IMPROVE THE CHARACTERIZATION OF TROPICAL FORESTS TO IMPROVE MANAGEMENT

POLICY BRIEF

CoForChange

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

- Our research shows that tropical forests of Central Africa are highly diverse: some are very dynamic and more or less disturbed, others are less so; some have a great diversity of trees, others very little.
- This variety is the wealth of the second largest rainforest in the world and explains its potential to react differently to different anthropogenic and climatic pressures.
- This implies that the vocation (production, conservation) and the management rules must be established for each type of forest and not at the national level, as is the case at present, if the objective is truly to develop sustainable management.
- Research must be continued to build up our knowledge of the three forest types that were described in the CoForChange project and contribute more data on the other forest types in Central Africa.
- The considerable amount of data compiled during the forest inventories needed for the management plans provide a precious world public good which, unfortunately, has been little used because of problems of access.

CoForChange has shown that management plans based on timber stock recovery are not enough to ensure the sustainability of these production forests. The variability of forest characteristics and their different responses to disturbance should be considered in management decisions.

Central African rainforests extend over 170 million hectares, second only to the Amazon rainforests. They provide considerable ecological, social and economic services for local populations, states and the international community. These forests are being subjected to increased anthropic (exploitation, fragmentation, conversion) and climatic (drought, changes in rainfall patterns, increased interannual rainfall variation) disturbances that will continue in the coming decades.

More than 60 million hectares are devoted to timber production within permanent forest estates, of which 49 million hectares are currently allocated to concessions. For more than four years, the CoForChange[1] project has been studying the functioning and history of these forests based on inventories of over 6 million hectares conducted by timber companies. The project identified three main forest types and provided an early assessment of their resilience to disturbance.
It also provided a methodology for describing tropical forests that could be applied in the future beyond the area studied in the project.

FLORISTIC COMPOSITION, FUNCTIONING, HISTORY OF DISTURBANCES: CENTRAL AFRICAN FORESTS ARE VARIED

Three main forest types and their variants were identified in the CoForChange project area (Figure). The soil type was recognized as the main driver of forest types, followed by the intensity of disturbance: ancient climatic and anthropogenic disturbance (2500 to 2000 years ago) and recent anthropogenic disturbance. Tree species in the area appear to be very drought tolerant: this might be the result of a selection stemming from severe drought events linked to the Pleistocene glaciations. However, some short-lived pioneer species like *Musanga cecropioides* (umbrella tree) are an exception. Where they are abundant, forests may be less drought resilient.

Diverse, productive forests on relatively rich soils: the *Celtis* forests. These forests grow on rather rich soils. They host a great number of trees belonging to the genus *Celtis* and to the species *Triplochiton scleroxylon* (Ayous) or *Terminalia superba* (Limba or Fraké) and can be found at various stages of evolution: young forests, old-growth forests, degraded forests dominated by the pioneer species *Musanga cecropioides,* or with low regeneration potential due to understorey colonization by lianas and giant herbaceous plants (Marantaceae, Zingiberaceae). When not degraded, *Celtis* forests have a great diversity of trees, most of which are deciduous, heliophilous, with low wood density and rather high growth rates. They are highly productive. *Celtis* forests have often been disturbed over the millennia: human tracks – crops, metalwork – and fire tracks are many and frequent in the soils.

1. See box page 4

Diverse, low-productive forests on poor soils: the *Manilkara* forests. These forests grow on poor sandy soils. They host a great number of trees belonging to the genus *Manilkara* and the species *Staudtia kamerunensis* (Niové). Old-growth *Manilkara* forests are as biodiverse as old-growth *Celtis* forests. Many trees belong to evergreen, shade bearing genera, with high wood density and relatively low growth rates. Their productivity is low. *Manilkara* forests have been little disturbed over the millennia; they host a small number of pioneer species and are probably more ancient than *Celtis* forests. Where *Manilkara* forests were disturbed by human activities, they have been invaded by pioneer species similar to those in the *Celtis* forests. Pioneer species then develop in an unpropitious environment with a higher risk of mortality in the event of severe drought. In these degraded locations they create conditions that facilitate the outbreak of fires that can weaken the edges of otherwise intact forests.

Little diverse, low-productive forests on medium rich soils: the *Gilbertiodendron* forests. These forests mainly grow in the floodplain, close to the main rivers, on medium rich soils. They are dominated by the species *Gilbertiodendron dewevrei* (Limbali), a dense-wooded and slow-growing evergreen species. They grow in areas that vary between a few hectares and a few hundred hectares in the project area. Their biodiversity and productivity are low. They have been little disturbed in the past and host a low number of pioneer species. In these forests, major disturbance causes invasion of short-lived pioneer species that create unfavorable conditions for the regeneration of G. *dewevrei*. Repeated, excessively intense disturbances would probably lead these forests to develop formations similar to those in the *Celtis* forests.

In a Marantaceae understorey

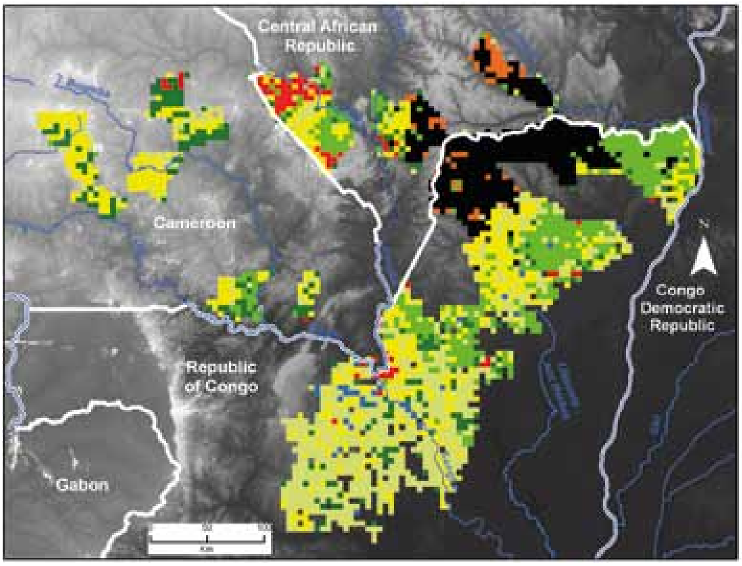

Figure. The main forest types in the CoForChange project area: spatially distinct entities affected by soil types and anthropogenic disturbances

***Celtis* forest**

- Young
- Old-growth
- With depletion of small trees
- Degraded with *Musanga cecropioides*
- Degraded, with Marantaceae and/or Zingiberaceae understorey

***Manilkara* forest**

- Young
- Old-growth

***Gilbertiodendron* forest**

- Various stages

These characteristics give the forests a resilience that can be evaluated ...

A diagnostic of a specific type of forest is always relative: one type can be deemed more resilient or less resilient than another. The forest type has to be seen in a more general context, which requires a large floristic data set, such as that compiled by the CoForChange project.

We have selected five evaluation criteria: (i) the forest's floristic and functional diversity – the higher the diversity, the greater the ability of the forest to adapt to change; (ii) the number of trees belonging to short-lived pioneer species, more drought sensitive than the others – the higher this number, the more vulnerable the forest to severe drought and fire; (iii) the biological characteristics of trees – if the majority of the trees belong to dense-wooded, slow-growing species, the forest is more resistant to water stress, but reacts more slowly and less well to anthropogenic disturbance; (iv) soil richness – it allows for faster tree growth, thus easier recovery after disturbance, but increases dependency on the soil water reserve; (v) the frequency and intensity of disturbances – they tend to favor disturbance-adapted species, increasing the resilience of the forest.

By applying these criteria to the project area, we have been able to evaluate the resilience of the various forest types identified (Table): the *Celtis* forests are generally the most resilient to anthropogenic disturbance. However, the more they are degraded, the more their resilience to anthropogenic disturbance and drought diminishes due to the loss of biodiversity and the increased number of short-lived pioneer trees. The *Manilkara* forests and the *Gilbertiodendron* forests tend to be more resilient to drought but less resilient to anthropogenic disturbance than the *Celtis* forests. In *Manilkara* forests, the short-lived pioneers are hampered by poor soils, and forest recovery can be endangered by increased mortality in case of severe drought. In *Gilbertiodendron* forests, pioneers invasion might prevent the dominant species from maintaining itself. The simultaneous increase of anthropogenic disturbance and drought endanger all forests, particularly when they develop on poor soils.

... TO SUPPORT MANAGEMENT RECOMMENDATIONS

Guidance for decisions on assigning objectives to forests at the regional level

Each forest type has particular characteristics that make it more or less resilient to anthropogenic and climatic disturbance. The objectives assigned to these forests must incorporate these differences (Table). Productive *Celtis* forests growing on the richest soils are resilient to anthropogenic disturbance: they have a good potential to produce timber (vocation: timber production). Conversely, low-productive *Manilkara* forests, like the *Gilbertiodendron* forests have little resilience to anthropogenic disturbance: uncontrolled exploitation of the former, that grow on the poorest soils, may lead to irreversible degradation through climate change; uncontrolled exploitation of the latter could jeopardize the dominant species (vocation: extensive production associated with protection measures).

Pool of light in a Celtis *forest*

Table. Adapt management options to forest types.

		Celtis forests					*Manilkara* forests		*Gilbertiodendron* forests
Results	**Forest type***	**Old growth**	**Old-growth with regeneration deficit**	**Young**	**Degraded with *Musanga***	**Understorey with Marantaceae and/or Zingiberaceae**	**Old-growth**	**Young**	
	Soil type	Relatively rich soils: clay soils on metamorphic substrates, sandy-clay soils on granitic substrates				Poor sandy soils on sandstone, medium rich sandy-clay soils on alluvium	Poor sandy soils on sandstone		Medium rich sandy-clay soils on alluvium
Diagnostic	**Resilience**								
	Anthropogenic disturbance	++	+	++	+/-	--	+ (?)	+ (?)	+ (?)
	Drought	+	+	+	-	?	++	-	++
Recommendations	**At the regional level**								
	Main vocation	Intensive production				Extensive production / Protection			
	At the concession level								
	Timber logging	Up to 4 trees/ha^{-1}**			Limited***	Limited***	Limited***, extension of protection areas	To be avoided	Limited***, extension of protection areas
	Post-logging silviculture	Thinning	Climber cutting, liberation, enrichment	Thinning	Thinning	Clearing of giant herbaceae and enrichment	To be avoided		*A priori* not useful

*See Figure. ** Results of the M'Baïki experimental trials in the Central African Republic, (http://dx.doi.org/10.1098/rstb.2012.0302), old-growth Celtis forest
*** To be determined depending on research results

Improvement to management rules in forest concessions

Where forests have been assigned a production objective, we recommend associating logging with post-logging silviculture (Table). Logging should not exceed four trees per hectare; long-term research on the M'Baïki experimental site in the Central African Republic, in an old-growth *Celtis* forest, has shown that beyond this intensity forest biomass cannot recover within one felling cycle – 25 to 30 years. Moreover, forest invasion by short-lived pioneers may weaken the forest in case of severe drought. Because logging operations target heliophilous species (*Entandrophragma* spp – Sapelli, Sipo, Kosipo) and long-lived pioneers (*Erythrophleum suaveolens* – Tali, *Pericopsis elata* – Assamela, *Terminalia superba, Triplochiton scleroxylon)*, to ensure adequate recovery of the timber stock, we recommend post-logging silvicultural operations such as thinning or liberation for the benefit of future crop trees and natural regeneration, climber cutting to protect future crop trees from invasive lianas and giant herbaceous plants, and forest enrichment where regeneration is insufficient.

Where the vocation of the forests is extensive production associated with protection measures, we recommend limiting canopy opening, thus keeping logging at low intensity (Table). Whenever possible – when management plans are being prepared or revised – we recommend making the production areas smaller than the comparable areas in zones where production is the main vocation.

Research still needed

These recommendations are guidelines for future action. They need to be refined for each case and each concession, and also adapted to fresh knowledge and the results of recent experiments. DynAfFor, a new project funded by the French Global Environment Fund, has just been launched and is building on CoForChange results. It will settle permanent sites in areas that are representative of the main environmental conditions in order to monitor the long-term evolution of forests subjected to different types of disturbance. At the same time, some enterprises have started experimenting with silvicultural itineraries that need to be strengthened. These are the first steps in finetuning the diagnostic on forest resilience, and an opportunity to continue the constructive partnership developed between research institutes and private companies in the CoForChange project.

Liana in the Manilkara *forests*

The CoForChange project

CoForChange is a European ERA-net BiodivERsA project co-funded by the French National Research Agency (ANR) and the Natural Environment Research Council (UK). It created a multidisciplinary team of researchers and forest engineers from public and private institutions in 8 European and African countries, that was associated with an international institution and 14 timber companies who worked together for 4-1/2 years, from 2009 to mid-2013. (list on http://www.coforchange.eu). The objective was to explain and predict the possible future of the diversity of the Congo basin rainforests, and to offer decision-support tools to improve their management in a context of increasing anthropogenic and climatic constraints. The project focused on a region of about 20 million hectares extending over the south-west of the Central African Republic, the south-east of Cameroon and the north of the Republic of Congo. The project used management inventory data produced by the timber companies.

Institutions involved

Research institutes: CNRS, Cirad, IRD (France), IRET (Gabon), Programme Forêts, Arbres et Agroforesterie du CGIAR/Cifor (Indonésie) CGIAR Research Program on Forests, Trees and Agroforestry CGIAR/Cifor (Indonesia), DG-JRC (Italy), CRDPI, DGRST (Republic of the Congo).

Universities: University of Bayreuth (Germany), University of Liege/Gembloux AgroBioTech (Belgium), University of Yaoundé I (Cameroon), University of Montpellier II (France), University of Bangui (Central African Republic), University of Marien Ngouabi (Republic of the Congo), University of Aberdeen, Oxford University (UK).

Professional organizations: Atibt, FRM (France)

Forestry company partners: Alpicam, Pallisco, Vicwood (Cameroon), IFB, Sefca, SCAD, SCAF, Vicwood (Central African Republic), BPL, Danzer, CIB/Olam, Likouala Timber, Rougier, Vicwood (Republic of the Congo)

Project participants

S. Gourlet-Fleury (coordinator), J. Aleman, N. Bayol, I. Bentaleb, F. Benedet, A. Billand, L. Bremond, C. Cohen, S. Coste, J.-L. Doucet, B.M.J. Engelbrecht, N. Fauvet, C. Favier, A. Fayolle, V. Freycon, J.-F. Gillet, V. Gond, A. Laraque, J. Maley, M.-C. Maraval, P. Mayaux, J. Morin-Rivat, F. Mortier, J.-M. Moutsambоté, R. Nasi, A. Ngomanda, Y. Nouvellet, D. Ouedraogo, R. Oslisly, N. Picard, C. Rollin, A. Saya, B. Sonké, M. Swaine, J.-P. Tathy, C. Tovar, M. Toto, P. Vigneron, O. Yongo, K. Willis

This paper is based on articles listed in: http://www.coforchange.eu/fr/produits/articles and CoForChange newsletters http://www.coforchange.eu/fr/produits/lettres_d_information.

cirad