Global Ecology and Conservation 15 (2018) e00436

Contents lists available at ScienceDirect

Global Ecology and Conservation

journal homepage: http://www.elsevier.com/locate/gecco

Safeguarding villagers' access to foods from timber trees: Insights for policy from an inhabited logging concession in Gabon

Hermann Taedoumg [a,*], Paulus Maukonen [a], Christian Mikolo Yobo [b], Donald Midoko Iponga [b], Ronald Noutcheu [c], Julius Chupezi Tieguhong [a], Laura Snook [d]

[a] *Bioversity International, P.O. Box 2008, Messa, Yaoundé, Cameroon*
[b] *Institut de Recherche en Ecologie Tropicale (IRET), BP 13354, Libreville, Gabon*
[c] *Department of Plant Biology, University of Douala, P.O. Box 24157, Douala, Cameroon*
[d] *Bioversity International, Via dei Tre Denari 472/a, Maccarese, 00057, Rome, Italy*

A R T I C L E   I N F O

Article history:
Received 29 May 2018
Received in revised form 5 September 2018
Accepted 5 September 2018

Keywords:
Congo Basin
Dacryodes buettneri
Forest fruits
Gambeya lacourtiana
NTFP
Timber concessions

A B S T R A C T

This study assessed the abundance of and access to tree species (Ozigo, *Dacryodes buettneri;* and Abam, *Gambeya lacourtiana)* that yield edible fruits to villagers and timber to the logging industry in and around a logging concession in Gabon. Participatory mapping combining GPS coordinates and interviews was carried out with 5 female and 5 male collectors in each of two villages within or adjacent to the logging concession. Precommercial and harvestable (>70 cm dbh) Ozigo and Abam trees, as well as their stumps, were also quantified on 20 five ha plots in the 2012 cutting area of the concession and on 21 five ha plots on 10 km transects from each village. Distances to 59 Abam and 75 Ozigo from which fruits were collected ranged from 0.7 to 4.46 Km from the village centres. Most collections were by mixed groups made up of men, women and children (54%) at an average of 1.21 ± 0.09 km; or by men and women (18%) at 2.21 ± 0.15 km; or women and children (14%) at 4.03 ± 0.22 km from the village. Almost 28% of all of the collection trees were inside the logging concession boundaries but outside the village agricultural zone, 43% were inside the village agricultural zone, and 29% were outside the logging concession. Only 33% of Ozigo collection trees had reached commercial size while 75% of Abam trees had. No stumps were found on any sample plots, probably reflecting the ban on felling Ozigo which was in effect at the time; and the relatively low commercial value of Abam. Densities of precommercial Ozigo trees in the cutting area were more than double their densities around the villages (236.0 ± 20.3100 $ha^{-1}$and 96.6 ± 17.2100 ha^{-1}, respectively), while densities of harvestable Ozigo trees were 7 times higher in the cutting area than around villages (120 ± 20.2100 $ha^{-1}$and 17.1 ± 3.4100 ha^{-1}respectively). This probably reflects past and current anthropogenic pressures around the villages, including logging and land clearance for agricultural fields. Densities of precommercial Abam were almost four times higher around the village (22.3 ± 5.6 and 6.0 ± 2.9) than on the cutting area. Villagers did not record a decline in availability of or access to these fruits over the past 5 years, suggesting little or no immediate conflict between timber production and access to fruits from these trees.

* Corresponding author.
E-mail addresses: h.taedoumg@cgiar.org (H. Taedoumg), pppmaukonen@gmail.com (P. Maukonen), mick_jagg2001@yahoo.fr (C.M. Yobo), dmiponga@gmail.com (D.M. Iponga), ronaldnoutcheu@yahoo.fr (R. Noutcheu), chupezi@yahoo.co.uk (J.C. Tieguhong), l.snook@cgiar.org (L. Snook).

https://doi.org/10.1016/j.gecco.2018.e00436

1. Introduction

1.1. General introduction

There has been increasing recognition of the potential impact of industrial logging on forests and tree resources that are of importance to the livelihoods of forest-dependent populations in the tropics (Ndoye and Tieguhong, 2004; Tieguhong and Ndoye, 2007; Guariguata et al., 2010; Rist et al., 2012). In the Congo Basin forest, the second largest remaining block of rain-forest after the Amazonian forests, more than 44 million hectares have been allocated to commercial logging companies under various lease arrangements (Megevand, 2013). These timber concessions are often rich in forest products other than timber (Non-Timber Forest Products or NTFPs), including vegetables, fruits, oils, edible caterpillars, medicinal barks and bush meat. These products are important for both food and income for forest-dependent people (Ingram and Schure, 2010; Chidumayo et al., 2011), especially in lean seasons between harvests (Tieguhong et al., 2009; Lescuyer et al., 2012), meaning that forests can contribute in important ways to food security (Adhikari et al., 2016). African forests provide livelihoods to 60 million people living within or near them, as well as fulfilling social and cultural functions (Nasi et al., 2011). In sub-Saharan Africa, when conservation efforts occur within the context of the rise in large-scale extractive industries, infrastructure projects and other land use changes, the impacts of conservation-related economic displacement can be exacerbated as a result of changes in peoples' livelihood space (Riddell, 2013). Given the large number of forest-dependent people living in or near the timber-producing forests, forest management should consider their needs. However, few studies have attempted to evaluate in a quantitative way the interaction between industrial logging activities and the availability of NTFPs to local people depending on and living in or near the forests (Boedhihartono et al., 2007; Rist et al., 2012; but see Noutcheu et al., 2016; Muvatsi et al., 2018). This study seeks to address that gap in Gabon by analyzing the collection of NTFPs from two multiple use timber species, and quantifying their abundance around villages and in cutting areas in an inhabited timber concession.

1.2. Introduction to the forest sector in Gabon

Gabon, one of 6 forested countries in the greater Congo Basin region, is resource-rich, endowed with a dense forest covering 21.7 million hectares, 85% of the country (Blaser et al., 2011), and a human population estimated at 1.72 million (United Nations, 2015). Its geographical situation, straddling the Equator, makes the country one of the richest in Central Africa in terms of biological diversity. Just over 5000 vascular plants species, of which about 10% are endemic or near-endemic, have been recorded in Gabon; and each year, new species to science and for the country and are found (Sosef et al., 2006). The annual deforestation rate is relatively low (less than 0.13%, or 10,000 ha/year) while average forest degradation is estimated at 0.09%, based on satellite images taken between 1990 and 2000 (Blaser et al., 2011).

The forestry sector is one of Gabon's leading economic sectors, ranked second behind the oil industry. It contributes about 6% to the country's GDP and is the primary private sector employer, with about 13,000 employees, second to the public sector (Blaser et al., 2011). Timber companies in remote rural forest areas are said to contribute to a chain of events leading to development at the expense of the environment. Conservation and development practitioners have commonly associated the creation of timber-related transport infrastructure in remote rural forested areas with the opening up of areas to hunting and trade of threatened species as well as other Non-Timber Forest Products (Hymas, 2016). Although the proportion of people depending on NTFPs in Gabon is unknown, multiple use timber species are an integral part of the subsistence of local people as sources of food, medicine, construction material and income generation.

The state has exclusive property rights and ownership over Gabon's forest and its resources. In 2002, for conservation purposes and livelihoods, the Gabonese government established a network of 13 National Parks covering about 11% of the country. In those National Parks, rights of access to and use of forest resources have been granted to local people living nearby, according to their customary rights and available management plans. Outside the National Parks, the government has divided the forest into Permanent Forest Estate (PFE) and Non-Permanent Forest Estate (NPFE), also known as Rural Forest Domain (RFD). According to the Forest Code of 2001 (République gabonaise, 2001), in the PFE no one may engage in harvesting or processing of any natural forest product or its commercialisation without prior authorization from the Administration of Forestry. Local communities are allowed a "limited" use of forest resources to meet their livelihood needs, based on their customary usufruct rights (See Art. 14, Law N° 16/2001; République gabonaise, 2001). In forest concessions that have been granted within the Permanent Forest Estate, management focuses on timber, not NTFPs, because the latter are considered a minor economic sector compared to timber. However, the Gabonese government has encouraged logging companies to adopt and implement sound social, economic and environmental measures for the sustainable management of forests and forest resources (Nasi et al., 2006; Blaser et al., 2011). The government has also recognized that the social and economic needs of local people have to be incorporated into any new forest management plans on timber concessions. These should ensure that some of the financial benefits of forest management operations are redistributed to local people living nearby, based on a commonly agreed social responsibility contract, “cahier de charges contractuel”. This contract represents a social agreement binding local communities, concessionaires and the state. Among livelihood activities permitted in the permanent forest domain, including within timber concessions, are: the use of tree products for rural house construction and dead wood or branches as fuel wood; b) the harvesting of minor forest products such as bark, latex, mushrooms, vines, medicinal plants and edible fruits; c) artisanal hunting and fishing; d) grazing of livestock in the savannah and in clearings and the use of branches and leaves for fodder; e) the practice of subsistence agriculture; and f) water use (Art. 252, Law N° 16/2001; République gabonaise, 2001). However, industrial agricultural activities are strictly prohibited in permanent forest domain because they are perceived as negatively affecting the forest (République gabonaise, 2001).

Within the Non-Permanent Forest Estate (NPFE) local people are allowed to meet their needs through open access. In the NPFE, hunting, agriculture and gathering of NTFPs can be carried out, although livelihood activities need to be undertaken according to a simple management plan approved by the Forest Administration (art. 156, Law N° 16/2001; République gabonaise, 2001); art. 2, Decree N° 001028/2004; République gabonaise, 2004). In the NPFE in rural areas, the state has granted to local communities the right to establish community forests (where local people can freely harvest all resources, including timber). The aims of community forests are twofold: i) to reduce illegal logging and ii) to reduce the poverty of local people depending on and living in or near the forests (République gabonaise, 2001).

An additional action taken by the government to meet conservation objectives and the needs of local people was the implementation of a 25 year ban, established in 2009, of the harvesting and trade of logs from multiple use timber species including Afo (*Poga oleosa*), Andock (*Irvingia gabonensis*), Douka (*Tieghemella Africana*), Moabi (*Baillonella toxisperma*) and Ozigo (*Dacryodes buettneri*), all of which provide food resources used by local people (Decree n^0 0137/PR/MEFEPA, 2009 of the Republic of Gabon; République gabonaise, 2009). This decree did not prohibit local collection of fruits for consumption and income generation from these 5 species. However, only 7 years later, another decree by the Gabonese government changed this situation, once again allowing the exploitation of Ozigo (Decree N0350/PR/MPERNFM of 7th June 2016; République gabonaise, 2016). This decree authorizes harvest, transformation and export of products made from Ozigo timber, but not the export of Ozigo logs. It aims to increase the industrialization of the wood sector, the productivity of forest concessions and the diversification of goods exported in order to make the Gabonese timber sector more competitive. Thus, timber industries are now obligated to export only transformed wood products from Ozigo, in accordance with the ban on the export of logs and roundwood from all commercial timber species that was enacted in May 2010 (Decree 2010–141).

To evaluate the potential conflict between villagers' gathering of fruits from these species and industry's use of their timber, and to provide additional information relevant to developing policy guidelines and regulations to address the potential conflicts between these uses and stakeholders, this study evaluated the abundance and use of two major multiple use species that produce both timber for industry and edible fruits valued by local people: Ozigo and Abam (*Gambeya lacourtiana)* (Raponda-Walker and Sillans, 1961). This study 1) mapped the locations of trees from which the fruits of these species were collected by villagers from the wild, determined whether these collection areas were located within the timber concessions, and documented who participated in these collections; and 2) evaluated the density of those trees around the villages and in the timber concessions. The information is intended to contribute better knowledge for improved management and policy regarding these multiple use tree species, especially for Ozigo, which seems to be a problematic case for the Gabonese Government.

2. Methods

2.1. Study site

The study was carried out in and around the CEB Precious Woods forest concession. This concession was selected for study based on several criteria: (i) the presence of trees having both timber and food values, (ii) easy access to the study sites by the research teams, (iii) the willingness of the concessionaire to collaborate in the study, (iv) the existence of baseline information on access and use of the selected forest resources, (v) the availability of a management plan, and (vi) the presence of human settlements (if possible, of different ethnic groups) inside or in the surrounding areas of the forest concession. The selected concession covers 615,000 ha and employs 1460 people (Massoukou, 2007). CEB-Precious Wood has a management plan approved in 2004 by the Forestry Administration (Massoukou, 2007). The cutting cycle covers a minimum period of 20 years and the forest concession is divided into 20 annual cutting areas (AAC). The management plan defines specific actions covering a period of seven years (Mba Assoumou, 2012).

Precious Woods is one of the leading companies, globally, in sustainable management of tropical forests. The group, with headquarter in Switzerland, was founded in 1990. In 2007, Precious Woods expanded its operations to Gabon in Central Africa and acquired majority shares in the companies ‘Compagnie Equatoriale du Bois CEB’ and ‘Thanry Gabon Industrie TGI’. CEB-Precious wood is striving to comply with the stipulation that the social and economic needs of local people should be taken into account and addressed through a mutually agreed social responsibility contract (Article 251 of the Forest Code N^o 16/01 of 31st December 2001). Gabon's Decree 105, which sets the contractual specifications, requires the concession-holder to sign an agreement with the local people “who live within the concession or are local residents”. Article 1 states that “this agreement aims to directly benefit the communities with the gains from forest logging carried out by the forest concession holder in their landholding”.

Staff of the CEB-Precious Woods concession worked for several years with sociologists and produced a map of land-holdings in 2012, with each landholding corresponding to a village or group of villages (Karsenty and Vermeulen, 2016). The term 'landholding' ("finage" in French) refers to the extent of land owned and more or less completely used by an agricultural community. The boundaries of these landholdings were defined in consultation with the villages concerned and while most of the concession is covered by landholdings, some areas are not under the village's influence (Karsenty and Vermeulen, 2016). Furthermore, the CEB-Precious Wood concession authorizes the concerned villagers to access and use freely lands from a zone referred to as the 'agricultural area' located in the concession around villages. Permitted livelihood activities in this space include the gathering of NTFPs and, occasionally, agriculture. The principal crops produced in the agricultural area are maize, plantain, fruit trees and cassava. Agricultural fields, seldom exceeding 2 ha, are established near the villages. The perennial crops (fruit trees) do not constitute true orchards and the industrial crops (cacao in particular) remain localized in the periphery of Okondja (Mba Assoumou, 2012).

The population in and around this forest concession consists of many ethnic groups including forest workers and their families (both local and from elsewhere). The villages are located along the main roads, reflecting the past colonial policy that pushed people to move out of the forest. Villages are still poorly developed and are characterized by inadequate schools and hospitals. As a result, local people still depend on the collection of natural resources, including NTFPs and hunting, along with subsistence agriculture, to meet their needs (Massoukou, 2007; Mba Assoumou, 2012). The studies were carried out within the CEB-Precious Woods forest concession and in the villages of Opoungou ('Opo') and Ondjeye ('Ond'). These two villages are located inside or on the boundary of the forest concession (Fig. 1).

2.2. Sample species

The study focuses on Ozigo (*Dacryodes buettneri* (Engl.) H.J. Lam (Burseraceae) and Abam (*Gambeya lacourtiana* (De Wild.) Aubrév. and Pellegr (Sapotaceae), two multiple use timber species selected because they occurred in the forest concession. Both of them are major commercial timber species in terms of volumes extracted (Wunder, 2003). Ozigo is one of the species for which logging was recently banned. Like Okoumé (*Okoumea klaineana*), Ozigo is an endemic species in Gabon. Ozigo is the second most important timber species in Gabon, after Okoume, which accounted for nearly 80% of the volume of timber produced in Gabon before 2009 (Sandison, 2014). Ozigo is important for plywood and paper-making (Laurance et al., 2006; Todou and Doumenge, 2008). Local populations collect Ozigo fruits from the wild for subsistence and consume them after soaking the fruit in boiling water (Walker and Sillans, 1961; Todou and Doumenge, 2008). In addition, its oil-rich pulp is valued for cooking (Lemmens, 2007; Onana, 2008). According to the IUCN criteria, Ozigo is assessed as vulnerable (VU B1b - iii). This reflects the fact that the quality and extent of its habitat are reduced due to logging and agriculture outside of the forest reserves (Onana, 2008).

Abam is found in many West and Central African countries. Its wood is used for construction and in the pulp and paper industry (Lemmens, 2007). Abam fruits are commonly eaten fresh or its sweet, acid pulp is salted and added to staple foods such as cassava and plantain before consumption (Walker and Sillans, 1961; Lemmens, 2007). The dried pulp of its fruits is occasionally used in making sauces (Lemmens, 2007). Exploitation of Abam timber is not prohibited, but it is considered a subsidiary timber species. The minimum cutting diameter of both Ozigo and Abam is 70 cm diameter at breast height (dbh), according to the current forest regulation (Arreté N^{0}000117/PR/MEFEPEPN du 01 mars 2004).

2.3. Field sampling and data collection

All field work was carried out between February and March 2013, during the period when the Ozigo harvest ban was in effect.

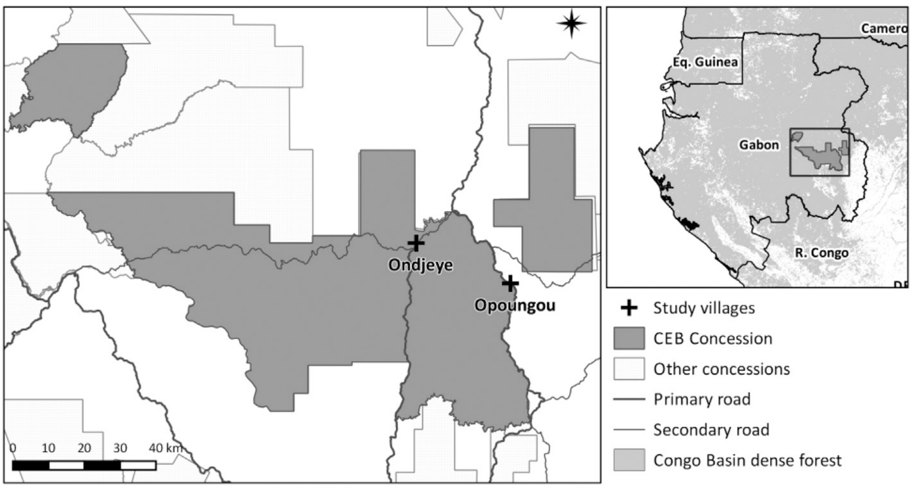

Fig. 1. Study villages and the CEB forest concession.

2.3.1. Mapping of fruit collection trees

Participatory mapping was used to: (1) locate the trees from which men and women collected fruits, in space and on maps that included the boundaries of the logging concession; (2) determine the distances travelled by men, women and children to collect these wild resources; (3) gather information on the trees and the collection, transformation and sale of these foods; and (4) assess the potential impacts of logging activities on local people's access to these food resources. Data was gathered by two teams, each consisting of three people: a researcher, an informant who was a local villager and fruit collector and a local guide for translating and clearing paths when necessary. Each team was equipped with a Garmin Dakota 20 GPS device, a diameter measurement tape, field data sheets and a questionnaire with twenty-one questions. Key informant interviews were combined with GPS mapping. Field teams were gender-differentiated: one team consisted of a female researcher, a female guide and a female key informant; the other of a male researcher accompanied by male guides and key informants. This approach ensured that responses captured gender-differentiated knowledge and interests and that collected information could be gender-disaggregated. In addition, this alleviated concerns over having a male researcher accompany a female villager during a day-long walk in the forest (and vice versa).

A different informant was selected each day for a period of five days in each village. In total ten persons, five men and five women, acted as informants in each village. Each key informant guided the researcher to the locations where he or she collected the fruits of Ozigo and Abam. At each standing tree, the researcher would identify the species in question, measure its diameter at breast height and take the GPS coordinates of its location. Then the researcher would ask the collector nine questions related to the availability of the target forest resources, access rights over forest resources, and respondents' roles in collection, transformation and sale of the resources. The remaining twelve questions, concerning the collection, processing, transformation and sale of the fruits, were asked throughout the day.

2.3.2. Quantifying density and distribution of trees

To determine the density and abundance of the selected multiple use species, these trees were identified and sampled on plots. Within the forest concession, sample plots were established in the 2012 cutting area. Five plots of 5 ha each were established at random within each of the four quadrants (North, South, East and West) of the 5000 ha cutting area, a total of 20 sample plots. To evaluate the density and abundance of the selected trees around the villages, 21 sample plots of 5 ha each were laid out around each village along three transects extending from the village centre towards the forest concession to a maximum distance of 10 km. The total sample area described a half circle of 157 km^2 (15,700 ha). The central transect was oriented towards the forest concession and two other transect lines were laid out at 45° on each side of it (see Fig. 2 in Noutcheu et al., 2016). The sample plots around villages were stratified among four different distance bands, 1–1.9 km (stratum A), 2–3.9 km (stratum B), 4–6.9 km (stratum C) and 7–10 km (stratum D) from the village centre towards the forest concession. To obtain a sampling intensity of 0.5% in each stratum, the number of plots per stratum increased in each successive distance band.

Within each plot, all individuals ≥20 cm dbh of Ozigo and Abam were identified and their diameters at breast height (dbh) measured using diameter tapes. When trees had buttresses, diameters were measured at 50 cm above the buttresses. GPS coordinates were recorded at each corner of the sampled plots. Stumps were also sought, identified and measured.

2.4. Data analysis

2.4.1. Mapping of fruit collection trees

The coordinates of the villages and the collection trees were exported from the GPS devices to Libre Office Calc (4.1.6), where additional variables were added. These included tree diameter (important for determining which trees were larger than the legal Minimum Felling Diameter or (DME). The researcher could set an indicator as to whether the tree diameter was greater than the legal Minimum Felling Diameter of (70 cm) for that species. The distance between the village and the collection trees was calculated along with the classification of distance intervals (0–9 km, 1–1.9 km, etc.).

Figures were produced using the g.gplot2 package (Wickham, 2009) while polygons were used to overlay the areas allocated to logging concessions and the location of agricultural areas, on the basis of information from various sources including the World Resources Institute, Global Forest Watch in Gabon (Atlas v.2) and the forest concession's database. Villages and the trees from which fruits were collected were mapped using QuantumGIS (1.8.0). Determining whether trees were within or outside of the forest concession or agricultural boundaries was done by counting points that fell within these polygons in QuantumGIS. The result was added as a variable in the.csv dataset. Qualitative data from the questionnaire was analysed using averages of the responses given by the informants.

2.4.2. Quantifying density and distribution of trees

Due to the high number of zeros for Abam trees in the resulting dataset, comparisons between the average tree density in the forest concession and the neighboring villages, and among the distance strata around the villages, were carried out using nonparametric Kruskal-Wallis tests. For Ozigo, ANOVA could be used because fewer plots included zero trees. Tukey tests were also used to determine pairwise differences in terms of: (1) the density of individuals of harvestable and precommercial sizes around different villages and at different distances from the villages; and (2) the density of trees around neighboring

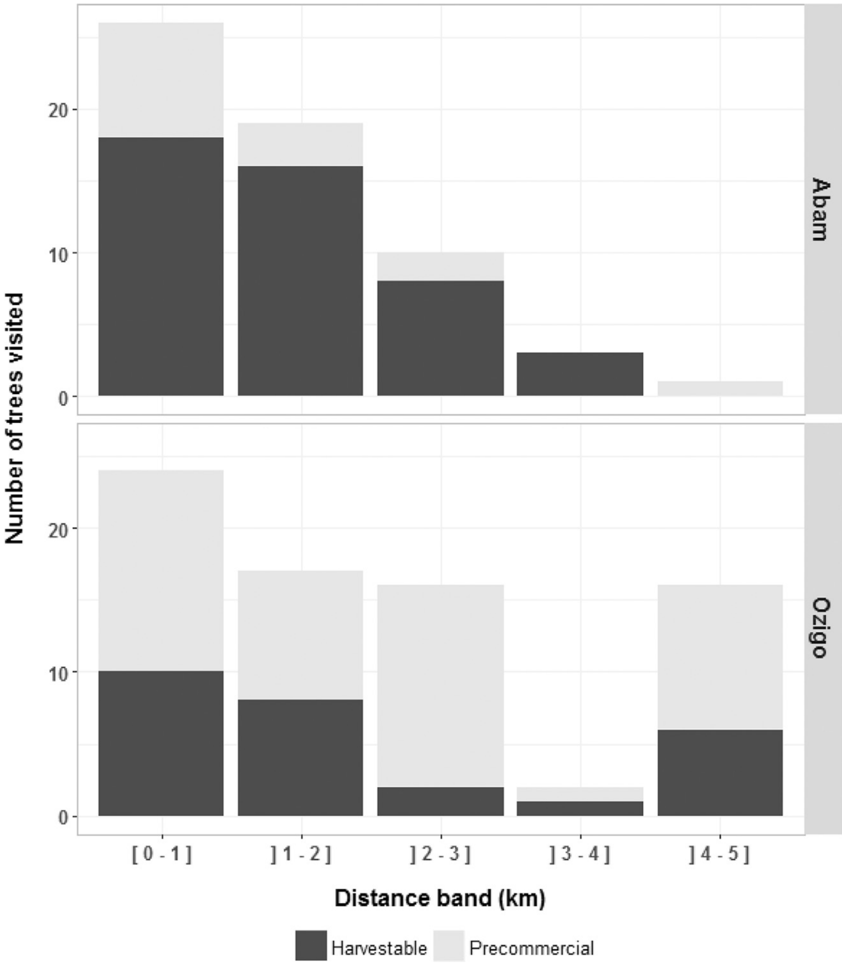

Fig. 2. Variation in the number of collection trees at different distances from the village centre.

villages compared to the density in forest concessions. "R" statistical software was used to carry out all these analyses (R Core Team, 2013).

3. Results

Densities of individuals are expressed per 100 ha except where indicated otherwise. Individuals are described as 'harvestable' if their diameters are larger than or equal to the minimum cutting diameter for that species (70 cm for both tree species) and 'pre-commercial' for individuals below those sizes.

3.1. Fruit collection

3.1.1. Abundance and location of collection trees

In total, the locations of 134 collection trees were recorded, 75 Ozigo and 59 Abam. Ozigo trees from which fruits were collected had an average diameter of 63.8 ± 3.4 cm, ranging from 10.4 to 163.0 cm; only one third (27) had reached harvestable diameters. Abam trees from which fruits were collected had an average diameter of 102.7 ± 6.4 cm, ranging from 30.5 to 328.0 cm. Over three quarters (45) of Abam from which villagers collected fruits were above the minimum cutting diameter for timber.

The number of trees visited varied among villages ($\chi2 = 5.04$, df = 1, $p = 0.02$), with 80 trees (67%) recorded in Opo and 54 trees (33%) recorded in Ond. The number of individuals of each of the two species visited did not vary significantly among villages. The number of trees visited did vary with distance from the villages ($\chi2 = 44.58$, df = 4, $p < 0.0001$; Fig. 2). The number of trees visited for resource collection decreased from 50 (37%) located under 1 km from the villages, to 36 (27%)

located between 1 km and 2 km, to 26 (19%) located between 2 km and 3 km, to 5 (4%) located 3–4 km from the village. However, 17 (13%) of collection trees were located at distances of 4–5 km. Trees located at distances greater than 3 km were collected by residents of Opo, while informants in the village of Ond did not visit trees further than 2.8 km from their village. The number of trees visited at each distance also varied by species ($\chi2 = 13.29$, $df = 4$, $p = 0.01$), although the only major difference noted was at distances of 4–5 km, where fruit was collected from 16 Ozigo trees, compared with only 1 Abam.

The distance between the village and the trees from which resources were collected on day trips varied significantly among the two villages, ranging from 70 m to 4.4 km (ANOVA, F54.97, $p < 0.0001$). Informants in Opo collected from trees located on average 1.9 ± 1.4 km from the village, and informants in Ond collected from trees located on average 1.5 ± 0.8 km from the village. In light of the standard errors, these differences are not consequential, but informants from Ond did not indicate collection trees further than 2.8 km from the village whereas informants from Opo took the researchers to trees up to 4.4 km from the village. The locations of the collection trees were mapped in relation to the village, its agricultural zone, and the concession boundaries. Almost 28% of all of the trees recorded (16 Ozigo and 21 Abam) were inside the logging concession boundaries but outside the village agricultural zone, whereas 43% of all of the trees recorded were inside the agricultural zones delimited by the logging concession for both villages (Fig. 3). A further 29% (15 Ozigo and 39 Abam) were outside the logging concession boundaries; but no information is available about the land tenure arrangements in this area. In Ond, which is internal to the concession, only 35% of all of the trees recorded (14 Ozigo and 5 Abam) were inside the village agricultural zone and those outside the agricultural zone were within concession lands. In Opo, which is located on the boundary of the concession, 51% of all of the trees recorded (22 Ozigo and 19 Abam) were inside the village agricultural zone delimited by the logging concession and the remaining 49% (24 Ozigo and 15 Abam) were outside the concession (Fig. 3).

According to the respondents in both villages, the availability of Ozigo fruits reportedly had either stayed the same over the last 5 years (93% and 70% of respondents in Ond and Opo respectively) or increased (7% and 30% of respondents in Ond and Opo respectively). None mentioned the decrease of fruits. In the case of Abam, 77% and 76% of the respondents in Ond and Opo, respectively, reported that the availability of fruit had not changed over the last 5 years; according to 19% and 20%, respectively, in Ond and Opo, fruit availability had increased, while the remaining 4% of respondents reported a decrease in both villages.

3.1.2. Gender and distance to the collection trees

The distances between the village centre and collection trees varied significantly by gender of the collector(s) (ANOVA, F 33.42, $p > 0.0001$) (Fig. 4). Of the trees mapped, a minority were visited exclusively by women (12%) or children (2%), at an average of 1.7 ± 0.5 km from the village. Most fruit trees were visited by mixed groups made up of men, women and children (54%) at an average of 1.2 ± 0.1 km; or by men and women (18%) at 2.2 ± 0.1 km; or by women and children (14%) at 4.0 ± 0.2 km from the village centre. There were no records of trees from which resources were collected solely by men, nor any reports of trees from which resources were collected by men and children together (Fig. 4).

A Post-hoc comparison using the Tukey HSD test indicated that the average distance travelled by women and children to collect fruits (4 km) was significantly greater than the distance travelled by any of the other combinations of men, women and children (1.0–2.2 km). Eighteen Ozigo trees (17 in Opo, dbh 10.4–95.0 cm; and one in Ond, dbh 49 cm) were recorded as visited by women and children together at an average distance of 4.0 ± 0.2 km from the centre of the villages. Only one Abam tree (dbh 33.1 cm) was visited by the same combination (at 4.3 km) in Opo. Collectors from Ond, located inside the concession, did not travel further than 2.8 km for fruit collection. A further summary of the distances from the village of trees of the two species is presented in Table 1.

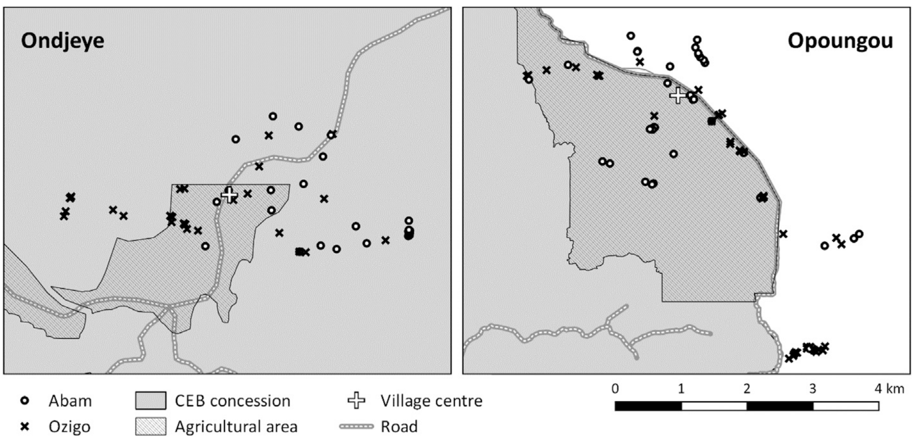

Fig. 3. Map of the locations of recorded collection trees in relation to the villages, their agricultural areas, and the concession boundaries.

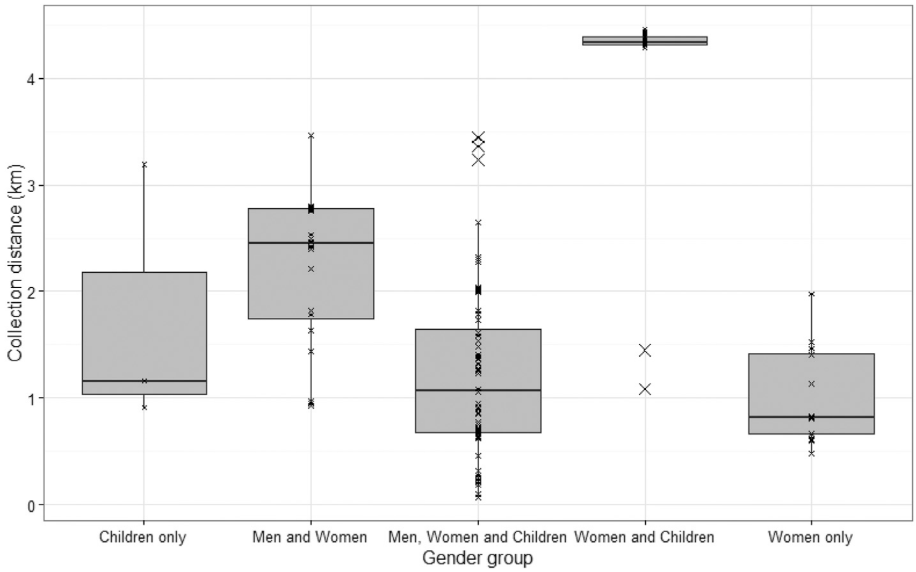

Fig. 4. Boxplot of the distances travelled to collection trees of both species by gendered groups.

This study considers the two villages as replicates because disaggregating the data would substantially reduce the sample size. However, it is interesting to note that 100% of the women interviewed in Ond organized specific collection trips for both Ozigo and Abam fruits; whereas 100% of women interviewed in Opo collected both fruits in passing, or in conjunction with other activities such as agriculture and the collection of other NTFPs. In both villages, groups of men and women organized deliberate collection trips for Abam fruits, representing 19% of the Abam trees recorded. Also, it is interesting to note that the distance to the tree was not significantly related to whether or not the collection of fruits from the tree was organized for that purpose.

Ozigo fruits are collected almost entirely for consumption. Abam fruits are collected for personal consumption and for sale (FCFA 50–100 per fruit). The fruit pulp of both fruits is often transformed, by women, into a cake/bloc, in order to conserve it. Some respondents said they sell the conserved Ozigo fruits when there is a specific external demand for it, but they do not sell the conserved Abam fruits.

3.2. Tree densities

3.2.1. Densities around villages

There were no statistically significant differences in the density of either species or either size class, between villages (see Table 2). The density of precommercial Ozigo trees was two and half times greater around Ond than in Opo, although this difference was not statistically significant ($134 \pm 21.8100\ ha^{-1}$ and $59.0 \pm 7.9100\ ha^{-1}$, respectively; $\chi 2 = 2.7524$, $df = 1$, $p = 0.097$). No significant differences were found between the two villages with regards to the density of precommercial Abam trees, although their mean density was two times higher in Opo than in Ond ($30.4 \pm 6.8100\ ha^{-1}$ and $14.2 \pm 3.7100\ ha^{-1}$, respectively; Table 3). For Ozigo of harvestable size, there was no significant difference in density between Ond and Opo ($15.2 \pm 3.5100\ ha^{-1}$and $19.0 \pm 3.4100\ ha^{-1}$, respectively). The density of harvestable Abam was not significantly different

Table 1
Number of Ozigo and Abam visited by each gender group in each distance stratum.

		Number of trees	Distance (km) Avg (±SE)	Range (km) [min - max]
Abam	Men, Women and Children	*34*	1 (±0.1)	0.1–3.4
	Men and Women	*11*	2.7 (±0.1)	1.8–3.5
	Women only	*10*	1.2 (±0.2)	0.6–2
	Women and Children	*1*	4.3	4.3
	Children only	*3*	1.8 (±0.7)	0.9–3.2
Ozigo	Men, Women and Children	*38*	1.4 (±0.1)	0.1–3.4
	Men and Women	*13*	1.8 (±0.2)	0.9–2.5
	Women only	*6*	0.8 (±0.1)	0.5–0.8
	Women and Children	*18*	4.0 (±0.2)	1.1–4.5
	Children only	*0*	–	–

Table 2
Average density (per 100 ha) of trees around villages, with standard errors. Minimum cutting diameter ≥70 cm. As shown by subscripts, there were no statistically significant differences between villages.

Species	Size	Village	
		Ond (Density 100 ha^{-1})	Opo (Density100 ha^{-1})
Ozigo	Harvestable	$15.2 \pm 3.5_c$	$19.0 \pm 3.4_c$
	Precommercial	$134.2 \pm 21.8_a$	$59.0 \pm 7.9_a$
Abam	Harvestable	$7.6 \pm 2.2_b$	$21.9 \pm 5.4_b$
	Precommercial	$14.2 \pm 3.7_d$	$30.4 \pm 6.8_d$

between the two villages ($\chi 2 = 2.98$, df = 1, p = 0.08) but was almost three times higher in Opo than in Ond (21.9 ± 5.4100 ha^{-1} and 7.6 ± 2.2100 ha^{-1}, respectively; Table 2).

The density of precommercial Ozigo trees was three to eight times higher than the density of harvestable trees, respectively, in Opo and Ond. Abam showed a similar pattern, with the density of precommercial trees one and half to two times higher than the density of harvestable trees, in Opo and Ond, respectively (Table 2).

The differences in density of Ozigo among distance strata were not significant, although Ozigo was more abundant in stratum D than stratum A around Ond. A similar pattern, with differences in densities with distance that were neither significant nor clear, was found for Ozigo around Opo. The same lack of statistically significant differences was found with regards to the density of Abam trees with distance from the village. The densities of Abam were quite similar (34 ± 6.4100 ha^{-1}) around both villages in stratum A. In Ond, no trees were encountered in stratum B, which was crossed by a major concession road and some old coffee farms.

3.2.2. Densities in the cutting area

The density of precommercial trees of Ozigo in the forest concession was almost twice as high as the density of harvestable trees (236.0 ± 20.3100 $ha^{-1}$and 120 ± 20.2100 ha^{-1}, respectively); but differences were not statistically significant. More than 60% of Ozigo trees in the concession were precommercial (Fig. 5). Abam showed an inverse pattern, with harvestable individuals occurring at densities three times higher than the density of precommercial individuals (21.0 ± 7.8100 $ha^{-1}$and 6.0 ± 2.9100 ha^{-1}, respectively), but this difference, too was not statistically significant. Nonetheless, fewer than 25% of Abam trees in the concession were precommercial (Fig. 5). No stumps of the two target tree species were recorded in the plots on the 2012 cutting area or in those around the villages.

3.2.3. Densities around villages compared to the cutting area

Densities of Ozigo around villages were significantly lower than densities on the cutting area (113.8 ± 18.8100 $ha^{-1}$and 256.0 ± 35.0100 ha^{-1}, respectively; P = 1.32E-06). This difference remained significant when the harvestable and the precommercial individuals were considered separately (96.6 ± 17.2 vs 236.0 ± 20.3; P = 1.27E-06 and 17.1 ± 3.4 vs 120 ± 20.2; P = 0.0002, respectively). In both cases, precommercial individuals were more abundant than harvestable trees (Table 3). Densities of Abam around villages were not significantly different to densities on the cutting area (Table 3).

4. Discussion

4.1. Fruit collection

4.1.1. Size and location of collection trees

Only one third of Ozigo fruit trees visited by fruit collectors had reached harvestable diameters. Little information is available on the biology/fruiting of Ozigo, but it appears that this species fruits at relatively low diameters (from 10.4 cm). This implies that most collection trees would not be threatened by timber harvesting for many years to come. Furthermore, only 21% of the Ozigo trees visited on one-day fruit collection trips were located inside the logging concession; the majority (50%) were growing in the village agricultural zone. This means that the potential for conflict between fruit gathering villagers and timber harvesting concessionaires is likely to be low, even without regulations prohibiting harvest.

Over 75% (45) of Abam that bore fruit collected by villages were of harvestable diameters. However, only 36% of Abam trees from which fruit were collected were growing within the timber concession; of these, 46% were of harvestable size. The fact that we found no stumps of these trees and their relatively low value for timber because of low demand on the local and international markets, means that the risk of potential conflict between villagers interested in fruit collection and industry interested in timber production is minimal, at least at the current time.

Resources found within the agricultural area delimited by the forest concession are managed as open access or common pool resources, meaning that any villager can use them. This area is close to what Karsenty and Vermeulen (2016) named 'customary territories' within and around the industrial concession in their 'Concession 2.0' model. There are no official guidelines or rules in connection with the use of these resources, but villagers seemed to be aware of the ban on Ozigo exploitation decreed by the Government in 2009. A few families of the employees of the concession also have access to this

Table 3
Average density (per 100 ha) of Ozigo and Abam trees in the 2012 cutting area and around neighboring villages, with their standard errors. Minimum cutting diameter ≥70 cm. Different subscripts reveal statistically significant differences between villages and the cutting area.

Timber species	Precommercial (Density 100 ha^{-1})		Harvestable (Density 100 ha^{-1})	
	Villages	Cutting Area (AAC 2012)	Villages	Cutting Area (AAC 2012)
Ozigo	$96.6 \pm 17.2_a$	$236.0 \pm 20.3_b$	$17.1 \pm 3.4_c$	$120 \pm 20.2_d$
Abam	$22.3 \pm 5.6_e$	$6.0 \pm 2.9_e$	$14.7 \pm 4.2_f$	$21.0 \pm 7.8_f$

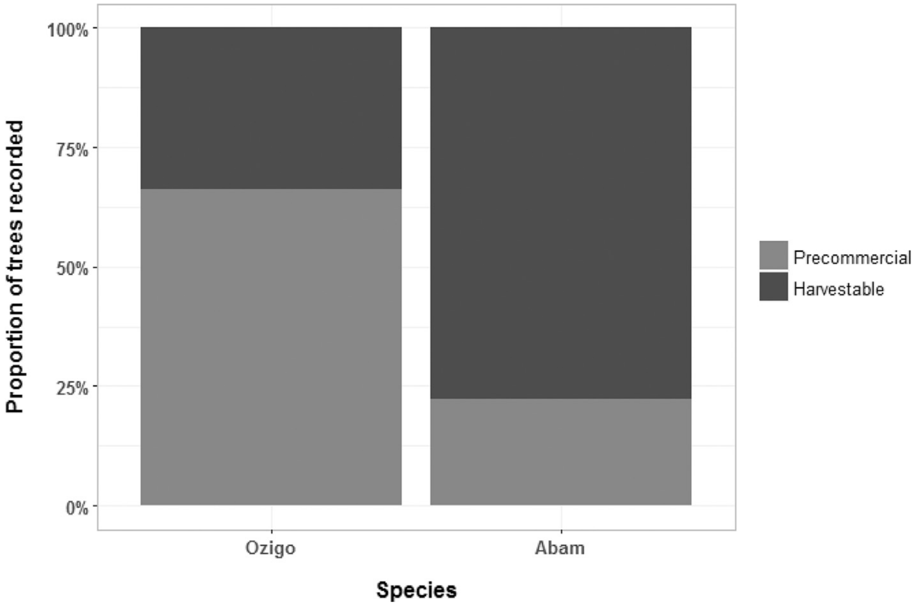

Fig. 5. Proportion of precommercial and harvestable timber trees of Abam and Ozigo recorded on the concession AAC 2012. Commercial individuals are those with diameters >70 cm.

area. We did not observe activities of non-local individuals in the agricultural area. The concessionaires remain flexible with the incursions of villagers into the concession slightly beyond the borders of the agricultural zone, considering that the collection of the fruits does not affects their potential to exploit timber in this area. But the concession prohibited the villagers from accessing the main forest concession (for example the 2012 cutting area, located 50–60 km from the villages).

Forty three percent of all of the trees visited by collectors (23 Abam and 35 Ozigo) were inside the village agricultural zone. The distance between the village and the trees from which resources were collected on day trips varied from 70 m to 4.46 km. We did not learn of any conflicts among villagers, for example, between those who want to use the wood, or sell it, and those who want to harvest the fruits (men vs women), unlike the situation described by Noutcheu et al. (2016) for other food and timber species in Cameroon. This may reflect the fact that Ozigo timber harvesting was prohibited at the time of the study, while Abam timber had low commercial demand. Conflicts between use of trees for timber or non-timber products are likely to reflect factors such as the non-monetary or monetary importance of non-timber uses for local livelihoods (Herrero-Jàuregui et al., 2013). Ozigo and Abam fruits do not have the same value for local populations as, for example, bush mango (*Irvingia gabonensis*) which is highly valued in the region (Mba Assoumou, 2012).

According to most respondents in both villages (93% in Ond and 70% in Opo), the availability of fruits of Ozigo stayed the same over the last 5 years; the same was reported for Abam, by 77% of respondents in Ond and 76% in Opo. This may mean that timber harvesting has not taken place over this period within the 5 km daily collection radius around the villages. However, it may be that declining abundance is masked by increased collection effort, as has been reported elsewhere in response to rising local demand associated with logging camps (Rist et al., 2012).

4.1.2. *Gender and fruit collection*

A number of authors have reported that forest-based livelihood activities are gender-related within the households (Simtowe, 2010; Shackleton et al., 2011; Session, 2012; Asfaw et al., 2013). The results of this study confirm what has been described in other studies on collection of wild and semi-wild food plants (Kalaba et al., 2009; Agea et al., 2011et al.), namely that women are the principal fruit collectors. They are also helped in this activity by children, who participate in fruit gathering even relatively far from the village (±5 km; Table 1). This result is in contradiction with the findings of Maukonen et al. (in press) near two forest concessions in south and east Cameroon, where women accompanied by children limited their collecting activities to trees very close to villages to avoid the potential dangers encountered in deep forest. As is typical in many Bantu traditions, education of the children before they reach their teens is the responsibility of women. Men are in charge of the education of the boys afterwards, when the young men give up fruit collection for more masculine activities such as hunting (Munga, 1982). The lesser involvement of men in fruit collection has to do with the fact that they tend to be involved in other livelihood activities such as land clearance and tree felling, more than women (Packham, 1993; Lovett and Haq, 2000; Akinnifesi et al., 2006; Sher and Hussain, 2009). However, men and women have roles in various stages of agricultural production (Sunderlin and Pokam, 2002), so both would be expected to collect from trees close to their farms or smallholdings, which are usually situated in areas accessible to the village. In this study, men were not found to collect fruits alone, but only with either women or women and children.

The collection of fruits appears to be an organized activity in Ond but combined with other activities in Opo. This may reflect the fact that collectors in Ond were visiting trees in the timber concession, whereas collectors in Opo were visiting trees located either in their agricultural zones or outside the concession. Fruit collection occurs mostly during the dry season, when the farmers are involved in activities such as land clearance and slash-and-burn operations (Lemmens, 2007). This may explain why fruits from some Abam trees are collected by women and children so far from the village (4 km) in Opo. Indeed, we noted, as did Mba Assoumou (2012), that the farthest farms were located at about 5 km from this village.

As reported from two similar cases studies in Cameroon (Snook et al., 2015; Noutcheu et al., 2016), when trees are near the village, there may be conflicts among villagers as to the best use of the tree, whether to cut it as timber, often the preference of men, or to retain it for its yield of NTFPs, as typically preferred by women. The fact that no stumps were found around the sample villages of either potential timber species studied in Gabon, it appears that these trees have not been targeted as timber sources by villagers. The transformation of the fruits, as in the case of many others, was found to be carried out by women, as was found by Ndoye et al. (1997) and Ingram et al. (2014). It may be that this means that women also play a role in decision making regarding access to and use of forest resources for household benefit, as described previously by Awono et al. (2010) and Villamor et al., 2014.

4.2. Tree densities

4.2.1. Tree densities around villages and in the cutting area

In the Lopé National Park in central Gabon, Todou and Doumenge (2008) found harvestable Ozigo trees at densities of 27 per 100 ha^{-1} in dense forest, as compared to 7 per 100 ha^{-1} in more open Marantaceae forest. The densities we recorded on the 2012 cutting are of the concession were more than 4 times higher than this (120 per 100 ha^{-1}), though around villages, densities were somewhat lower (Ond: 15.2 per 100 ha^{-1}; Opo: 19.0 per 100 ha^{-1}). These could reflect natural variations in density; however, the lower densities around villages may reflect the fact that this commercially important timber tree was harvested and commercialized during the years before its harvest was banned in 2009.

Although we found no stumps of these species in our sample plots, villagers and people living in Okondja (the main town/village in the area), reported that the sites sampled around villages had been exploited for timber a decade ago. According to the CEB management plan, cutting cycles are 20 years and harvests around villages took place in 2000–2001 and 2002–2003 in Opo and Ond, respectively. This means that stumps had time to rot or to become un-identifiable, before our sampling. In addition, the villagers reported that in the past, more or less organized illegal logging took place in the vicinity of the villages. Few local people were involved in such logging activities, but it yielded substantial income to a small number of people in the villages, as previously reported in this region by Massoukou (2007) and Mba Assoumou (2012). Former timber harvesting seemingly had a negative impact on the density of Ozigo around the villages, whereas Abam, which is mostly cut by local populations for their own constructions, is thus less likely to be illegally logged for sale, and was less affected. Local people do not consider it scarce. As stated by Morin-Rivat et al. (2017), since 1885, when colonial administrations concentrated people and villages along the primary communication axes, there has been less itinerancy and thus, disturbance in the forest. This means that disturbances tend to be more frequent within a closer radius of the villages. The density of Ozigo trees, both precommercial and harvestable, was lower near villages compared to the cutting area, which may reflect not only legal and illegal logging operations but also the establishment of agricultural fields through slash-and-burn agricultural practices. During land clearing for farming, trees that are considered less valued, including Abam, are felled. Similar trends were described by Noutcheu et al. (2016) for other multipurpose timber species in the South and East regions of Cameroon. Moreover, land clearing is typically followed by burning, which affects seedlings and soil seed banks, including Ozigo. To reduce these negative consequences, famers often remove fallen trees, branches and herbs around the mature and productive trees of desired species so that fire does not burn them.

The commercial timber industries in many Central African countries are over 100 years old, but historical data on logging events which have occurred in these areas is either difficult to find or does not exist. This makes it hard to evaluate the longer-term changes in forest resource availability over time. Data on artisanal/informal logging are lacking in Gabon. However, the market for artisanally logged timber appears to be underestimated by most decision-makers, given that this sector is largely informal (Lescuyer et al., 2011).

Overall, the densities of Ozigo and Abam were higher on the annual cutting area than in the immediate surroundings of villages. More than 60% of Ozigo trees in the cutting area were of precommercial size. This probably reflects the fact that large-diameter Ozigo were harvested in the past, but also that forest concessions are managed according to specific guidelines including minimum cutting diameters. No stumps of either of the two targeted tree species were recorded in the plots on the cutting area. This probably reflects the prohibition of 2009 on felling Ozigo; and perhaps, low demand for Abam. Fewer than 25% of Abam trees on the cutting area were precommercial. This could reflect the fact that few harvestable trees had been removed, but it may also reflect a lack of natural regeneration. The growth of Abam seedlings is very slow, especially during the first three years, and the seedlings around mother trees are very rare. This has been attributed to intensive predation of the fruits by rodents and wild pigs, which destroy the fruits (Lemmens, 2007).

5. Conclusion

Ozigo and Abam are important to local populations for their fruits. The same species are important to logging companies for timber. For villages that are located within timber concessions, access to fruits is enhanced by the safeguarding of these trees by timber companies and reduced by harvesting of the largest individuals. This study showed that CEB timber company did not harvest Ozigo and Abam trees in 2012. In one case, this probably reflected the policy prohibiting the felling of Ozigo; in the case of Abam, however, the lack of stumps probably reflected lack of demand for this timber. It is noteworthy, however, that the concessionaire prohibited villagers from using the annual cutting area we studied (which was also very distant from the villages). This reveals that access to fruits from timber trees is limited not only by whether or not they are felled, but also by rights of access, as well as by distance.

It is noteworthy that the agricultural areas allocated to villagers retained sufficient wild trees to account for 43% of the fruit collection trees documented in this study. By making the effort to define these agricultural areas, CEB Precious Woods have contributed to safeguarding community access to resources. Villagers have the possibility of defining how these areas and trees therein are managed and could make decisions to conserve them. They could even decide to increase the density of such trees by planting them, although this would involve waiting for them to mature and would also require that villagers have sufficient area for their agricultural production as well.

Another factor of importance in evaluating the potential for conflict between timber and non-timber uses of fruit trees is the diameter at which trees start to produce fruit, as compared to their minimum cutting diameter. For these two species, it seems that the minimum diameter for fruit production differed considerably: whereas 75% of Abam fruit collection trees were above the minimum cutting diameter, only a third of Ozigo fruit collection trees had reached this diameter. Where trees below the minimum cutting diameter produce fruit, there is no immediate conflict between fruit collection and timber production.

Clearly, to evaluate policy options for conserving access to fruit from timber trees for villagers, it is important to know the geographic distribution of those trees, the potential for villagers to reach them, both physically and through access rights; and the size at which they start to produce fruit as compared to the minimum cutting diameter. At a minimum, information needs to be gathered, on a species by species basis, about abundance, size classes and physical location of the trees in question, as well as about their biology (ie. diameter at which they begin to fruit). This information can provide the foundation for forest management under Karsenty and Vermeulen's proposed Concession 2.0 model (Karsenty and Vermeulen, 2016), to promote both conservation and benefits from both timber and non-timber resources, to meet multiple stakeholder interests. Similarly, more encompassing and adapted approaches to forest management were documented by Ros-Tonen et al. (2008) from the Brazilian Amazon, where a partnership among local forest users, private sector and civil society facilitated the insertion of NTFPs into timber-oriented models. Though a number of logging companies in the Congo Basin have been certified as well-managed (Nasi et al., 2006), concessions with no management plans remain numerous. It is likely that their exploitation practices negatively impact both the forest ecosystem (Nasi et al., 2012) and livelihoods, including access to food resources from timber trees by villagers. Responsible and ecologically-sensitive logging can be a source of multiple benefits: biodiversity conservation, timber and livelihood benefits for forest communities. Many more studies are needed to evaluate whether conflicts are reducing access and to understand the best ways to address them if that is the case.

Acknowledgements

This study was supported by the Congo Basin Forest Fund/African Development Bank through grant 5650155000601 for Project P-Z1-COO-024, “Beyond Timber: Reconciling the Needs of the Logging Industry with those of Forest-Dependent People”, to Bioversity International, as part of the CGIAR Research Program on Forests, Trees and Agroforestry (FTA). FTA is the world's largest research for development program to enhance the role of forests, trees and agroforestry in sustainable development and food security and to address climate change. It is led by CIFOR in partnership with Bioversity International, CATIE, CIRAD, INBAR, the World Agroforestry Centre and Tropenbos International and supported by the CGIAR Fund Donors: on.cgiar.org/CGIARFundDonors. Additional funding was provided to Bioversity International by the Government of Italy. We also thank CIFOR for providing support from their EU/FORETS grant to support the participation of the first author in a “writeshop” at Bioversity to work on this article. We gratefully thank Landry Lomboubady and Lydia Atsima from IRET (Institut de Recherche en Ecologie Tropicale) in Gabon, for their help with the data collection in the villages and in the cutting area. Similarly, we wish to express our thanks to the concessionaires of CEB-Precious Woods and their field technicians based in Okondja for their contributions as guides and helpers installing the sample plots and carrying out the inventories. The villagers from Ondjeye and Opoungou are thanked for their hospitality and collaboration during participatory mapping data collection. We also thank the anonymous reviewers for their useful comments.

Appendix A

GPS mapping questionnaire

Questions about the tree		
1		When do you collect the Ozigo/Abam from this tree?
	a	Does this tree produce these every year?
	b	How many times do you collect from this tree in a season?
	c	Has the amount that you collect or the amount available from this tree increased, decreased or stayed the same over the last 5 years?
	d	Are there trees of this species that do not produce these products, how many and why?
	e	Has the number of this particular tree species increased, decreased or remained the same over time?
2		Who is entitled to collect products from this tree (for consumption, sale and timber)?
	a	Women, men, children, everyone or selected individuals?
	b	If access is limited, who controls the access and how?
3		Do you organise specific collection trips for Ozigo/Abam?
	a	Has the collection distance increased, decreased or stayed the same in the last 5 years?
	b	Has the availability of the product increased, decreased or remained the same in the last 5 years?
4		Do you sell any of the Ozigo/Abam?
	a	What is the proportion consumed and the proportion sold?
	b	For how long have you been selling them?
	c	How is the market for the product and how has it changed in the last 5 years?
	d	To whom do you sell it and where?
	e	How much do people pay for it (per unit to be defined)?
5		Do you transform the product?
	a	Who does that work?
	b	Do you use the transformed product at home?
	c	Do you sell the transformed product? To whom and for how much?
6		How much can you get from the sale of such a tree?

Questions about the resource (these can be asked throughout the day)	
1	Has the collection distance increased, decreased or stayed the same in the last 5 years?
2	Has the availability of the product increased, decreased or remained the same in the last 5 years?
3	Do you sell the resource, and what is the proportion consumed and the proportion sold?
4	For how long have you been selling them?
5	How is the market for the product and how has it changed in the last 5 years?
5	To whom do you sell it and where?
7	How much do people pay for it (per unit to be defined)?
8	Do you transform the product?
9	Who does that work (men, women and/or children)?
10	Do you use the transformed product at home?
11	Do you sell the transformed product? To whom and for how much?
12	How much can you get from the sale of such a tree?

Appendix B

GPS mapping collection sheet

Date			Data Collector			
Village			Guide			
Coordinates	lat	lon	Villager			
GPS Point	**Latitude**	**Longitude**	**Species**		**Dbh**	**Comments**
			Ozigo	Abam		
			Ozigo	Abam		
			Ozigo	Abam		
			Ozigo	Abam		
			Ozigo	Abam		
			Ozigo	Abam		
			Ozigo	Abam		
			Ozigo	Abam		
			Ozigo	Abam		
			Ozigo	Abam		
			Ozigo	Abam		
			Ozigo	Abam		
			Ozigo	Abam		
			Ozigo	Abam		
			Ozigo	Abam		
Observations						

References

Adhikari, J., Ojha, H., Bhattarai, B., 2016. Edible forest? Rethinking Nepal's forest governance in the era of food insecurity. Int. For. Rev. 18 (3).

Agea, J.G., Okia, C.A., Abohassan, R.A.A., Kimondo, J.M., Obua, J., Hall, J., Teklehaimanot, Z., 2011. Wild and semi-Wild food plants of Bunyoro-Kitara Kingdom of Uganda: growth forms, collection niches, parts consumed, consumption patterns, main gatherers and consumers. Environ. Res. J. 5 (2), 74–86.

Akinnifesi, F.K., Kwesiga, F., Mhango, J., Chilanga, T., Mkonda, A., Kadu, C.A.C., Dhliwayo, P., 2006. Towards the development of miombo fruit trees as commercial tree crops in southern Africa. For. Trees Livelihoods 16 (1), 103–121.

Asfaw, A., Lemenih, M., Kassa, H., Ewnetu, Z., 2013. Importance, determinants and gender dimensions of forest income in eastern highlands of Ethiopia: the case of communities around Jelo Afromontane forest. For. Pol. Econ. 28, 1–7.

Awono, A., Ndoye, O., Preece, L., 2010. Empowering women's capacity for improved livelihoods in non-timber forest product trade in Cameroon. Int. J. Soc. For. 3 (2), 151–163.

Blaser, J., Sarre, A., Poore, D., Johnson, S., 2011. Status of Tropical Forest Management 2011. ITTO Technical Series No 38. International Tropical Timber Organization, Yokohama, Japan.

Boedhihartono, A.K., Gunarso, P., Levang, P., Sayer, J., 2007. The principles of conservation and development: do they apply in Malinau? Ecol. Soc. 12 (2), 2.

Chidumayo, E., Okali, D., Kowero, G., Larwanou, M. (Eds.), 2011. Climate Change and African Forest and Wildlife Resources. African Forest Forum, Nairobi, Kenya.

Guariguata, M.R., García-Fernández, C., Sheil, D., Nasi, R., Herrero-Jáuregui, C., Cronkleton, P., Ingram, V., 2010. Compatibility of timber and non-timber forest product management in natural tropical forests: perspectives, challenges, and opportunities. For. Ecol. Manag. 259, 237–245.

Herrero- Jàuregui, C., Guariguata, M., Cardenas, D., Vilanova, E., Robles, M., Licona, J.C., Nalvarte, W., 2013. Assessing the extent of « conflict of use » in multipurpose tropical forest trees: a regional view. J. Environ. Manag. 130, 40–47.

Hymas, O., 2016. L'Okoumé, fils Du Manioc : Post-logging in Remote Rural forest Areas of Gabon and its Long-term Impacts on Development and the Environment. PhD. University College London, London.

Ingram, V., Schure, J., 2010. Review of Non Timber Forest Products in Central Africa: Cameroon. CIFOR, p. 155 (+v).

Ingram, V., Schure, J., Tieguhong, J., Ndoye, O., Awono, A., Iponga, D., 2014. Gender implications of forest product value chains in the Congo Basin. For. Trees Livelihoods 23, 67–86.

Kalaba, F.K., Chirwa, P.W., Prozesky, H., 2009. The contribution of indigenous fruit trees in sustaining rural livelihoods and conservation of natural resources. J. Hortic. For. 1 (1), 1–6.

Karsenty, A., Vermeulen, C., 2016. Toward "Concessions 2.0": articulating inclusive and exclusive management in production forests in Central Africa. Int. For. Rev. 18 (S1).

Laurance, W.F., Alonso, A., Lee, M., Campbell, P., 2006. Challenges for forest conservation in Gabon, central Africa. Futures 38 (4), 454–470.

Lemmens, R.H.M.J., 2007. Chrysophyllum lacourtianum de wild. [Internet] record from PROTA4U. In: Louppe, D., Oteng-Amoako, A.A., Brink, M. (Eds.), PROTA (Plant Resources of Tropical Africa/Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands. http://www.prota4u.org/search.asp. (Accessed 23 March 2014).

Lescuyer, G., Cerutti, P.O., Manguiengha, S.N., Bilogo bi Ndong, L., 2011. Le marché domestique du sciage artisanal à Libreville, Gabon: État des lieux, opportunités et défis. CIFOR.

Lescuyer, G., Cerutti, P.O., Essiane Mendoula, E., Eba'a Atyi, R., Nasi, R., 2012. Évaluation du secteur du sciage artisanal dans le bassin du Congo. In: de Wasseige, C., de Marc ken, P., Bayol, N., Hiol Hiol, F., Mayaux, Ph, Desclée, B., Nasi, R., Billand, A., Defourny, P., Eba'a, R. (Eds.), Les forêts du bassin du Congo - État des forêts 2010. Office des publications de l'Union européenne, Luxembourg, pp. 97–107. http://www.observatoire-comifac.net/docs/edf2010/FR/EDF_2010_FR_04.pdf.

Lovett, P.N., Haq, N., 2000. Evidence for anthropic selection of the Sheanut tree (*Vitellaria paradoxa*). Agrofor. Syst. 48 (3), 273–288.

Massoukou, L., 2007. La rétrocession d'une partie des revenus de l'exploitation forestière aux populations locales gabonaises : efficacité, équités et pérennité. Mémoire de stage de Master, vol. 2. ENGREF, Montpellier, p. 59.

Maukonen, P., Snook, L., Donn, P., Tieguhong, J., 2018. Forest foods from multiple use timber trees in Cameroon: do villagers depend on timber concessions to obtain fruits and caterpillars? Forests. For. Trees Livelihoods (in press).

Mba Assoumou, F., 2012. Caractérisation des usages locaux des produits forestiers dans les concessions forestières en Afrique Centrale: cas de deux concessions forestières: la CFAD CEB-Precious Woods et la CPAET Bayonne au Gabon. Mémoire de stage de Master 2. ENGREF, Montpellier, p. 106.

Megevand, C., 2013. Dynamiques de déforestation dans le bassin du Congo: Réconcilier la croissance économique et la protection de la forêt. Directions in Development, Environment and Sustainable Devlopment. World Bank. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/12477 License: CC BY 3.0 IGO.

Morin-Rivat, J., Fayolle, A., Favier, C., Bremond, L., Gourlet-Fleury, S., Bayol, N., Lejeune, P., Beeckman, H., Doucet, J.L., 2017. Present-day central African forest is a legacy of the 19th century human history. eLife 6 (January). https://doi.org/10.7554/eLife.20343.

Munga, A.S., 1982. L'éducation traditionnelle en Afrique et ses valeurs fondamentales. Ethiopiques 29 cultures et civilisations).

Muvatsi, P., Kahindo, J.M., Snook, L., 2018. Can the production of wild forest foods be sustained in timber concessions? The impact of logging on the availability of edible caterpillars hosted by sapelli (*Entadrophragma cylindricum*) and tali (*Erythrophleum suaveolens*) trees in the Democratic Republic of Congo. For. Ecol. Manag. 410, 56–65. https://doi.org/10.1016/j.foreco.2017.12.028.

Nasi, R., Cassagne, B., Billand, A.B., 2006. Forest management in Central Africa: where are we? Int. For. Rev. 8, 14–20.

Nasi, R., Taber, A., van Vliet, N., 2011. Empty forests, empty stomachs: bushmeat and livelihoods in Congo and Amazon Basins. Int. For. Rev. 355–368.

Nasi, R., Billand, A., Van Vliet, N., 2012. Managing for timber and biodiversity in the Congo Basin. For. Ecol. Manage. 268, 103–111.

Ndoye, O., Tieguhong, J.C., 2004. Forest resources and rural livelihoods: the conflict between timber and Non-timber forest products in the Congo Basin. Scand. J. For. Res. 19 (4), 36–44.

Ndoye, O., Manuel, R., Eyebe, A., 1997. The Markets of Non-timber forest Products in the Humid forest Zone of Cameroon. Rural Development Forestry Network. Overseas Development Institute, London.

Noutcheu, R., Snook, L., Tchatat, M., Taedoumg, Tchingsabe O., Tieguhong, J., 2016. Do logging concessions decrease the availability H. to villagers of foods from timber trees? A quantitative analysis for Moabi (*Baillonella toxisperma*), Sapelli (*Entandrophragma cylindricum*) and Tali (*Erythrophleum suaveolens*) in Cameroon. For. Ecol. Manag. 381, 279–288. https://doi.org/10.1016/j.foreco.2016.09.039.

Onana, J.M., 2008. A synoptic revision of *Dacryodes* (Burseraceae) in Africa, with a new species from central Africa. Kew Bull. 63, 385–400.

Packham, J., 1993. The Value of Indigenous Fruit-bearing Trees in Miombo Woodland Areas of South-Central Africa. ODI Rural Development Forestry Network Paper 15c, pp. 13–20.

R Core Team, 2013. R: a Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/.

Raponda-Walker, A., Sillans, R., 1961. Les plantes utiles du Gabon. Q. J. Of Crude Drug Res. 1 (1), 27-27.

République gabonaise, 2001. Loi nº 016-01 portant code forestier en République gabonaise. http://www.droit-afrique.com/upload/doc/gabon/Gabon-Code-2001-forestier.pdf.

République gabonaise, 2004. Décret n° 1028/PR/MEFEPEPN du 1er décembre 2004 fixant les conditions de création des forêts communautaires. http://extwprlegs1.fao.org/docs/pdf/gab143377.pdf.

République gabonaise, 2009. Décret n°0137/PR/MEFEPA du 4 février 2009 portant mise en réserve de certaines espèces végétales à usages multiples de la forêt gabonaise - Gabon. https://www.documents.clientearth.org/library/download-info/decret-n0137-pr-mefepa-du-04022009-portant-mise-en-reserve-de-certaines-especes-vegetales-a-usages-multiples-de-la-foret-gabonaise/.

République gabonaise, 2016. Décret n°350/PR/MPERNFM du 7 juin 2016 fixant les conditions d'exploitation du Kévazingo et de l'Ozigo - Gabon. https://www.documents.clientearth.org/library/download-info/decret-n350-pr-mpernfm-du-7-juin-2016-fixant-les-conditions-dexploitation-du-kevazingo-et-de-lozigo-gabon/.
Riddell, M., 2013. Assessing the impacts of conservation and commercial forestry on livelihoods in Northern republic of Congo. Conserv. Soc. 11 (3), 199–217.
Rist, L., Shanley, P., Sunderland, T., Sheil, D., Ndoye, O., Liswanti, N., Tieguhong, J.C., 2012. The impacts of selective logging on non-timber forest products of livelihood importance. For. Ecol. Manag. 268, 57–69.
Ros-Tonen, M.A.F., van Andel, T., Morsello, C., Otsuki, K., Rosendo, S., Scholz, I., 2008. Forest-related partnerships in Brazilian Amazonia: there is more to sustainable forest management than reduced impact logging. For. Ecol. Manag. 256, 1482–1497.
Sandison, A., 2014. L'Economie du Gabon: Une Economie à la Remorque de son Pétrole. Doctoral dissertation, University of Ghana.
Session, T.S., 2012. Committee on forestry. Change 38, 1–13.
Shackleton, S., Paumgarten, F., Kassa, H., Husselman, M., Zida, M., 2011. Opportunities for enhancing poor women's socioeconomic empowerment in the value chains of three African non-timber forest products (NTFPs). Int. For. Rev. 13 (2), 136–151.
Sher, H., Hussain, F., 2009. Ethnobotanical evaluation of some plant resources in Northern part of Pakistan. Afr. J. Biotechnol. 8 (17).
Simtowe, F.P., 2010. Livelihoods diversification and gender in Malawi. Afr. J. Agric. Res. 5 (3), 204–216.
Snook, L., Donn, P., Duminil, J., Fungo, R., Kahindo, J.M., Loo, J., Maukonen, P., Midoko Iponga, D., Mikolo Yobo, C., Monthe Kameni, F., Muvatsi, P., Ngongi, J., Noutcheu, R., Taedoumg, H., Tchatat, M., Tchingsabé, O., Tieguhong, J., 2015. Trees for Food and Timber: Are Community Interests in Conflict with Those of Timber Concessions in the Congo Basin? XIV World Forestry Congress, Durban, South Africa, pp. 7–11.
Sosef, M.S.M., Wieringa, J.J., Jongkind, C.C.H., Achoundong, G., Issembe, Y.A., Bedigian, D., van der Berg, R.G., Breteler, F.J., Cheek, M., Degreef, J., Faden, R.B., Goldblatt, P., van der Maesen, L.J.G., Ngok Banak, L., Niangadouma, R., Nzabi, T., Nziengui, B., Rogers, Z.S., Stévart, T., van Valkenburg, J.L.C.H., Walters, G., de Wilde, J.J.F.E., 2006. Check-list des plantes vasculaires du Gabon/Checklist of Gabonese vascular plants. Scripta Bot. Belg. 35.
Sunderlin, W., Pokam, J., 2002. Economic crisis and forest cover change in Cameroon: the roles of migration, crop diversification, and gender division of labor. Econ. Dev. Cult. Change 50, 581–606.
Tieguhong, J.C., Ndoye, O., 2007. The Impact of Timber Harvesting in forest Concessions on the Availability of Non-Wood Forest Products (NWFP) in the Congo Basin. FAO Forest Harvesting Case Study, 23.
Tieguhong, J.C., Ndoye, O., Vantomme, P., Grouwels, S., Zwolinski, J., Masuch, J., 2009. Coping with crisis in Central Africa: enhanced role for non-wood forest products. Unasylva 233 (60), 49–54.
Todou, G., Doumenge, C., 2008. *Dacryodes buettneri* (Engl.) H.J.Lam. In: Louppe, D., Oteng-Amoako, A.A., Brink, M. (Eds.), Prota 7(1): Timbers/Bois D'œuvre 1. [CD-rom]. PROTA, Wageningen, Netherlands.
United Nations, Department of Economic and Social Affairs, Population Division, 2015. World Population Prospects: the 2015 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP.241.
Villamor, G.B., van Noordwijk, M., Djanibekov, U., Chiong-Javier, M.E., Catacutan, D., 2014. Gender differences in land-use decisions: shaping multifunctional landscapes? Curr. Opin. Environ. Sustain. 6, 128–133.
Walker, A., Sillans, R., 1961. Les plantes utiles du Gabon. Encyclopedie Biologique LVI. Editions Paul Lechevalier, Paris.
Wickham, H., 2009. ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag, New York.
Wunder, S., 2003. When the Dutch Disease Met the French Connection: Oil, Macroeconomics and forests in Gabon. CIFOR, Bogor, Indonesia.