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The role of bushmeat in food security and nutrition

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Abstract

Bushmeat (primarily the meat of wild mammals) can provide a food security safety net for tropical forest inhabitants. In this paper we focus on use of wildlife as food in Rainforest Biotic Zone (RBZ) of western and central Africa. First, we briefly describe which wildlife species are important as bushmeat in the RBZ. We then review the available literature on consumption of wild species to argue that many peoples in the RBZ invariably consume bushmeat, but highlight that although data are available on amounts of bushmeat eaten the importance of bushmeat in people's diets cannot be merely assessed by volume consumed. We then examine how bushmeat consumption and food security may be linked by presenting data on the importance of bushmeat protein to overall protein consumption in central Africa and how the loss of bushmeat consumption may be correlated with the reported incidence of human malnutrition in the same region. Finally, we propose a roadmap towards better governance for a more sustainable formal bushmeat sector that can ensure food security of peoples using wild species for food.

Keywords: bushmeat, wild meat, food security, sustainability, rainforests, west/central Africa, human nutrition

Introduction

The Bushmeat Liaison group of the Convention of Biological Diversity (CBD, 2009) has acknowledged the importance and complexity of the issue of the use of wildlife for food, recognizing the need to broaden the picture from an ecological perspective to a socio-economic, cultural and ecological standpoint to ensure that the bushmeat trade does not lead to the extirpation of wildlife species. Hunting for food in tropical forests is now a matter of concern for the following three main reasons:

1. Ecological impacts: there is growing evidence that the scale of hunting poses a real threat to many wildlife species.
2. Food security and nutrition: wildlife is intimately linked to the food security and livelihood of numerous urban or rural people; bushmeat provides meat for urban and rural families, and as a source of income, is a common component of household economies throughout the supply chain from the hunter to urban markets and food stalls.
3. Health and zoonotic diseases: bushmeat is an important reservoir of zoonotic pathogens, but we still know relatively little about the transfer dynamics of such infections. The list of infectious diseases thought to have their origin in wildlife encompasses some of the most feared diseases including Ebola virus, Lassa virus, hanta virus, bubonic plague, and human immunodeficiency virus (Weiss 2001).

For primary producers in the bushmeat market chain, bushmeat often represents both the main source of animal protein and the principal cash-earning commodity for the inhabitants of the humid forest regions of the tropics. Parts of the extractive sector (logging, mining for examples) operating without sustainable management plans is also a driver of the bushmeat trade, because in the course of their activities, companies a) directly destroy critical habitat, disturb movement patterns and alter behaviour, and b) indirectly facilitate hunting by building roads and/or providing hunters transportation. The loss of both traditional hunting territories (e.g., those belonging to certain traditional groups) and methods (e.g. hunting zone rotations) allow open access to the resource and concentration of hunting, thereby resulting in a loss of sustainability (Poulsen et al., 2009). Another root cause of overhunting is the breakdown in the traditional control over access to land and the breakdown of

the traditional sets of local regulations governing hunting by members of the local communities. Finally, insecurity, poor governance, the lack of respect for law and order and lack of enforcement have all contributed to varying degrees to the problem of overexploitation.

In this paper, we examine the available sources of information available in support of the food security and human nutrition linkages with wild meat. We focus on the wildlife used in countries within the Rainforest Biotic Zone (RBZ) of western and central Africa. The intention of this paper is to highlight our current understanding, briefly highlight gaps, and emphasise that the importance of conserving those species that can be exploited sustainably so these can continue to supply crucial nutritional resources to the many peoples that hunt them.

Wild animals as food

Bushmeat includes a large variety of wild species that are eaten as food (Bennett & Robinson, 2000; Wilkie *et al*., 2005; Nasi *et al*. 2011). Vertebrates, however, contribute to almost all the bushmeat consumed in the RBZ. As many as 129 wild vertebrate species are known to be traded and consumed in west and central Africa (Petrozzi *et al*. in press). By class, mammals are the most common (n = 91), followed by reptiles (n = 19), birds (n = 14), and amphibians (n = 2); mammals also dominate the bushmeat trade in terms of individual animals and biomass sold. Petrozzi *et al*. (in press) also indicate that habitat specialists predominate (96 taxa, 76.1% of all traded species), with the main traded taxa being *Cephalophus* duikers (32.5% of total traded individuals and 18.6% of biomass), rodents (especially Emin's giant pouched rat *Cricetomys emini*, 7.8% of the individual traded, 1% biomass), primates (6.2% of the traded individuals and 3.6% of the biomass) and antelopes (37.5% of individuals, 42% of biomass). According to Petrozzi *et al*. (in press) the blue duiker (*Philantomba monticola*) provides the largest number of animals traded of any one species (20.7% of total individuals), and *Tragelaphus eurycerus* the largest volume (20.2% of biomass).

Much of the published literature on the use of wild meat is set against a gloomy prognosis from the point of view of biological sustainability (Fa *et al*. 2002). However, the precise value of bushmeat to human livelihoods and wellbeing still requires more detailed assessment. This is so not just because of any dispute of the importance of wild meat in the diets of many people throughout the world (e.g. Ojasti 1996, Ntiamoa-Baidu 1987, Caspary 1999a,b, Hofmann *et al*. 1999, Bennett and Robinson 2000, Caspary *et al*. 2001, Bennett 2002), but also because of its positive contribution to other components of livelihoods such as pro-poor trade mechanisms, and its role in risk mitigation strategies (Inamdar *et al*. 1999).

Though detailed analyses are still limited, there is substantial evidence that bushmeat figures strongly in rural economies not only as a traded item, but also as a pillar of livelihood safety, including food security. Bushmeat is eaten as fresh or smoked meat in soups and stews and also, occasionally, roasted or fried. A study undertaken in Ghana by Ntiamoa-Baidu (1998) mentions that most people interviewed (96%) ate bushmeat in soups. The majority of people cooked the meat in their homes, but 'chop bars' (local restaurants) were also important (around 20% of interviewees). Cowlishaw *et al*. (2005) stress the importance of chop bars in the bushmeat commodity chain in Ghana, and East *et al*. (2005) also suggest this to be important in continental Equatorial Guinea.

The literature assessing the relative and absolute contribution of bushmeat to household economies is still sparse. This makes it difficult to design mitigation approaches, given that the role of bushmeat in diet and household income is not sufficiently well quantified. This is because studies of bushmeat consumption often report frequency (days in a week) during which bushmeat is consumed (e.g. Ntiamoa-Baidu, 1998; East *et al*., 2005) and, less frequently, actual quantities of bushmeat eaten from weighed amounts of meat consumed in households (e.g. Koppert and Hladik, 1990; Koppert *et al*., 1996). Other studies have calculated bushmeat eaten from 24-hr recalls in which households are interviewed and asked to name what meats and quantities were eaten the day before (Starkey, 2004; Albretchsen *et al*., 2006). Estimates of wild meat consumed in different tropical regions have been published, ranging enormously from 0.05 kg/person/day to 0.28 kg/person/day. This variation in amounts of bushmeat consumption is difficult to explain since it could reflect differences in the study population's dependence on game meat versus fish, but also could reflect differences in time of year in which the studies were undertaken, and of course sample sizes. The major issue affecting many studies is that there is not enough information reported (see Ntiamoa-Baidu, 1998; Chardonnet *et al*., 1995) to assess potential sources of error or compare methodological accuracy. For large-scale studies (such as the data derived from Food Balance Sheets, see Ziegler 2009), there is no indication of the statistical distribution of the data since only

means are presented.

A study by Koppert *et al*. (1996) is probably one of the most extensive investigations of the diet of a number of human populations in equatorial Africa, including forest-dwelling families. The study concentrated on a number of ethnic groups in Cameroon, where food intake was weighed in large samples of households, and in different seasons. In all populations studied, the staple food (e.g. cassava) is the main source of energy, but fish and meat the main source of proteins. Diets based on roots and tubers, especially cassava, are known to be very low in proteins and other nutrients. This paucity is met by an important intake of animal proteins from fish and bushmeat. Thus, agricultural crops provide most of the calories to human populations, while animal meat, including bushmeat, is the main source of protein. The study indicated that wild meat accounted for between 70% and 88% of protein in the diets of the various ethnic groups, but the source of protein varied according to the population's proximity to the coast. Thus, the Yassa, living on the Atlantic coast, fish at sea and grow cassava, while for the Kola pygmies living in climax forest, the main protein source is bushmeat. One conclusion to be drawn is that unless families have access to true substitutes for bushmeat, any attempt to curtail bushmeat production may result in children suffering the consequences of protein deficiency — i.e. slowed growth and learning delays. At present fish and domestic animals are the only plausible substitutes for bushmeat as a source of protein.

What clearly emerges from the different studies is that in west and central Africa urban bushmeat consumption is significant, and from a demand viewpoint this may account for a major source of pressure on wildlife populations. 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 7.2kg/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 the diets of many inhabitants in the RBZ.

Country statistics on the amounts of bushmeat consumed per inhabitant, though somewhat limited, can be obtained from analyses of food balance sheets, provided by the UN Food and Agriculture Organization's statistical database, FAOSTAT. While the FAOSTAT bushmeat data are probably underestimates and should be regarded with caution, the data are the most readily available official sources of information on production of wild meat in the Congo Basin and are valuable indicators of bushmeat production and consumption trends. Ziegler (2009), using FAOSTAT data, showed that consumption of bushmeat in the Congo Basin was highest in Gabon where inhabitants consumed on average more than 16 kg of bushmeat per year between 1990 and 2005—almost four times the amount consumed in other Central African countries. Average bushmeat consumption in all countries was 6.78 kg/capita in 1990 but fell to 5.89 kg/capita in 2005. With the exception of the Republic of Congo, bushmeat consumption per capita decreased in central Africa after 1990; for Gabon, each inhabitant consumed almost 4 kg less bushmeat in 2005. The trend of declining bushmeat consumption was moderate in Cameroon, DRC and CAR, with less than 1 kg of bushmeat/year per capita from 1990 to 2005. Ziegler's (2009) study also provides strong statistical evidence that more bushmeat consumption occurs in countries with a higher value of forest area per inhabitant, and that there is a negative correlation between rural population and bushmeat consumption. Bushmeat consumption increases significantly with personal wealth, expressed as GDP at purchasing power parity per capita.

Wild protein and food security

The association between wild meat and food security has sometimes included discussions around wild animals as a source of income, as well as its role in the practice of traditional medicine (Williamson 2002). But, even though the procurement of wild meat may contribute indirectly to food security, it is the role it plays in fulfilling the nutritional wellbeing of users that remains the main topic of discussion. Food security essentially refers to the availability of food and access by all people, at all times, to sufficient amounts, for an active, healthy life (Maxwell and Wiebe 1999). In other definitions, such as the one proposed by the World Food Summit, food security should also include elements of access to safe and nutritious food (Pinstrup-Andersen 2009).

If food security is taken as the provision of nutritionally adequate and safe foods, that have a steady supply

during the year, and to which households have access, the contribution of bushmeat has to be adequately measured Wild meat, as a component of the dietary intake of many people in tropical regions, is well established. However, the contribution bushmeat makes to food security will be greatest where it the only or the main source of animal protein (and vitamins) and is difficult to replace, but the importance to food security declines when wild animal meat is simply one of a number of interchangeable choices that are readily available to the consumer.

The fundamental issue still to answer remains on whether the loss of the providers of wild meat, i.e. the fauna itself, will create a crucial downturn in the nutritional wellbeing of many people using the resource. In terms of this concern, an important consideration is that it is often the poorest people who are most dependent on biodiversity, including bushmeat, for their well-being. The prevalence of food insecure households is usually higher in marginalised areas where a variety of constraints contribute to vulnerability: environmentally fragile ecosystems, low productivity, geographical isolation, and limited access to health or education services. Hence, any attempt to understand the importance of wild meat to food security must include measurement of the amounts eaten per person, over time, relative to the availability of other food sources, and should take into account the geographical setting of the consumers themselves (Bennett *et al*. 2007).

Although country-wide studies of average wild meat consumption are valuable (see Ziegler 2009), partitioning information according to the availability of non-wild meat can help us better understand the association between wild meat and food security. A study by Fa *et al*. (2003) assessed amounts of bushmeat protein available to peoples living in the main central African countries (Cameroon, Gabon, Congo, CAR and DRC) relative to the amount of non-bushmeat protein produced by the countries in 2000, and the likely quantities in the future. This study provided some salutary views on a future on how the predicted dwindling wild meat protein resources could affect the food security of main people. The evidence indicated, in line with Ziegler's (2009) country study, that Gabon (180 g/person/day) and Congo (89 g/person/day) would produce the highest amounts of bushmeat protein per inhabitant whilst Cameroon (26 g/person/day) and the DRC (28 g/person/day) would be the lowest producers. Given the rates of exploitation of bushmeat in the region (Fa *et al*. 2002), projected drops in bushmeat protein supply per capita would be high in all countries concerned, from 61% in the CAR to 78% in the DRC. However, Gabon, not only had the largest bushmeat supply of any central African country but also produced (or imported) the largest amounts of non-wild protein. Hence, food security varies according to each country's socioeconomic and population sizes. Overall, Fa *et al*. (2003) calculated that for the baseline year (2000), bushmeat protein supply could be higher (48 g/person/day) than the non-bushmeat protein supply (34 g/person/day) for the central African countries. Moreover, protein supply would be expected to fall from about 85g in 2000 to 41g/person/day by 2050, due to reductions in bushmeat availability; this is 79% of the WHO recommended minimum of 52 g/person/day.

Disentangling associations: malnutrition and wild meat supply

Investigations of the role of wildlife on human health in central Africa are limited. Wildlife declines are likely to have direct and powerful effects on human health and nutrition, particularly via lost access to critical micronutrients (Neumann *et al*. 2003). Animal source foods, such as wildlife, are rich in energy, protein, and micronutrients that have greater bioavailability than vegetable sources (Neumann *et al*. 2003). However, there is some evidence that indicates a strong causal link between bushmeat consumption and human nutrition. In a study of children under 12 y of age in rural northeastern Madagascar, the lack of access to wild meat caused a 29% increase in the numbers of children suffering from iron deficiency anaemia and a tripling of anaemia cases among children in the poorest households (Golden *et al*. 2011). Thus, if consumption of sufficient amounts of nutrients to meet the body's needs are limited, including those contained in meats, chronic malnutrition will occur over time and will result in growth retardation in children (stunting) and eventually ill health in later life.

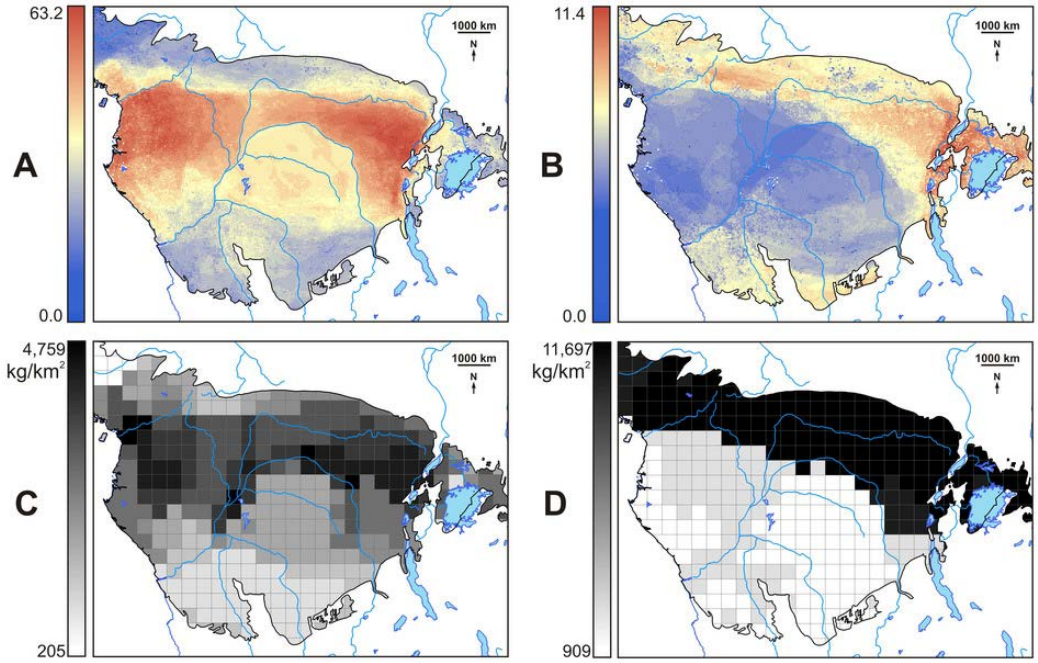

Fig. 1. Diversity and standing biomass of mammals in central Africa. (A) Deep Rainforest Diversity, DRD. (B) Marginal Rainforest Diversity, MRD. DRD and MRD are the accumulated favourability values, weighted by hunting sustainability values, of all hunted mammals found within the Rainforest Biotic Zone. (C) Potential standing biomass in DRD mammals. (D) Potential standing biomass in MRD mammals. Maps were generated using ArcGIS. Figure taken from Fa *et al*. (2015).

In the absence of direct measures of nutritional status of human populations at a subnational level, stunting prevalence to the lowest administrative unit can be employed as a useful indicator of chronic malnutrition in Africa. Stunting can then be used to correlate with the availability of different food items e.g. meats, even though various factors may affect retention of nutrients (e.g. disease). Fa *et al*. (2015) studied whether potential availability of wild meats was linked to stunting in children in central Africa. The study was based on the backdrop of the distribution of mammalian species assemblages, which they classified according to their hunting potential, and in which wild meat biomass likely to be at the disposal of humans. Hunted mammal assemblages were divisible two separate mammalian assemblages: (1) a Deep Rainforest Diversity (DRD), largely composed of low hunting-resilient species i.e. large-bodied, slow reproducing taxa, mostly found within wet Guinea-Congolian lowland rainforest in the centre of the RBZ (Fig. 1A), and (2) a Marginal Rainforest Diversity (MRD), comprised of high hunting-resilient taxa, i.e. smaller-bodied, fast-reproducing mammals inhabiting the woody savanna/grasslands in the northern, eastern and southern RBZ (Fig. 1B). Using standing biomass as a surrogate of potential wild meat resources available to humans, we showed that higher mammalian biomass was typical of MRD but not of DRD areas, despite the latter areas having six times more diversity than MRD areas (Figs. 1A and 1B). Potential standing biomass in DRD areas (Fig. 1C) was lower (mean ± SE = 1,805 ± 1,074 kg/km^2, median = 1,535 kg/km^2, range = 205 - 4,759 kg/km^2) than that in MRD areas (Fig. 1D) (mean ± SE = 5,618 ± 4,296 kg/km^2, median = 2,461 kg/km^2, range = 909 - 11,697 kg/km^2).

Potential bushmeat extraction levels were mapped to demarcate how anthropogenic demands are distributed throughout the region (Fig. 2). Total standing crop mammalian biomass within each mammalian assemblage correlated significantly and positively with both DRD (n = 367 grid cells; r = 0.167; P < 0.001) and MRD areas (n = 367 grid cells; r = 0.595; P < 0.001). However, potential standing biomass of mammal species of low hunting potential 19 was significantly and positively correlated with DRD areas (n = 367 grid cells; r = 0.652; P < 0.001). Likewise, the potential standing biomass of mammal species of high hunting potential was significantly and positively correlated with MRD areas (n = 367 grid cells; r = 0.773; P < 0.001).

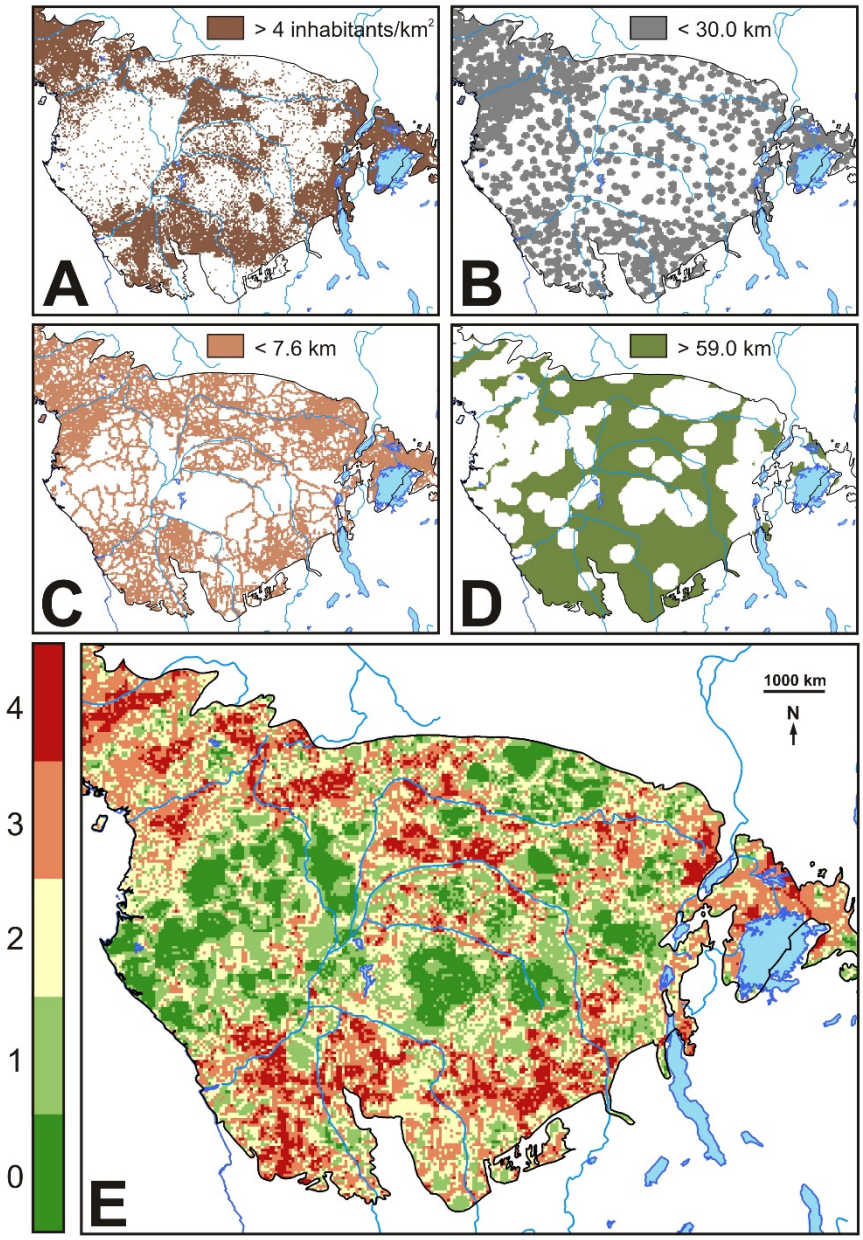

Fig. 2. Anthropogenic pressures. (A) Brown: above median areas of rural human population density. (B) Grey: below median areas of distance to urban areas. (C) Pink: below median areas of distance to roads. (D) Green: above median areas of distance to protected areas. (E) Bushmeat extraction patterns emerging from the overlay of urban areas, road networks, protected areas and densely populated rural areas (areas with a total score of 4 had the highest bushmeat extraction potential, whereas areas with a total score of a 0 had the lowest). Maps were generated using ArcGIS. Figure taken from Fa *et al*. (2015).

Stunting was unevenly distributed throughout the study region with more stunting occurring away from the central DRD areas (Fig. 3). Stunting was negatively correlated with mammalian diversity in DRD areas ($n = 60$; $r = -0.288$; $P = 0.027$) but positively associated to MRD areas ($n = 60$; $r = 0.325$; $P = 0.012$). Bushmeat extraction values were positively correlated with the prevalence of child stunting ($n = 60$; $r = 0.373$; $P < 0.005$) and with mammalian diversity in the MRD areas ($n = 60$; $r = 0.484$; $P < 0.001$). Extraction was negatively correlated with mammalian diversity in the DRD areas ($n = 60$; $r = -0.469$; $P < 0.001$).

By combining hunted mammal diversity, extraction and malnutrition levels the statistical associations between these can be analysed. The most significant finding was that stunting is uppermost in rainforest-savanna mosaic regions where bushmeat extraction is highest, but lowest in the more intact rainforest blocks. These associations are intuitive. However, the Fa *et al*. (2015) study demonstrated, for the first time, that different types of diversity

are linked with nutritional status of people. Although more targeted work should be done, we are confident that deep forest areas may have sufficient protein available for their inhabitants. These areas arguably should be kept, as they are as much as possible. By contrast, rainforest-savanna mosaic regions require much more attention from the conservation and human development communities. Hence, the study advances the debate by presenting a more complex scenario, in which deep rainforest wildlife may still support food security of hunter-gatherers and others on condition that human concentrations are kept low. Instead, along the RBZ margins, composed of more sustainable wildlife and more productive in terms of wild meat, higher population densities here explain the observed levels of malnutrition. More specifically, adequate human nutrition is likely in rural landscapes, but as our analyses show, collapses around urban areas, where child malnutrition is more prevalent. Although these results require further empirical tests and more work on the ground to investigate how the different drivers affect malnutrition and the role wildlife plays, the strong correlations we confirm between wild meat and malnutrition are noteworthy. We thus argue that this is not a spurious effect, but one that powerfully points to the significance of wild meat in sustaining human populations in central Africa. However, our results should be considered of heuristic value and this stage not to be used to propose unfettered access rights for the poor nor draconian conservation schemes. What it does underline, rather, is the need to consider a wider political agenda for developing practical policies that benefit both people and biodiversity. Emerging strategies from this framework would increase public recognition of bushmeat's economic value and the need to regulate and plan its use, but it would also emphasize the need for adequate and accessible alternative food sources to overturn the malnutrition levels seen along the marginal RBZ habitats. All this would raise an interesting set of questions about (for example) the relationship between natural resource use and economic growth, or between effective conservation and resilient development.

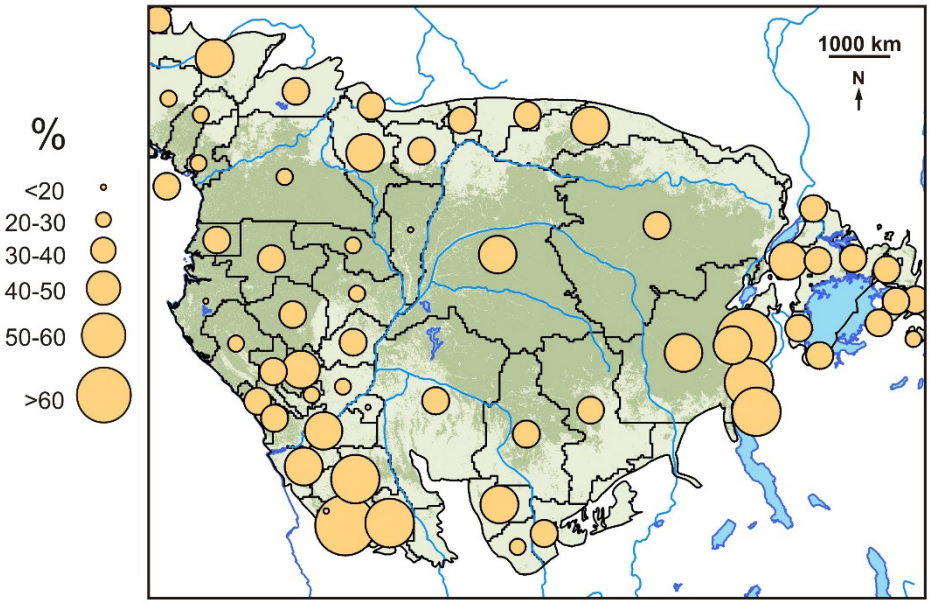

Fig. 3. Prevalence of stunting among children under five (data from FAO, 2003). Circles are located at the centroids of subnational units providing data. Circle size indicates prevalence. Map was generated using ArcGIS. Figure taken from Fa *et al*. (2015).

Securing wildlife and food security: a road map

In central and west Africa, 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 tons (Nasi *et al*. 2011), if bushmeat consumption in the Congo Basin was to be replaced by locally produced beef, an area as large as 25 million hectares would have to be converted to pastures -without even considering the African trypanosomiasis. Focusing on pig or chicken with their much higher feed conversion

rates makes more sense but producing additional 4.5 million tons of pig of chicken is unlikely to happen soon in the Congo Basin and will be laced with its own environmental issues.

Achieving sustainable harvest of bushmeat is therefore a necessity and by far, the best short to medium term option compatible with conservation, livelihoods, food security and nutrition. 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.

It is likely we could learn a lot by using successes and failures from other renewable natural resource sectors: fisheries because of the nature of the resource and the supposed substitutability between fish and meat (see Bowen-Jones *et al*. 2002 and Cochrane 2000) or wood energy (Mahamane *et al*. 1995, Mahamane and Montagne 1997). In both sectors, i) the use of rights-based management systems (e.g. individual transferable quotas) and productivity monitoring tools based on harvest data could offer some promise for wild meat management; ii) the transfer of these rights and associated management to local people could be at least as good for the environment as when governments were in charge and certainly much better in terms of improved local livelihoods.

A comprehensive roadmap for better governance towards a sustainable bushmeat sector requires:

- **Working with the upstream actors to improve the sustainability of supply**
    - Hunters: negotiate hunting rules and quotas allowing harvesting resilient species and banning vulnerable ones; design and agree on simple participatory monitoring tools
    - Extractive industries: enforce codes of conducts and include wildlife concerns in companies' standard operating procedures; forbid transportation on company's vehicles; establish manned checkpoints; provide alternative sources of protein at cost; organize, support community hunting schemes; adopt certification
- **Reducing the demand**
    - Rural consumers: develop alternative sources of protein at a cost similar to bushmeat; improve economic opportunities in productive sectors; use local media (e.g. radio) to deliver environmental education and raise awareness
    - Retailers, urban consumers: strictly enforce ban on protected/endangered species sales and consumption, confiscating and publicly incinerating carcasses; taxing sales of authorized species
    - International consumers: Institute very heavy fines for transport – eventually targeting airline companies - possession or trade of bushmeat (whatever the status or provenance of the species); raise awareness of the issue in airports or seaports; train custom personnel
- **Create an enabling environment for a controlled, sustainable bushmeat sector**
    - Local institutions: negotiate full support of communities that have a vested interest in protecting the resource; increase capacity to setup and manage sustainable bushmeat markets.
    - National level: enhance ownership, linked to tenurial and rights reform; legitimize the bushmeat debate; make an economic assessment of the sector and include in national statistics; acknowledge contribution of bushmeat to food security in national strategies; develop a framework to "formalize" parts of the trade; review national legislation for coherence, practicality and to reflect actual practices (without surrendering key conservation concerns); include bushmeat/wildlife modules in curricula.
    - International level: strictly enforce CITES with more consideration on regional trade; ensure wildlife issues are covered within internationally-supported policy processes; link international trade with increased emerging disease risks; impose tough fines and shame irresponsible behaviour.
- **Develop more targeted research**

- Create a shift away from descriptive studies of wildlife exploitation to more incisive investigations on the roles which bushmeat might play in poverty eradication in balance with the sustainable use of the resource (Brown 2003).
- Develop cost-effective systems for examining the importance of wild meat to human populations in different ecological and socioeconomic settings. In particular, examine the further application of existing global mechanisms for data gathering on nutrition, such as FAO's Food Balance Sheets.
- Determine causal links between alternative protein sources (e.g. marine and freshwater fish supply) and wildlife populations, and the ecological footprints of increasing accessibility to domestic meats (e.g. livestock, poultry).
- Elaborate effective systems for monitoring the status of hunted wildlife that can be operated by local communities and managers.
- In combination with the conservation sector, instigate original research on the role of source-sink dynamics of hunted wildlife, including the role of protected areas.
- Understand the relationships and trade-offs between bushmeat and other meat/protein sources for human populations inhabiting distinct faunal areas, such as those identified by Fa *et al*. (2015) for central Africa.

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