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TOWARD SUSTAINABLE LIVELIHOODS AND THE USE OF NON-TIMBER FOREST PRODUCTS IN SOUTHEAST CAMEROON: AN OVERVIEW OF THE FOREST-SAVANNA SUSTAINABILITY PROJECT

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ABSTRACT We present the results of a research project aimed at establishing sustainable agricultural and forest-use systems in southeast Cameroon. Our research focused on three main topics: the ecological potential of non-timber forest products (NTFPs), the importance of NTFPs in subsistence and as income sources, and existing social systems related to resource management. We demonstrate that current agricultural practices appear sustainable, as only a small percentage of the land allocated to agriculture is currently cultivated. An investigation of the distribution, abundance, and fruit production of the major NTFP species *Irvingia gabonensis* revealed large resource potential, whereas very little of the total fruit produced annually was being harvested. NTFPs are particularly important to Baka hunter-gatherers as side dishes, condiments, medicines, artifacts, and construction materials. They are also an important income source, although we note that social customs result in Konabembe people earning more from this resource by acting as intermediaries between Baka people in forest camps and outside markets. The areas used for harvesting NTFPs by different groups were visualized using participatory mapping. The resulting map is expected to be useful in designing a system to avoid competition and exploitation of forest resources among different local groups.

Key Words: Baka hunter-gatherers; Ecological potential; Konabembe farmers; Livelihood; NTFPs; Social relationships.

INTRODUCTION

I. Aims and Scope

We initiated a research project entitled *Forest-Savanna Sustainability Project: Establishing a Sustainable Livelihood in the Forest Areas of Cameroon* (FOSAS Project) with our collaborator, the National Institute of Agricultural Research for Development (IRAD) in Cameroon (Woin et al., 2012) in 2001. The first stage of this project concluded in 2016. Here, we present an outline of the main results obtained to date. Our focus throughout has been the development of sustainable resource use in tropical rainforests, specifically through integrating forest conservation with local people's welfare and development. A key research topic has been the use of non-timber forest products (NTFPs).

We took a landscape approach to this project by including both permanent and non-permanent forest zones in the study area (Fig. 1). Our work has centered on two related components and we have undertaken multiple research projects for

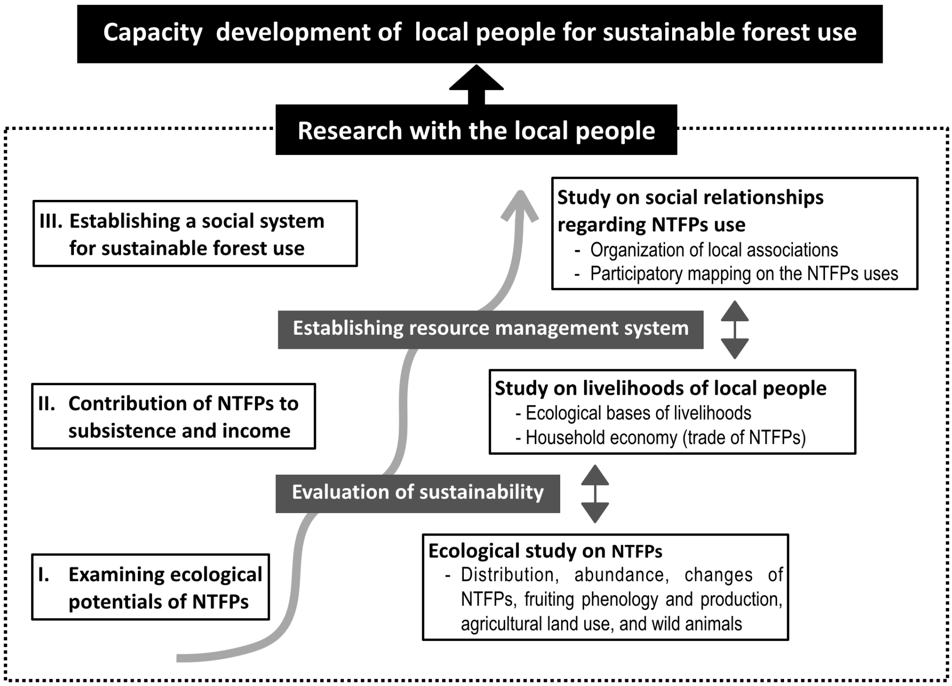

Fig. 1. Study design of the NTFP component of the FOSAS Project.

both. The first project component was agricultural intensification, i.e., enhancing the productivity of existing agricultural land and thereby reducing the clearing of forest land caused by agricultural expansion. The second component was forest sustainability, specifically, exploiting NTFPs as alternatives to timber harvesting. By definition, NTFPs are produced by living trees, and their use is therefore compatible with forest conservation and the maintenance of forest ecosystem services.

The forest sustainability component comprised three research projects. First, we examined the ecological potential of NTFPs by determining their abundance, productivity, and availability in forests. Second, we tried to determine the actual use of NTFPs by local people, and the contribution of NTFPs to subsistence and household incomes. Finally, we considered social aspects such as local practices and customs regarding forest resource use to determine potential future avenues for designing sustainable resource management strategies.

For each component and research area, field activities were undertaken with the participation of local people. This provided an opportunity for knowledge exchange, whereby researchers gained traditional indigenous knowledge of the forest environment. It was hoped that participation in research activities represented a capacity-building opportunity for the collaborating local communities.

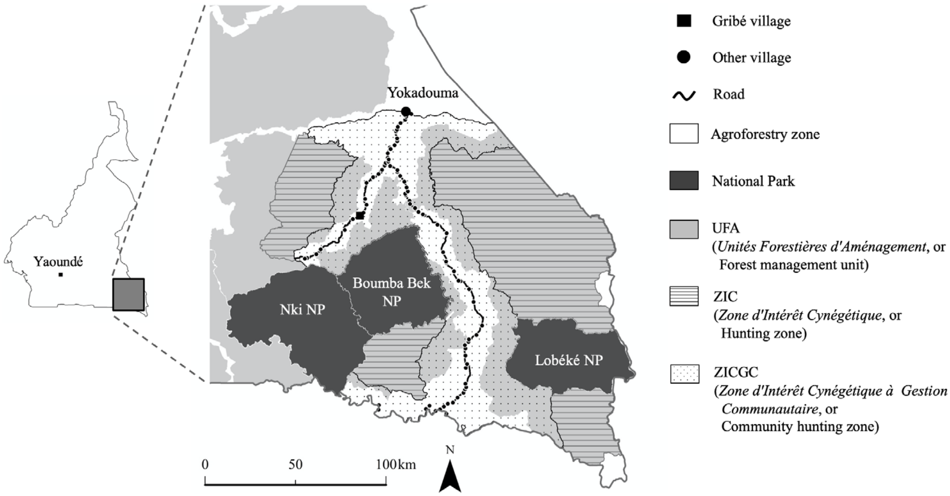

Fig. 2. Zoning in the study area of southeast Cameroon (adapted from Hirai, 2014).
Source: Interactive Forest Atlas of Cameroon, version 3.0, published by the World Resources Institute, http://www.wri.org/publication/interactive-forest-atlas-cameroon-version-30.

II. Study Area

Field research was conducted in Gribé, a village in southeast Cameroon comprising approximately 400 Baka hunter-gatherers and 350 Konabembe and other Bantu-speaking individuals (Toda, 2014). A newly constructed road connects Gribé to Ngato in the east and Lomie in the west. Gribé is adjacent to Boumba-Bek and Nki National Parks on the south and west sides, respectively, with UFA (*Unités Forestières d'Aménagemen,* or Forest Management Unit) on both sides of the village (Fig. 2). People living in this area are subjected to forest destruction through industrial logging and further excluded from protected areas that in the past were a source of sustenance. Moreover, portions of logging zones, i.e., UFA, are now allocated to sport hunting. The theoretical purposes of sport hunting are to promote sustainability and to provide the government with revenue to be used for conservation (Fig. 2). As a result of these enterprises, nearly 90% of the forested area is allocated to external stakeholders and local people are excluded from lands they had utilized for centuries. This is a typical scenario of land grabbing or green grabbing (Fairhead et al., 2013). Similar scenarios are encountered in various areas of tropical forests around the world, especially in the Congo basin, where local people inhabit lands with rich biological diversity.

The field station in Gribé was constructed in 2012 from local materials; wood, soil bricks, raffia, etc. Clearing and flattening the plot area was done with the assistance of Konabembe and Baka community members (Yasuda, 2015). Communication during building meant that local people became acquainted with the project, and they received wages for their work. We also held a workshop on the project in Gribé. Konabembe cultivators and Baka hunter-gatherers were invited to the workshop for discussion and were asked for their cooperation with the project.

REVIEW OF MAJOR FINDINGS

I. Shifting Cultivation Practices in Gribé

With the assistance of community members, Hirai (2014) inventoried and measured active and abandoned agricultural plots used in Gribé. He reported that approximately 4,000 plots had been cleared since the 1960s in the vicinity of the village. Of these, nearly 90% (3,637 plots) had been cleared in secondary forest, i.e., areas that had already been cleared at least once. Therefore, there had been little agricultural expansion into mature forests for the past several decades. Surveyed plots were typically 0.12–0.24 ha. Between 2012 and 2013, 239 new plots were cleared, encompassing 47 ha (89 plots [11 ha] by the Baka and 150 plots [36 ha] by the Konabembe). The area of land zoned for cultivation, i.e., land classified as non-permanent forest zones and allocated for community use, is approximately 7,100 ha, which is more than 140 times the area cultivated annually. Although some of this area is likely unsuitable for agriculture due to topo-edaphic conditions, it is unlikely that the residents of Gribé would clear this entire area given their current cultivation practices, even over a 100-year period. The shifting-cultivation method currently practiced by farmers in Gribé appears to be sustainable, provided that the current population and production levels remain constant over time.

We further explored the impacts of cultivation and other human activities on the local plant community. First, the Cameroon botany team established a 16-km fixed transect line between Gribé and Boumba-Bek National park. From both sides of this main transect, 16 transects (20 m wide × 5 km long) were established and surveyed to determine the presence and distribution of NTFP and other species (Fig. 3). Four transects were in agricultural or agroforestry zones (non-permanent forest zone), eight were in the UFA of the permanent forest zone, and four were in transitional areas and were comprised of both zone types (Fongzossie et al., 2014; Tajeukem et al., 2014; Hirai, 2014).

Botanists recorded and measured the diameters at breast height (DBH) of all trees >10 cm DBH and all trees >5 cm DBH for NTFP species. Tree density and mean diversity indices were assessed by Evariste Fongnzossie and Vice Tajeukem. Tajeukem et al. (2014) suggested that although average tree density and basal area were higher in the UFA (446.9 stems/ha and 42.9 m^2/ha, respectively) and intermediate zones (496 stems/ha and 49.7 m^2/ha) compared with the agricultural zone (368.5 stems/ha and 39.0 m^2/ha), mean species diversity (as calculated by a Shannon-Weiner diversity index) was higher in the agricultural zone (H’=6.39) compared with the UFA zone (H’=6.20). This implied that moderate impacts by small-scale shifting cultivation may increase forest tree diversity, which

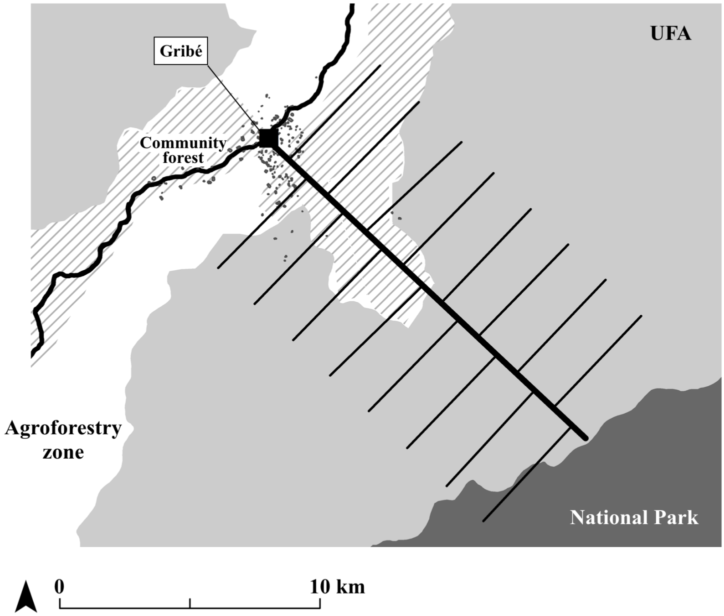

Fig. 3. Vegetation survey of NTFPs and other species using 16 transects (20 m × 5 km) (adapted from Fongnzossie et al., 2014).

is contrary to the widely held paradigm of shifting cultivation having adverse and detrimental impacts on forest vegetation.

II. Non-Timber Forest Products (NTFPs)

(1) Distribution and abundance of NTFP tree species

Hirai (2014) surveyed trees that had been left uncut in otherwise cleared fields. Within the 47 ha cleared between 2012 and 2013, 3,142 trees >10 cm DBH of 240 species remained, for a total tree density of 66.4 stems/ha. Local community members had various reasons for maintaining trees in cultivated areas. Some people stated that they left trees intentionally to shade immature crops, while others said the trees were too large and hard for clearing using their tools. We noted that certain retained species, such as *Irvingia gabonensis* (*peke*) and *Ricinodendron heudelotii* (*gobo*), are important food species, and proposed that this may have been another reason for their retention, which local people later confirmed. The differences in the densities of NTFP tree species between cultivated and forest land zoned for logging merits further investigation to elucidate the impacts of small-scale cultivation on the availability of NTFP species.

In a study of the distribution of NTFP food species among vegetation zones, Fongzossie et al., 2014) showed that two of the eight major NTFP species, *Afrostyrax lepidophyllus* (*gimba*) and *Pentaclethra macrophylla* (*mbalaka*), were more abundant in the agricultural zone (52.4 and 16.6 stems/ha, respectively) than

Table 1. Density (stems/ha) estimates for three non-timber forest product tree species.

	Irvingia gabonensis		*Ricinodendron heudelotii*		*Afrostyrax lepidophyllus*	
	All trees recorded	Trees >30 cm DBH	All trees recorded	Trees >30 cm DBH	All trees recorded	Trees >30 cm DBH
Hirai (2014)	3.8	0.9	1.3	0.7	22.5	0.4
Tajeukem et al. (2014)	3.0	1.1	2.4	2.1	2.2	0.7
Fongzossie et al. (2014)	3.7	n/a	4.7	n/a	52.2	n/a

in the UFA (10.8 and 6.3 stems/ha, respectively). The remaining six species did not differ in density between zones, even under different human-activity types. We hypothesize that moderate human activity may improve forest habitats for humans themselves in terms of increasing the availability of wild food species (e.g., maintaining shade-intolerant species). Ngansop et al. (2019) noted that among NTFP species growing in 13 vegetation types, seven of the eight major species reached peak abundance in young secondary forests. If this pattern is observed elsewhere, it may cause to re-think the relationships between human activities like small-scale agriculture and forest degradation in tropical forests.

We also note that the densities of NTFP species varied considerably over space in our study area. While *I. gabonensis* tended to show similar densities across all sites, *A. lepidophyllus* had more than 10-fold differences in density between sites (Table 1). The observed patchy distributions for species like *A. lepidophyllus* warrant further investigation.

(2) Fruit-set in NTFP tree species

Hirai (2014) investigated seasonal and annual changes in fruit production for important NTFP species. He selected 10 NTFP species that had a demonstrated importance to subsistence and/or household income. Ten to 25 individuals were selected for each of the 10 species, and four traps were set under the canopy of each individual to capture falling fruit. This simple method effectively estimates annual or seasonal changes in fruit production, and local people may be interested in employing it in the future to monitor fruit production.

Fallen fruit was recorded from 2011–2015. *I. gabonensis*, the most important NTFP species in terms of both subsistence and income, had a clear fruiting season that peaked between June and September. *A. lepidophyllus* and *Baillonella toxisperma* (*mabe*) had a similar peak fruiting season. In contrast, *Irvingia excelsa* (*gangendi*), *I. robur* (*kombele*), *Panda oleosa* (*kana*) and *R. heudelotii* had a longer fruiting season or bore fruit more or less throughout the year.

Hirai & Yasuoka (2020) estimated the production and economic value of *I. gabonensis* from the number of fruit in traps, canopy size, the density of fruiting trees, and the total forest area used for harvesting fruit. Commercial value was also estimated from the value of dried kernels and the ratio of fresh or whole fruit weight to dry kernel weight; dried kernels are the principle commercial product of *I. gabonensis*.

The results indicated a nearly 10-fold difference in kernel production between years. In good years, approximately 6–7 kg of kernels (dry weight) were produced per hectare. This corresponds to 10,000–15,000 FCFA per hectare and 40,000–50,000 kcal, the caloric equivalent of 20–25 man-days. In contrast, production in poor years was only 0.5 kg/ha. The underlying ecological factors causing the variation in fruit-set are unknown and further research focused on *I. gabonensis* phenology is strongly encouraged.

An additional finding was that only a small percentage of the available fruit is commercialized. The traditional territory of the people of Gribé is approximately 360 km^2, which can produce up to 250 tons of kernels (dry weight) in good years. However, only 1–4% of this amount is currently sold. Even accounting for self-consumption, it is unlikely that more than 5–6% of the total kernels produced are consumed or sold. A similar pattern has been found in other NTFP species (Hirai & Yasuoka, 2020). This implies that current NTFP resources are substantially under-utilized and that these species are not at risk of overharvesting.

The amount of kernels sold to or exchanged with villagers or traders is limited by the laborious, time-consuming work of splitting the fruit into two pieces with a machete or axe, taking the kernels out with a knife, and then drying them in a humid forest environment. Harvesters can process approximately 2.3 kg of fruit in 5 hours (Hirai & Yasuoka, 2020). A more efficient extraction and/or drying system would likely increase the utilization of *I. gabonensis*, even given the large fluctuations in annual fruit production.

III. Hunting Practices and Harvest Rates

(1) Commercial hunting

Bobo Kadiri and his research team (Bobo et al., 2014; 2015) investigated the distribution and abundance of large and medium-sized mammals in ZICGC (*Zone d'Intérêt Cynégétique à Gestion Communautaire*, or Community Hunting Zone) 13 and 14, located to the northeast of Boumba-Bek and Nki National Parks. In a survey of animal signs (scat, tracks, etc.) conducted along 126 × 2-km transects, they recorded 31 mammal species. They found relatively high densities of threatened species, such as gorillas and elephants, indicating the potential of this area for biodiversity conservation. However, human activities are widespread in the study area, which may negatively affect mammal abundance in the future, particularly under an increasing demand for bush meat.

The hunting practices and harvest rates of both the Baka and Konabembe people were studied to evaluate hunting pressure and sustainability (Yasuoka, 2006; 2014; Bobo et al., 2014; Kamgaing et al., 2018; 2019). These studies implied that duikers, especially blue duikers (*Philantomba monticola*), are under excessive hunting pressure in the study area, wherein the catch exceeds the amount of natural recruitment. Recruitment of red duikers (*Cephalophus* spp.) was estimated to be 0.89–2.85 heads/km^2, whereas the harvest rate was 2.93 heads/km^2, and the rates of blue-duiker recruitment and harvest were 1.28–3.91 heads/km^2 and 12.17 heads/km^2, respectively.

Commercial hunting is likely imposing a stronger hunting pressure than subsistence hunting on the local game populations. Of the total harvest, greater than 90% of red duikers and 73% of blue duikers are hunted for commercial purposes (Kamgaing et al., 2018). Yasuoka (2006) reported that harvest amounts rose by 15- to 18-fold, which is many times the maximum sustainable yield, when the construction of a new logging road gave increased access to commercial traders. Heavy hunting pressure from commercial hunters may be depleting the mammal resource base, which threatens biodiversity as well as the livelihood of people who depend on hunting for subsistence.

(2) Changes in mammal composition

The major target species in southeast Cameroon are ungulates, primarily forest duikers, which account for as much as 80% of the total harvest (Yasuoka, 2006). Where gun hunting is practiced, arboreal primates are also harvested with shotguns. In other Central African forested areas, for example among the Mbuti in the Democratic Republic of Congo and the Aka in Congo-Brazzaville, duikers are also major targets of net hunting. In the Ituri Forest, 60% of all animals animals caught with nets are small blue duikers, weighing 4–6 kg (Ichikawa, 1983). In contrast, the snare harvesting used by the Baka typically targets medium-sized red duikers weighing 15–25 kg, which comprise 80% of the total harvest (Yasuoka, 2006; 2014). Differences in catch composition are related to the hunting methods used, which in turn reflect the relative abundance of major game species in hunting areas. In Ituri, where net hunting is prevalent, blue duiker are more abundant, whereas the red duiker predominates in southeast Cameroon.

A notable exception to this are roadside areas around Lobeke National Park in Cameroon, where snare hunting is a common method despite the relative abundance of blue duikers, which may be a product of overharvesting of red duikers (Yasuoka 2014). Given this, Yasuoka (2014; Yasuoka et al., 2015) proposed a new indicator for assessing hunting pressure on game populations. The B/R ratio is a ratio of blue to red duikers, wherein red duikers are expected to decrease relative to blue duikers under increases in hunting pressure. An advantage of this indicator is that changes in catch composition can be easily recognized by local hunters, who are expected to self-manage forest resources in the study area.

Typically, rodents and other small animal species account for a larger proportion of the catch in West African regions, where there is a long history of heavy hunting pressure (Davies & Robinson, 2007). In theory, hunting pressure on larger mammals results in their replacement by smaller animals with higher reproductive rates and greater resistance to high harvest levels. Previous studies have clearly demonstrated that changes in the relative abundance of game species influence forest ecosystems by strongly affecting certain plant and animal species (Nasi et al., 2010; 2011; Abernethy et al., 2013; Wilkie et al., 2011). In extreme cases, “empty forest syndrome” (Redford, 1992) results, and this complete absence of game species has been reported in some parts of the Congo Basin. Careful monitoring of game-population dynamics, especially the relative abundance of species in harvests, is necessary to maintain functioning forest systems. Game animals have profound effects on forest dynamics through herbivory and seed dispersal. Furthermore, without healthy game populations, the role of forests in carbon sequestration may be disrupted (Nasi et al., 2010).

(3) Hunting regulations in Cameroon

In Cameroon, under a 1994 forest law and a subsequent decree issued in 1995, local people without hunting licenses may engage in “traditional hunting”, meaning hunting with implements made from plant materials (Decree No. 95-466-PM of 20 July 1995: To lay down the conditions for the implementation of wildlife regulations, Section 2, Article 20). However, a recent study demonstrated that nearly 90% of the total catch obtained by certain Baka people was trapped using steel wire, which is illegal (Hattori, 2005; 2012). Even in villages where gun hunting is common, steel-wire traps and guns contribute almost equally to the total catch (Bobo et al., 2015). Gun hunting is also practiced at night using flashlights, which is an illegal practice (Law No. 94/01 of 20 January 1994: To lay down forestry, wildlife and fisheries regulations, Section 80).

The 1994 law and 1995 decree, as well as a Ministerial Ordinance, designate the protection level provided to animal species by classifying them into three categories. Class A animals are those threatened with extinction and are therefore protected species. Of the 32 Class A mammal species currently listed, 16 are found in southeast Cameroon. Class B animals are protected, but can be hunted with a government-issued permit. Eleven species of Class B animals occur in the study area. People who are found in possession of protected animals without a permit can be punished by a fine and/or sentenced to imprisonment (Forest Law, Article 155). Class C animals can be hunted for consumption by local people using traditional methods (Djeukam, 2012). In principle, the list of protected animal species is meant to be periodically reviewed by the Minister of Forests and Wildlife (Djeukam, 2012), but no revisions have been made to date. Although the differences in catch composition observed by Yasuoka (2014) imply differences in local species’ abundances, the protection classification system does not account for local abundance. Red duikers are the most frequently hunted mammals in southeast Cameroon; in particular, Peter’s duikers (Class B) may comprise up to 60% of the total harvest (Yasuoka, 2006). Class A and B animals, collectively, account for 70–90% of the total harvest in some villages (Yasuoka, 2006; Hattori, 2012; Ichikawa et al., 2016). Regulations for protected animals, therefore, largely disregard the realities of actual hunting practices by local people. We note, however, that if these regulations were to be strictly applied, it would seriously affect the livelihood of forest hunters who are heavily dependent on wildlife.

Caution is needed in assessing animal population data, because metrics such as density are often extremely variable and can fluctuate given the year, season, survey timing and survey method (e.g., scat, tracking, or direct observations). For example, Kamgaing et al. (2018) showed substantially different population estimates between day-time (direct observation and scat) and night-time (direct observation only) surveys. Surveys conducted at night estimated densities 8–18 times greater than those conducted during the day for blue duikers, and 2–3 times greater for red duikers. This highlights the importance of longitudinal data, as well as the need to apply multiple methods in assessing species abundance. We anticipate that ongoing research by Yasuoka will address this issue further by providing systematic data collected using various methods, including camera traps.

IV. NTFPs and Human Livelihoods

(1) NTFPs and subsistence

Quantitative research was also conducted on the importance of NTFPs for subsistence and income generation. Market research on certain major NTFP species, including *I. gabonensis*, *R. heudelotti*, *Gnetum africanum*, and others, was conducted by Awono et al. (2016), Ingram et al. (2012), and by researchers at the Center for International Forestry Research (CIFOR) for the Central and South Provinces of Cameroon. However, no detailed, quantitative research on the importance of NTFPs for subsistence and income is available for the East Province, although we believe that NTFPs are gaining importance in this region.

A livelihood study addressing subsistence and household incomes was conducted in the Gribé area. Products brought into the village were inventoried (vernacular name, collector identity, collection location, and quantity obtained) with the assistance of literate Baka men. Sales of NTFPs in the village were also documented through interviews with merchants and traders.

In total, 41 households comprised of 162 Baka people were surveyed. Hirai (2014) describes, for example, a five-person household surveyed over 63 days from August 28 to November 14, 2012. Over the survey period, household members brought 293 items into their home, including food items, medicinal plants, materials for tools and construction, fuel wood, water, narcotics, and various non-essential items such as tobacco. Of the starchy food products recorded, more than 95% were agricultural crops and <5% were wild food items from local forests by weight. All the meat, firewood, and materials for making tools were wild products obtained from cultivated fields, fallows, or dense forests. Most of the traditional medicines, condiments, and construction materials were forest-obtained products. While NTFPs do not comprise a major part of villagers' caloric intake, they remain important to their livelihoods as side dishes, condiments, and materials for construction and tool-making.

(2) Income value of NTFPs among ethnic groups

Among Baka hunter-gatherers, NTFPs accounted for 95% of the total household income. In contrast, these products accounted for <23% of the total income among Konabembe farmers. Products from *I. gabonensis* alone accounted for one third of the total fruit NTFP contributions to Baka household incomes (Hirai, 2014)

NTFPs harvested by the Baka are exchanged with Konabembe people for food in forest camps and are later sold for cash to transient merchants and traders in the village. An example of transactional practices is described for *I. gabonensis.* At forest camps, Baka people harvest the kernels and later sell or exchange them with visiting Konabembe famers. Kernels are sold at a fixed rate of 500 FCFA (approximately 1 USD) per combo, which is the typical unit of exchange and is a full bowl (typically weighing approximately 1.4 kg). Transactions in forest camps are rarely completed for cash. Instead, kernels are exchanged for food. Most often, one combo of kernels would be exchanged for 10 beignets (round donuts made from flour and sugar), equivalent to 500 FCFA. Kernels obtained by trade in camps are then dried and transported to the village by Konabembe individuals for later sale to merchants or traders at an average price of 1,500–2,500 FCFA per combo (weighing 1.7 kg in the village), depending on the season, a substantial profit. The average market price in the nearby town of Yokadouma was as high as 100 FCFA per 42.3 g, or 3,500–4,000 FCFA per combo. If Baka community members had sold their harvest directly to traders in the village, or had self-transported the kernels for sale in nearby towns, they would have received substantially greater income.

However, such actions would be in opposition to the traditional, long-standing relationship between the Baka and Konabembe, wherein Konabembe people play an intermediary role between the Baka and outside markets. Due at least in part to this dynamic, sales of kernels contributed 11,432 FCFA and 42,190 FCFA to Baka and Konabembe, respectively, in 2015 (Hirai Masaaki, personal communication). Furthermore, unit prices for *I. gabonensis* kernels differed between Baka and Konabembe (Bantu) villagers. In 2015, Konabembe villagers sold dried kernels at an average cost of 2,425 FCFA/combo, which was nearly 10% higher than the price at which kernels were sold by Baka people (2,235 FCFA) (Hirai Masaaki, personal communication).

(3) Social aspects of sustainable NTFP use

Establishing sustainable environmental and social systems requires an understanding of human social relationships as they pertain to forest use. A social system that regulates resource use is vital to sustainable practices. Open access to common resources leads to over-exploitation, wherein people pursue short-term benefits at the cost of long-term sustainability, known as the "tragedy of the commons" (Hardin, 1968).

We suggest that any attempts to create and promote sustainable forest use must be based, at least initially, within existing, accepted social customs. An effective tool in understanding human resource use is participatory mapping, which is done by collecting spatial data from people as they use forest resources and later visualizing those data using a geographic information system (GIS). The resulting maps provide insight for both researchers and local people on how different groups of individuals use forest resources, and these maps are therefore vital tools to avoid excessive competition and exploitation of resources. If competition for the same spaces and resources is low, it is more likely that local people will manage resources in a manner that is sustainable over the long-term.

Prior to participatory mapping, Hirai & Yasuoka (2020) mapped the major NTFP trees in a 120-ha plot to estimate their overall density. He found that the distribution of *I. gabonensis* was close to random, and estimated a total density of 3.9 stems/ha for all individuals (including seedlings), 1.2 stems/ha for reproductive individuals (DBH > 30 cm), and 0.6 stems/ha for fruiting individuals in the study area.

Then, participatory mapping was conducted by different Baka social groups to record the places they visited when collecting *I. gabonensis* kernels. These GPS data were visualized using a GIS (Fig. 4, Hirai & Yasuoka, 2020). The resulting map was used to initiate discussion of how best to avoid competition for land and resources, although this discussion had not been completed by the end of

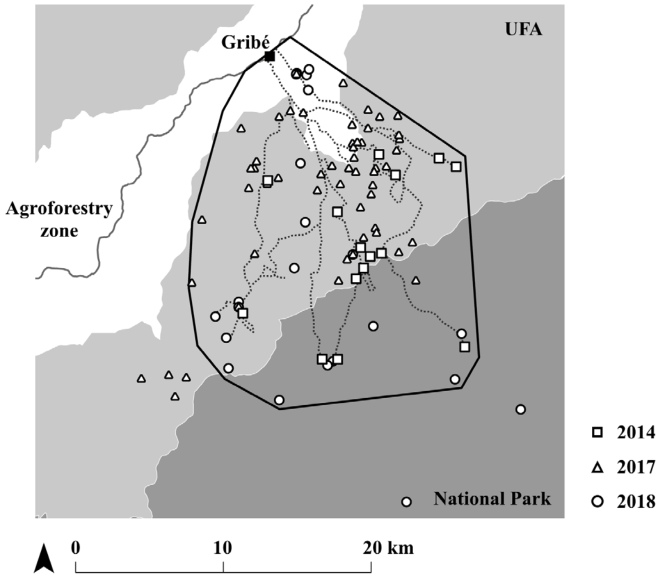

Fig. 4. The results of participatory mapping for *Irvingia* collection sites, using observations collected by different Baka groups (Hirai & Yasuoka, 2020). Participatory mapping was carried out: (1) Identifying social units concerning the forest use; (2) Mapping for understanding and sharing basic information on their customary use of forest, and "visualize" them in a map form; (3) Discussion about how to avoid over-competition over the resources.

this project.

We consider this set of research work, which includes estimates of the distribution, abundance, fruit production, consumption, and exchange and sale of NTFPs, as well as participatory mapping, as a strong example of integrated research on the ecological potential of NTFPs.

DISCUSSION AND CONCLUSION

Tropical rain forests are complex ecosystems with extremely rich floral and faunal diversities. They are inherently dynamic systems that fluctuate over time and space that present a challenge to researchers. Large natural variability can lead to inconsistency among results from different studies conducted in different areas or over different years and seasons. Therefore, the results of short-term studies from small areas are not suitable for drawing generalizations. We note that the people who live in these forest ecosystems, such as those in Gribé, are subject to these changes in forest conditions. Given these limitations, we summarize the key results of our work and relate important implications below.

1. The survey of shifting cultivation practices implied that agricultural land use in the study area is currently sustainable, but this is contingent on the current

population and level of production. If the demand for agricultural crops increases, we think there will be an inevitable change in land-use patterns. It is likely that fallow periods would be reduced and a larger land area would be cleared. These changes could result in expansion of agricultural land into primary forest, unless productivity (production per unit area) increases via the introduction of new technology or more productive crop varieties.

2. We found that the overall diversity of tree species was slightly higher in secondary forests relative to primary forests, which are zoned for industrial logging. This caused us to re-evaluate the paradigm of cultivation inevitably leading to negative impacts on native floral diversity. It is reasonable to assume that the real-world impacts of shifting cultivation on vegetation vary depending on the intensity and extent of cultivation, and that moderate impacts may improve forest vegetation diversity.

3. Although various NTFPs are used by local people, only 10 to 15 species demonstrated socio-economic impacts. Of these, *I. gabonensis* was the most important NTFP species. Species such as *A. lepidophyllus* and *P. macrophylla* (*mbalaka*) were more abundant in secondary forests than in primary forests zoned for logging, whereas no significant differences were observed in other species between these two forest types. Recent research also demonstrated that 8 of 13 target NTFP species were more abundant in secondary forests. We note that the abundance of NTFP species is highly variable depending on survey methods and the study plot location. We strongly suggest more extensive vegetation surveys employing a variety of methods across a broader area.

4. Fruit production in NTFP species varied dramatically between seasons and years. For example, we observed up to 10-fold changes in the fruit production of *I. gabonensis* between years. The factors related to such large variation in fruit-set are unknown and warrant further investigation. We further determined that *I. gabonensis* kernels are under-utilized, wherein very little of the total production is harvested by local people. This is likely due to a laborious cleaning process, which could be alleviated by the development of more efficient techniques for removing the kernels from the fruits, thereby increasing the total kernel harvest.

5. In total, 31 large- and medium-sized mammal species were recorded from transect surveys in ZICGC 13 and 14, which were located around the village of Gribé. Some of the game harvest was used for personal consumption, but some was used for income. We consider that commercial hunting poses the greatest risk to the sustainability of hunting in the study area.

6. A new index, the B/R ratio, has been proposed to evaluate hunting pressure on duikers in the study area. The key assumption of this metric is that as hunting pressure increases, the proportion of blue duikers (B), which have a faster growth rate, will increase relative to red duikers (R), which have a slower growth rate. The applicability of this indicator will be tested in future work. We also note that caution must be used when interpreting species' abundance estimates obtained by surveys that vary in methodology or timing.

7. We observed a 10- to 20-fold difference in the value of sales of *I. gabonensis* kernels between Konabembe farmers and Baka hunter-gatherers. The latter are the disadvantaged group, and we note that they may require specific consideration to obtain equal access to the benefits obtained through commercializing NTFPs.
8. Participatory mapping conducted by Baka community members demonstrated that they have a custom-based process for reducing resource competition, namely segregation of the forest spaces used to collect NTFP resources. This existing social practice may serve as a basis for designing a socially accepted system for sustainable forest management in the study area.

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REFERENCES

Abernethy, K.H., L. Coad, G. Taylor, M.E. Lee & F. Maisels 2013. Extent and ecological consequences of hunting in Central African rainforests in the twenty-first century. *Philosophical Transactions of the Royal Society B*, 368: 20120303.

Awono, A., R. Eba'a Atyi, D. Foundjem-Tita & P. Levang, 2016. Vegetal non-timber forest products in Cameroon: Contribution to the national economy. *International Forestry Review*, 18(1): 66–77.

Bobo, K.S., T.O.W. Kamgaing, B.C. Ntumwel, D. Kagalang, P.N.J. Kengne, M.M.N. Badject & F.F.M. Aghomo 2014. Species richness, spatial distributions and densities of large- and medium-sized mammals in the northern periphery of Boumba-Bek National Park, southeastern Cameroon. *African Study Monographs Supplementary Issue*, 49: 91–114.

Bobo, K.S., T.O.W. Kamgaing E.C. Kamdounm & Z.C.B. Dzefack 2015. Bushmeat hunting in southeastern Cameroon: Magnitude and impact on duikers (*Cephalophus* spp.). *African Study Monographs Supplementary Issue*, 51: 119–141.

Davies, G. & J.G. Robinson 2007. Bushmeat: Market and households. In (G. Davies & D. Brown, eds.) *Bushmeat and Livelihood: Wildlife Management and Poverty Reduction*, pp. 11–14. Blackwell, Oxford,

Djeukam, R. 2012. *The Wildlife Law as a Tool for Protecting Threatened Species in Cameroon*. Ministry of Forestry and Wildlife (MINFOF), Government of Cameroon.

Fairhead, J., M. Leach & I. Scoones 2013. Green grabbing: A new appropriation of nature? In (J. Fairhead, M. Leach & I. Scoones, eds.) *Green Grabbing: A New Appropriation of Nature*, pp. 1–15. Routledge, London.

Fongzossie, F.E., T.M. Ngansop, L. Zaphack, V.A. Kemeuze, D.J. Sonwa, G.M. Nguenang & B.A. Nkongmeneck 2014. Density and natural regeneration potential of selected non-timber forest products in the semi-deciduous rainforest of southeastern Cameroon. *African Study Monographs Supplementary Issue*, 49: 69–90.

Hardin, G. 1968. The tragedy of the commons. *Science*, 162(3859): 1243–1248.

Hattori, S. 2005. Nature conservation project and hunter-gatherers' life in Cameroonian rain forests. *African Study Monographs Supplementary Issue*, 29: 41–51.
Hattori, S. 2012. *Challenge for Co-existence of Forests and People: Conservation of Tropical Rainforests and the Culture of Hunter-gatherers in Cameroon*. The Center for African Area Studies, Kyoto University (in Japanese).
Hirai, M. 2014. Agricultural land use, collection and sales of non-timber forest products in the agroforest zone in southeastern Canroon. *African Study Monographs Supplementary Issue*, 49: 169–202.
Hirai, M. & H. Yasuoka 2020. It's not the availability, but the accessibility that matters: Ecological and economic potential of non-timber forest products in southeast Cameroon. *African Study Monographs Supplementary Issue*, 60: 59–83.
Ichikawa, M. 1983. An examination of hunting-dependent life of the Mbuti Pygmies. *African Study Monographs*, 4: 55–76.
Ichikawa, M., S. Hattori & H. Yasuoka 2016. Bushmeat crisis, forestry reforms and contemporary hunting among Central African forest hunters. In (V. Reyes-García & A. Pyhälä, eds.) *Hunter-Gatherers in a Changing World*, pp. 59–75. Springer.
Ingram, V, O. Ndoye, D.M. Iponga, J.C. Tieguhong & R. Nasi 2012. Non-timber forest products: Contribution to national economy and strategies for sustainable management In (C. de Wasseige, P. de Marcken, N. Bayol, F. Hiol-Hiol, P. Mayaux, B. Desclee, R. Nasi, A. Billand, P. Defourny & R. Eba'a Atyi, eds.) *The Forests of the Congo Basin: State of the Forest 2010*, pp. 137–154. Publications Office of the European Union, Luxembourg.
Kamgaing, T.O.W, K.S. Bobo, D. Djekda, K.V.B. Azobou, R.H. Bobo, M.Y. Balangounde, K.J. Simo & H. Yasuoka 2018. Population density estimates of forest duikers (*Philantomba monticola* & *Cephalophus* spp.) differ greatly between survey methods. *African Journal of Ecology*, 56: 908–916.
Kamgaing, T.O.W., Z.C.B. Dzefack & H. Yasuoka 2019. Declining ungulate populations in an African rainforest: Evidence from local knowledge, ecological surveys and bushmeat records. *Frontiers in Ecology and Evolution*, 7: 249.
Nasi R., T. Christophersen & C. Belair 2010. Ending empty forest. *Tropical Forest Update*, 20(1): 19–21.
Nasi, R., A. Taber & N. van Vliet 2011. Empty forests, empty stomachs?: Bushmeat and livelihoods in the Congo and Amazon Basins. *International Forestry Review*, 13(3): 355–368.
Ngansop, T.M., E.H. Biye, F.E. Fongnzossie, P.F. Forbi & D.C. Chimi 2019. Using transect sampling to determine the distribution of some key non-timber forest products across habitat types near Boumba-Bek National Park, South-east Cameroon. *BMC Ecology*, 19: 3.
Redford, K.H. 1992. The empty forests. *Bioscience*, 42(6): 412–422.
Tajeukem, V.C., F.E. Fongzossie, V.A. Kemeuze & B.A. Nkongmeneck 2014. Vegetation structure and species composition at the northern periphery of the Boumba-Bek National Park, southeastern Cameroon. *African Study Monographs Supplementary Issue*, 49: 13–46.
Toda, M. 2014. People and social organizations in Gribe, southeastern Cameroon. *African Study Monographs Supplementary Issue*, 49: 139–168.
Wilkie D.S., E.L. Bennett, C.A. Peres & A.A. Cunningham 2011. The empty forest revisited. *Annals of the New York Academy of Sciences*, 1223: 120–128.
Woin, N., B. Foahom, S. Araki & Y. Sugiyama 2012. *Progress Report 2011: Forest-Savanna Sustainability Project in Cameroon*. The Center for African Area Studies, Kyoto University, Kyoto.
Yasuda, H. 2015. *Manuel de Construction de la Maison Économique en Terre*. FOSAS Project,

Kyoto University, Kyoto.

Yasuoka, H. 2006. The sustainability of duiker (*Caphalophus* spp.) hunting for the Baka hunter-gatherers in southeastern Cameroon. *African Study Monographs Supplementary Issue*, 33: 95–120.

Yasuoka, H. 2014. Snare hunting among Baka Hunter-gatherers: Implications for sustainable wildlife management. *African Study Monographs Supplementary Issue*, 49: 115–136.

Yasuoka, H., M. Hirai, T.O.W. Kamgaing, Z.C.B. Dzefack, E.C.B. Kamdoum & K.S. Bobo 2015. Changes in the composition of hunting catches in southeastern Cameroon: A promising approach for collaborative wildlife management between ecologists and local hunters. *Ecology and Society*, 20(4): 25.

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