but also accurate data with a pixel size of 30 m. We thus located and mapped the network of main and secondary tracks opened during logging.

The process is based on the local contrast between the green canopy (with high photosynthetic activity) and the bare ground (little or no photosynthetic activity). The identification of bare soil pixels helps piece together the track network currently in use. Undetected pixels are considered to represent the "intact" forest. Pixels detected during one year or more may not be detected later on. This indicates that forest regrowth has occurred and provides information on the capacity of the forest ecosystem to fill the open space. This does not mean total recovery of the forest, but that plants resumed growth and therefore gradually filled the tracks.

To make the process work in annual inventories over very large areas, we have been developing a spatial and temporal synthetic tool. LANDSAT data at 30 m are re-sampled over 500 m long areas (equivalent to the MODIS satellite imagery pixel size) and the track information is changed into a degradation index on the new pixel. This circumvents the difficulty of exactly locating the tracks on the successive images (variability estimated at 2 or 3 pixel sizes of 30 m), and helps avoid clouds and missing data. At the end of the chain, we will be able to add information on the recent history of degradation (20 years) to the spatial analysis of the distribution of forest structures obtained by processing MODIS image data, and to the spatial organization of trees functional traits.

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The object "logging track" searched by the algorithm.

In white, location of human impacts: network of main and secondary tracks; also roads and bordering villages.

Focus on

Soil water availability

Vincent Freycon is a soil scientist at CIRAD. In CoForChange, he maps the maximum capacity of the soil water reserve available for plants (workpackage 2); he develops a model of soil water reserve across time in relation to soil type, rainfall amounts, and evapotranspiration (workpackage 3); he performs measurements of the carbon isotopic composition to detect forest replacement by savannas during the Holocene (workpackage 4).
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Fidèle Baya holds an Advanced Vocational Training Certificate (BTS) from the Higher Institute of Rural Development (ISDR) in the Central African Republic. He works in the forest research support project (ARF) and is in charge of Mbaiki Experimental Station. Within CoForChange he participates in seed collecting as well as measurements of soil water content.
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Mapping soil water availability

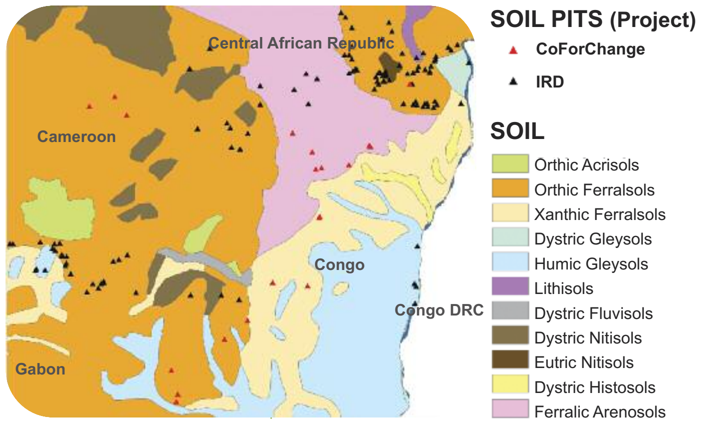
Soil water reserve and forest species distribution

In the study area of CoForChange, the geological substrate determines the distribution of tree species. On Carnot sandstones, dense-wooded evergreen species dominate, whereas on the other substrates light-wooded deciduous species dominate (see *Newsl.* No 3). As parent material is one of the main factors of soil formation and influences its physicochemical properties, we investigated whether the soil water reserve explained the relationship between species distribution and geological substrate during the dry season. This work was carried out by S. Rabaud as part of her Master's internship.

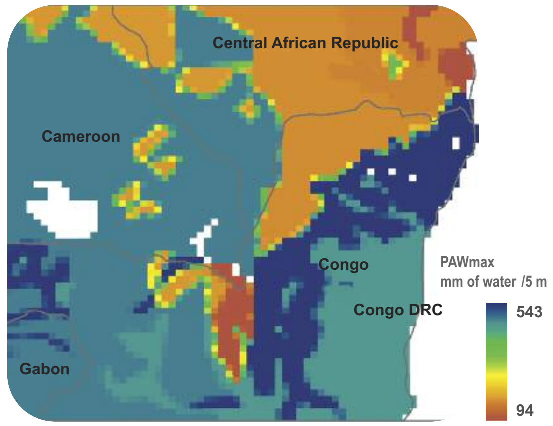
The study was conducted in several stages: (i) production of a map of the maximum water reserve, based on soil data from 21 pits studied in the project (see *Newsl.* No 4) and 200 pits from the grey literature; (ii) application of a model of soil water reserve over the period 2000–2010, using rainfall and evapotranspiration data with an 8-km spatial scale and a 10-year time scale; (iii) calculation of an index of soil dryness and mapping of the index; (iv) study of the relationship between soil dryness and species spatial distribution.

Initial results show no relationship between soil dryness and species distribution. One may suppose, on the one hand, that this relationship exists but could not be revealed because of the use of too simple a model (e.g. the water table depth is not included in the model), poorly-known model input data (e.g. root depth and evapotranspiration), and of a sample period not characterized by a major dry episode such as El Niño. Or, on the other hand, this relationship does not exist. Other factors such as soil fertility or the history of human occupation would then explain the relationship between tree species distribution and geological substrate.

Vincent Freycon



Soil map of CoForChange study area.
Location of the pits that provided data to calculate the maximum soil water reserve.



Map of the maximum soil water reserve.
The model used considers a rooting depth of 5 m.