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IT’S NOT THE AVAILABILITY, BUT THE ACCESSIBILITY THAT MATTERS: ECOLOGICAL AND ECONOMIC POTENTIAL OF NON-TIMBER FOREST PRODUCTS IN SOUTHEAST CAMEROON

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ABSTRACT This study examined the ecological availability and economic potential of 10 non-timber forest product (NTFP) species. *Irvingia gabonensis* and *Ricinodendron heudelotii* produce large quantities of fruits and have higher economic values compared to other species. The number of nuts and kernels harvested and sold was a small percentage of the total annual production in the area. This is likely to be due to the low human population density and the difficulty in increasing the efficiency of gathering the nuts and kernels. Given the affluent ecological availability demonstrated in this study, even when innovations to improve the efficiency of harvesting are achieved, the trees produce more than 10 times the amount of fruits that can be gathered by all the people in the region, even with their maximum labor input. However, because of the forest zoning carried out by the government in the 1990s, the area that local people can harvest, without any concerns, is limited. What is of concern when promoting the use of NTFPs in southeast Cameroon is not the ecological availability of resources but limited accessibility to the resources, due to conflicts between local people and stakeholders, recently introduced under the national and international forest policies.

Key Words: *Irvingia gabonensis*; *Ricinodendron heudelotii*; Energy value; Forest zoning; Conservation; Sustainability.

INTRODUCTION

Non-timber forest products (NTFPs) are considered to contribute to both household and national economies across the Congo Basin (Ingram et al., 2012); they are also regarded as a tool that conserves the forest while simultaneously improving rural livelihoods (Peters et al., 1989). However, comprehensive knowledge on the ecology and socio-economic value of NTFPs is largely lacking and, thus, their contribution to household subsistence and national economies is difficult to evaluate (Ingram et al., 2012).

In southeast Cameroon, as well as many other forested areas in the tropics, NTFPs are harvested and traded in large quantities (Ayuk et al., 1999; Tieguhong & Nkamgnia, 2012). Among a variety of NTFPs, nuts and kernels produced by tree species, especially *Irvingia gabonensis* and *Ricinodendron heudelotii*, are prevalent in trade in this area (Hirai, 2014; Toda & Yasuoka, 2020). As these fruits are harvested without damaging the trees, the harvesting process does not seem to directly affect the availability and renewal of these resources.

However, for commercialization, the ecological availability of these resources is of great concern, as it affects the sustainability of its value, and management and governance of NTFPs are impossible without knowledge of resource availability (Ingram, 2014). Nevertheless, although there are many studies on the domestication of NTFP species into the agroforestry system (Dawson et al., 2014; Leakey et al., 1996; 2005; Simons & Leakey, 2004), very few studies have investigated the ecological availability of NTFP species in the wild.

One of the advantages of using NTFPs as a tool for improving the livelihoods of locals in areas where they are produced is that commercialization can be realized without drastic changes in people's familiar way of resource use (Belcher & Schreckenberg, 2007). In other words, when promoting the use of NTFPs, it is more realistic to maintain the familiar way as long as it is sustainable, and conflicts over the resources can be avoided.

In this paper, the ecological availability and economic potential of 10 NTFP species are examined. And, it is argued that the major bottleneck in promoting the use of NTFPs is not the ecological availability but the limited accessibility to the resources themselves, due to conflicts between local people and stakeholders caused by the recent introduction of national and international forest policies.

STUDY AREA

The research was conducted in Gribé, Department of Boumba-et-Ngoko, East Region, Cameroon (Fig. 1). The village of Gribé is located on the northern periphery of the Boumba-Bek National Park (BBNP). The vegetation of the area is classified as semi-deciduous forest around the village, and a mixture of evergreen and semi-deciduous forests within BBNP (Letouzey, 1985). The mean temperature is around 24ºC throughout the year, and the mean annual rainfall is about 1,600 mm. There are four seasons in a year: the minor rainy season (roughly March–June), minor dry season (July–August), major rainy season (September–November), and major dry season (December–February). Some species produce fruit in a concentrated manner solely in the minor dry season (annual fruiting), such as *Irvingia gabonensis*; other species produce fruit continuously throughout the year, such as *Irvingia excelsa* (continual fruiting) (Hirai, 2014).

As of 2013, the village is inhabited by 407 people in 96 households of Baka hunter-gatherers, and 339 people in 75 households of Bantu-speaking and other farmers (Toda, 2014). Most of the latter inhabitants are Konabembe; the others include Kako and Mbimo. In addition, there are about 10 merchants, occasionally with their wives and children, who came from other regions and live in the village. Seasonally since the 1990s, many merchants have visited the village to buy NTFPs and cacao.

The livelihoods of both the Baka and farmers in Gribé depend on a variety of forest resources, as well as agricultural crops (Hirai, 2014). As many previous studies have reported, the Baka and Bantu neighbors have long maintained close social and economic relationships with each other, wherein the Bantu have occupied

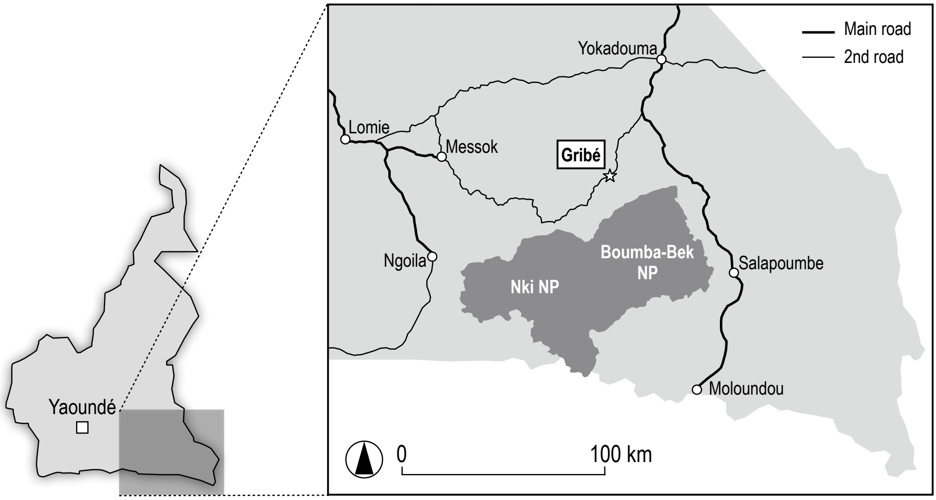

Fig. 1. Study site.

a politically and economically dominant position over the Baka (Toda, 2014; Toda & Yasuoka, 2020).

In the 1990s, the region was zoned and the forest where people had been practicing their daily subsistence activities was classified into different types of zones: national park, forest management units (*Unités Forestières d’Aménagement*) where logging and safari hunting are conducted, agroforestry zone, etc. This zoning was carried out without a detailed understanding of local people’s forest resource use and, therefore, brought about many restrictions on the resource use of local peoples (Ichikawa, 2006; Yasuoka, 2006a; Njounan Tegomo et al., 2012; Hirai, 2014).

METHODS

I. Target NTFP species

Ten major tree species that produce fruits, nuts, or kernels that are sold to merchants and/or consumed by local people were selected: *Afrostyrax lepidophyllus* (Huaceae), *Baillonella toxisperma* (Sapotaceae), *Beilschmiedia louisii* (Lauraceae), *Irvingia excelsa* (Irvingiaceae), *Irvingia gabonensis* (Irvingiaceae), *Irvingia robur* (Irvingiaceae), *Klainedoxa gabonensis* (Irvingiaceae), *Klainedoxa microphylla*, *Panda oleosa* (Pandaceae), and *Ricinodendron heudelotii* (Euphorbiaceae). The kernels of these species are edible, except for *B. toxisperma*, from which consumable oil is extracted. Of these, *A. lepidophyllus*, *B. toxisperma*, *B. louisii*, *I. gabonensis*, and *R. heudelotii* have been commercialized in the study area (Hirai, 2014).

II. Production of NTFPs

(1) Annual production

Annual production of dry nuts or kernels in a unit area, P [kg/ha/year], was calculated for each target species based on the following formula:

$$P = \Sigma CPA \times MDR \times DNW/1{,}000$$

where ΣCPA is an accumulated crown projection area (CPA) of reproductive trees in a unit area [m^2/ha]; MDR is the mean number of dropped ripe fruits in a unit crown projection area per year [num of fruits/m^2/year]; DNW is the mean dry nut (kernel) weight of a fruit [g].

(2) ΣCPA

To estimate ΣCPA in a given area, two pieces of information are needed: the DBH (diameter at breast height) of every reproductive tree of the species in the area, and the allometric relationship, which allows for the conversion of DBH into CPA.

DBH data were obtained from a tree census carried out in an area of 124 ha, located about 15 km southeast from the central settlement of Gribé. First, the plot area was roughly set. While walking through the plot, further subdivided into units of 20 m by 250 m, the location and DBH were recorded for all individuals of the 10 species, including saplings with ≥0.1 cm of diameter. We used GPS to identify the exact locations of censused trees. Its precision was consistently around 4 meters.

As our objective was to estimate fruit production, only reproductive individuals were taken into account to calculate CPA. Whether each tree was in a reproductive stage is judged based on its DBH: a tree with DBH ≥30 cm was considered reproductive.

Next, allometric variables that convert DBH into CPA were identified by analyzing measurements of 8–24 samples for each species. DBH of each sample was measured directly, and CPA was estimated using the equation $CPA = \pi (\Sigma r/8)^2$, where distances (r) from the trunk to crown edges were measured in eight directions. Then, based on the measurements of the samples, α and β in the following formula were identified.

$$CPA = \beta \times DBH^{\alpha}$$

Finally, applying this relationship to all the individuals recorded in the 124 ha plot, CPA was estimated for each species. Then, CPA of individual trees was summed and divided by 124 (ha) and, thus, ΣCPA for each species (m^2/ha) was obtained.

In addition, to determine whether it was rational to extrapolate the data obtained from the aforementioned plot into a larger area, the spatial pattern of each species was examined using Morisita's index of dispersion (I_δ) (Morisita, 1959). The analysis was carried out using GIS software; quadrats of different scales were put onto the census plot of 124 ha to determine the relationship between $I\delta$ and quadrat size. The maximum quadrat was divided by factors of $1/2$, $1/2^2$, $1/2^3 \ldots 1/2^{13}$, and I_δ for each size of quadrat that was calculated. Then, the relationship between I_δ and different quadrat sizes was visualized and the spatial pattern was identified for each species. Based on the ratio of the index on sections S and 2 × S, i.e., $I_{\delta (S)}/I_{\delta (2S)}$, a clump size of spatial distribution was detected at quadrat size S with a peak of $I_{\delta (S)}/I_{\delta (2S)}$ curve. When the clump size, if any, was identified at a smaller quadrat size than the maximum, and I_δ approached 1 in a smaller quadrat than the maximum, the census plot was considered large enough to extrapolate the data into a larger area, as long as the vegetation type was similar.

(3) MDR

MDR was calculated based on a fruit trapping survey around the village. For each species, 8–25 samples were selected from reproductive individuals. In the beginning, 8–10 samples were set for each species, but samples were added for *Irvingia gabonensis* and *Ricinodendron heudelotii*, recognizing their importance in terms of diet and trade.

The CPA of each sample tree was divided into quadrants, and a fruit trap was set at the center of each quadrant. The size of the traps was 1 m^2, except for 4 m^2 traps that were set for *Baillonella toxisperma* and *Irvingia robur,* which produce smaller numbers of fruits.

The number of fruits in the traps were recorded 2–3 times a week for *I. gabonensis* and once a week for others from May 2012 to November 2015 (for *I. gabonensis*, this was continued until December 2018). Monitoring was carried out throughout the year, except for *A. lepidophyllus*, *B. toxisperma*, and *I. gabonensis*. Monitoring for these species was carried out between April and November because fruiting was distinct to this period (Hirai, 2014). Dropped fruits were classified into ripe and immature, and only the number of ripe fruits were included for calculating the MDR.

Next, the accumulated number of ripe fruits in the four traps at each sample for each year was divided by 4, or 16, to calculate the total annual production of each sample per 1 m^2 of the crown projection area. Finally, the mean numbers of dropped ripe fruits in a unit crown projection area per year [num of fruits/m^2/year] were calculated for each species, for each year.

(4) DNW

For each species, 118–2,049 fruit samples were collected and weight measured. Edible parts (kernel) of nuts were extracted and weighted in both fresh and dry states. Finally, by dividing the mean dry nut weight extracted from one fruit by the mean fruit weight, the conversion factor to calculate DNW from the weight of the fruit was identified for each species.

(5) Potential energy value

To estimate potential energy value [kcal/100g], the nutrient analyses(1) were carried out for 7 out of the 10 target species: *Beilschmiedia louisii*, *Irvingia excelsa*, *Irvingia gabonensis*, *Irvingia robur*, *Klainedoxa gabonensis*, *Panda oleosa*, and *Ricinodendron heudelotii*.

First, kernels were ground and milled. The powder was dried in a hot oven;

the loss of weight was estimated to be water. The content of crude protein was measured according to the Kjeldahl method. A conversion factor of 5.30 was used as the N factor. Lipids were extracted as a crude fat in the presence of ether by a Soxhlet extractor. The powder was incinerated and what remained was estimated to be an ash component. Carbohydrate levels were calculated as the difference of the weight of water, crude protein, crude fat and ash from the total weight of the powder. Energy value per unit weight (E) was estimated by using the following coefficients: 3.47 kcal/g for protein, 8.37 kcal/g for fat and 4.07 kcal/g for carbohydrate.

The potential energy value (kcal/ha/year) for each species was calculated by P × E, where P is the annual production of dry nut in a unit area. The number of people the potential energy supply of the species can sustain [people/km^2] was also estimated, based on the assumption that a person needs 2,000 kcal a day. Of course, a diet based only on one species is not realistic, but these estimations show the importance of NTFPs not only with regard to economic value but also in relation to the diet of locals.

III. Harvests of NTFPs

(1) The area used by people of Gribé

To estimate the forest area used by local people, locations of all of the campsites where the Baka of the Central quarter of Gribé stayed in the fruiting season of *Irvingia gabonensis* in 2014, 2017, and 2018, were identified with GPS. Next, plotting the campsites on the map, the area that contains the campsites was calculated using GIS software. This area (A) was considered the extent of the area where the people of Gribé gather the nuts and kernels. Then, potential annual production from the accessible area [kg/year] was estimated by P × A, where P is the annual production of dry nut in a unit area.

(2) Incomes from NTFPs

To estimate the economic value of commercialized species, i.e., *Afrostyrax lepidophyllus*, *Baillonella toxisperma*, *Beilschmiedia louisii*, *Irvingia gabonensis*, and *Ricinodendron heudelotii*, transactions between the villagers and merchants in Giribé, were monitored from September 2012 to March, 2015. For *I. gabonensis*, the most important NTFP, sales were recorded at every merchant store in Gribé until 2016.

In transactions, combo, a two-liter enamel bowl, is generally used for measuring the quantity. For every transaction, seller name, species in vernacular name, state (dry or fresh, extracted kernels or kernels with nut), the number of combos, and selling price for a combo were recorded. Then, the number of combos was converted into the weight in kg, using the conversion factor identified by weighing nuts or kernels heaped in a combo for each species. *Ricinodendron heudelotii* was sold in three forms, i.e., dry nuts, fresh nuts, and fruits. The weights recorded for the latter two forms were conveyed into the weights in dry nuts. Based on these figures, the volume of sold kernels (or nuts) and incomes generated from each species were estimated for each year.

(3) Potential economic value of NTFPs

For the commercialized species in this study, the potential economic value [FCFA/year] that can be produced in the whole area used by the people in Gribé was estimated with the following formula:

$$\text{Potential economic value} = P \times A \times UP \times 100$$

Where P is the annual production of dry nut in a unit area [kg/ha/year], A is the area used by people of Gribé [km^2], and UP is the unit price [FCFA]. FCFA is the *franc de la coopération financière en Afrique centrale*, or the Central African CFA franc, the rate of which is fixed as 1 Euro = 655.957 FCFA.

(4) Daily harvests of NTFPs per person

In one of the sampled camps in 2014, where five households stayed, all harvests during September 7–15, 2014 were recorded. To measure working time for an entire day, three women were monitored using GPS on September 9 and 11.

RESULTS

I. Production of NTFPs

The parameters to estimate the production of each species are summarized in Tables 1–5 and in the Appendix. Only the key numbers are noted in the following text.

(1) *Afrostyrax lepidophyllus*

A total of 3,185 trees were observed. DBH of 37 trees were 30 cm or more, the density of which was 0.30 trees/ha. Based on the allometric relationship identified as $CPA = 0.0852 \times DBH^{1.55}$, ΣCPA was estimated at 9.9 m^2/ha (Tables 1 & 2). As the relationship between I_δ and quadrat sizes indicates clumps at sizes of 938–1,876 m^2 and 12–24 ha, and I_δ gradually approaches to 1 (Fig. 2), the census plot was considered large enough. MDR was estimated at 10.6 fruits/m^2/year, or 2.7, 7.2, and 19.7, for 2012–2015, respectively (Table 3). DNW was estimated at 2.0 g (Table 4).

Based on these, annual production of dry nut in a unit area (P) was estimated at 0.21 kg/ha/year (95% CI, 0.07–0.55), 0.05 (0.00–0.28), 0.14 (0.04–0.32), and 0.39 (0.13–0.99), for 2012–2015, respectively (Table 5).

The nuts of *A. lepidophyllus* are consumed as a seasoning, so the energy value was not analyzed.

(2) *Baillonella toxisperma*

No individual was found in the 124 ha plot. So, ΣCPA was not estimated, although the allometric relationship was identified as $CPA = 0.00423 \times DBH^{2.15}$. MDR was estimated at 3.5 fruits/m^2/year, 0.6, 1.2, and 3.3, for 2012–2015, respectively (Table 3). DNW was estimated at 3.6 g (Table 4).

P was not estimated because no tree was found in the plot. The nutrient analyses were not carried out for *Baillonella toxisperma*.

(3) *Beilschmiedia louisii*

A total of 592 trees were observed. DBH of 26 trees were 30 cm or more, the density of which was 0.21 trees/ha. Based on the allometric relationship identified as CPA = 0.0000783 × $DBH^{3.05}$, ΣCPA was estimated at 5.3 m^2/ha (Tables 1 & 2). As the relationship between I_δ and quadrat sizes indicates clumps at a size of 938–1,876 m^2, and I_δ soon settles around 1 (Fig. 2), the census plot is considered large enough. MDR was estimated at 13.4 fruits/m^2/year, or 10.3 and 10.0, for 2013–2015, respectively (Table 3). Because the fruiting period of this species includes January to April, the data from 2012 were excluded from this analysis. DNW was estimated at 1.7 g (Table 4).

Based on these, P was estimated at 0.12 (0.03–0.21) kg/ha/year, 0.09 (0.00–0.39), and 0.09 (0.02–0.19), for 2013–2015, respectively (Table 5).

The energy value was estimated at 3.49 kcal/g (Table 6). Thus, the potential energy of the kernels in a unit area was estimated at 431 kcal/ha/year, 331, and 322, which are equivalent to the energy that can sustain 0.1 people/km^2, 0.0, and 0.0, each year (Table 5).

(4) *Irvingia excelsa*

A total of 39 trees were observed. DBH of 29 trees were 30 cm or more, the density of which was 0.23 trees/ha. Based on the allometric relationship identified as CPA = 0.000451× $DBH^{2.80}$, ΣCPA was estimated at 31.0 m^2/ha (Tables 1 & 2). As the relationship between I_δ and quadrat size indicates no clumps and I_δ soon settles around 1 (Fig. 2), the census plot is considered large enough. MDR was estimated at 11.9 fruits/m^2/year, 9.0, and 15.4, for 2013–2015, respectively (Table 3). Because the fruiting period of this species includes January to April, data from 2012 were excluded from the analysis. DNW was estimated at 2.1 g (Table 4).

Based on these, P was estimated at 0.79 (0.19–1.55) kg/ha/year, 0.60 (0.11–1.62), and 1.02 (0.10–2.84), for 2013–2015, respectively (Table 5).

The energy value was estimated at 6.22 kcal/g (Table 6). Thus, the potential energy of the kernels in a unit area was estimated at 4,900 kcal/ha/year, or 3,725, and 6,338, which are equivalent to the energy that can sustain 0.7 people/km^2, 0.5, and 0.9, each year (Table 5).

(5) *Irvingia gabonensis*

A total of 479 trees were observed. DBH of 146 trees were 30 cm or more, the density of which was 1.18 trees/ha. Based on the allometric relationship identified as CPA = 1.95 × $DBH^{0.977}$, ΣCPA was estimated at 156.4 m^2/ha (Tables 1 & 2). As the relationship between I_δ and quadrat size indicates small clumps at a size of 234–469 m^2, and I_δ gradually approaches 1 (Fig. 2), the census plot is considered large enough. MDR was estimated at 15.3 fruits/m^2/year, 1.3, 9.1, 17.8, and 30.4, for 2012–2016, respectively (Table 3). DNW was estimated at 3.0 g (Table 4).

Based on these, P was estimated at 7.17 (3.56–12.51) kg/ha/year, 0.62 (0.10–1.67), 4.27 (1.65–8.22), 8.35 (2.91–17.96), and 14.28 (6.91–26.49), for 2012–2016, respectively (Table 5). Notably, *I. gabonensis* produced the fruits in the highest

Table 1. An accumulated crown projection area in a unit area (ΣCPA) for each tree species studied.

Species	Plot size [ha]	Number of trees (all)	Number of trees (DBH ≥30)	Density (DBH ≥30) [num of trees/ha]	Accumulated crown projection area (Σ CPA) for the plot [m^2/124 ha]			Σ CPA [m^2/ha]		
					Mean	95% CI		Mean	95% CI	
Afrostyrax lepidophyllus	124	3,185	37	0.30	1,232.3	708.7	2,145.5	9.9	5.7	17.3
Baillonella toxisperma	124	0								
Beilschmiedia louisii	124	592	26	0.21	652.7	330.9	813.6	5.3	2.7	6.6
Irvingia excelsa	124	39	29	0.23	3,840.2	1,479.0	5,869.3	31.0	11.9	47.3
Irvingia gabonensis	124	479	146	1.18	19,389.0	14,808.2	25,590.6	156.4	119.4	206.4
Irvingia robur	124	4	2	0.02	1,388.2	1,068.8	4,660.8	11.2	8.6	37.6
Klainedoxa gabonensis	124	484	99	0.80	41,356.1	20,359.6	151,796.7	333.5	164.2	1,224.2
Klainedoxa microphylla	124	14	9	0.07	1,719.5	1,173.0	2,574.1	13.9	9.5	20.8
Panda oleosa	124	742	142	1.15	12,899.7	5,270.6	39,027.5	104.0	42.5	314.7
Ricinodendron heudelotii	124	167	119	0.96	11,600.1	8,014.6	17,000.7	93.5	64.6	137.1

Table 2. Parameters concerning the allometric relationship between DBH (diameter at breast height [cm]) and CPA (crown projection area [m^2]).

Species	Number of sample	DBH		α	β	R^2	F-value	p-value
		Mean ± SD	Min–Max					
Afrostyrax lepidophyllus	10	41.3 ± 15.4	26.7–70.7	1.55	0.0852	0.60	10.491	0.014
Baillonella toxisperma	9	218.0 ± 77.6	84.9–337.6	2.15	0.00423	0.61	10.830	0.013
Beilschmiedia louisii	10	67.9 ± 12.8	34.4–85.0	3.05	0.0000783	0.81	30.388	0.001
Irvingia excelsa	8	92.5 ± 33.0	38.4–158.7	2.80	0.000451	0.63	10.314	0.018
Irvingia gabonensis	24	74.1 ± 33.8	17.1–140.0	0.977	1.95	0.60	33.257	0.000
Irvingia robur	10	125.7 ± 57.9	33.8–247.9	1.65	0.111	0.43	6.097	0.039
Klainedoxa gabonensis	10	139.8 ± 67.3	41.4–238.0	2.37	0.00280	0.54	8.271	0.024
Klainedoxa microphylla	10	80.7 ± 21.7	41.6–108.7	1.18	1.05	0.54	8.095	0.025
Panda oleosa	10	40.9 ± 8.8	29.0–61.0	3.79	0.0000450	0.61	10.755	0.013
Ricinodendron heudelotii	15	105.9 ± 29.8	48.4–147.6	1.79	0.0276	0.68	25.185	0.000

The relationship of the parameters is the following: $CPA = \beta \times DBH^{\alpha}$.

quantity, but production fluctuated year by year. Nut generation in 2016 was 20 times more than that in 2013.

The energy value was estimated at 6.90 kcal/g (Table 6). Thus, the potential energy of the kernels in the unit area was estimated at 49,497 kcal/ha/year, 4,280, 29,454, 57,640, and 98,540, which are equivalent to energy that can sustain 6.8 people/km^2, 0.6, 4.0, 7.9, and 13.5, respectively, each year (Table 5).

(6) *Irvingia robur*

A total of 4 trees were observed. DBH of two trees were 30 cm or more, the density of which was 0.02 trees/ha. Based on the allometric relationship identified as CPA = 0.111 × DBH$^{1.65}$, ΣCPA was estimated at 11.2 m^2/ha (Tables 1 & 2). As the number of individuals was very small, the spatial pattern was not identified. Therefore, the exploration into a larger area may be biased. MDR was estimated at 4.5 fruits/m^2/year, 2.8, and 2.9, for 2013–2015, respectively (Table 3). Because the fruiting period of this species includes January to April, data from 2012 were excluded from the analysis. DNW was estimated at 2.0 g (Table 4).

Based on these data, P was estimated at 0.10 (0.07–0.40) kg/ha/year, 0.06 (0.02–0.30), and 0.06 (0.01–0.40), for 2013–2015, respectively (Table 5).

The energy value was estimated at 6.44 kcal/g (Table 6). Thus, the potential energy of the kernels in a unit area was estimated at 659 kcal/ha/year, 401, and 420, which are equivalent to energy that can sustain 0.1 people/km^2, 0.1, and 0.1, each year (Table 5).

(7) *Klainedoxa gabonensis*

A total of 484 trees were observed. DBH of 99 trees were 30 cm or more, the density of which was 0.80 trees/ha. Based on the allometric relationship identified as CPA = 0.00280 × DBH$^{2.37}$, ΣCPA was estimated at 333.5 m^2/ha (Table 1 & 2). As the relationship between I_δ and quadrat sizes indicates clumps at sizes of 234–469 m^2 and 0.75–1.5 ha, and I_δ soon settles around 1 (Fig. 2), the census plot was considered large enough. MDR was estimated at 8.8 fruits/m^2/year, 7.4, and 8.5, for 2013–2015, respectively (Table 3). Because the fruiting period of this species includes January to April, data from 2012 were excluded from the analysis. DNW was estimated at 0.7 g (Table 4).

Based on these, P was estimated at 2.02 (0.76–9.58) kg/ha/year, 1.70 (0.23–9.81), and 1.95 (0.28–11.74), for 2013–2015, respectively (Table 5).

The energy value was estimated at 4.88 kcal/g (Table 6). Thus, the potential energy of the kernels in a unit area was estimated at 9,869 kcal/ha/year, 8,278, and 9,502, which are equivalent to the energy that can sustain 1.4 people/km^2, 1.1, and 1.3, each year, respectively (Table 5).

(8) *Klainedoxa microphylla*

A total of 14 trees were observed. DBH of 9 trees were 30 cm or more, the density of which was 0.07 trees/ha. Based on the allometric relationship identified as CPA = 1.05 × DBH$^{1.18}$, ΣCPA was estimated at 13.9 m^2/ha (Tables 1 & 2). As the relationship between I_δ and quadrat sizes indicates clumps at a size of 1,876–60,025 m^2, and I_δ soon settles around 1 (Fig. 2), the census plot is considered

Table 3. The mean number of dropped ripe fruits (MDR) of each tree species studied in a unit crown projection area per year.

Species	Year	Sample size [num of trees]	Fruiting period		MDR [num of fruits/m^2/year]		
			Month	Days	Mean	95% CI	
Afrostyrax lepidophyllus	2012	10	May–Aug.	70	10.6	6.0	15.9
	2013	10	Jun.–Oct.	137	2.7	0.0	8.2
	2014	10	May.–Jul.	70	7.2	3.5	9.4
	2015	10	Jun.–Oct.	148	19.7	11.0	28.7
Baillonella toxisperma	2012	6	May–Jul.	64	3.5	2.1	4.9
	2013	7	Jun.–Aug.	83	0.6	0.0	1.6
	2014	7	May–Aug.	92	1.2	0.0	3.6
	2015	8	Jun.–Sep.	104	3.3	1.8	4.7
Beilschmiedia louisii	2013	8	Jan.–May, Oct.–Dec.	168	13.4	6.3	18.2
	2014	8	Jan.–Mar., May–Jul., Sep.–Dec.	199	10.3	0.0	34.9
	2015	8	Jan.–Nov.	330	10.0	3.7	16.4
Irvingia excelsa	2013	10	Jan.–Jul., Sep.–Dec.	308	11.9	7.8	14.5
	2014	10	Jan.–Dec.	364	9.0	4.4	15.2
	2015	10	Jan.–Nov.	365	15.4	4.0	26.7
Irvingia gabonensis	2012	11	May–Jul.	63	15.3	10.1	19.5
	2013	25	Apr.–Oct.	173	1.3	0.3	2.6
	2014	25	May–Sep.	140	9.1	4.7	12.8
	2015	25	Jun.–Oct.	171	17.8	8.2	28.1
	2016	25	May–Sep.	115	30.4	19.6	41.4
Irvingia robur	2013	10	Jan.–Jul., Sep.–Dec.	308	4.5	4.1	5.1
	2014	10	Jan.–Dec.	364	2.8	1.4	3.8
	2015	10	Jan.–Nov.	330	2.9	0.7	5.1
Klainedoxa gabonensis	2013	10	Jul.–Dec.	174	8.8	6.3	12.0
	2014	10	Jan.–Jun., Aug.–Dec.	301	7.4	1.9	12.2
	2015	10	Jan.–Nov.	330	8.5	2.3	14.6
Klainedoxa microphylla	2013	10	Jan., Apr.–Dec.	253	55.2	35.4	80.2
	2014	10	Jan.–Feb., Jun.–Dec.	209	6.0	2.9	9.3
	2015	10	Jan.–Nov.	330	12.4	4.4	20.3
Panda oleosa	2013	10	Jan.–Dec.	364	19.8	14.1	25.7
	2014	10	Jan.–May, Sep.–Dec.	224	5.4	1.4	10.3
	2015	10	Jan.–Nov.	330	4.3	0.1	8.5
Ricinodendron heudelotii	2012	9	May–Dec.	197	55.3	33.6	70.0
	2013	14	Jan., Apr.–Dec.	277	50.4	34.9	64.2
	2014	14	Apr.–Dec.	258	54.3	34.9	70.2
	2015	14	Jan.–Nov.	330	62.6	31.6	93.6

Table 4. The mean dry nut (kernel) weight (DNW) of the fruit of each tree species studied.

Species	Fruit weight [g]				Fresh nut weight [g]				Dry nut weitht (DNW) [g]				DNW /Fruit weight [%]	DNW /Fresh nut weight [%]
	Sample size	Mean	95% CI		Sample size	Mean	95% CI		Sample size	Mean	95% CI			
Afrostyrax lepidophyllus	322	3.7	3.7	3.8	322	3.3	3.3	3.4	2	2.0			53.7	59.9
Baillonella toxisperma					5	8.6			5	3.6				41.9
Beilschmiedia louisii	2,049	5.4	5.4	5.5	897	3.7	3.6	3.7	2,049	1.7	1.7	1.7	31.9	47.5
Irvingia excelsa	148	106.6	103.2	110.0	118	3.6	3.4	3.7	118	2.1	2.0	2.2	2.0	60.1
Irvingia gabonensis	315	72.1	70.2	74.0	315	4.3	4.2	4.4	315	3.0	3.0	3.1	4.2	70.4
Irvingia robur	157	206.8	199.4	214.2	147	3.5	3.4	3.6	147	2.0	1.9	2.1	1.0	58.2
Klainedoxa gabonensis	145	230.3	222.2	238.4	139	2.2	2.2	2.2	139	0.7	0.7	0.7	0.3	31.7
Klainedoxa microphylla	145	80.0	78.4	81.7	128	0.6	0.5	0.6	128	0.3	0.3	0.3	0.4	56.1
Panda oleosa	180	37.8	36.8	38.8	155	2.0	1.9	2.1	155	1.3	1.3	1.3	3.4	64.7
Ricinodendron heudelotii	200	26.4	26.0	26.9	200	1.2	1.2	1.2	200	1.0	1.0	1.0	3.8	85.6

large enough. MDR was estimated at 55.2 fruits/m²/year, 6.0, and 12.4, for 2013–2015, respectively (Table 3). Because the fruiting period of this species includes January to April, data from 2012 were excluded from the analysis. DNW was estimated at 0.3 g (Table 4).

Based on these data, P was estimated at 0.24 (0.10–0.56) kg/ha/year, 0.03 (0.01–0.07), and 0.05 (0.01–0.14), for 2013–2015, respectively (Table 5).

The nutrient analyses were not carried out for this species.

(9) *Panda oleosa*

A total of 742 trees were observed. DBH of 142 trees were 30 cm or more, the density of which was 1.15 trees/ha. Based on the allometric relationship identified as CPA = 0.0000450 × $DBH^{3.79}$, ΣCPA was estimated at 104.0 m²/ha (Tables 1 & 2). As the relationship between I_δ and quadrat sizes indicates clumps at sizes smaller than 234 m² and I_δ gradually approaches 1 (Fig. 2), the census plot is considered large enough. MDR was estimated at 19.8 fruits/m²/year, 5.4, and 4.3, for 2013–2015, respectively (Table 3). Because the fruiting period of this species includes January to April, data from 2012 were excluded from the analysis. DNW was estimated at 1.3 g (Table 4).

Based on these data, P was estimated at 2.68 (0.76–10.76) kg/ha/year, 0.72 (0.07–4.33), and 0.58 (0.01–3.54), for 2013–2015, respectively (Table 5).

The energy value was estimated at 5.62 kcal/g (Table 6). Thus, the potential energy of the kernels in a unit area was estimated at 15,055 kcal/ha/year, 4,074, and 3,268, respectively, which is equivalent to the energy that can sustain 2.1 people/km², 0.6, and 0.4, each year (Table 5).

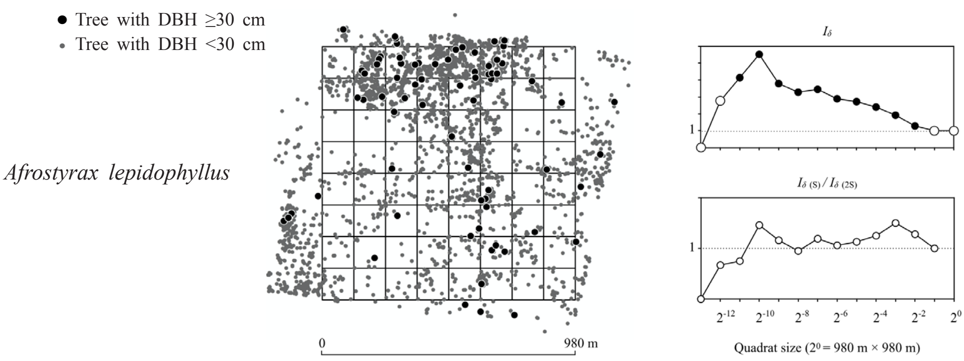

Fig. 2. Distribution of individuals for each species in the study plot (left), Morisita's index (I_δ) for different quadrat sizes (upper right), and $I_{\delta\,(S)}/I_{\delta\,(2S)}$ for different quadrat sizes (S) (lower right). The trees with DBH ≥30 cm were used for calculating I_δ values. Black circles for I_δ values dviate significantly from 1 ($p < 0.01$). The largest quadrat of 980 m by 980 m corresponds to 2^0 in the x-axis.

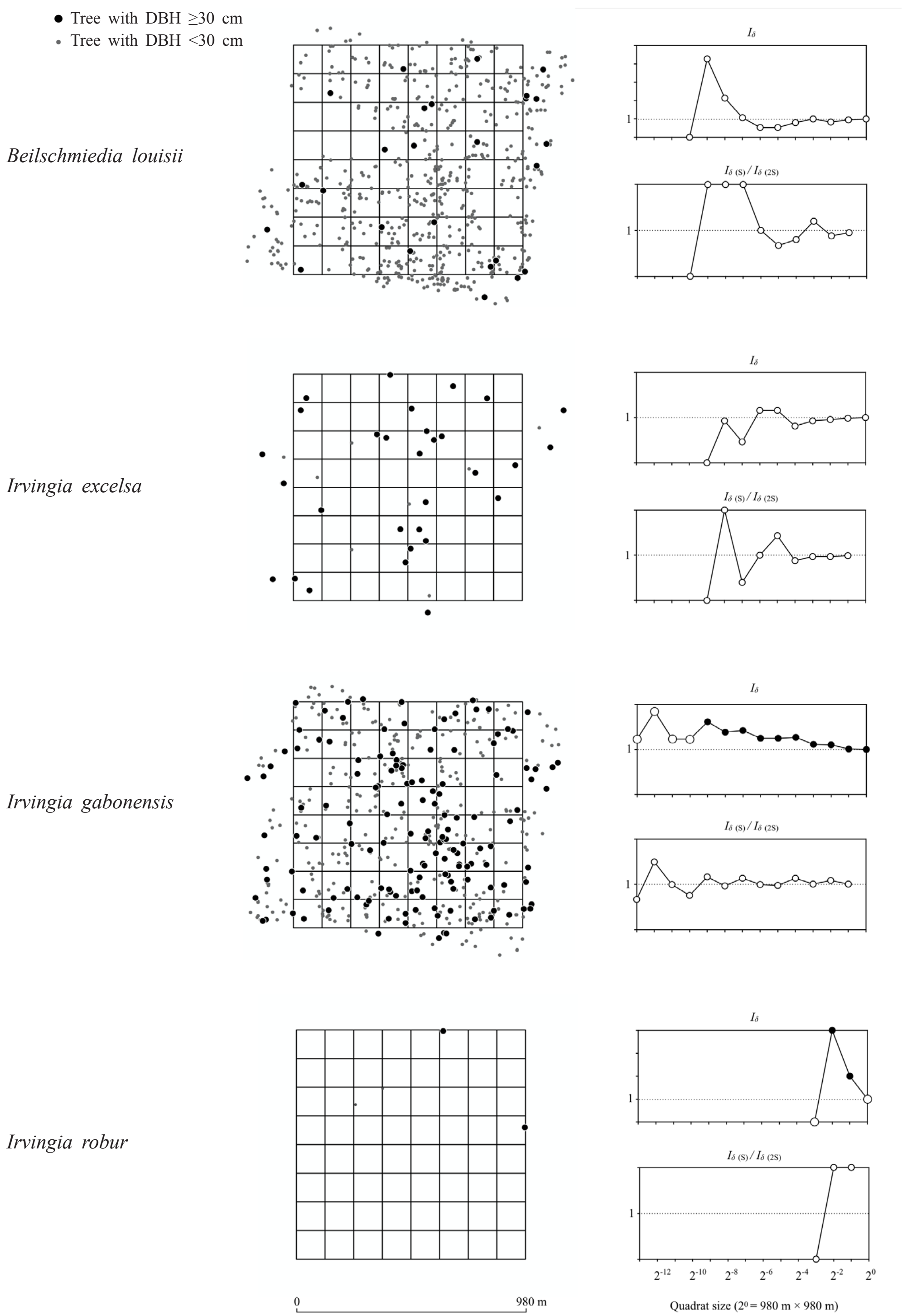

Fig. 2. (continue)

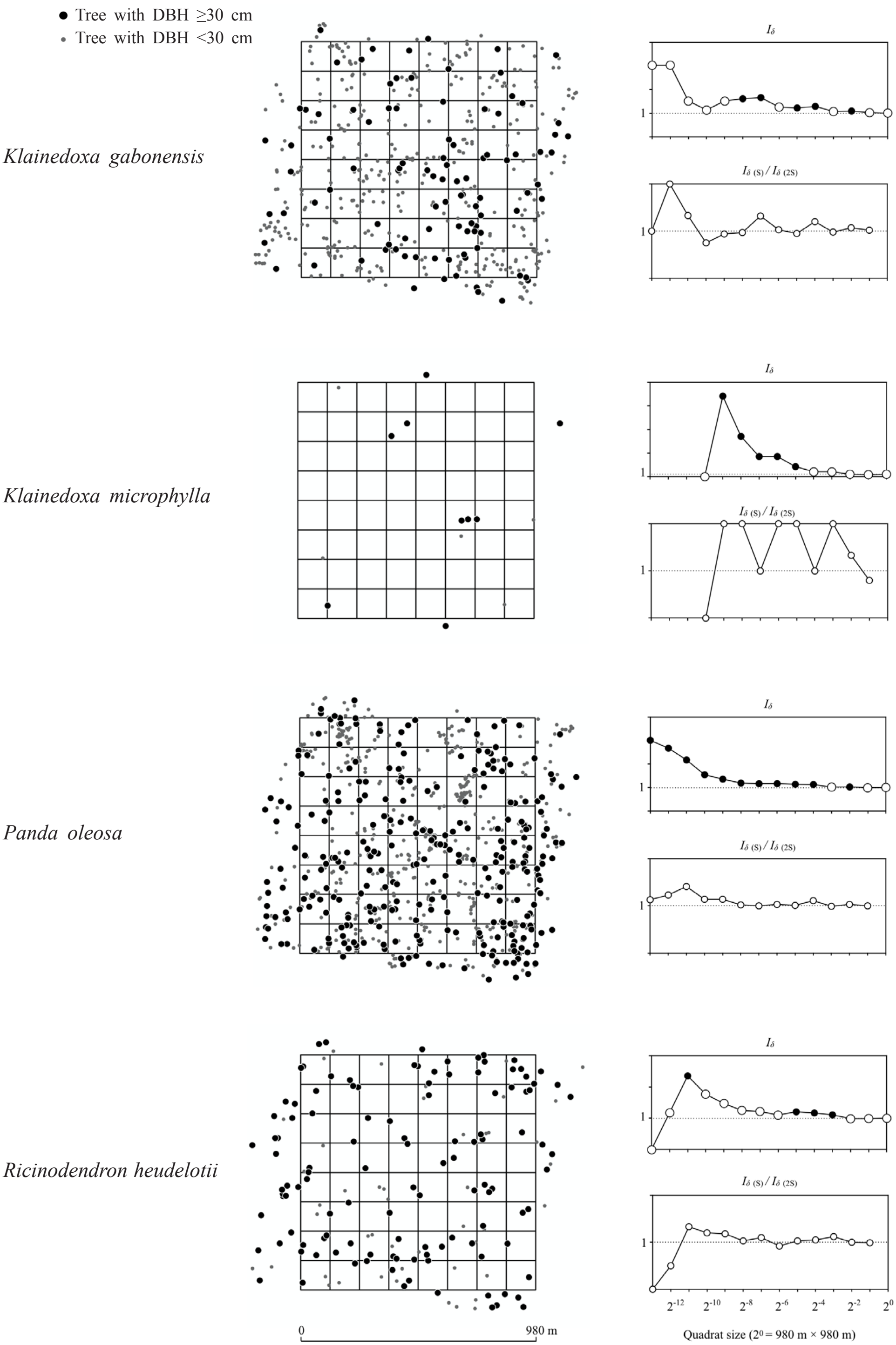

Fig. 2. (continue)

(10) *Ricinodendron heudelotii*

A total of 167 trees were observed. DBH of 119 trees were 30 cm or more, the density of which was 0.96 trees/ha. Based on the allometric relationship identified as CPA = 0.0276 × $DBH^{1.79}$, ΣCPA was estimated at 93.5 m^2/ha (Tables 1 & 2). As the relationship between I_δ and quadrat sizes indicates clumps at sizes smaller than 469–938 m^2 and I_δ soon settle around 1 (Fig. 2), the census plot is considered large enough. MDR was estimated at 55.3 fruits/m^2/year, 50.4, 54.3 and 62.6, for 2012–2015, respectively (Table 3). DNW was estimated at 1.0 g (Table 4).

Based on these, P was estimated at 5.22 (2.15–9.86) kg/ha/year, 4.77 (2.23–9.04), 5.13 (2.23–9.88), and 5.91 (2.02–13.17), for 2012–2015, respectively (Table 5). This species produced large quantities after *I. gabonensis*. And, there was no noticeable year-to-year difference in production.

The energy value was estimated at 5.18 kcal/g (Table 6). Thus, the potential energy of the kernels in a unit area was estimated at 27,043 kcal/ha/year, 24,683, 26,585, and 30,633, which are equivalent to the energy that can sustain 3.7 people/km^2, 3.4, 3.6, and 4.2, each year, respectively (Table 5).

II. Harvest of NTFPs

(1) The area used by people of Gribé

All the camps for gathering *I. gabonensis* kernels built by the Baka of the central quarter of Gribé in July–December in 2014, 2017, and 2018, are described in Fig. 3. The camps were built in UFA and BBNP. Generally, 4–5 households stayed in a camp. The area used in 2 years out of the 3 was considered an area frequently used by the people in Gribé. It accounted for 360 km^2, which is comprised of 36 km^2 of the Agroforestry Zone (10%), 204 km^2 of UFA (57%), and 120 km^2 of BBNP (33%).

(2) Potential annual production of NTFPs in the area used by people of Gribé

Converting the annual production in a unit area into that in 360 km^2, the potential annual production in an area used by people of Gribé, i.e., 400 Baka and 300 Bantu people, was estimated for each species (Table 7).

Notably, 514 tonnes, or 3,547,000,000 kcal, of *I. gabonensis* kernels were produced in the area in 2016, which is equivalent to the energy that can sustain 4,860 people for a year. *R. heudelotii* also produced a large number of nuts, 170–210 tonnes/year, or 880,000,000–1,100,000,000 kcal/year, which is equivalent to energy for 1,200–1,500 people for a year.

The second group includes *I. excelsa*, *K. gabonensis*, and *P. oleosa*. These species produced 21–36 tonnes, 61–72, and 21–96, respectively, each of which is equivalent to energy for hundreds of people for a year. *B. toxisperma*, *B. louisii*, *I. robur* were not distributed so many and did not produce as many fruits.

Summing up the energy produced by all the analyzed species, it can sustain 2,900–5,300 people every year. Even if excluding *I. gabonensis*, production of which is seasonally concentrated and fluctuates year by year, the potential energy can sustain 2,100–2,800 people, or 5.8–7.8 people/km^2.

Table 5. Annual production of the dry nut of each tree species studied in the sample area and potential energy supply.

Species	Year	Annual production of dry nut [kg/ha/year]			Potential energy [kcal/ha/year]	Number of people that the potential energy can sustain [people/km^2]
		Mean	95% CI			
Afrostyrax lepidophyllus	2012	0.21	0.07	0.55		
	2013	0.05	0.00	0.28		
	2014	0.14	0.04	0.32		
	2015	0.39	0.13	0.99		
Beilschmiedia louisii	2013	0.12	0.03	0.21	431	0.1
	2014	0.09	0.00	0.39	331	0.1
	2015	0.09	0.02	0.19	322	0.1
Irvingia excelsa	2013	0.79	0.19	1.55	4,900	0.7
	2014	0.60	0.11	1.62	3,725	0.5
	2015	1.02	0.10	2.84	6,338	0.9
Irvingia gabonensis	2012	7.17	3.56	12.51	49,497	6.8
	2013	0.62	0.10	1.67	4,280	0.6
	2014	4.27	1.65	8.22	29,454	4.0
	2015	8.35	2.91	17.96	57,640	7.9
	2016	14.28	6.91	26.49	98,540	13.5
Irvingia robur	2013	0.10	0.07	0.40	659	0.1
	2014	0.06	0.02	0.30	401	0.1
	2015	0.07	0.01	0.40	420	0.1
Klainedoxa gabonensis	2013	2.02	0.76	9.58	9,869	1.4
	2014	1.70	0.23	9.81	8,278	1.1
	2015	1.95	0.28	11.74	9,502	1.3
Klainedoxa microphylla	2013	0.24	0.10	0.56		
	2014	0.03	0.01	0.07		
	2015	0.05	0.01	0.14		
Panda oleosa	2013	2.68	0.76	10.76	15,055	2.1
	2014	0.72	0.07	4.33	4,074	0.6
	2015	0.58	0.01	3.54	3,268	0.4
Ricinodendron heudelotii	2012	5.22	2.15	9.86	27,043	3.7
	2013	4.77	2.23	9.04	24,685	3.3
	2014	5.13	2.23	9.88	26,585	3.4
	2015	5.91	2.02	13.17	30,633	4.2

(3) Sales of NTFPs and the potential economic value

During the study period, nuts or kernels of 4 species were traded in Gribé: *A. lepidophyllus*, *B. louisii*, *I. gabonensis*, and *R. heudelotii* (Table 7).

Kernels of *I. gabonensis* were sold in the largest quantity: 3,051 kg, 184, 4,659, 7,753, and 4,163, in 2012–2016, respectively. It is estimated that these amounts of kernels brought to the village 3.2 million FCFA, 0.2 million, 2.8 million, 9.3 million, and 4.2 million in 2012–2016, respectively.

However, it is remarkable that the amounts of kernels harvested and sold were only a small percentage of the production in the area of 360 km^2: 1.2%, 0.8%, 3.0%, 2.6%, and 0.8%, for 2012–2016, respectively. Although the Baka consumed the kernels themselves, these amounts were likely to be much smaller than those they sold.

This means that the forest in this area has a huge potential economic value. If all the fruits produced in the area had been harvested, the kernels would have brought about 269 million FCFA, 23 million, 94 million, 360 million, and 517 million, each year, although these sales are an approximation, more or less overestimated because an increase in supply would be likely to lower the selling price.

The same can be said for *R. heudelotii*. Only less than 1.0% of its production was harvested, and brought to the village a sum of 0.6–1.2 million FCFA. But, if all the fruits produced in the area had been harvested, the kernels would have brought 163–185 million FCFA a year.

Sales of *A. lepidophyllus* nuts sharply increased in 2014 to 1.7 million FCFA, which is comparable with *I. gabonensis*, and *R. heudelotii*. This is likely to be because its market had expanded, which is indicated by the doubled unit prices from 2012 to 2014; it may have occurred in 2013 but the production was comparatively small.

(4) Daily harvests of *Irvingia gabonensis*

In the camp monitored for 9 days (September 7–15, 2014), a sum of 69.4 kg of *I. gabonensis* fresh kernels, with an average of 1.54 kg/household-day, were gathered by five households. The labor required for gathering the kernels was estimated by monitoring three women. They began by walking 1–2 km to go to the gathering spots and began working. To extract a pair of kernels from a fruit, they split the hard shell with a machete and picked the kernels out with a knife, which takes about 15 seconds. Two women gathered a sum of 5.5 kg of fresh kernels after 7 hours of work. Another woman gathered 2.7 kg after 5 hours of work. Therefore, about 0.43 kg of fresh kernels, equivalent to 0.25 kg of dry kernels, were extracted in an hour. As the average fresh nut weight harvested at the camp was 1.54 kg/household-day, it appears that they worked for 3.6 hours a day.

Since they stayed in this camp for 58 days from July 20 to September 15, the total harvest can be estimated at 403 kg. According to a converting factor of 0.582 shown in Table 4, it is equivalent to 234 kg of dry kernels. The area they used was measured and estimated at 1.4 km^2, which produced 598 kg of dry kernels in 2014, according to an annual production of 4.27 kg/ha/year. Therefore,

Table 6. Nutrition content of the kernels of seven of the tree species studied.

Species	Water [g/100g]	Protein [g/100g]	Lipid [g/100g]	Ash [g/100g]	Carbohydrate [g/100g]	Energy [kcal/g]
Beilschmiedia louisii	12.7	6.6	1.3	1.9	77.5	3.49
Irvingia excelsa	3.6	8.1	56.9	2.6	28.8	6.22
Irvingia gabonensis	4.8	6.4	73.2	2.1	13.5	6.90
Irvingia robur	2.9	7.8	61.2	2.3	25.8	6.44
Klainedoxa gabonensis	8.1	7.8	31.3	4.0	48.8	4.88
Panda oleosa	7.5	24.4	49.6	3.2	15.3	5.62
Ricinodendron heudelotii	2.5	22.9	38.3	7.3	29	5.18

Adapted from Tani et al. (2015). According to Tani et al. (2015), except for *Beilschmiedia louisii*, all of the six species showed a lower content of protein but an even higher content of fat when compared to soybeans. They also had a higher caloric value than that of soybean, a result of higher fat content. Amino acid analysis of the two species, *Irvingia gabonensis* and *Ricinodendron heudelotii*, indicated the content of the branch chain amino acids leucine, isoleucine, and valine, to be 16.8% and 18.1%, respectively, being compared to that of acid-precipitated protein from soybean (17.4%). On the other hand, the fat analysis showed a marked contrast between *I. gabonensis* and *R. heudelotii*. *I. gabonensis* contains even more crude fat than *R. heudelotii*, but the former is rich in saturated fatty acids such as lauric acid (C12:0) and myristic acid (C14:0). In contrast, *R. heudelotii* is rich in polyunsaturated fatty acids, linoleic acid (C18:2) and conjugated linolenic acids (C18:3). Furthermore, antioxidant activity as a superoxide-eliminating activity was significantly detected in both *I. gabonensis* and *R. heudelotii*. These results suggest these species are functional food candidates.

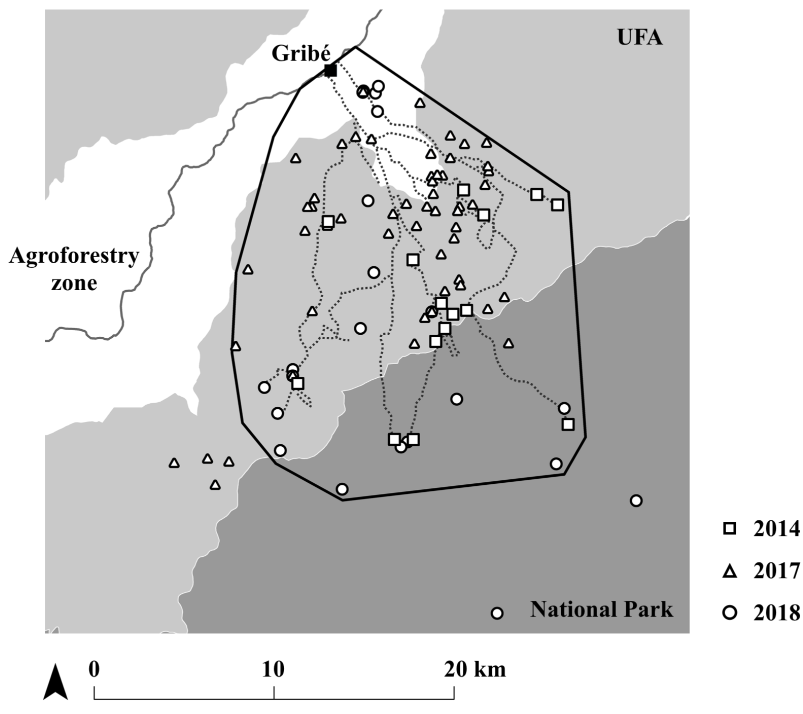

Fig. 3. Distribution of camps of the Baka of Gribé for gathering *Irvingia gabonensis* kernels in 2014, 2017, and 2018. UFA stands for *Unités Forestières d'Aménagement*, or forest management units.

Table 7. Annual production of each tree species studied, potential energy supply and potential economic value in an area used by local people.

Species	Year	Annual production in 360 km^2 [kg/year]			Potential energy in 360 km^2 [kcal/year]	Number of people that the potential energy in 360 km^2 can sustain [people]	Total dry weight of sold nuts [kg]	Harvest rate to the annual production in 360 km^2 [%]	Total sales [FCFA]	Average unit price [FCFA/kg]	Potential economic value generated from 360 km^2	
		Mean	95% CI								FCFA	Euro
Afrostyrax lepidophyllus	2012	7,586	2,475	19,767			105	1.4	26,800	256	1,940,000	2,960
	2013	1,900	0	10,211			117	6.2	97,500	833	1,580,000	2,410
	2014	5,157	1,455	11,668			3,144	61.0	1,772,200	564	2,910,000	4,440
	2015	14,109	4,515	35,731								
Beilschmiedia louisii	2013	4,447	1,062	7,387	15,500,000	21	99	3.0	27,300	274	910,000	1,390
	2014	3,418	0	14,176	11,900,000	16	7	0.2	2,500	357	1,150,000	1,750
	2015	3,320	613	6,672	11,600,000	16						
Irvingia excelsa	2013	28,358	6,812	55,696	176,400,000	242						
	2014	21,558	3,852	58,205	134,100,000	184						
	2015	36,683	3,492	102,359	228,200,000	313						
Irvingia gabonensis	2012	258,245	128,326	450,386	1,782,000,000	2,441	3,051	1.2	3,177,200	1,041	268,950,000	410,010
	2013	22,329	3,714	60,083	154,000,000	211	184	0.8	191,200	1,041	23,250,000	35,440
	2014	153,674	59,494	295,751	1,060,000,000	1,452	4,659	3.0	2,861,100	614	94,380,000	143,880
	2015	300,729	104,692	646,472	2,075,000,000	2,842	7,753	2.6	9,283,600	1,197	360,100,000	548,970
	2016	514,122	248,893	953,519	3,547,000,000	4,859	4,163	0.8	4,182,900	1,005	516,570,000	787,510
Irvingia robur	2013	3,681	2,468	14,512	24,000,000	33						
	2014	2,243	863	10,875	14,000,000	19						
	2015	2,349	397	14,522	15,000,000	21						
Klainedoxa gabonensis	2013	72,804	27,290	344,946	355,000,000	486						
	2014	61,067	8,318	353,288	298,000,000	408						
	2015	70,100	9,915	422,467	342,000,000	468						
Klainedoxa microphylla	2013	8,813	3,768	20,154								
	2014	952	305	2,346								
	2015	1,973	467	5,103								
Panda oleosa	2013	96,441	27,536	387,242	542,000,000	742						
	2014	26,097	2,626	155,764	146,700,000	201						
	2015	20,935	284	127,354	117,700,000	161						
Ricinodendron heudelotii	2012	187,946	77,257	354,916	973,600,000	1,334	682	0.4	598,600	877	163,240,000	248,860
	2013	171,540	80,224	325,486	888,600,000	1,217	1,210	0.7	1,214,800	1,004	170,480,000	259,900
	2014	184,762	80,277	355,592	957,100,000	1,311	750	0.4	740,100	986	180,410,000	275,030
	2015	212,895	72,692	474,128	1,102,800,000	1,511	245	0.1	215,900	881	185,720,000	283,130

it is concluded that they harvested 40% of the total production in the area.

To grasp the maximum possible harvest amount, if it is assumed that 200 people devote 6 hours a day for 90 days to gathering *I. gabonensis* kernels at an efficiency of 0.25 kg of dry kernels per hour, the total harvests would be 27 tonnes of dry kernels, which brings 27 million FCFA, adopting the selling price of 1,000 FCFA/kg. This amount is about 5–10% of the total production in the area used by the people, except for the extremely low productive year of 2013.

DISCUSSION

I. Affluent Ecological Availability of NTFPs

As summarized in Tables 5 and 7, *Irvingia gabonensis* and *Ricinodendron heudelotii* produce larger quantities of kernels and have greater economic value when compared to other species. In addition, when summing up the energy produced by all the species surveyed, even if excluding *Irvingia gabonensis*, fruit production of which is seasonally concentrated and fluctuates year by year, the potential energy generated from the kernels can sustain 5.8–7.8 people/km^2. This is remarkable because wild fruits were considered too scarce and spatially dispersed as energy sources to sustain human subsistence (Hart & Hart, 1986; Bailey et al., 1989), and wild tubers, i.e., wild yams, were the primary candidate for human subsistence in rainforest (Bahuchet et al., 1991; Sato, 2001; 2006; Sato et al., 2012; Yasuoka, 2006b; 2009; 2013). The results shown in this paper renew our understandings of the potential of wild fruits and nuts as energy sources in the human diet.

In addition, one of the most notable findings of this study is that only a small percentage of the potential production of these species was harvested and sold. This is likely to be because of the low human population density (2 people/km^2) and the difficulty in increasing the efficiency of gathering the kernels (0.25 kg/hour in case of *I. gabonensis*). As mentioned above, even if all the Baka in the village invested their maximum labor into gathering *I. gabonensis* kernels, they can harvest only 5–10% of the total potential production.

As the NTFPs discussed in this paper are harvested without damaging the capital, the trees themselves, harvests to this degree are certainly sustainable and do not seem to affect the ecosystem. Given the affluent ecological availability demonstrated in this study, even when innovations to improve the efficiency of harvesting are achieved, the resources will still greatly exceed the amount that can be harvested by all the people with their maximum labor input.

II. Limited Accessibility to NTFPs

There are, however, at least two issues to be addressed when promoting the use of NTFPs in the study area: one is accessibility to the resources, which is restricted by national and international forest policies; and the other is the disparity in profit distribution among local peoples rooted in traditional inter-ethnic relationships. The latter issue concerns the division of labor in the NTFPs trade and the certainty that the Bantu will take most of the added profits when the selling price is raised. As this latter issue is mentioned in detail in Toda & Yasuoka (2020), the former issue will be discussed here.

As described in Fig. 3, the area used by the people in Gribé overlaps different areas of the forest zoning, i.e., agroforestry zone (AZ), forest management units (*unités forestières d'aménagement*, or UFA), and national park (NP), where different types of stakeholders are involved. AZ is the area where local people can reside and create crop fields. However, community forest (CF) and *vente de coupe* (VC) can be designated in this area. Although CF aims, in principle, to promote timber and NTFPs production that benefit the local people, in practice, few activities other than logging are carried out. VC is an area where logging right in terms of cubic meters is sold to a timber production company and a local community gains the profits.

UFAs are the area in which logging concessions are allocated to timber companies directly by the government. Based on the zoning of UFA, the *Zone d'Intérêt Cynégétique*, or hunting zone, is designated and has granted permission to safari hunting companies. In the UFA of the study area, a timber company had been operating since the 1990s, and a safari company started its operation in 2018. These companies benefit from the resources in the forest, and they are responsible for sustainability and security in relation to the exploitation of these resources. From this point of view, these stakeholders, especially safari companies, do not like local people entering the hunting area, even if the main purpose is gathering nuts and kernels, because people staying at forest camps usually engage in hunting that potentially damages their commodities.

For NP, the situation is simple but strict because only the conservation authority, the Ministry of Forestry and Wildlife (MINFOF), is involved in land management. According to the forest code of Cameroon, gathering wild fruits is not prohibited in the NP. But in practice, it causes conflicts between local people and the conservation authority, because when staying at forest camps people often carry out hunting and fishing in addition to gathering, the former two activities being prohibited in NP. For the local people, it is just an ordinary way to use a variety of resources available in the forest, but the forest code has made it illegal.

In these circumstances, the area that local people can use for gathering nuts and kernels without any concerns is severely limited. While harvesting them in the forest, they always have the fear that someone could suddenly appear, destroy the camp, and force them to go back to the village.

There are two options for avoiding conflicts concerning resource use on the part of local people in UFA and the NP; one is to recognize access to the area as a customary right and reconcile the conflicts among different stakeholders, the other is to concentrate the area used by local people by increasing the land productivity of NTFPs, e.g., by cultivating them. The latter option is often proposed by conservation and development agencies and put into practice in other Regions of Cameroon. However, for the people in southeast Cameroon, particularly the Baka, this option is nonsense as the forest has plenty of trees that produce the nuts and kernels. Moreover, rushed enforcement of this approach, when combined with land zoning that restricts the use of NTFPs in the wild, would force the Baka to abandon their forest-dependent way of life and undermine their quality of life. Such an approach is often criticized by activists advocating for indigenous people’s way of life and their rights against the backdrop of the *United Nations Declaration on the Rights of Indigenous Peoples* (United Nations, 2007).

To achieve the goals of both mitigating conflict and improving local people’s livelihoods at the same time, the former option, i.e., to recognize their customary right and reconcile the conflicts among different stakeholders, appears more practical. It is more respectful of the local people’s knowledge and practices, which are rooted in the historical interactions between humans and the forest.

In addition, an important point to make with this approach that is even more practical should be noted. Given what local people undertake in forest camps, including hunting, and the Cameroonian forest policy that emphasizes anti-poaching measures, it is crucial to establish methods to keep hunting at a sustainable level and to ensure its sustainability. Having put such methods in practice, conflicts with the conservation authority and the safari hunting companies will be relieved, and the forest resources will be more accessible for local people. Preferably, the monitoring of hunting is carried out by the local people themselves and it must be scientifically appropriate enough to convince the conservation authority (Yasuoka et al., 2015).

In conclusion, what is of concern when promoting the use of NTFPs in southeast Cameroon is not the ecological availability of resources but the accessibility to resources. In principle, access to the forest, even in protected areas, should be recognized as a customary right for local people. Practically, it is needed to elaborate on a comprehensive package of resource management that includes both promoting the use of NTFPs and ensuring sustainable hunting.

NOTE

(1) The results were presented in the FOSAS International Symposium held on November 11–12, 2015, in Yaoundé, Cameroon. Hirai Masaaki is included in the authors of the presentation (Tani et al., 2015).

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