Empty forests, empty stomachs? Bushmeat and livelihoods in the Congo and Amazon Basins

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SUMMARY

Protein from forest wildlife is crucial to rural food security and livelihoods across the tropics. The harvest of animals such as tapir, duikers, deer, pigs, peccaries, primates and larger rodents, birds and reptiles provides benefits to local people worth millions of US$ annually and represents around 6 million tonnes of animals extracted yearly. Vulnerability to hunting varies, with some species sustaining populations in heavily hunted secondary habitats, while others require intact forests with minimal harvesting to maintain healthy populations. Some species or groups have been characterized as ecosystem engineers and ecological keystone species. They affect plant distribution and structure ecosystems, through seed dispersal and predation, grazing, browsing, rooting and other mechanisms. Global attention has been drawn to their loss through debates regarding bushmeat, the "empty forest" syndrome and their ecological importance. However, information on the harvest remains fragmentary, along with understanding of ecological, socioeconomic and cultural dimensions. Here we assess the consequences, both for ecosystems and local livelihoods, of the loss of these species in the Amazon and Congo basins.

Keywords: bushmeat, livelihoods, forest, Amazon, Congo

Forêts vides, estomacs vides? Viande de brousse et condition de vie dans les bassins du Congo et de l'Amazone.

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Les protéines tirées de la faune sauvage sont cruciales pour la sécurité alimentaire et les conditions de vie des populations tropicales. Le prélèvement d'animaux comme tapirs, céphalophes, cochons sauvages, pécaris, primates, gros rongeurs, oiseaux et reptiles représente des bénéfices valant plusieurs millions de US$ par an et approximativement 6 millions tonnes extraites annuellement. La vulnérabilité vis-à-vis de la chasse varie avec certaines espèces qui se maintiennent dans des zones très chassées ou secondarisées et d'autres qui nécessitent des forêts intactes et des prélèvement minimaux pour maintenir des populations viables. Certaines des espèces chassées sont considérées comme des espèces clé de voute, sortes "d'ingénieurs" des écosystèmes. Elles jouent un rôle primordial dans la distribution des plantes et la structure des écosystèmes au travers de la dispersion ou la prédation des semences, le broutage, la pollinisation, etc. Leur perte est l'objet de l'attention générale au travers des débats sur la crise de la viande de brousse, le syndrome des "forêts vides" et leur importance écologique. Cependant les informations sur la récolte restent fragmentaires, de même que notre compréhension de ses dimensions écologiques, socio-économiques et culturelles. Dans ce texte nous évaluons les conséquences, pour les écosystèmes et les conditions de vie locales, de la perte de ces espèces dans les bassins de l'Amazone et du Congo.

¿Bosques vacíos, estómagos vacíos? Caza y medios de subsistencia en las cuencas del Congo y el Amazonas

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La proteína obtenida de la fauna salvaje del bosque es crucial para la seguridad alimentaria en zonas rurales y para los medios de subsistencia en los trópicos. La explotación cinegética de animales como el tapir, duiker, cerdo salvaje, pecarí, primates, grandes roedores, aves y reptiles, aporta millones de dólares anuales en ingresos a las comunidades locales y representa un total de 6 millones de toneladas de animales aprovechados anualmente. La vulnerabilidad a la actividad de la caza varía con la especie: algunas mantienen sus poblaciones en hábitats secundarios intensamente explotados mientras que otras requieren bosques intactos y una presión cinegética mínima para poder mantener poblaciones saludables. Algunas especies o grupos han sido caracterizadas como ingenieras de ecosistemas y especies clave ("*keystone*") ecológicamente hablando ya que afectan a la distribución de especies vegetales y estructuran ecosistemas por dispersión y predación de semillas, herbivoría, ramoneo, al alimentarse de raíces o por otros mecanismos. Globalmente se ha prestado mucha atención a la pérdida de estas especies en debates relacionados con la caza en el bosque, el "síndrome del bosque vacío" y su importancia ecológica. Sin embargo, la información en cuanto a su aprovechamiento se encuentra fragmentada, junto con la comprensión de sus dimensiones ecológicas, socio-económicas y culturales. En este artículo evaluamos las consecuencias que tiene la pérdida de estas especies en los ecosistemas y los medios de subsistencia locales de las cuencas del Congo y el Amazonas.

INTRODUCTION

There is ample and diverse evidence (see Nasi *et al.* 2008 for a review) that the scale of current hunting is a serious threat to many forest species and ecosystems in the Amazon and Congo Basin, the two largest and least populated dense forest areas of the world. In two seminal pieces using data from the end of the 1990's, Fa and Peres (2001) and Fa *et al.* 2002, concluded that "*over 5 million tons of meat feed millions in Neotropical (0.15 million tons) forests and Afrotropical (4.9 million tons) forests annually*". Local extirpation of hunted species is widespread, with West and Central Africa particularly hard hit (Milner-Gulland *et al.* 2003).

Despite this evidence and increased international attention, more than ten years later information on the bushmeat harvest and trade is still fragmentary and our understanding of the complex interactions between ecological, socio-economic and cultural dimensions of the issue remains limited. Studies are frequently limited to single sites, using a multiplicity of research approaches, limiting prospects for comparisons. Further, results are frequently disseminated in unpublished reports or peer-reviewed articles that are not easily accessible to key audiences. As a result, governments and other stakeholders have limited objective information at national and regional levels to inform and support policy or management decisions.

The present synthesis aims to draw renewed attention to the ecological and livelihood impacts of defaunation by updating and contrasting relevant information from both the Amazon and Congo Basins. We first provide an overview of the ecological consequences of overhunting. Then we analyse the impacts in terms of food security and local livelihoods. We conclude by pointing to key actions needed to fill information gaps and set the use of wildlife in these two regions on a more sustainable course.

HUNTED SPECIES AND ECOLOGICAL IMPACTS OF UNSUSTAINABLE HUNTING

Composition of the catch

In both basins a wide variety of taxa are hunted for food. In Gabon alone, 114 species have been recorded in hunter catches, household consumption and markets (Abernethy and Ndong Obiang 2010). In Latin America over 200 species of mammals, *ca.* 750 bird species (including over 530 species for the pet trade), more than 60 species of reptiles and a minimum of 5 species of amphibians have been registered as harvested for household consumption and for markets (Ojasti 2000). Mammals make up the bulk of the catches both in number and biomass terms, with ungulates and rodents representing more than two thirds of the carcasses sold in urban markets or recorded from hunter off takes in both Congo and Amazon Basin (Table 1).

In both basins medium-sized species between 2 and 50 kg are the most frequently hunted, though hunters will not shy from killing larger taxa when encountered (e.g., tapirs, wild pigs, forest buffalo, large antelopes, great apes). Monkeys are hunted in large numbers in some areas but because of their generally small body size they usually represent a small part of the harvested biomass. Brush-tailed porcupine *(Atherurus africanus),* pouched rat (*Cricetomys eminii*), blue (*Cephalophus monticola*) and red duikers (other *Cephalophus* spp.), represent the majority of the catch in the Congo Basin with blue duikers alone accounting often for about a third of the harvest (Kümpel 2006a, van Vliet 2008). Similarly, in the Amazon Basin, large rodents (*Dasyprocta* spp. and *Cunniculus paca*) and medium-sized ungulates such as brocket deer (*Mazama* spp.) and peccaries (*Tayassu pecari* and *Pecari tajacu*. 12–45 kg) typically make up the bulk of the harvest, although the hunting of a few tapir (*ca.* 200 kg) can be very important in biomass terms (Bodmer and Lozano 2001, Bodmer *et al.* 2004, Ojasti 2000, Peres 2000b, Robinson and Bennett 2000).

Differing hunting methods target particular species in both basins. Rifles and shotguns are typically used for larger animals and arboreal species (Coad 2007, Kümpel 2006a, van Vliet 2008), although some native people still use blow pipes and or bows and arrows where constrained by the availability of fire arms and the cost of ammunition. Dogs are frequently used to find and corner prey (Noss *et al.* 2004). Netting and trapping were traditionally carried out using a variety of specialized techniques (Dounias 1999, Smith 2010); but the use of steel wire snares is now prominent in Africa, although often "illegal", as the material is inexpensive, durable and strong enough to capture large animals. Steel leg hold traps have been used extensively to hunt furbearers such as ocelots and jaguars (Swank and Teer 1989). Hunting in high forest with snares and traps appears more frequent in the Congo Basin, but in both basins "garden hunting" is common using traps for relatively small game (mainly rodents) to protect farming plots (Naughton-Treves *et al.* 2003, Smith 2005).

The majority of mammal species (70%) hunted in the Congo Basin is not listed as threatened on the IUCN Red List of Threatened Species. Average extraction rates calculated for African forest mammals within each Red List category indicate that non-threatened species have the highest extraction rates. In Gabon, 23 of the partially protected species and 24 of the totally protected species were found to be used as bushmeat, but rare and vulnerable species such as great apes and elephants usually represent a small proportion (often less than 5%) of the total catch (Abernethy and Ndong Obiang 2010, van Vliet and Mbazza 2011). The situation in the Amazon Basin is similar with 19 of 30 commonly hunted prey species not being listed in any of the threatened categories of the IUCN Red List (Vulnerable or Endangered), while a further four are data deficient. This contrasts with the 21% of all mammal species which are considered threatened globally (IUCN 2008). This should however be qualified by the fact that where overhunting has occurred over long periods, larger and more vulnerable species (often endangered) have already disappeared with smaller, generally non-threatened species, becoming prevalent in the harvest (Altrichter 2006, Bennett and Robinson 2000, Cowlishaw *et al.* 2005, Stearman 2000).

TABLE 1 *Percentage of carcasses from ungulates, primates, rodents and other species in different hunting sites in the Congo and Amazon Basins (including some tropical forests sites from elsewhere in Latin America)*

Country	Location	Ungulates	Primates	Rodents	Other	Source
		CONGO				
DRC	Ituri forest	60–95	5–40	1	1	Hart 2000b
Gabon	Makokou	58	19	14	9	Lahm 1993
	Dibouka, Baniati	51.3	10.6	31		Starkey 2004
	Dibouka, Kouagna	27	8.3	48.7		Coad 2007
	Ntsiete	65	23.5	9		van Vliet 2008
Congo	Diba, Congo	70	17	9	4	Delvingt *et al.* 1997
	Oleme, Congo	62	38			Gally and Jeanmart 1996
	Ndoki and Ngatongo	81–87	11–16	2–3		Auzel and Wilkie 2000
CAR	Dzanga-Sangha	77–86	0	11–12	2–12	Noss 1995
Equatorial Guinea	Bioko and Rio Muni	36–43	23–25	31–37	2–4	Fa *et al.* 1995
	Sendje	30	18	32		Fa and Yuste 2001
	Sendje	35	16	43		Kümpel 2006b
Cameroon	Dja	88	3	5	4	Dethier 1995
	Ekim	85	4	6	5	Delvingt *et al.* 1997
	Ekom	87	1	6	6	Ngnegueu and Fotso 1996
		AMAZON				
Guyana	Rupununi Region	32		27		Read *et al.* 2010
Brazil	Japuaranã, Nova Bandeirantes, Brazil	72		12	16	Trinca and Ferrari 2007
	Agrovila Nova Fronteira, Para	56	1	15	28	Smith 1976
	Agrovila Leonardo da Vinci, Para	61	0	18	20	Smith 1976
	Agrovila Coco Chato, Para	6	1	51	42	Smith 1976
Latin America	Native Americans - 7 communities	25	23	26	26	Ojasti 1996
Latin America	Colonists - 6 communities	50	9	24	16	Ojasti 1996

Impacts on hunted populations

Hunting (like other human extractive activities in tropical forests) is, depending on the scale, a disruptive process. It can and does trigger numerous indirect effects, which in turn alter both (i) the hunted populations and (ii) the functioning, structure and composition of the ecosystem (Nasi *et al.* 2010).

Empirical studies in both basins show that population densities are lower in hunted versus un-hunted areas, implying a potential decline in stocks (Table 2). Not all species respond equally to hunting pressure. This is especially the case because central place foragers typically deplete large bodied species close to their base camps. As a result a common trend is to see the density of large bodied species increasing with distance from hunter settlements.

Some taxa appear highly vulnerable while others seem unaffected, and populations of a few taxa may even be enhanced by hunting (Bodmer *et al.* 1997, Cullen *et al.* 2000, Hurtado-Gonzales and Bodmer 2004, Isaac and Cowlishaw 2004, Salas and Kim 2002) – typically as a function of their ecological adaptability and population biology. Irrespective of the region, larger-bodied longer-lived species with low intrinsic rates of population increase, such as apes, other large primates, carnivores and antelopes as well as tapirs, buffaloes or elephants are less resistant to intensive hunting than species with high intrinsic rates of population increase such as rodents or small- to medium-sized ungulates (Robinson and Redford 1991). Primates and large carnivores appear extremely vulnerable and their populations plummet with intense hunting (Henschel 2009, Oates 1996). Hunting is the major cause for a reported 50% decline in apes in Gabon within two decades (Walsh *et al.* 2003). Hunted populations of Black colobus (*Colobus satanas*) in the Congo Basin, spider (*Ateles* sp.) and Woolly monkeys (*Lagothrix* sp.) in the Amazon basin have declined precipitously (Bodmer *et al.* 1994, Kümpel *et al.* 2010a, Robinson and Redford 1994).

In areas where larger species have been significantly depressed, the abundance of small and medium-sized species can remain unaffected or even increase. For example, in

TABLE 2 *Decrease in population densities in hunted areas compared to unhunted areas. Modified from Nasi et al. 2008*

Country	Location	Percentage by which mammal densities are lower in moderately to heavily hunted forests than in un-hunted forest	Reference
		AMAZON	
Brazil	23 Amazonian sites	80.8	Peres 2000b
Ecuador	Quehueiri-ono	35.3	Mena *et al.* 2000
Paraguay	Mbaracayu	53.0	Hill and Padwe 2000
Paraguay	Mbaracayu	0 to 40	Hill *et al.* 2003
Brazil	Mata de Planalto	27 to 69	Cullen *et al.* 2000
		CONGO	
D.R. of Congo	Ituri I	42.1	Hart 2000
D.R. of Congo	Ituri II	12.9	Hart 2000
C. African Republic	Mossapoula	43.9	Noss 2000
Gabon	Makokou	43.0 to 100	Lahm 2001

Gabon, the small Blue duiker is significantly less abundant in remote forests within the boundaries of the Ivindo National Park than in hunted areas with similar vegetation cover close to the town of Makokou, while the larger Peter's (*Cephalophus callipygus*) and Bay duiker (*C. dorsalis*) are less abundant or even depleted (van Vliet 2008, van Vliet *et al.* 2007). Similar patterns have been recorded in the Amazon with declining White-lipped peccary (*Tayassu pecari*) populations being accompanied by increasing density and larger group sizes for Collared peccaries (*Pecari tajacu)* (Fragoso 1994). This is highly suggestive of density compensation (Peres and Dolman 2000) processes where the abundance of resilient species rises if their more vulnerable competitors for resources (space, food, etc.) are removed. Source-sink effects (Novaro *et al.* 2000, Salas and Kim 2002), spatial heterogeneity (Kümpel *et al.* 2010a, van Vliet *et al.* 2010a) or high dispersal (Hart 2000a) can also help maintain populations in hunted areas, masking or compensating for hunting driven population decline.

Impacts on ecosystems

The loss of wildlife from forest ecosystems can lead to the disruption of ecological and evolutionary processes, changes in species composition within ecosystems and probably a general reduction in biological diversity (Emmons 1989, Redford 1992) creating "Empty Forests". Most ecosystem processes are driven by the combined activities of many species. Plant regeneration (affected by pollinators, seed dispersers and predators) and plant diversity (affected by a change in herbivory patterns or pest increase) are often dependent upon the presence of specific species or groups of species (Beck 2006, 2008, Keuroghlian and Eaton 2009, Nuñez Iturri and Howe 2007, Terborgh *et al.* 2008, Vanthomme *et al.* 2010, Wright *et al.* 2007b). Reviews and discussion on ecological impacts of defaunation in general are covered elsewhere (Bennett and Robinson 2000, Şekercioğlu *et al.* 2004, Stoner *et al.* 2007, Wright 2003, Wright *et al.* 2007b).

The disappearance, or even extreme reduction, of populations of 'keystone species', 'ecosystem engineers', or other species or groups of importance in ecological communities is expected to have a disproportionate impact on the ecosystem compared to the loss of other species (Campos-Arceiz and Blake 2011, Fragoso 1997, Keuroghlian and Eaton 2009). Hunters preferentially target large animals whenever they are available and these are often keystone species. Top predators (e.g. large cats, raptors, crocodiles) impact biodiversity by providing resources that would otherwise be scarcely available to other species (e.g. carrion) or by initiating trophic cascades (Sergio *et al.* 2008, Terborgh 2010). Local extinction of these predators can trigger major changes in prey populations, which in turn can dramatically alter browsing or grazing by herbivorous species to the point where large regime shifts or ecosystem collapse happen. Elephants (Campos-Arceiz and Blake 2011), but also ungulates such as tapirs and peccaries (Beck 2006, Fragoso 1997, Keuroghlian and Eaton 2009), can play major roles in modifying vegetation structure, composition and dynamic through their feeding habits and movements in the forest. Tapirs, peccaries, wild pigs, deer, duikers and the larger rodents are among the most active seed dispersers or predators; thus a significant change in their population densities will have a major effect on seedling survival and forest regeneration (Beck 2005, Bodmer 1991, Fragoso 1997).

BUSHMEAT IN LOCAL PEOPLE'S LIVELIHOODS

The importance of bushmeat in the diets of rural and urban populations

Bushmeat consumption by rural and urban populations

Bushmeat consumption by rural communities has been reported in a number of studies (Table 3) for the two basins. Rigorous comparison across sites is not possible as ratios are

TABLE 3 *Average daily wild meat consumption (kg/person/year) in rural communities and indigenous people settlements*

Indigenous group (or site) and country	Annual consumption of bushmeat based on deadweight (kg/person/year)	Source
	AMAZON	
Bari, Colombia	35.8	Ojasti 1996
Cuiba, Colombia	191.6	Ojasti 1996
Jivaro, Peru and Ecuador	101.5	Ojasti 1996
Kainsang, Brazil	34.7	Ojasti 1996
Transamazon highway, Brazil	2.1–15.8	Smith 1976
Japuaranã, Nova Bandeirantes, Brazil	73	Trinca and Ferrari 2007
Sharanahua, Peru	99.6	Ojasti 1996
Shipibo, Peru	17.2	Ojasti 1996
Siona, Secova, Ecuador	74.8	Ojasti 1996
Trio, Suriname	47.5	Ojasti 1996
Sirino, Bolivia	79.9	Ojasti 1996
Yanomano, Venezuela	52.2	Ojasti 1996
Yékwana, Venezuela	58	Ojasti 1996
Yukpa, Venezuela	10.2	Ojasti 1996
	CONGO	
Ituri Forest, DRC	58.4	Bailey and Peacock1988
Ituri Forest, DRC	43.8	Aunger 1992
Ogoué Ivindo, Gabon	36.5–62.05	Lahm 1993
Mossapoula, CAR	18.3	Noss 1995
Dja Reserve, Cameroon; Ngotto CAR and Odzala National Park, Congo	29.2–58.4	Delvingt 1997
Campo Man Reserve	69.4	Dounias *et al.* 1995 reported in Dethier 1995
Mvae, Cameroon	67.0	Bahuchet and Ioveva 1999
Kola, Cameroon	79.0	
Northern Congo (forest villages)	33.0	Auzel 1997
Northern Congo (forestry camp)	53.0	
Badjoué, Cameroon	16.4–35.9	Delvingt *et al.* 2001
Azande, DRC	14.6	De Merode *et al.* 2004
Dibouka and Baniati villages, Gabon	97.8	Starkey 2004
Forest villages near Okondja, Gabon	94.9	
Coastal villages near Omboué, Gabon	18.3	

based on varying parameters (whole carcass, dressed, or boned-out weights; per capita or using Average Male Equivalents). The range of values does not seem, however, to differ significantly for the two basins: for the Amazon (average: 63 ± 25 kg/capita/year; range: 10–190 kg/capita/yr; n = 14) and for the Congo Basin (average: 51 ± 14kg/capita/year; range: 7–110 kg/capita/yr; n = 15).

Data on bushmeat consumption by urban dwellers is especially scarce for the Amazon Basin (see however the case of Iquitos in the following section). Rushton *et al*. (2005) consider urban bushmeat consumption in South America is negligible because of the existence of one of the most important livestock production systems in the world – but we would need some updated reviews to confirm anecdotal evidence. A relatively low percentage of the population consumes bushmeat (mostly indigenous and the smaller rural communities). When they become "richer" the non-indigenous people turn generally to alternative sources of protein. As South America has some of the most important livestock production systems (beef, pork and poultry) in the world the authors suggest that bushmeat is likely to be slowly replaced by domestic sources of protein: "*Bushmeat in South America is not of*

great importance in terms of either of the proportion of people in a population who eat bushmeat nor in terms of its contribution to the livestock and fisheries economy". Though the income elasticity of demand for bushmeat is still poorly understood, it seems that bushmeat in South America stops being an economic necessity as household income increases. Note also that Rushton *et al*. (2005) emphasize that though only a small percentage of people in South America consume bushmeat – they are typically the poorest and most marginalized. We note that for wealthier sectors of society bushmeat is harvested, sometimes heavily, for sports hunters (many hunting and fishing clubs in small towns across the Amazon) as well as a novelty food for tourists in high-end restaurants in the region. However, the volume and impact of these latter uses are essentially unstudied.

In the Congo Basin the situation is totally different and urban bushmeat consumption is significant. Chardonnet *et al*. (1995) report that urban populations in Gabon, DRC and CAR consumed on average 4.7 kg/person/year; consumption in Libreville (Gabon) is estimated at 7.2 kg/person/year (Wilkie *et al*. 2005), in Bangui (CAR) at 14.6 kg/person/year (Fargeot and Dieval 2000), in Mbanjock (Cameroon) at 2 kg/person/year, etc. Although urban bushmeat consumption per capita appears significantly lower than in rural areas according to most available studies, the contribution of urban areas to the overall bushmeat consumption is high and likely to become higher as the population of Central African countries becomes more urbanised. Given the very significant urban and rural consumption and the either inexistent (e.g. Gabon, DRC, Congo) or pretty limited (Cameroon, CAR) domestic livestock sector, bushmeat remains a crucial component of food security for the Congo Basin.

Using consumption data gathered in this work (Table 3) and updated population figures we can provide updated estimates of bushmeat consumption and wildlife extraction (considering a 0.7 meat/live animal ratio) for the Amazon and Congo Basins in 2010. Our estimates for the Amazon Basin are ten times higher than Fa *et al*. 2002 and similar for the Congo Basin. It would be very dangerous to jump to the conclusion that bushmeat consumption has increased in the Amazon and stabilized in the Congo Basin. Fa *et al*. (2002) estimates for the Amazon were very low, equating to a consumption of 35 g/capita/day, largely below any published data (even contradicting their own data). As for the Congo Basin, data (e.g. population) are notoriously unreliable and consumption patterns very variable.

We can reasonably estimate that our figures are of the right order of magnitude and that annually 6 million tonnes of wildlife in the two basins.

Reasons behind the consumption of bushmeat

In remote forest areas of Central Africa and the Amazon basin bushmeat is often the main source of animal protein available and plays an essential role in people's diets especially where livestock husbandry is not a feasible option and wild fish not available. Eating bushmeat is therefore a matter of survival with few if any alternatives. When wild fish is available it can outweigh the importance of bushmeat in the diet of forest dwellers (Rushton *et al.* 2005 in Peru or Wilkie *et al.* 2005 in Gabon). The consumption of fish and/or bushmeat seems to be closely linked to both availability and/or price of substitutes. Overall, people who depend on wild protein will substitute wild fish and wild meat for one another, depending on the price and availability of each. This means that a decline in one wild resource tends to drive up unsustainable exploitation of the other (Brashares *et al.* 2004). There are also incidences where fish is either or not preferred to bushmeat. This further complicates the understanding of the feedback loop between fish and meat catches (Nasi *et al.* 2008). The other possible wild substitute invertebrates, represents an important traditional habit and also, considering their nutritional composition, a substantial contribution to the human diet (Marconi *et al.* 2002, Vantomme *et al.* 2004) but they are generally seasonal and cannot fully substitute for meat and fish.

Unlike rural or forest dwellers, urban consumers usually have a choice of several sources of protein but may opt for bushmeat for a variety of reasons (e.g. cost, taste or preference) that vary between regions. In such context, bushmeat consumption level can vary according to variations in prices of alternative foods, such as fish (Wilkie *et al.* 2005). In several African cities, bushmeat is still the cheapest source of protein and represents a crucial source of meat for the poorest urban households. In Kisangani, Democratic Republic of Congo (DRC) and Bangui, Central African Republic (CAR), bushmeat is cheaper than many other alternative sources of protein (Fargeot 2010, van Vliet *et al.* in press) or essentially perceived as a 'lower cost' protein as it can be captured rather than purchased (Kümpel 2006a). By contrast, in large cities of Equatorial Guinea, Gabon and Cameroon, bushmeat is more of a luxury product. Although preferred for its taste, it is less frequently consumed than frozen mackerel, chicken or pork due to their lower cost (Kümpel *et al.* 2007, Abernethy and

TABLE 4 *Estimated bushmeat consumption and wildlife extraction in the two Basins in 2010*

Basin	Dense Forest (km^2)	Population (×1 000)		Consumption (tonne/meat/yr)			Extracted (tonne/yr)
		Rural	Urban	Rural	Urban	Total	
Amazon[1]	3 938 000	14 425	24 352	909 000	Negligible	909 000	1 299 000
Congo[2]	1 612 000	57 046	41 199	2 909 000	289 000	3 198 000	4 569 000

[1]: Environment Outlook in Amazonia – GEO Amazonia; UN Population Division databases
[2]: State of the Forest 2008; UN Population Division databases

Ndong Obiang 2010). Analysis of taste choices in Gabon indicated that consumers differentiate amongst bushmeat species and that wildlife cannot be treated as a generic food source (Knights 2008, Schenck *et al.* 2006). In Latin America, fruit eating species are preferred over folivores, the meat of which is frequently described as "sweet". These include primates of the genera *Ateles* and *Lagothrix*, rodents such as Agoutis and Pacas, and the tropical forest ungulates which tend to be more frugivorous than open country species.

We must finally recognize the cultural significance of bushmeat use, particularly for traditional indigenous peoples confronting major societal and socioeconomic change. In Gabon, bushmeat is associated with the village, with rituals and with ceremonies, such as men's circumcision ceremonies (Angoué *et al.* 2000, van Vliet and Nasi 2008). The traditional role of bushmeat has also been shown in Equatorial Guinea, where some species are considered to have magical or medicinal properties that increase their value and others are taboo (Kümpel 2006a). Taboos on certain foods are widespread in parts of Central Africa (Okouyi 2006, van Vliet and Mbazza in press). Similarly in the Amazon Basin, various key bushmeat species have significant importance within native culture. For instance different Native American groups in the Amazon believe that shamans may reincarnate as peccaries, and these species may even be worshipped as deities in traditional belief systems (Donkin 1985). There are also prohibitions or taboos on hunting some of the species as well, for instance for brocket deer by the Ayoreo People of Bolivia and Paraguay. We have been unable however to find evidence that these taboos play a significant role in regulating harvests.

Sale or self-consumption: trade and income generated by bushmeat

Local trade

Even where bushmeat is used to satisfy basic subsistence requirements, many families also hunt wild game for sale to meet short term cash needs (Table 5). For hunters, the distinction between subsistence and commercial use is often blurred, with meat from the forest supplementing both diets and incomes (e.g. Bodmer and Lozano 2001, Bodmer *et al.* 2004, Kümpel *et al.* 2010b, 2010c).

It is important to understand to what extent rural people depend on bushmeat and would therefore suffer if the resource diminished. Many depend on wildlife resources as a buffer to see them through times of hardship (e.g. unemployment, illness of relatives, crop failure), or to gain additional income for special needs (e.g. school fees, festivals, funerals) (Fa and Brown 2009), and this 'safety net' is often more important for the more vulnerable members of a community (Allebone-Webb 2009, de Merode *et al.* 2004). In South America, for small holders it buffers domestic livestock such as goats and cattle, key economic reserves that can be easily converted into cash for poor country dwellers (Altrichter 2006). In a similar way, bushmeat can further subsidize large ranch owners economically since they often resist providing livestock meat for their workmen, who are encouraged to hunt instead. Bushmeat can also be differentially important during times of stress for local people, such as when crops fail. In some cases it tends to be relied on more by community members who practice seasonal migrant labour (e.g., to participate in agribusiness harvests), and hence have less time to plant family gardens or for livestock husbandry (Noss 1999, Noss and Cuellar 2001). Another factor in South America is that as household wealth has increased in some rural communities wild game consumption has increased, in part due to greater availability of firearms (Espinosa 2008, Godoy *et al.* 2009).

Commercial trade is probably the primary driver of the increasing levels of bushmeat off take in the Congo Basin (Bennett *et al.* 2007, Davies 2002). On average per capita urban consumption across the region appears an order of magnitude smaller than rural consumption but while per capita urban consumption of bushmeat is lower than per capita rural consumption, aggregate urban consumption is usually higher than aggregate rural consumption due to the size of the urban population (Chardonnet *et al.*1995, Starkey 2004). In the Congo Basin, bushmeat trade occurs in established markets together with the commercialisation of other agricultural products. However, since much bushmeat is also sold through informal channels such as from rural hunters directly to urban consumers, established bushmeat markets channel only a portion (probably 50–60%) of the total urban consumption (Bahuchet and Ioveva 1999, Starkey 2004, Trefon and de Maret 1999). Starkey (2004) estimated that a total of 161 tonnes of bushmeat was sold per year in five markets in Gabon. Similarly, Fa *et al.* (1995) suggested that the volume of bushmeat traded annually in Equatorial Guinea's two main markets is of the order of 178 tons. An inventory in 1995–96 of the four main markets in the Cameroon capital, Yaoundé, estimated sales of 840–1 080 tons of bushmeat per year (Bahuchet and Ioveva 1999). In Yaoundé, Edderai and Dame (2006) identified 15 markets and 145 restaurants and cafeterias selling bushmeat and providing an occupation for 249 people, of whom 84.3% are women. Fargeot and Dieval (2000) estimate annual consumption in Bangui, Central African Republic, to be of the order of 9 500 tons per year.

In the Amazon Basin commercialisation occurs in largely hidden markets and bushmeat consumption in urban areas is unevenly studied. Here, the scale of the bush meat trade is less well-known than in the Congo Basin and appear highly variable. Bodmer *et al.* (2004) estimated the number of animals hunted annually in the Peruvian Amazon (Loreto region) as above 110 000 but how much of this catch is sold through open-markets is almost impossible to estimate. The best known and largest wild game market is in Iquitos Peru where for instance in the 1990s bush meat prices could reach $4 per kg (e.g., for meat from the highly prized paca *Cunniculus paca*) and the meat from an individual large peccary could be worth as much as US$60 with the hide bringing in an additional $10 to the hunter (Bodmer and Lozano 2001, Claggett 1998). This market arose due to the lack of cattle ranching in this part of the lowland Amazon.

TABLE 5 *Wild meat use (self consumption and sold) in various communities*

Country	Locally consumed (% biomass)	Sold (% biomass)	Source
		CONGO	
DRC	10	90	de Merode *et al.* 2004
CAR	27	73	Noss 1995
	65	35	Delvingt 1997
Equatorial Guinea	57	34	Fa and Yuste 2001
	10	90	Kümpel 2006a
Gabon	41	59	Starkey 2004
	60	40	van Vliet and Nasi 2008
	56	44	Carpaneto *et al.* 2007
Cameroon	36	64	Wright and Priston 2010
	44	56	Solly 2004
	34	40	Delvingt 1997
	63	15	Takforyan 2001
	59	28	Takforyan 2001
	68	14	Dounias 1999
Congo	28	68	Delvingt 1997
	42	54	Delvingt 1997
	45	35	Delvingt 1997
		AMAZON	
Brazil	100		Trinca and Ferrari 2007
	100		Parry *et al.* 2009
	100		Fragoso *et al.* 2000
Peru	14	86	Bodmer *et al.* 1994
	59	41	Claggett 1998
	54	46	Claggett 1998
	42	58	Claggett 1998

Another special example of such use is the commercial harvest of Capybara meat for lent in Venezuela (Hoogesteijn and Chapman 1997, Ojeda 1997) although cash benefits from this tend to accrue to large ranch owners rather than benefit poor rural livelihoods because the remaining land available for capybaras tends to be on extensive land holdings as opposed to small farms. Elsewhere, bush meat may be sold in cities and on road side stands across the region, but typically not commanding higher prices than for domestic livestock such as cattle.

International trade

There is very scarce quantitative data concerning the international trade of bushmeat and almost nothing on the Amazon Basin where the problem seems to relate more to the international exotic pet trade, as well as the hide trade as is the case for peccaries. Bushmeat trade across borders is frequent in the Congo Basin, especially in forest blocks located close to national borders where civil unrest and war have increased the availability of ammunitions and the demand for bushmeat. Bushmeat trade to Western countries also exists. A recent study at Roissy-Charles de Gaulle airport, in France, researchers identified eleven bushmeat species from confiscated luggage, including primates, crocodiles and pangolins and estimated that around 270 tonnes of bushmeat passing unchecked through a single European airport per year (Chaber *et al.* 2010) The Central African Republic, Cameroon and the Democratic Republic of Congo were identified as the main sources of bushmeat.

CONCLUSION: EMPTY FORESTS AND EMPTY STOMACHS?

Increased hunting pressure has tangible effects on wildlife and is likely to have long term impacts on forest ecosystems. As it is expected in hunted areas, the abundance and composition of mammal assemblages differ from un-hunted areas.

Many vulnerable species such as elephants, tapirs and great apes, although not representing high percentages in the hunter's catch, have declined or become locally depleted due to hunting. Very little is known however for the majority of Central African hunted species that are partially or totally protected. Knowledge on the ecology of major bushmeat species in the Amazon is better but four of some 30 such species are in the data deficient category of the IUCN Red List. The effects of hunting on these species need further investigation, with a particular focus on the impacts of hunting at varying spatial and temporal scales and under different hunting techniques, to provide objective information for sustainable wildlife management.

On the other hand, despite long and continuous sustained heavy harvesting, some bushmeat species continue to thrive in natural and modified habitats. The most resilient species are often able to adapt to hunting pressure, either by modifying their biological parameters and their ecology or by taking the niches left empty by the most vulnerable species. Thus, high harvesting pressure should not always be equated with local extinction. As a result, and because bushmeat plays a crucial role in the diets and livelihoods of people, options for sustainable harvest need to be investigated. Indeed, rural and urban people in Central Africa and indigenous people and part of the rural poor in the Amazon, use bushmeat as a major source of protein and income or to serve multiple social roles.

The level of dependency on bushmeat is however different in both basins: In the Amazon Basin, a relatively small number of indigenous people depend on bushmeat for their everyday life and hunt at sustainable levels for most species. As the rural non-indigenous or pioneer population becomes wealthier it looks more towards alternative protein sources (livestock, poultry). The urban population has access to one of the most active livestock sector of the world and therefore does not depend on bushmeat for protein intake. Urban trade in bushmeat is limited in size and location - though not very well known – and is not a major driver. With urbanization, wealth, and the availability of other meat sources, bushmeat harvest is likely to decline sharply in the future. The flip side of the coin is that the production of the main alternative source of protein (e.g. cattle) is also the main driver of deforestation in the Amazon basin, with well known negative effects on wildlife and ecosystems. The policy approach in the Amazon could well be inspired by Sarawak, Malaysia (Bennett *et al.* 2000), where A Master Plan for Wildlife has been developed. In Sarawak a strictly enforced law bans trade in wild animals and their parts, ensures strict control of shotgun cartridge availability and of hunting in logging concessions, and provides for broad education programs and involvement of local communities in the management of protected areas. This was enacted in 1998 through a "Wild Life Protection Ordinance" put into effect through intensive programmes of education and enforcement combined with strong support from rural community leaders as a means to conserve the resources on which the rural constituents depend (Bennett and Madhu Rao 2002). This success was possible in Sarawak because the commercial wildlife trade mainly supplies a luxury, urban market with plenty of alternative protein sources available. This situation has some similarities to prevailing circumstances in most urban areas in the Amazon Basin, and might be a useful model to adapt or replicate.

In the Congo Basin, increasing population and trade from rural to urban areas compounded with the lack of any sizeable domestic meat sector are the main drivers of unsustainable levels of hunting. Even where urban consumers have access to domesticated sources of meat they are imported and/or expensive and bushmeat remains an important part of their diet. With an estimated yearly extraction rate in the Congo Basin of 4.5 million tonnes, we would need to transform large areas of tropical forests or savannas into pasture to replace bushmeat by cattle. As comparison, the Brazilian beef production (8.6 million tonnes in 2005[1]) is considered responsible of about 50 million ha of deforestation. If bushmeat consumption in the Congo Basin was to be replaced by locally produced beef, an area as large as 25 million hectares might have to be converted to pastures. Pigs and chickens have much higher feed conversion rates than do cattle and both can thrive on kitchen scraps and crop residues. Focusing on pig or chicken husbandry rather than cattle ranching would then make more sense in the Congo Basin, but managing wildlife resoures will remain a necessity for decades to come.

Achieving sustainable harvest of bushmeat is therefore a necessity and by far, the best available option compatible with biodiversity conservation, local livelihoods, food security and food self sufficiency. Banning and strictly enforcing the sale of endangered or at risk species in urban markets but allowing the continued sale of resilient species would be a good step in Central Africa. If banned species where confiscated in the market and publically incinerated (to demonstrate that the police were not simply going to resell the meat elsewhere) market sellers would quickly see no profit in selling these species and would stop buying then from traders. At least that is the theory. Furthermore, as much of the commercial bushmeat that is consumed in urban households comes from logging concessions that represent the single largest landuse in the Congo Basin, increasing certification and forcing logging companies to halt hunting and export of bushmeat from their concessions would do much to reduce urban consumption (see Nasi *et al.* 2011 for examples).

Multidisciplinary approaches are needed to combine a better knowledge of the use and trade of bushmeat, the strengthening of legal frameworks, the provision of food and livelihood alternatives and the sustainable use of wildlife. None of these alone appear to be able to solve the so-called "bushmeat crisis", but combined and incorporated into solid national and regional bushmeat strategies, there is potential to achieve a more sustainable use of wildlife for food in the Congo Basin.

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[1] FAOStat database

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