XIV WORLD FORESTRY CONGRESS, Durban, South Africa, 7-11 September 2015

Trees for Food and Timber: are community interests in conflict with those of timber concessions in the Congo Basin?

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Abstract

Much of the Congo Basin is managed for timber from dozens of species. More than 60% also produce non-timber products, including foods. For five multiple use tree species in Cameroon, Democratic Republic of Congo (DRC) and Gabon (*Entandrophragma cylindricum*, *Baillonella toxisperma*, *Erythrophleum suaveloens*, *Dacryodes buettneri* and *Gambeya lacourtiana*), we studied gathering and consumption by communities, edible caterpillars hosted, the densities of trees around villages and in concessions and the impacts of timber harvesting . We also studied the consumption of forest foods and the nutritional values of fruits and seeds of various tree species. Villagers walked up to six km during day trips to collect fruits or caterpillars, gathering from concessions if the village was within or near it. When foods were gathered from trees smaller than the cutting diameter (which varied by country and species), there was no conflict with timber harvesting. However, the volume of edible caterpillars hosted increased with diameter and harvestable trees were the most productive. Caterpillars, tree fruits and seeds provide fats, vitamins and minerals that complement agricultural foods. Densities of *B. toxisperma*, valued for its edible oil, were higher around villages than in concessions. The proportion of commercial trees harvested for timber varied from less than 3% to more than 50%, depending on the species. Different species had different geneflow distances, meaning viable regeneration could be expected with residual adults at different maximum distances. *E. cylindricum* had more effective dispersal than *E. suaveolens*. The production of timber and nontimber products can be sustained from the same concessions, for different stakeholders, with appropriate practices and arrangements.

Keywords: Congo Basin, timber concessions, nontimber forest products, food trees, logging impacts

Introduction, scope and main objectives

The debate on reconciling timber and non-timber production is central for the Congo Basin forest, the second largest rainforest in the world. The livelihoods of over 50 million people depend on these forests., which are also a vital economic resource in the region: over 40% of its 200 million hectares are allocated to commercial logging leases (Feintrenie 2014, Gatti et al. 2014, Tieguhong and Ndoye 2007, Nasi et al. 2011, Ndoye and Tieguhong 2004). A collaborative, multidisciplinary research project was conducted to document the degree to which local populations depend on forest resources, particularly for food, the nutritional value of those foods, whether people obtained those resources from timber concessions, and the effect of logging on the abundance and future availability of those resources. The study was conducted in and around two concessions each in Cameroon and the Democratic Republic of Congo (DRC) and one in Gabon (Figure 1).

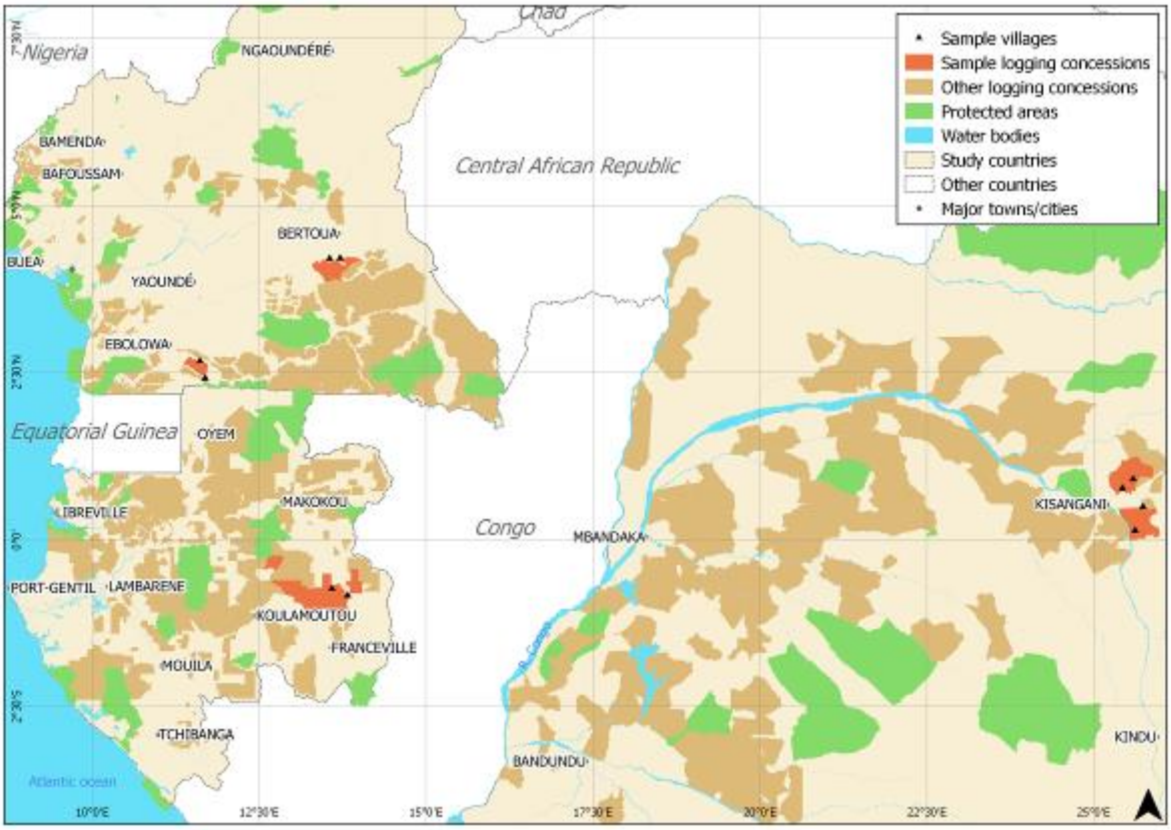


Figure 1. Sample concessions in Cameroon, Gabon and Democratic Republic of Congo

Methodology/approach

Seven studies were conducted:

A-1 The consumption of tree and forest foods

In 34 communities living within or adjacent to the forest concessions, 724 households were selected using Fisher's (1998) formula and a calculation based on the proportion of the population suffering from severe wasting, with one stage of purposeful selection and one stage of randomization. Food consumption data were collected every three months using a food-frequency questionnaire assessing consumption of the thirteen recommended food groups (FAO 2012), including forest foods.

A-2 Nutritional values of tree foods

At Yaoundé I University nutritional laboratory analyses were done using standard methods (AOAC, 2006), for macronutrients, micronutrients (vitamins and minerals) and bioactive compounds of samples in triplicate of fresh, ripe fruits collected from ten trees of each species: mvout (*Trichoscypha abut*), ebaye (*Pentaclethra macrophylla*) and moabi (*B. toxisperma*) in Cameroon and of abam (*G. Lacourtiana*), ozigo (*D. buettneri*), afo (*Poga oleosa*), and three other species in Gabon; no nutritional analysis was done in DRC because of the difficulty getting samples to a laboratory.

B. Food-producing timber trees

Five timber tree species were selected for more intensive study because they produce locally important food and occurred within the selected concessions: moabi, which produces an edible fruit and oil, in Cameroon; sapelli (*Entandrophragma cylindricum*), host of the edible caterpillar *Imbrasia oyemensis,* and tali (*Erythrophleum suaveolens*), host of the edible caterpillar *Cirina forda*, in both Cameroon and DRC; and in Gabon, ozigo and abam, producers of edible fruits.

B-1 Participatory mapping of food collection trees

To determine whether villagers obtained food resources from trees in neighbouring concessions, a female or a male researcher accompanied a different female or male collector, respectively, each day for five days to trees of the selected species from which they obtained food resources around each of two sample villages within or near each sample concession. Trees were measured and their GPS coordinates overlain on concession maps. R and QGIS software were used to analyse the distances travelled to each tree.

B-2 The density of food trees around villages and on timber concessions

Tree densities around two villages per concession were evaluated in 21 5-ha plots (100 m X 500 m) laid out at a sampling intensity of 0.5% along three 10km transects from the village towards the concession. On the concessions, 20 5-ha plots were randomly located within each of four quadrants of the 2012 cutting area. Within each plot all individuals ≥ 20cm dbh of the selected species were identified and their diameters measured. In addition, stumps were identified and noted. Wilcoxon tests were used to analyse differences.

B-3 Quantification of caterpillar production

The yield of edible caterpillars was quantified for 170 tali and 50 sapelli between 20cm and 190cm in diameter in DRC. Around each tree, a ditch 20cm deep and 20cm wide was dug at the edge of the canopy. From July to September in two successive years, caterpillars were collected from these ditches and weighed twice a day during the 4–10 days that caterpillars were falling from each tree. Differences were analysed using regressions and Wilcoxon tests.

B-4 Evaluation of patterns of gene flow

Patterns of gene flow (mating system and pollen- and seed-mediated gene dispersal) were estimated for moabi, sapelli and tali in Cameroon. Leaves or cambium were sampled from seeds, seedlings and adults of each species, which were then genotyped at nuclear microsatellite markers (Duminil et al., 2011; Garcia et al., 2004; Ndiade Bourobou et al., 2009). Relying on genotype data of progeny arrays, the mating system (levels of self-reproduction) was estimated using MLTR v.3.2 (Ritland, 2002). Pollen- and seed-mediated gene dispersal were estimated using NM+ (Chybicki and Burczyk, 2010).

Initial Results

A-1 Consumption of tree foods

Households consumed forest foods five times a week on average, but patterns varied among countries. In DRC, households ate forest fruits and bushmeat as well as caterpillars, consumed daily while in season. In Cameroon, households consumed forest fruits, mostly bush mango (*Irvingia gabonensis),* moabi, mvout, bitter cola *(Garcinia cola)*, cola nuts *(Cola acuminate)* and njangsa (*Ricinodendron heudelotii)* as well as bushmeat (mostly rats, porcupine, squirrel, wild birds and moles). During the season, 20% of households ate caterpillars three days/week or more. In Gabon, households consumed forest fruits (ozigo and bush mango) as well as bushmeat (antelope, porcupine, warthog, rats and wild birds). Fewer than 20% of households consumed caterpillars, a maximum of one day/week, but Gabonese households also consumed processed foods such as margarine, butter and protein-rich cheese.

A-2 Nutritional values of tree foods

Mvout fruit was an exceptional source of vitamin C (80mg/100g) while ebaye seeds were rich in fat (39%) and protein (16%) as well as vitamin E (19mg/100g). Moabi fruit has high carbohydrates (90%), potassium (28mg/100g) and calcium (38mg/100g). Ozigo was a good source of lipid, with a fat content of 53%, while the fruits of abam were high in carbohydrate (80%), potassium (715mg/100g), calcium (378mg/100g), phosphorous (232mg/100g), and magnesium (181mg/100g). Afo was high in potassium (241mg/100g), phosphorous (232mg/100g) and iron (21mg/100g).

B-1 Participatory mapping of food collection trees

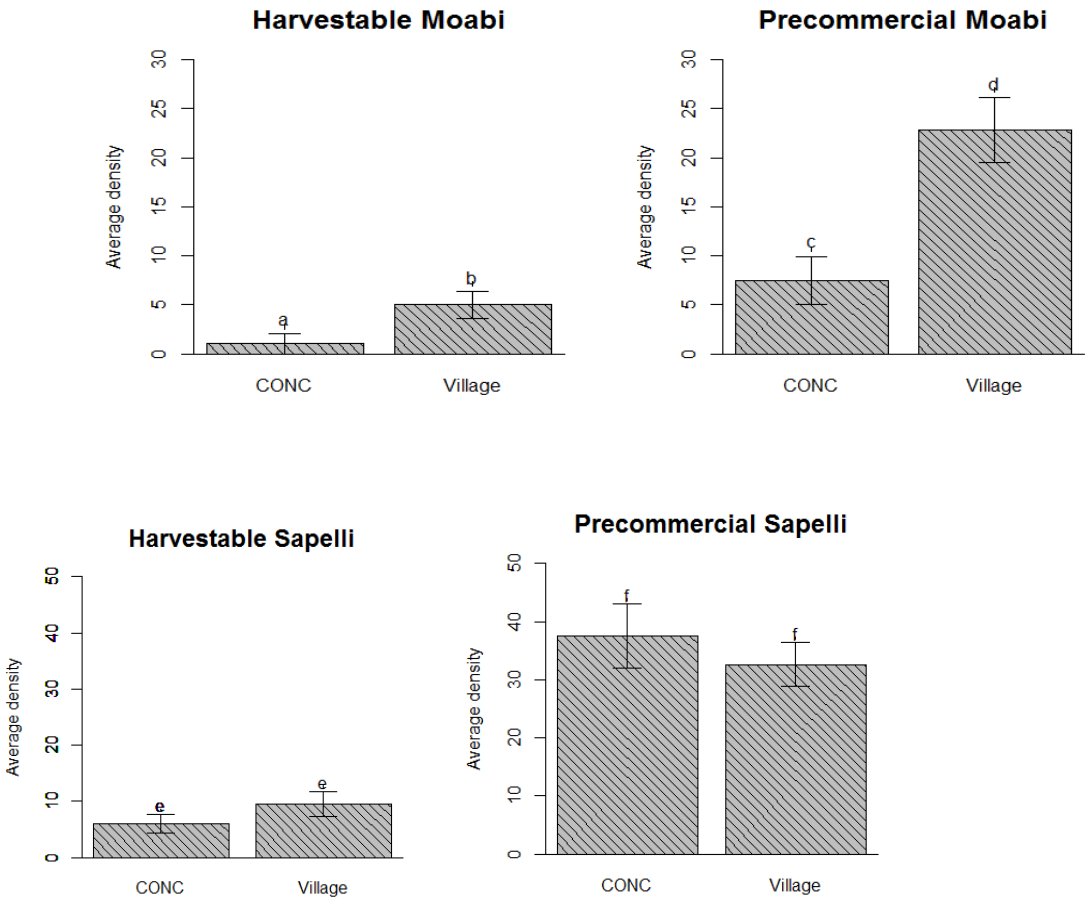
In one day people walked an average of 2.2km from their villages to collect food resources (Table 1). Of the trees visited, 72% were within logging concessions (reflecting the large number of trees recorded in the four sample villages in the DRC, inside logging concessions). Most trees were larger than the felling diameter, meaning they could be felled for timber by the concession owner.

	Tree location rel. to logging concession (# of trees)		**Size rel. to felling diameter (# of trees)**		**Distance (km) between village and the trees**			
	Outside	Inside	< felling diameter	≥ felling diameter	Avg.	St. Dev.	Min.	Max.
Total	**200**	**524**	**169**	**555**	**2.2**	**1.2**	**0.1**	**6.2**
Cameroon	161	27	31	157	2.7	1.4	0.2	6.2
DRC	0	402	88	314	2.2	1.0	0.2	5.9
Gabon	39	95	50	84	1.8	1.3	0.1	4.5
Moabi	52	10	12	50	2.5	1.3	0.4	6.1
Sapelli	59	74	67	66	2.7	1.3	0.2	6.2
Tali	50	345	40	355	2.2	1.1	0.6	5.9
Ozigo	24	51	48	27	2.0	1.3	0.1	4.5
Abam	15	44	2	57	1.5	1.0	0.1	4.3

Table 1. Locations and distances to different species and sizes of trees visited by collectors to obtain foods.

B-2 The density of food trees around villages and on timber concessions

In DRC, where the villages were located within the concessions, the density of sapelli and tali trees within 10km of the villages was not significantly different from their density on the 2012 cutting area of the concessions (for harvestable sapelli ≥80 cm dbh, 5.7±1.1/100ha around villages and 3.0±1.3/100ha on concessions and in both settings, approximately 14/100ha of precommercial size; for tali about 35/100ha harvestable trees ≥60 cm dbh and about 33/100ha of precommercial size both around villages and in concessions). In Cameroon, moabi trees were more abundant around villages while precommercial tali were more abundant on concessions (Fig 2).



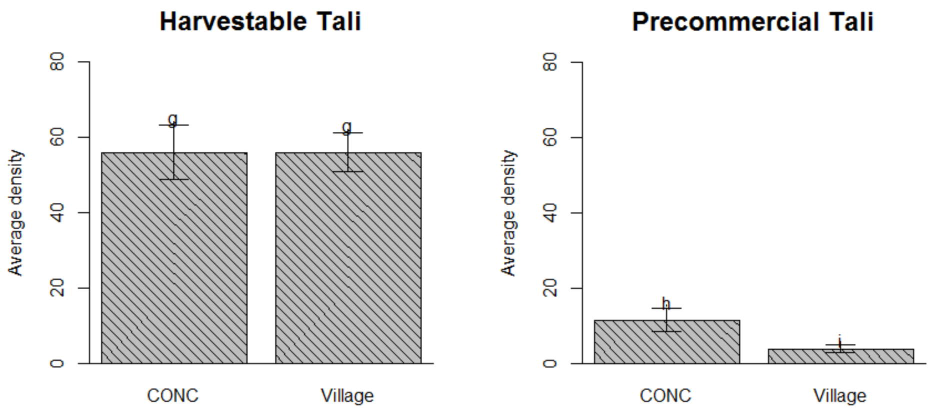


Figure 2. Density per 100ha of sapelli, moabi and tali, harvestable and precommercial, on concessions and around villages in Cameroon. Cutting diameters: moabi ≥80 cm, sapelli ≥100 cm, tali ≥60cm. Different letters indicate statistically significant differences between bars.

No moabi stumps were found on sample plots in the 2012 cutting area of the two concessions, indicating that timber companies had respected their agreement with communities not to fell these trees. In Cameroon, stump densities revealed that 6%–11% of harvestable tali trees were extracted in 2012 by concessionaires as compared to 21%–50% of sapelli trees. Tali is harvested to order whereas sapelli has practically unlimited demand. The fact that not all harvest-size individuals were extracted may reflect quality requirements, but also the fact that access to parts of the concession is constrained by flooded lowlands or steep slopes. These areas are protected from harvesting, and are also inaccessible. Furthermore, regulations require that seed trees be left standing.

In Gabon, the density of ozigo trees on forest concession areas was significantly higher than the density around villages (for precommercial trees <70cm dbh, 236±20/100ha vs. 97±17/100 ha, respectively; for harvestable trees 120±20/100ha vs. 17±3/100ha, respectively). No harvesting of this species had occurred on concessions in 2012, due to a moratorium imposed by the government. The densities of abam trees were not significantly different between concessions and villages, but harvestable trees (≥50 cm) occurred at densities about four times higher than trees of precommercial sizes in both settings (27/100ha compared to 7/100ha).

B-3 Quantification of caterpillar production on timber trees

Larger trees hosted larger quantities of edible caterpillars. Commercial sapelli trees (≥80cm dbh in DRC) produced 10.9±0.3kg/tree of *I. oyemensis* compared to 1.1±0.6kg/tree, for precommercial trees. Commercial-sized tali trees (≥60cm dbh) yielded 8.2±0.1kg/tree of *C. forda* compared to 5.5±0.1kg/tree for precommercial trees (Figure 2). Given the estimated density and size classes of trees around the villages (study B-3), sapelli trees provided approximately 1.8kg/ha of *I. oyemensis* caterpillars and tali trees provided about 4.8kg/ha of *C. forda* caterpillars each season.

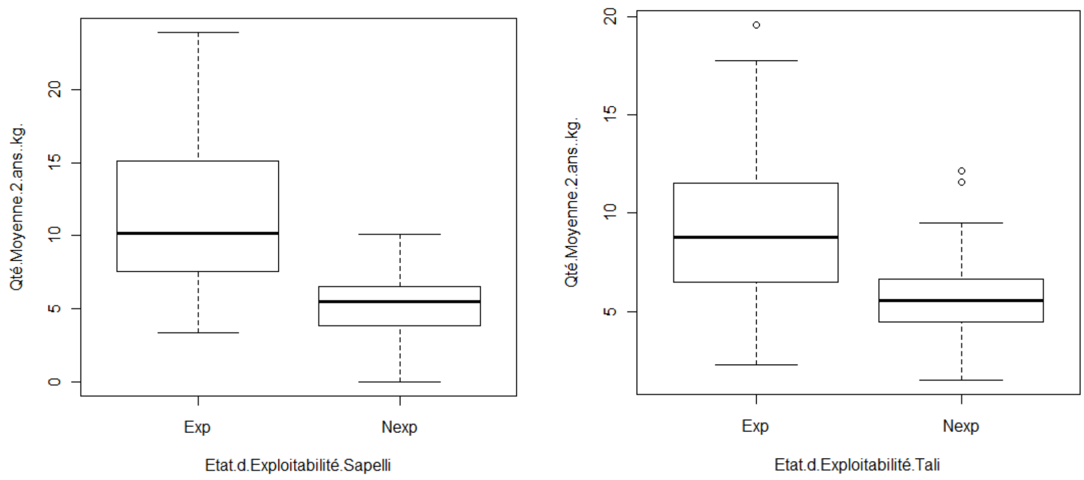


Figure 3. Average annual yield of caterpillars on trees of sapelli (left) and tali (right) of exploitable (Exp) and pre-commercial (Nexp) classes were significantly different.

B-4 Evaluation of patterns of gene flow in three tree species

Each species presented idiosyncratic patterns. Levels of self-pollination were particularly high in tali and moabi (20% and 27% respectively) and relatively low in sapelli (about 7%). The mean pollen dispersal distancse for moabi, sapelli and tali were about 650m, 500m and 350m, respectively. Gene dispersal through seeds was particularly important in moabi, which is dispersed by elephants, with a mean distance of 1000m. Seed dispersal was relatively limited in tali, with a mean distance of 200m. Seed dispersal distance (by wind) in sapelli was similar to the pollen-dispersal distance, with a mean of 600m.

Discussion

Households living on or around timber concessions all consume forest foods. Fruits and seeds provide protein, fats, vitamins and minerals that complement agricultural staples in their diets, as do edible caterpillars (particularly in Cameroon and DRC). Dried and ground, the caterpillar *I. oyemensis* contains 58% protein and 24% fats (Amon Aphael et al., 2009) while *C. forda* contains 14% protein (similar to beef). Caterpillars are also rich in magnesium and iron, essential for the nutrition of pregnant women and babies (FAO, 2013). In Gabon households had started to transition from foods they grew or collected to purchased processed foods with added sugar and fat. Such changes are associated with the emergence of obesity and associated non-communicable diseases (Steyn et al. 2001).

In all three countries, people collected foods from trees within concession boundaries. Harvesting non-timber products from trees that have not yet reached commercial size is compatible with timber harvesting. Trees within a certain radius of villages (about 6km) are probably the most important for villagers, who typically travel on foot (though motorcycles are being used by some to go further, where roads provide access). Villagers' rights to meet their subsistence needs from the forest in timber concessions are recognized by law. However, they are not allowed to commercialize these resources, and some reported having fruits or other products confiscated by forest guards (not concessionaires) if they tried to collect and transport large quantities.

Both caterpillars and fruits are more abundant on large trees with expansive canopies so timber harvesting removes the trees with the highest yields. Other studies in Cameroon showed a reduction in consumption of caterpillars after a timber company felled their forage trees (Asseng Ze 2008; Tieguhong and Ndoye 2007; Ndoye and Tieguhong 2004). However, when large trees are either inaccessible or have poor timber quality and are left standing, as observed in this study, they continue to provide forage for caterpillars and sources of fruits for the local population. One of our collaborating concessions, as well as others in Cameroon, agreed with villagers to stop felling moabi due to the value of the tree to local communities. In Gabon, ozigo is one of the fruit-producing species for which the government has recently suspended timber harvesting permission. However, the majority of trees from which fruits were collected during this study were smaller than the former minimum felling diameter. This study was conducted in a logging concession which seeks certification for good management and the concession operator has delineated community areas within the logging concession to provide land for forest activities and agriculture. Most of the abam (68%) and ozigo (79%) inside the logging concession fell within these areas, and therefore are available to the communities with no threat of logging by the concession operator.

In Cameroon, the majority of the collection trees were larger than their minimum felling diameters, but most of them were located outside logging concessions. They are nevertheless vulnerable to logging. In two cases these trees were located within a community forest where the main activity has been felling for timber production (Logo, 2003), which often yields benefits only to individuals or specific groups rather than the whole community (Ezzine de Blas et al., 2011; Ofoulhast-Othamot, 2014). Even when trees are near the village, outside a concession or a community forest, there may be conflicts among villagers as to the best use of the tree, whether to sell it as timber or to retain it for its yield of non-timber products. When the non-timber benefit is a food product there is often a gendered aspect to preferences. Women, for example, produce moabi oil; men are more inclined to sell the tree for timber, which is one of the best options for obtaining significant quantities of cash quickly, if needed, for example for a health emergency. A significant illegal timber sector exists in Cameroon and Congo DRC, which is estimated to be larger than the export sector in terms of annual sawn wood production volume (Lescuyer et al., 2012), and sapelli and moabi are among the species felled by local timber producers (Levang et al. 2015).

Conclusions/outlook

Where non-timber products are obtained outside concessions or from trees that are below commercial size, or where commercial sized trees are not felled, there is no conflict between timber harvesting and gathering of non-timber products. Arrangements that consider the uses of non-timber products from timber species by resident villagers can also forestall conflicts, either through agreements not to harvest those species (as agreed voluntarily by the concessionaires in Gabon or in Cameroon with regards to moabi), or by regulation (as imposed by the government of Gabon with regards to ozigo and abam). However, even outside concessions timber trees are not protected from felling. Internal negotiations among villagers seem important to balance the interests of those who want to harvest forest foods every year with those who seek a one-time windfall from selling a tree for timber.

Over the long term, the availability of these resources, both timber and non-timber, depends on successful regeneration. This study revealed that tree seeds resulting from self-pollination do not survive, so defining minimum distances between parent trees that allow for cross-fertilization is important to ensure viability of regeneration. Because patterns of gene flow vary from species to species, the establishment of harvesting guidelines requires understanding species-specific patterns. This study obtained insights into the patterns for moabi, sapelli and tali, but more research on individual timber species is needed so that forest management practices take into account the genetic aspects of sustainability.

Acknowledgements

This research was funded by the Congo Basin Forest Fund and the CGIAR Research Programme on Forests, Trees and Agroforestry. Molecular analyses were conducted at the Laboratory of Evolutionary Biology and Ecology (Université Libre de Bruxelles), thanks to Dr Olivier Hardy. We thank the concession holders (CEB-precious wood, Bayonne, FIPCAM, SCTB, CFT and COTREFOR) and the villages around these concessions for their collaboration and hospitality.

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