From Tree Species to Forest Services: Ethnic Differences in Lomami, Democratic Republic of the Congo

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From tree species to forest services: ethnic differences in Lomami, Democratic Republic of the Congo. Ethnicity is well–known to affect plant species' utilization, but how ethnicity affects the identification and importance ranking of forest ecosystem services has been less documented, particularly in the Congo Basin. This research investigates how six different ethnic groups (farmers of Bantu origin and Mbote hunter–gatherers) use and value tree species and forest ecosystem services in Lomami National Park, in central Democratic Republic of the Congo (DRC). Data were collected through 24 focus–group discussions with village elders, four for each ethnic group studied. Considerable variation in preferred tree species was observed: of the 89 morphospecies cited in total only two were cited by all ethnic groups for the same usage. Ethnicity also affected the identification and importance ranking of forest ecosystem services. Mbote hunters–gatherers prioritized bushmeat, honey, and identity, while farmer groups prioritized bushmeat, fish, and microclimate regulation. We discuss the implications of the findings for forest management in the Buffer Zone of the national park.

Key Words: Sociocultural assessment, tropical forests, forest use, ecosystem services, local communities.

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Des espèces d'arbres aux services écosystémiques forestiers: les différences ethniques à Lomami, en République Démocratique du Congo. L'ethnicité est bien connue pour affecter l'utilisation des espèces végétales. Cependant, la façon dont l'appartenance à une ethnie affecte l'identification et le classement prioritaire des services écosystémiques forestiers a été moins documentée, particulièrement dans le bassin du Congo. Cette recherche examine comment six différents groupes ethniques (agriculteurs d'origine bantoue et chasseurs–cueilleurs Mbote) utilisent et valorisent les espèces d'arbres et les services écosystémiques forestiers dans le Parc National de Lomami, au centre de la RDC. Les données ont été recueillies au cours de 24 groupes de discussion avec les anciens du village, quatre pour chaque groupe ethnique étudié. Une variation considérable des espèces d'arbres préférées a été observée: sur les 89 morpho–espèces citées au total, seules deux ont été citées par tous les groupes ethniques pour le même usage. L'ethnicité a également affecté l'identification et le classement par importance des services écosystémiques forestiers. Les Mbote ont priorisé la viande de brousse, le miel et l'identité, tandis que les groupes d'agriculteurs ont priorisé la viande de brousse, le poisson et la régulation du microclimat. Nous discutons des implications de ces résultats pour la gestion forestière dans la zone tampon du parc national.

Mots-clés: Évaluation socioculturelle, Forêt tropicale, Utilisation des forêts, Services écosystémiques, Communautés locales

Introduction

The forests of the Congo Basin, the second largest block of tropical forests after the Amazon, provide numerous goods and services, contributing to the livelihoods of more than 60 million people (de Wasseige et al. 2015). Forest–edge communities, dependent on tropical forests for their livelihoods, often hold great ethnobotanical knowledge, which can contribute towards forest conservation. For example, in the Bolivian Amazon, Tsimane' people who have greater traditional ecological knowledge (TEK, which includes ethnobotanical knowledge) can use the forest in a larger number of ways and are therefore less prone to cut it, and villages with greater TEK have a greater maintenance of traditional institutions that may be better suited to foster sustainable forest management (Paneque-Gálvez et al. 2018).

Several factors affect local communities' ethnobotanical knowledge, socio–cultural values (i.e., social needs, perceptions, and preferences towards nature) related to ethnicity being an important one (e.g., Assogbadjo et al. 2012; Sop et al. 2012; Yogom et al. 2020). We understand socio–cultural values as a type of assigned value as defined by Lockwood (1999), which denotes those values that people attach to things, in this case, to nature. For a review of socio–cultural values see Kenter et al. (2019). A recent study on use and management practices of bitter kola (*Garcinia kola* Heckel) by six different ethnic groups in Cameroon showed that ethnic groups used different plant parts (seeds, bark, roots) and harvesting techniques, some of which were unsustainable (uprooting, felling trees) (Yogom et al. 2020). However, how ethnicity affects the use and value of forest ecosystem services has been less studied, particularly in the Congo Basin, with only two studies available from Cameroon (Carson et al. 2018; Lhoest et al. 2020) and one from the Democratic Republic of the Congo (hereafter DRC) (Cuni-Sanchez et al. 2019a). In the latter study, it was shown that Twa hunter–gatherers identified more food–provisioning forest ecosystem services than farmer ethnic groups, and that Twa ranked bushmeat and honey as the most important forest ecosystem service, while farmer ethnic groups ranked micro–climate regulation as most important (Cuni-Sanchez et al. 2019a).

Ecosystem services (hereafter ES) are defined as the ecological characteristics, functions, or processes that directly or indirectly contribute to human wellbeing (Costanza et al. 2017; MEA 2005). ES are generally grouped into provisioning (e.g., timber, food, medicine), regulating (e.g., of local climate), supporting (e.g., soil formation), and cultural services (e.g., identity)

(MEA 2005). Understanding how different stakeholders use and value forest ES is of key importance for ecosystem management, including the design of effective forest conservation interventions, since willingness to conserve one ES might be at the expense of another (e.g., Kari and Korhonen-Kurki 2013).

In ES assessments, local communities are often aggregated into one stakeholder group called "locals dependent on provisioning services" (Iniesta-Arandia et al. 2014), a group often considered as homogenous (e.g., Kari and Korhonen-Kurki 2013). However, some authors have highlighted that this group must be seen as an assembly of subcultures with different livelihood practices, social institutions, values, identities, and/or interrelationships (Lakerveld et al. 2015). This "heterogeneous" group might have competing interests regarding forest ES, because of their livelihood strategy (e.g., Carson et al. 2018) or ethnicity (e.g., Lakerveld et al. 2015). In southeastern Cameroon, Baka hunter–gatherers identified a greater number of food provisioning forest ES than Bantu farmers (Carson et al. 2018).

Lomami National Park was created in July 2016 to protect a large patch of relatively intact tropical forest in central DRC. Surrounding the park's Core Zone, this park has a large Buffer Zone in which forest–edge communities are allowed to carry out certain extractive activities (including hunting) to satisfy their own needs (Mushagalusa-Batumike 2016). The Park provides habitat for threatened flagship species such as the forest elephant *Loxodonta africana cyclotis*, the bonobo *Pan paniscus*, the okapi *Okapia johnstoni*, the Congo peafowl *Afropavo congensis*, the recently discovered Dryas monkey *Cercopithecus dryas* (previously known from Salonga National Park only), and the newly described Lesula monkey *Cercopithecus lomamiensis* (endemic to this park) (ICCN 2012). Socio–cultural diversity around the park is high: Mbote hunter–gatherers co–exist with several farmer ethnic groups of Bantu origin (Batumike et al. 2021).

In order to inform the design of the management plan of the park Buffer Zone (being drafted as of 2020), we wanted to investigate if ethnicity affected local communities' uses and values of both tree species and forest ES. We also wanted to investigate if tree species of conservation concern were being used. Considering other studies on hunter–gatherers of the Congo Basin (Carson et al. 2018; Cuni-Sanchez et al. 2019a), we hypothesized that Mbote hunter–gathers would (i) recognize more useful tree species, (ii) identify a larger number of forest ES, and (iii) place higher value on cultural services than farmer ethnic groups. We compare our findings with previous work in the region and discuss the implications of our findings for forest conservation.

Methodology

Study Area

Lomami National Park has a core zone of about 8,800 km^2 and a buffer zone of about 20,000 km^2 (Fig. 1). Most of the park is covered by lowland tropical forests dominated by limbali (*Gilbertiodendron dewevrei* [De Wild.] J. Léonard), swamp forests, and savannas. The climate is equatorial, with a mean annual rainfall of 1,600 mm and mean monthly temperature of 23–26 °C (ICCN 2012). The dry season (June–July) lasts less than 2 months. The main inhabitants of the region are farmers of Bantu origin practicing small–scale slash–and–burn subsistence agriculture (cassava, maize, and rice), hunting and fishing; and Mbote (Pygmy) hunter–gatherers. Gold can be found in parts of the study area, and it is extracted in an artisanal way through panning in streams.

Village Surveys

We organized focus–group discussions (FGDs) in 24 villages located around the southern part of the park, which has more villages and is more accessible by road than the northern part of the park (Fig. 1). We organized FGDs in four different villages of each of the following ethnic groups: Mbote (hunter–gatherers), Kusu, Ngengele, Kuti, Silwamba, and Tetela (farmers). Kusu and Ngengele are two closely related ethnic groups, which speak the same language. Although some scholars consider the Kusu a tribe within the Ngengele ethnic group, we considered them separately (e.g., plant species' names differ). Each FGDs involved four to eight male village elders (over 60 years old) including

the village chief, as is customary in the area. After we explained the aim of the study to the village chief, he explained it to the elders, and some decided to participate on a voluntary basis. Free, prior, and informed consent was orally secured as all study participants were illiterate. None of the villages studied have access to electricity, running water, or mobile phone network. There are few primary schools and health centers in the region (often > 20 km apart). All inhabitants are extremely poor, including the chiefs and the elders. Access to Kindu town (largest urban center in the area) is limited to motorbike due to poor road infrastructure (see Fig. 1).

FGDs were facilitated and translated by a person of the same ethnicity of the village studied. There were no differences in the organization of the FGDs between villages. Discussions focused on: (i) selecting the three species they preferred for firewood, construction, edible fruits/seeds, and medicine, (ii) assessing the importance of the forest by listing the benefits it provides; and (iii) identifying the three most important benefits. The FGD facilitator guided the groups to reach consensus; e.g., if an FGD participant identified the ES "medicinal resources," other FGD participants were asked to agree if that service was provided by the forest or not. Therefore, important species and ES identified in a single FGD were considered to be a general opinion within that FGD. Participants identified forest benefits using their own terminology. These benefits were subsequently grouped according to the Millennium Ecosystem Assessment (MEA) classification of ES types and sub–categories (MEA 2005). For example, "the forest attracts rains" became microclimate regulation. For cultural services, we used the categories provided by Teff-Seker and Orenstein (2019). As these authors highlighted, subcategories reflect participants' emphases of various aspects of a given ES, and should not be perceived as exclusive, but rather as revealing of the nuances within ES. The study follows the same methodology and FGD guiding questionnaire used in Cuni-Sanchez et al. (2019a). The study underwent the ethical review process of the Biology Department, Université Officielle de Bukavu. Park managers were also informed of the methodology and FGD guiding questionnaire and agreed to the study.

Plant species' names mentioned in FDGs were related to scientific names as follows: for common timber trees (e.g., limbali), local names were matched with scientific names as available in the literature; but for non–timber species, a sample was collected and taken to the Herbarium of Yangambi for identification. Plant nomenclature follows the African plant database (https://www.ville–ge.ch). Some species are reported using their local name as their samples were sterile, of poor quality, and could not be identified. Note that this is the first botanical survey carried out in Lomami and no reference material is available in the Herbarium of Yangambi or elsewhere. For all species identified we checked their conservation status as reported in the IUCN Red List (http://www.iucnredlist.org).

To determine the effects of ethnicity on responses, the four villages of each ethnic group were pooled together (as these were mostly located in close vicinity, see Fig. 1). To compare the similarity between plant species mentioned in the different ethnic groups, we computed the Jaccard similarity coefficient (Jaccard 1901), defined as the size of the intersection divided by the size of the union of the sample sets:

$$J(A,B) = \frac{A \cap B}{A \cup B}$$

where A and B are the binary descriptions of species presence/absence in different ethnic groups. A value of 1 indicates complete similarity, whereas 0 indicates complete dissimilarity. We considered that the same morphospecies and usage had to be mentioned by two groups to consider this morphospecies as a shared one.

Results

Preferred Tree Species

Considerable variation in preferred species for edible fruits/seeds, medicine, construction, and firewood was observed, with 89 morphospecies cited in total by the different ethnic groups studied (see Electronic Supplementary Material [ESM] Table S1). The Mbote mentioned as many morphospecies as Ngengele and Tetela (30 in total, see ESM Table S1). While the Mbote mentioned a similar number of species for the

different categories, Ngengele cited fewer species for edible fruits (Fig. 2). Only two species were cited by all ethnic groups for the same usage: *Alstonia boonei* De Wild. (for medicine) and *Anonidium manni* (Oliv.) Engl. & Diels (edible fruits). Four other species were cited by five ethnic groups for the same usage: *Chrysophyllum lacourtianum* De Wild. and *Synsepalum stipulatum* (Radlk.) Engl. (edible fruits), *Gilbertiodendron dewevrei* (for construction of houses and bridges), and *Aphanocalyx microphyllus* (Harms) Wieringa for firewood (ESM Table S1). When comparing across groups, responses were more similar between Kuti and Mbote (J = 0.37) than by any other combination of ethnic groups (Table 1).

Very few species cited by respondents are light–demander species typically found in fallows or secondary forests (e.g., *Myrianthus arboreus* P. Beauv. See Okafor 2004). Five species mentioned were of conservation concern according to the IUCN Red List: *Autranella congolensis* (De Wild.) A. Chev. (CR, critically endangered), *Entandrophragma angolense* (Welw.) C. DC. (VU, vulnerable), *Garcinia kola* (VU), *Michelsonia microphylla* (Troupin) Hauman (VU), and *Milicia excelsa* (Welw.) C.C. Berg (NT, near threatened).

Forest Services

Overall, the ethnic groups studied identified between 13 (Mbote) and 19 (Ngengele and Kuti) forest ES (Table 2). All ethnic groups identified more provisioning than other categories of ES, with the Mbote not citing any regulating ES; and Tetela and Silwamba not citing any cultural ES (Fig. 3). All groups cited at least one supporting ES (habitat for biodiversity). The Mbote cited fewer ES than other groups because (i) they did not identify forest ES relevant to farming (e.g., soil formation, micro–climate regulation, pest control), and (ii) the forest foods they identified were also cited by some farmer groups (Table 2). Some differences were also observed among farmer groups; e.g., Tetela did not mention edible caterpillars (Table 2).

For all ethnic groups studied, the most important forest ES was a provisioning ES: bushmeat (Fig. 3), with comments such as "*wild animals give you both, strength* [in terms of health] *and money*" (Kuti participant). With regard to the second and third most important forest ES, clear differences were observed between the Mbote and farmers, but no differences were observed among farmer groups. Farmers cited a supporting (soil formation) and another provisioning ES (fish) as second and third most important forest ES, while the Mbote mentioned a provisioning one (honey) and a cultural one (identity). Mbote comments included "Honey is very important to us [the Mbote], it gives you lots of energy to walk in the forest" and "the forest is very important to our people, to who we are as [Mbote] people." Farmers mentioned, e.g., "the soil under the forest is very fertile, it is the best place to grow crops" (Kuti participant); "Forests give us good soils for our cassava, which is our main food" (Ngengele participant); "fish is important, when we eat fish we are strong and healthy" (Kusu participant); "if you get good fish and sell it, you have money to buy other things" (Ngengele participant).

Table 1. Jaccard similarity coefficient (J) of morphospecies cited

	Kuti	Mbote	Ngengele	Tetela	Silwamba
Kusu	0.12	0.09	0.13	0.27	0.1
Kuti		0.37	0.22	0.1	0.26
Mbote			0.18	0.11	0.23
Ngengele				0.13	0.23
Tetetela					0.13

Discussion

Preferred Tree Species

A great diversity of preferred tree species for different uses was observed; of the 89 morphospecies cited, only six were mentioned for the same usage across ethnic groups. While part of these differences in preferred species could be related to some species being more abundant where each ethnic group is located (people generally use and value trees that are abundant (e.g., Lucena et al. 2007; Thomas et al. 2009), divergent ethnobotanical knowledge and cultures is also likely to play a role. In Kahuzi-Biega National Park in eastern DRC, the Jaccard indices of preferred tree species among

Table 2. Most important forest ecosystem services (ES) and all ES mentioned in the focus–group discussions (FGDs)

		Examples of local definitions of ES	No FGDs	Ethnic groups
Most important ES	Bushmeat (first)	Wild animals give you both, strength [health] and money	22	All
	Soil formation (second)	The soil under the forest is very fertile, it is the best place to grow crops	19	KU, KT, N, S, T
	Honey (second)	Honey is very important to us [the Mbote], it gives you lots of energy to walk in the forest	4	M
	Fish (third)	When we eat fish we are strong and healthy	17	KU, KT, N, S, T
	Identity (third)	The forest is very important to our people, to who we are as [Mbote] people	4	M
Provisioning	Water	The forest gives us fresh water	17	All
	Timber	There are big trees we use to make bridges	17	KU, KT, N, S, T
	Poles for construction		23	All
	Firewood	You can get sticks for cooking	14	All
	Charcoal		7	KT, N, T
	Bush meat	There are many wild animals we can eat in the forest	24	All
	Caterpillars, mushrooms	There are some tasty mushrooms which can only be found in the forest	12	KU, KT, M, N, S
	Fish	There is lots of fish in the streams in the forest	21	All
	Honey	There is sweet natural honey in the forest we collect	6	KU, M
	Wild fruits	The forest has many edible fruits	22	All
	Medicinal resources	The forest is like our pharmacy	23	All
	Baskets, ropes, etc	There are natural ropes in the forest	20	All
	Minerals	There is gold in the forest	3	KT, N, S
Regulating	Micro–climate regulation	The forest attracts the rains	7	KU, N, T
	Air purification	The forest gives clean air	17	KU, KT, N, S, T
Supporting	Soil formation	The forest has good soil for cassava	19	KU, KT, N, S, T
	Disease regulation (pests)	If your farm is near the forest your cassava has less pests	1	T
	Habitat for biodiversity	The forest is the home of many animals	16	All
Cultural	Recreation	It is nice to walk in the forest	1	KU
	Aesthetics	The forest is just beautiful	1	N
	Ceremonies	There are many ceremonies which can only be done in the forest	5	KU, KT, M, N
	Identity	The forest is very important to our people, to who we are as [Mbote] people	5	M, N

Four FGDs were organized per ethnic group

KU Kuti, *KS* Kusu, *M* Mbote, *N* Ngengele, *S* Silwamba, *T* Tetela

ethnic groups were also quite low (< 0.25, Cuni-Sanchez et al. 2019a), the highest we obtained in this study being J = 0.37.

We hypothesized that the Mbote would cite more morphospecies as important for provisioning services, but they cited as many species as two farmer ethnic groups. The Mbote and Kuti were the two groups with most shared morphospecies mentioned (J = 0.37), which was rather unexpected. The Mbote villages studied are located next to the Kuti villages (Fig. 1). Apart from accessing parts of the forest with similar floristic composition, they might have shared ethnobotanical knowledge as sometimes they use the same local name (ESM Table S1). In spite of this, it is possible that if more morphospecies were identified, or local names were investigated in more detail, the Jaccard indices changed slightly. Sometimes, one local name can refer to both a specific species and several similar–looking species of the same genus. For example, the Baka hunter–gatherers of Cameroon use "payo" for referring to *Irvingia excelsa* Mildbr. and other *Irvingia* spp. (Gallois et al. 2020). Apart from identifying the morphospecies we were not able to identify, future work should consider investigating local names in greater detail. Greater availability of botanical reference material (e.g., if there is only one or more *Irvingia* spp. in this park) is also needed to be able to disentangle the details of local names.

Overall, our work on preferred tree species highlights two important points. First, that the forest in the Buffer Zone is rather pristine: species from secondary forests were not cited, and high–value timber species (e.g., *Autranella congolensis, Entandrophragma* spp., and *Milicia excelsa)* were mentioned to be used for house and bridge construction—high value timber species in international markets are rarely used for local uses, this happens where they have never been commercially exploited. Indeed, vegetation surveys using temporary plots in the Lomami Buffer Zone confirmed that this is the case (Batumike et al. in review). This situation is different in other studies: in Kahuzi-Biega National Park (DRC) and Kibira National Park (Burundi), several species from secondary forests (e.g., *Macaranga* spp. and *Polyscias fulva* [Hiern] Harms) were cited (Cuni-Sanchez et al. 2019a; Ndayizeye et al. 2020).

Secondly, some species of conservation concern are being used by local communities, not just at the household level, but also for trade. Apart from being cited in the FGDs (see ESM Table S1), preliminary observations in Kindu markets indicate that the bark of *Alstonia boonei* is sold to treat diarrhea and anemia, the bark of *Autranella congolensis* and *Milicia excelsa* are sold to treat hemorrhoids, and the seeds of *Garcinia kola* are sold to treat stomach pain and as sexual stimulant (vendors mentioned that these species are collected in Lomami). To determine if these species require management interventions within the park Buffer Zone, further research on harvesting techniques and volumes harvested, as well as on population density and structure, are needed. Slow growing, old–growth forest species that occur in low densities are particularly vulnerable to overharvesting (Peters 1996). *Autranella congolensis,* for instance, is known to occur mostly at very low densities (Lemmens 2007).

Apart from showing which species might be at risk, ethnobotanical research on preferred trees can help identify which species can be further promoted to help diversity income–generation for forest–edge communities. When road infrastructure is poor and transportation costs are high, it is preferred to promote the trade of forest products that have high price per kilo (Jusu and Cuni-Sanchez 2013). Medicinal plants and wild fruits/seeds already traded in markets in Kindu and Kisangani (two large cities around Lomami) might be good candidates. The preferred edible fruits mentioned in this study (*Annonidium mannii*, *Chrysophyllum lacourtianum*, and *Synsepalum stipulatum*) are traded in the urban market of Kisangani (Termote et al. 2012). If sustainably harvested, these fruits could become a source of income for these forest–edge communities, as, for example, *Irvingia* species trade is for the Baka people in Cameroon (Gallois et al. 2020). First, however, information is needed on species' abundance, population structure, and harvesting techniques used.

Forest Services

We had hypothesized that important differences in the identification of forest ES related to ethnic group would be observed, which we found was the case. However, differences between the

Mbote and farmer ethnic groups were not as marked as in other parts of the Congo Basin. The Mbote responses—identifying numerous forest foods, placing bushmeat, honey and identity as most important forest ES—agreed with their livelihood strategy (hunter–gathering) and with the literature (Cuni-Sanchez et al. 2019a; Ndayizeye et al. 2020). What differed from our expectations based on the literature, were farmers' responses.

In Lomami, all five farmer ethnic groups cited bushmeat as the most important forest ES, which was not the case in other parts of DRC, Burundi, or Cameroon (Cuni-Sanchez et al. 2019a, b; Ndayizeye et al. 2020). In Lomami, all farmer groups also mentioned wild fruits and fish from streams in the forest, and most (except Tetela) also cited edible caterpillars and mushrooms. Respondents mentioned that they consume these forest foods often and that they are important for their food security and nutrition. This is different from Kibiria National Park in Burundi, for example, where farmers only use forest foods when crops fail (Ndayizeye et al. 2020). It should be noted that in Lomami, bushmeat is also traded to the urban center of Kindu, being an important—often the only—source of income to local communities (Batumike et al. 2021), as poor road infrastructure limits the trade of agricultural products or timber. Both uses (food security and source of income) contributed to place this forest ES as the most important among both the Mbote and farmer ethnic groups.

After bushmeat, a clear distinction between the Mbote and farmer groups was observed for the second and third most important forest ES. The Mbote cited honey and identity, as hunter–gatherers did in Kahuzi-Biega in DRC (Cuni-Sanchez et al. 2019a). Honey is also a staple food for hunter–gatherers in the Congo Basin, and identity refers to the connection hunter–gatherers have with "their forest." Although three farmer ethnic groups mentioned sacred sites in the forest, their spiritual connection with the forest was not as strong, as only Ngengele mentioned identity links with the forest. The Mbote relationship with the forest was seen as a reciprocal one: the forest takes care of humans (it provides many benefits), but the humans have the duty of taking care of the forest. The same view was reported for Twa hunter–gatherers in eastern DRC and Burundi (Cuni-Sanchez et al. 2019a; Ndayizeye et al. 2020). This is similar to the "Mother Earth" perception of indigenous people elsewhere (see Díaz et al. 2015 and references therein). Cultural values of forests are frequently considered more important for sustainable forest conservation than many provisioning services, especially for populations whose cultural identity is intimately linked to forests (Farber et al. 2002). Importantly, most assessments of ES in DRC that investigated cultural ES only included tourism (e.g., Kasangaki et al. 2012; Willemen et al. 2013). A recent assessment on ES as perceived by Baka hunter–gatherers and Bantu farmers around Dja Biosphere Reserve in Cameroon (Lhoest et al. 2020) considered five cultural ES, including cultural heritage, but it did not explore "identity" links with the forest. Clearly, more research should consider the broad spectrum of cultural services tropical forests can provide to people.

All farmer groups studied cited soil formation as the second most important forest ES. Respondents explained that when clearing land for farming (they practice slash–and–burn agriculture), they prefer to clear old–growth forest land (rather than young or old fallows) because they consider that the soil is more fertile underneath old–growth forests. Soil formation was also identified as first or second most important forest ES by other ethnic groups in DRC (Cuni-Sanchez et al. 2019a). Some authors (e.g., Lhoest et al. 2020) suggest focusing on provisioning and cultural services when studying the stakeholder group "locals dependent on provisioning ES." Our research shows that regulating or supporting ES can also be very important to local communities.

Apart from the differences between the Mbote and farmers, differences were also observed among farmer ethnic groups: remarkably Tetela and Silwamba did not identify any cultural ES. For the Tetela, this might be explained by their status of "foreigners." The Tetela ancestral lands are found further south, but they settled around Lomami in the past few decades attracted by the high abundance of wildlife and potential of being involved in the commercialization of bushmeat (participants' comments during FGDs; also see Batumike et al. 2021). Moreover, Tetela did not mention caterpillars or mushrooms as forest ES; it may be that they might not know which

species are edible, or maybe cultural taboos prevent Tetela from eating them. For the Silwamba it is unclear if they showed a stronger cultural attachment with Lomami forest in the past—and it has now been weakened—or if their culture never showed such an attachment.

We show that the Lomami forest is crucial for the nutrition and health of the communities living around it, not just for the Mbote hunter–gatherers. As food items and medicinal plants can be gathered in the park's Buffer Zone, it can be argued that the creation of the park has not affected local communities' access to these vital resources. However, the creation of the park negatively affected access to one important forest resource: space for ceremonies. Four of the six ethnic groups studied highlighted that they perform ceremonies in the forest, and that some ceremonies can only be performed at certain locations, which for some villages happen to be now located in the park Core Zone (participants' comments). Given that only a few male elders (the guardians of the tradition) must access these locations to perform such ceremonies, an agreement could potentially be reached with the park staff so that these community members can access these sacred sites. This situation is not widespread, but it is a major concern in the villages where this happens.

Most ES mentioned in this study have been mentioned in other studies on forest ES in Africa (e.g., Byg et al. 2017; Dave et al. 2017; Guerbois and Fritz 2017; Hartter and Goldman 2011; Ward et al. 2018), with the exception of minerals. Minerals were only identified in the Nyungwe Forest in Rwanda, where gold is extracted in an artisanal way (Dawson and Martin 2015), as it is done in our study area. Remarkably, the Mbote did not mention minerals as a forest ES; their traditional beliefs forbid them from extracting mineral resources.

We should acknowledge that our study approach has two important limitations: we only investigated the views of elders and those of males. Several authors have reported that elders have greater ethnobotanical knowledge and that they identify more forest ES than younger people (e.g., Scholte et al. 2015; Sodhi et al. 2010). Although the remoteness of the study area (e.g., no phone coverage, limited road infrastructure, little emigration) suggests that different generations hold similar traditional ecological knowledge, future work should consider the views of younger generations. The effects of gender should also be considered in ES assessments (Cruz-Garcia et al. 2019; Yang et al. 2018). In the Colombian Amazon, indigenous men and women identify a similar number of forest ES, but they identify some different ES and have different criteria for valuing ES importance (Cruz-Garcia et al. 2019). In our study area, as males spend considerably more time in the forest than females because of hunting, it is likely that they identify more forest ES and have more knowledge of medicinal plants and edible fruits. However, future work should confirm if this is the case.

Implications of the Findings and Conclusions

Our relatively rapid assessment approach has proven useful for showing that in Lomami, "locals that dependent on forest provisioning services" are not a homogeneous group. Ethnicity affects the use and value of tree species and forest services. Our assessment also showed that the forest in the Buffer Zone is relatively pristine, and that some species traded could be further promoted to help diversify the livelihood strategies of these communities. First, though, further research is needed on available stock and harvesting techniques. Further research is also needed for the six species of conservation concern mentioned by study participants. Remarkably, four farmer groups showed cultural links with the forest, and these cultural values could be used to promote forest conservation. Park managers in DRC, and elsewhere, should consider the numerous cultural values that protected areas provide to local communities beyond tourism, and how these may be capitalized to help conserve and sustainably manage them.

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Declarations

Conflict of interest The authors have declared that no competing interests exist.

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