



RESEARCH
PROGRAM ON
Forests, Trees and
Agroforestry

FTA HIGHLIGHTS OF A DECADE
2011-2021

Wild Meat

Ten years of
forests, trees and agroforestry
research in partnership for
sustainable development



About the FTA Highlights series

This publication is part of a series that highlights the main findings, results and achievements of the CGIAR Research Program on Forests, Trees and Agroforestry (FTA), from 2011 to 2021 (see full list of chapters on the last page).

FTA, the world's largest research for development partnership on forests, trees and agroforestry, started in 2011. FTA gathers partners that work across a range of projects and initiatives, organized around a set of operational priorities. Such research was funded by multiple sources: CGIAR funders through program-level funding, and funders of bilateral projects attached to the programme, undertaken by one or several of its partners. Overall this represented an effort of about 850 million USD over a decade.

The ambition of this series is, on each topic, to show the actual contributions of FTA to research and development challenges and solutions over a decade. It features the work undertaken as part of the FTA program, by the strategic partners of FTA (CIFOR-ICRAF, The Alliance of Bioversity and CIAT, CATIE, CIRAD, Tropenbos and INBAR) and/or with other international and national partners. Such work is presented indifferently in the text as work "from FTA" and/or from the particular partner/organization that led it. Most of the references cited are from the FTA program.

This series was elaborated under the leadership of the FTA Director, overall guidance of an Editorial Committee constituted by the Management Team of FTA, support from the FTA Senior Technical Advisor, and oversight of the FTA Independent Steering Committee whose independent members acted as peer-reviewers of all the volumes in the series.

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Wild Meat

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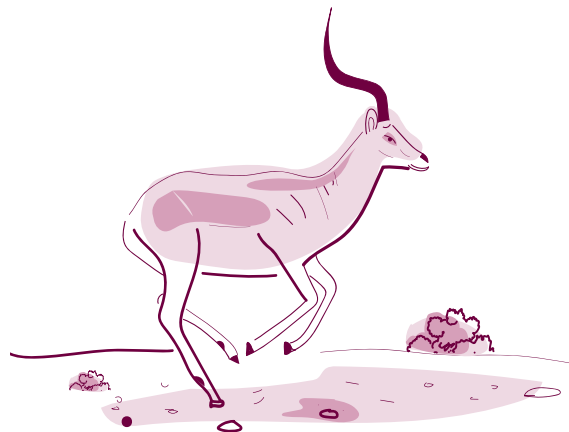
List of acronyms

ATICOYA	Asociación de Autoridades Indígenas
BRI	Bushmeat Research Initiative
DRC	Democratic Republic of the Congo
EVD	Ebola Virus Disease
FORETS	Formation, Recherche, Environnement dans la Tshopo
IFA	Institut Facultaire de Sciences Agronomiques
INERA	Institut National des Etudes et Recherches Agronomiques
NAEA	Núcleo de Altos Estudios Amazónicos
NWFPs	Non-Wood Forest Products
ROC	Republic of the Congo
SWM	Sustainable Wildlife Management
YBR	Yangambi Biosphere Reserve



Executive summary

The meat of wild animals is a crucial part of the diets of millions of families in the tropics and subtropics. It is often the most accessible and sustainable source of protein and micronutrients and can also be a significant source of revenue for many people. Enabling these people, mostly the poor, to continue consuming wildlife in a sustainable manner — while reducing the impacts of overhunting on animal populations — are the main challenges facing researchers and policymakers. Since 2011, the research and policy initiatives led by the Bushmeat Research Initiative (the BRI-CIFOR team), in conjunction with many partners and collaborators worldwide, have made substantial contributions to this topic. These efforts increase the understanding of the current levels and trends of wild meat extraction and of the importance of this wild meat to consumers. The BRI-CIFOR team has generated important new data of wild meat use across a diverse number of environments worldwide. This publication presents some of the key FTA outputs on wild meat; over the last decade these efforts have contributed to inform science, policy and practice.





1. Introduction

Forests and woodlands provide more than timber to the millions of people worldwide that live within them. Some of these forest inhabitants are Indigenous Peoples who have lived there for generations, while other people have recently moved there. All of them, to varying degrees, depend on non-wood forest products (NWFPs).¹ Despite being referred to as “minor forest products” within more traditional forest management, these products, especially in their local context, may be considerably more valuable to local peoples than the wood obtained from the forest.

NWFPs include plants for food and medicinal purposes, fibres, dyes, animal fodder and other necessities. They also include the meat of wild animals, also known as wild meat (see Box 1), which is still a crucial part of the staple diet of millions of families in forests throughout the globe. Often this meat is the most accessible and sustainable source of protein (Abernethy et al. 2013; Fa et al. 2003); it is also important for the micronutrients it provides (Golden et al. 2011; Sarti et al. 2015; Sirén and Machoa 2008). Wild meat is important in the livelihood strategies of poor peoples since it can also constitute a significant source of revenue (Brown and Williams 2003; Milner-Gulland and Bennett 2003). It is also consumed regularly by urban peoples, but more as a commodity product than a necessity.

¹ The term “non-wood forest products” or “NWFPs” excludes all woody raw materials. Consequently, timber, chips, charcoal and fuelwood, as well as small woods such as tools, household equipment and carvings, are excluded. Non-timber forest products (NTFPs), in contrast, generally include fuelwood and small woods; this is the main difference between NWFPs and NTFPs.

Box 1. What is wild meat?

For some time, the term “bushmeat” was a catchall phrase for the meat of wild animals that is obtained through hunting. Hunting is defined as the extraction of any wildlife, from the wild, by whatever means and for whatever purpose. Wildlife is hunted for food, trophies (most often skins, teeth, antlers and horns), medicines and other traditional uses (most hard and soft body parts) and people also capture wild animals for pets (especially primates, birds and reptiles). The meat from hunted animals has been defined as any “non-domesticated terrestrial mammals, birds, reptiles and amphibians harvested for food” (Nasi et al. 2008, 6). Insects, crustaceans, grubs, molluscs and fish, which people also eat, are excluded from this definition. The term “bushmeat,” which originated in Africa, has been used to refer to the meat of wild animals. Recently, there has been a move towards using the more generic term “wild meat,” since it has no geographical associations. Thus, Coad et al. (2019) use the term “wild meat” following its adoption by the World Conservation Union (IUCN) General Assembly Resolution 2.64 (IUCN 2000), to refer to terrestrial animal wildlife used for food in any part of the world. The CBD (2012) description of wild meat hunting — “the harvesting of wild animals in tropical and subtropical countries for food and for non-food purposes, including for medicinal use” — should be applied more broadly to the hunting of wild animals for their meat anywhere in the world.

Hunting animals for human consumption has persisted since prehistoric times. It is still widespread in many of the world’s ecosystems, stretching from the poles to the regions surrounding the equator, the tropics and subtropics. Biological and cultural diversity is greatest in equatorial regions, where around two-thirds of the world’s population will be living by 2050. The people in the tropics generally experience higher levels of poverty and undernourishment than those in the rest of the world. The international community has paid particular attention to issues related to the conservation of tropical biodiversity, but there is also a crucial need, at all levels, to raise awareness of and to underline the important role that tropical countries will play in achieving the Sustainable Development Goals.

A range of habitats are found within the tropics. Tropical rainforests have the largest living biomass and boast some of the highest rates of terrestrial

biodiversity. But rainforests are perhaps the most endangered habitat on earth and are the most vulnerable to deforestation. The loss of tropical forests has rightly dominated the attention of conservationists, who argue that the destruction of these habitats will cause a mass extinction in coming years (Alroy 2017). However, protecting tropical forests alone is not enough; there is also a need to ensure that people who live in these forests can continue to use the natural resources within them, including wildlife, without depleting these. The hunting of wildlife is considered the single most geographically widespread form of resource extraction in the tropics (Fa et al. 2002, 2005; Milner-Gulland and Bennett 2003). Thus, abating the overhunting of wild animals in many tropical countries must be a priority since there is increasing evidence that this is seriously depleting the populations of many forest animals, leading to the “emptying” of forests and depriving local populations of nourishment.

Many different animals constitute locally important dietary items. However, vertebrates (amphibians, reptiles, birds and mammals) constitute the majority of the terrestrial wild animal biomass consumed by peoples in the tropics and subtropics. In terms of weight and numbers, mammals make up the largest proportion of animals eaten and traded. Contrary to a popular view, the cultural preference for wild meat is not due to a lack of awareness or lack of entrepreneurship for other activities such as animal husbandry.

It relates ultimately to the low productivity of domestic livestock in tropical forest conditions for small farmers. Although livestock ranching has been the driving force behind deforestation in tropical rainforests, as seen in the Brazilian Amazon (Carvalho et al. 2020), poor farmers who raise livestock for their meat face high risks and investment costs. Successful livestock husbandry is rarely feasible.



Bush meat at the weekly market of Yangambi, DRC. The main animals that are hunted are warthogs, monkeys and Gambian rats.

Photo by Axel Fassio/CIFOR

In situations where livestock such as the ever-present domestic chicken can be raised, these animals are often more a form of reserve banking, kept to satisfy cultural needs. In contrast, wild meat is an open access resource, so the cost of its production is always lower than that of raising livestock. In recent decades, there has been a large growth in the scale of commercial hunting and trading of wildlife, because of accelerating population growth, modernization of hunting techniques and greater accessibility of remote forest areas.

For the millions of Indigenous Peoples and non-Indigenous communities in tropical and subtropical environments, who are often among the world's rural poor, wild meat is frequently the most consumed source of protein, vitamins and minerals (Sirén and Machoa 2008). The hunting and consumption of wild meat is a widespread practice that often provides food security and supplements basic income for participating households. In the Global South, more than 150 million people have been estimated to depend on wild meat as a meat source (Nielsen et al. 2018). In surveyed households in 24 countries, 39% reported hunting for wild meat, and of those who reported hunting wild animals, 89% reported that wild meat harvest was directly applied to dietary needs (Nielsen et al. 2017, 2018). Additionally, hunting for wild meat tends to be most prevalent in areas with greater biodiversity indices, which frequently coincide with regions that experience higher poverty and food insecurity (Cawthorn and Hoffman 2015; Fisher and Christopher 2007; Adams et al. 2004).

The meat of wild animals is also an important trade item, in terms of both value-to-weight ratio and transportability. Fuelled by human population increases, the demand for and lucrative trade associated with wild meat have risen dramatically; this increase can explain the high extraction rates estimated for wildlife species in many West African and Central African countries. Estimates suggest that millions of tonnes of wild meat are hunted and consumed in the Congo and Amazon basins every year (Fa et al. 2003; Fa and Peres 2001; Nasi et al. 2011). These large numbers are mostly because commercial hunting has been growing in importance, with increasing numbers of hunters either earning or supplementing their incomes through the sale of wild meat (Milner-Gulland and Bennett 2003; Abernethy et al. 2013). Such trade increases the amount of hunting and reduces the sustainability of numerous wildlife species, mostly because it enlarges the effective human population density of consumers who eat wild meat from a given area of forest (Robinson and Bennett 2000b).



2. Wild meat biology as an emerging science

People hunt wildlife in a variety of habitats, primarily to eat it or sell it (Nasi et al. 2008). While vulnerability varies among species and localities, uncontrolled exploitation could bring about marked declines in wildlife populations and eventually the extinction of several hunted species. Coupled with threats from habitat loss and deforestation (Laurance et al. 2006; Wright and Muller-Landau 2006), overhunting can result in the extinction of species, especially of larger-bodied species of mammals and birds. These species have a naturally limited ability to produce large numbers of offspring per reproductive event, have a reduced number of reproductive events in an individual's lifetime and achieve reproductive maturity at a later age than smaller species. The global, local or functional extinction of populations or species of the larger-bodied taxa, referred to as defaunation by Dirzo et al. (2014), is driven by human activity. Critically, defaunation can result in the loss of seed dispersers in tropical forests, which causes detrimental changes in the long-term dynamics and structure of these ecosystems and, therefore, their ecosystem services and even carbon stocks (Bello et al. 2015).

Tropical and subtropical landscapes have a range of characteristics, with various wildlife communities and dynamics and human pressures. There are some important intercontinental variations in vulnerability. The recent rapid acceleration in losses of tropical forest species due to unsustainable

hunting occurred first in Asian forests: more than 12 large vertebrate species are known to have become extinct in Vietnam, largely because of hunting (Bennett and Rao 2002). As demonstrated by the comparisons of wild meat extraction levels in Fa et al. (2002) and Nasi et al. (2011) between the Amazon and Congo Basins, the problem is more acute in Africa than in South America. Nonetheless, there is increasing evidence that the supply of wild meat to urban settlements throughout the Amazon is increasing pressures on wildlife (Parry et al. 2014; El Bizri et al. 2020b) that will cause losses even in the most remote parts. This pattern follows that of major impacts of development and forest loss on the three continents, which are linked to human population growth: there are on average 522 people/km² of remaining forest in South Asia, 99 in West/Central Africa and 46 in Latin America (Fa and Peres 2001). Globally, there is now sufficient evidence of the plight of many species, particularly mammals, primarily due to overhunting (Ripple et al. 2016).

Attention to this issue — both scientific and from the point of view of assisting forest communities to manage the use of wildlife as food — has only recently emerged. The origins of this attention can be traced back to a scientific paper published in 1983 on bushmeat in Nigeria as a natural resource (Martin 1983). Since that date, research on various aspects of wild meat hunting has been published by many academic journals. According to a Web of Science survey of publications containing the key words “bushmeat” or “wild meat,” 1,257 papers had been published by the end of 2020. These papers appeared in 308 academic journals; 284 journals published eight or fewer papers, while only 24 journals published more than eight. Since the turn of the millennium, the yearly number of papers has increased steadily and has now reached more than 100 per year. Many papers also deal with the consequences of wild meat hunting, especially zoonotic transmission (i.e., from animals to humans) of diseases, including, anthrax, HIV/AIDS, Ebola, Monkeypox, SARS, COVID-19 and many more. Moreover, numerous papers in the hunting literature deal with wild meat without explicitly mentioning “bushmeat” or “wild meat” in the title or abstract.

Although early studies were mostly descriptive, the number of subjects covered has increased considerably. Alongside this burgeoning scientific attention, there has been much interest in advancing policies and actions that remedy the loss of biodiversity that results from the overexploitation of species for food. Campaigns around the so-called “bushmeat crisis” that emerged in the early 1990s, such as the Bushmeat Crisis Task Force (Eves et al. 2008) primarily advocated protectionist measures to reduce wildlife consumption or were based on an understandable concern for the fate of the

great apes. Those initiatives have given way to efforts to develop alternative livelihoods ensure the sustainable use of wild meat (Alves and van Vliet 2018; Wicander and Coad 2018) or to discover more comprehensive and context-specific biological and policy responses to prevent wildlife declines while promoting human well-being (CBD 2017b; Nasi and Fa 2015). Technical documents that summarize the knowledge of the wild meat issue include Robinson and Bennett’s seminal book (2000b). Bakarr’s et al. (2001) collection of papers on bushmeat in West and Central Africa has been followed by others that provide guidance for better governance to support a more sustainable wild meat sector; these have emerged more recently (Coad et al. 2019; Nasi et al. 2008). A document² prepared by CIFOR for the CBD was presented to the Subsidiary Body on Scientific, Technical and Technological Advice to the Convention on Biological Diversity (CBD) at its 21st meeting, 11–14 December 2017. It included recommendations for consideration by the Parties to the Convention (see Box 3).

Open-air restaurants in Amazonian Colombia are a popular destination for weekend family outings.

Photo by Barbara Fraser/CIFOR

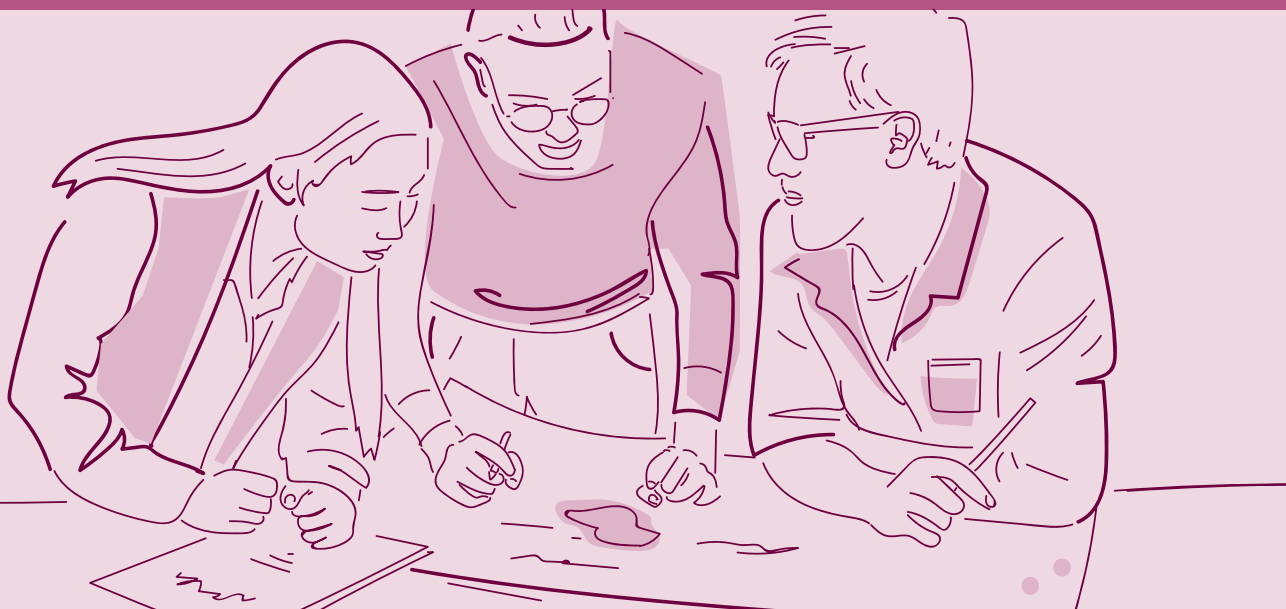


² <https://www.cbd.int/doc/c/8e64/9e91/13f53749f450a3d04d40bfe0/sbstta-21-inf-06-en.pdf>.

Hunting wild animals for food in tropical and subtropical forests is a matter of concern for three main reasons:

- Ecological impacts: there is growing evidence that the scale of hunting poses a real threat to many wildlife species.
- Food security and nutrition: wildlife is intimately linked to the food security and livelihoods of numerous urban and rural people. Bushmeat provides meat for urban and rural families, and as a source of income it is a common component of household economies throughout the supply chain, from the hunter to urban markets and food stalls.
- Health and zoonotic diseases: wild meat is an important reservoir of zoonotic pathogens, and relatively little is known about how such infections start and spread.



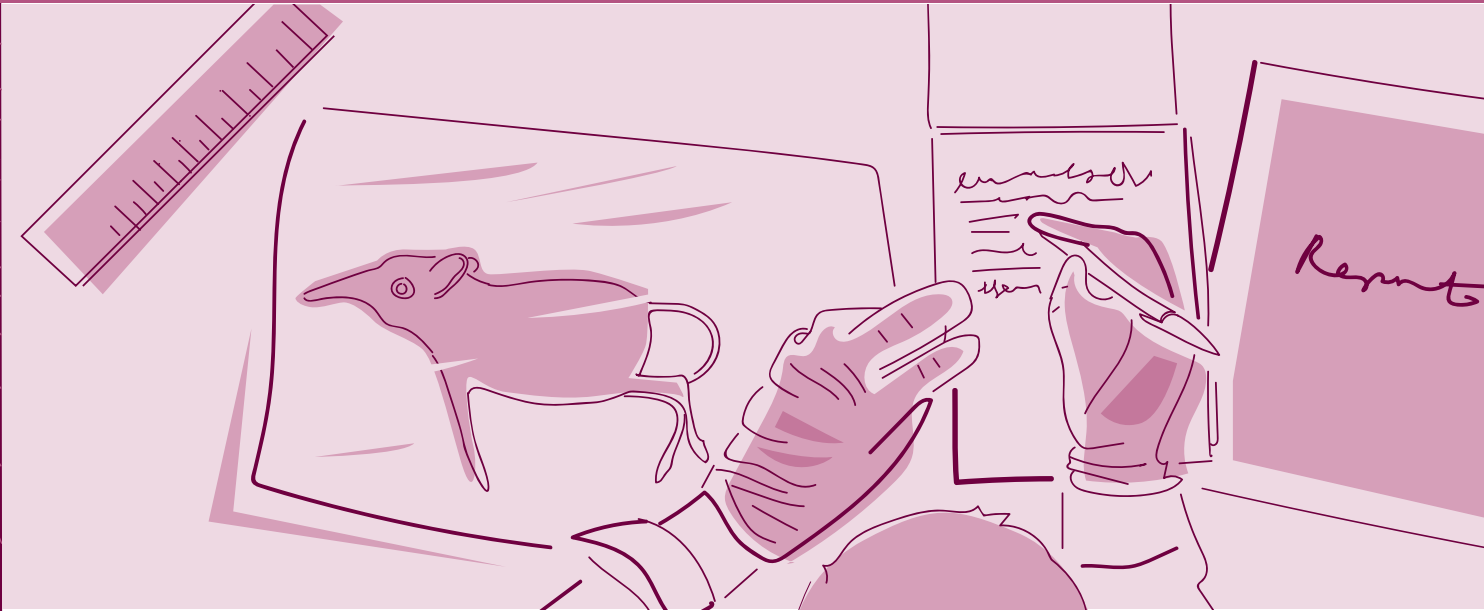


3. The Bushmeat Research Initiative

The Bushmeat Research Initiative (BRI) was established by CIFOR in 2011. It brings together diverse researchers and practitioners to generate and share knowledge on the harvesting, marketing and consumption of wild meat across Africa, Asia and Latin America. The initiative was established under the CGIAR Research Program on Forests, Trees and Agroforestry. BRI builds on the work of CIFOR scientists and partners by focusing on three main strategic objectives:

- to strengthen the evidence base for effective interventions;
- to identify gaps in knowledge and the areas where further work is required; and
- to recommend policy changes to mitigate the impacts of overexploitation of wild meat.

The team integrating BRI has varied from six members in the past to its current size of four. Despite its relatively small size, BRI has engaged in research collaborations with more than 20 universities globally, more than 15 different national governments, and with the Convention on Biological Diversity and international organizations such as the United Nations Food and Agriculture Organization (FAO).



4. Contributions to science: overview

Since BRI's inception in 2011, peer-reviewed research by the initiative and its partners has resulted in a total of 144 publications: 138 scientific papers in 40 different peer-reviewed journals, four book chapters, and two books. Publications have increased significantly since 2011 (Figure 1a), accruing a total of 2,949 citations by April 2021. Among the more than 100 organizations that publish on wild meat (or bushmeat), BRI stands out (Figure 1b), contributing 10 percent of all publications since 2011.

A clear motivation for BRI is to reconcile the research agenda with the needs and expectations of society, in order to guarantee that the information generated becomes a shared asset that benefits both biodiversity and the people who depend on it. By providing extensive field data, including global analyses, BRI's scientific productivity and engagement have generated new knowledge that has fed into international and national policies.

Focusing on research related to wild meat in tropical forests, BRI has produced studies in ten African countries, five Latin American countries and one country in Asia. Global assessments of wild meat issues have been published (Swamy and Pinedo-Vasquez 2014), as well as regional assessments for West and Central Africa (Taylor et al. 2015), the Amazon region (van Vliet et al. 2015a, b) and Asia (Lee et al. 2014; Lee et al. 2020). BRI has also

participated in assessments of wild meat extraction in African savannahs (Lindsey et al. 2013, 2015).

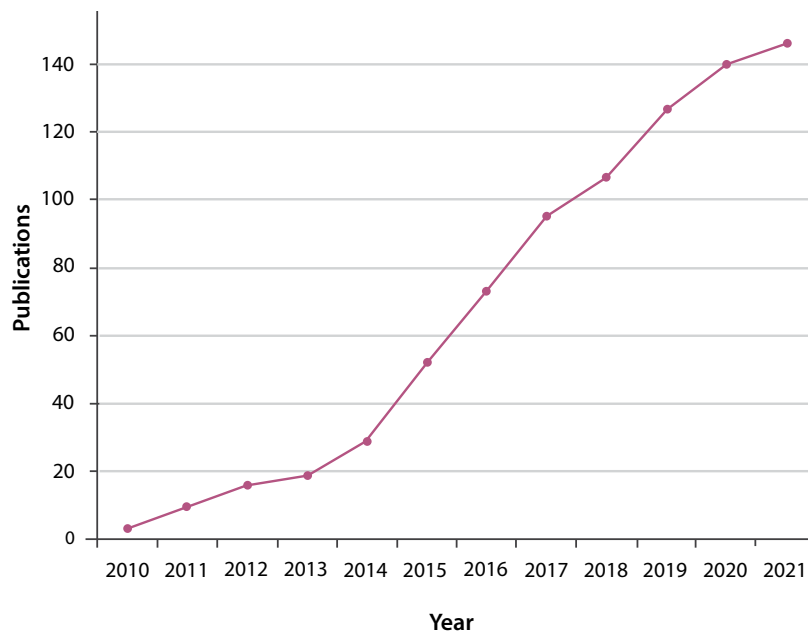


Figure 1a. Increase in the number of BRI peer-reviewed journal papers, book chapters and books published since 2011

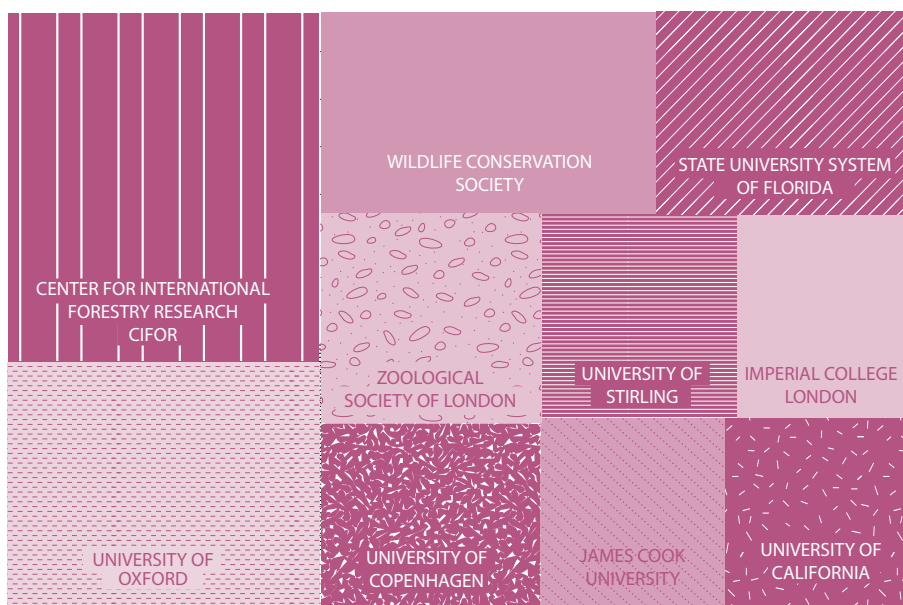


Figure 1b. Distribution of contributions made by the top ten institutions to the total number of journal papers ($n = 1,257$) appearing during the period 1980–2021 in Web of Science

Note: Results are from a general search within the Web of Science using the key words “bushmeat” OR “bush meat” OR “wild meat.”

Other BRI outputs — including focused work with communities (see Section 5.3), much of it novel — have influenced regional and global perspectives. BRI's work has also generated a better understanding of Indigenous Peoples, including broader perspectives on the global distribution of their lands (Garnett et al. 2018); the distribution of Pygmies in the Congo Basin (Olivero et al. 2016); the importance of Indigenous Peoples' lands for biodiversity protection (Fa et al. 2020; O'Bryan et al. 2020); health issues afflicting Pygmy groups in Cameroon (Funk et al. 2020a, 2020b); and the importance of wild meat hunting to African Pygmies (Fa et al. 2016, 2021b).

More specific research has also emerged on the biology of hunted species (El Bizri et al. 2018, 2020b; van Vliet and Nasi 2019), the impact of hunting on great apes (Fa et al. 2020), and how the use of LED flashlights has changed hunting in African and Amazonian tropical forests by increasing the frequency and efficiency of nocturnal hunting (Bowler et al. 2020).

Interest in the association between wild meat species and disease has stimulated a line of research on modelling the links between potential reservoir species and Ebola virus disease (EVD) outbreaks in African tropical forests (Olivero et al. 2017, 2019; also, see Section 5). And to provide context for the work on linkages between wild meat species and Ebola, the BRI-CIFOR team has also published research on how deforestation is associated with EVD outbreaks (Olivero et al. 2017) and how climate can influence the emergence of Ebola in Africa (Real et al. in press). A review of the links between wild meat and human health was published by van Vliet et al. (2017d).

Several more broad-ranging and concept-led papers have also been published by the BRI-CIFOR team (Pooley et al. 2015; van Vliet et al. 2015b; van Vliet 2018), including more extensive assessments of the wild meat sector in the tropics and subtropics (Coad et al. 2019). More recently, the book *State of the Apes: Killing, Capture, Trade and Ape Conservation*, a primer on this topic, was published by Cambridge University Press (Fa et al. 2021a).

To ensure that efforts to sustainably govern and manage wild meat resources are based on the best available evidence, the BRI-CIFOR team, in conjunction with its partners, has created the WILDMEAT database (WILDMEAT 2020). See Box 2. The database provides open access to all available data on wild meat hunting offtakes, consumption and sales generated by hunters, rural communities, traders, and town and city dwellers around the world. By compiling raw data generated in hundreds of studies the WILDMEAT database can be used to better understand the drivers, uses

and users of wild meat across the globe. Such a store of information can go beyond localized snapshots and provide a powerful evidence base for policy makers, practitioners, researchers and civil society.

Box 2. The WILDMEAT database

The WILDMEAT database holds data on wild meat consumption, hunting offtakes and market sales within one database and in one standardized format. This allows data from different sites and studies to be combined and compared, providing a holistic understanding of the volumes, characteristics, and locations of wildmeat use across space and time. When data is available over time from the same site, the database can be used to track changes in wild meat harvest characteristics and use. When these time-series datasets are used as part of a monitoring and evaluation strategy, they can help users evaluate the effectiveness of wildmeat management and policy interventions.

The WILDMEAT database holds three different types of data:



Hunting offtakes

-the number of individual animals harvested by hunters over a given period.



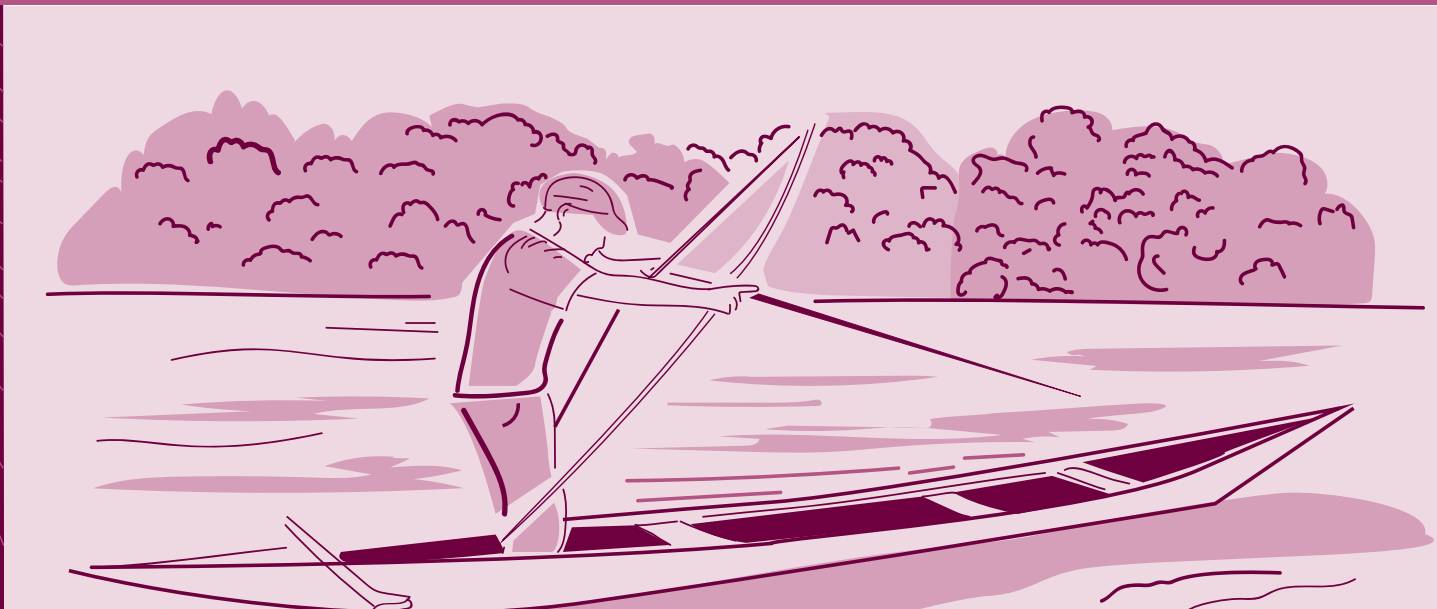
Consumption

-the quantity of animal biomass consumed by individuals or within households over a given period.



Market sales

-the price and number of individual animals, or pieces thereof, being sold at wild meat markets over a given period.



5. Key areas of work

This section summarizes the work undertaken by the BRI-CIFOR team during the last ten years. It covers five main topics:

- **5.1:** zoonotic disease linked to wild meat (specifically, the case of Ebola in Africa);
- **5.2:** the flow of wild meat from rural to urban areas, a major driver in overexploitation of wildlife;
- **5.3:** sustainable use of wildlife resources;
- **5.4** working with local communities; and
- **5.5:** national and international policy interventions.

5.1 Zoonotic disease, wild meat and the One Health approach: the case of Ebola

Providing food and a healthy life for the ever-increasing human population while preserving the environment and natural resources for future generations remains a major challenge. The health of humans, animals and the environment are inextricably linked, as shown in the One Health approach of the FAO (FAO 2011). One Health requires the collaborative efforts of people from multiple disciplines to work together locally, nationally and globally

to achieve food safety, sustainable food production and environmental stewardship. BRI's contribution to understanding the use of wild meat as a source of food for millions of poor people worldwide has also incorporated a better understanding of how diseases linked to the consumption of wildlife emerge.

Studying the ways in which hunting, food preparation and consumption of wild meat help to mitigate infections is also a priority, especially when awareness of zoonoses and occupational injury for community members involved in the wild meat commodity chain is often limited (Ordaz-Németh et al. 2017; Dell et al. 2020). At another level, to understand the basic structure and interactions between people, animals and diseases, several approaches have been explored to predict infectious diseases in both humans and animals. Often these methods rely on determining how transmission occurs (animal to human and human to human), understanding the origins of new infectious diseases, detecting widespread diseases in human and animal populations, and testing intervention techniques (Mathers et al. 2007; Erraguntla et al. 2017). Ebola disease in Africa is known to be transmitted and spread through the hunting, butchering and processing of the meat of wild animals. Determining how sustainable wild meat can remain part of the human food chain without representing a health risk to consumers is still poorly documented and largely under-assessed. Ebola outbreaks since the 1970s have resulted in thousands of confirmed deaths; these numbers are probably underestimates, since in some places many — even most — cases are not reported. Despite being overshadowed by the COVID-19 pandemic, Ebola disease is still a major global challenge.

There is a need for a multiscale effort that spans the globe and extends down to the community level, engaging partnerships between and within levels. Although regional and international modelling efforts provide important tools for forecasting risk zones, community-based surveillance will be necessary to effectively identify the emergence of Ebola virus disease in wildlife (i.e., through detection of sickness or death) before outbreaks occur among humans. BRI assembled a multi-disciplinary team of highly experienced European and international scientists who could combine not just field practice and research on wild meat and wildlife in Africa, but also high-level expertise in mathematical spatial modelling. The latter was provided by a team led by Dr. Jesus Olivero at the Universidad de Málaga in Spain. The results of this work that have already been published (Olivero et al. 2016a, 2017, 2019; Real et al. in press) can be used by health, wildlife and emergency assistance institutions to implement activities to prevent or control epidemics.

BRI's research centred on four main hypotheses:

1. there is a connection between zoonotic disease outbreaks and contact with wild animal meat;
2. deteriorating environmental conditions (e.g. deforestation, fragmentation of habitat) increase the likelihood of zoonotic disease regardless of human-wildlife contact;
3. larger outbreaks of zoonotic disease are correlated with greater human-caused pressures (e.g., human population density, infrastructure) and peoples' mobility; and
4. fine-scale predictive mapping of hotspots of zoonotic diseases can be used to mobilize efforts on the ground to prevent impacts to vulnerable human populations.

This BRI-led research is the first to assemble a comprehensive system to quantify potential zoonotic hazard levels for humans exposed at the various stages of the wild meat commodity chain; and to develop predictive models that synthesize the impacts of habitat changes, climate and potential reservoir species³ on Ebola (Figure 2). These results can be used as a tool to describe and predict future Ebola outbreaks. They will also provide the basis for on-the-ground, community-driven wildlife surveillance strategies in partnership with country governments. Ultimately, determining the ways in which sustainable wild meat can remain part of the human food chain without representing a health risk to consumers must involve a multiscale effort.

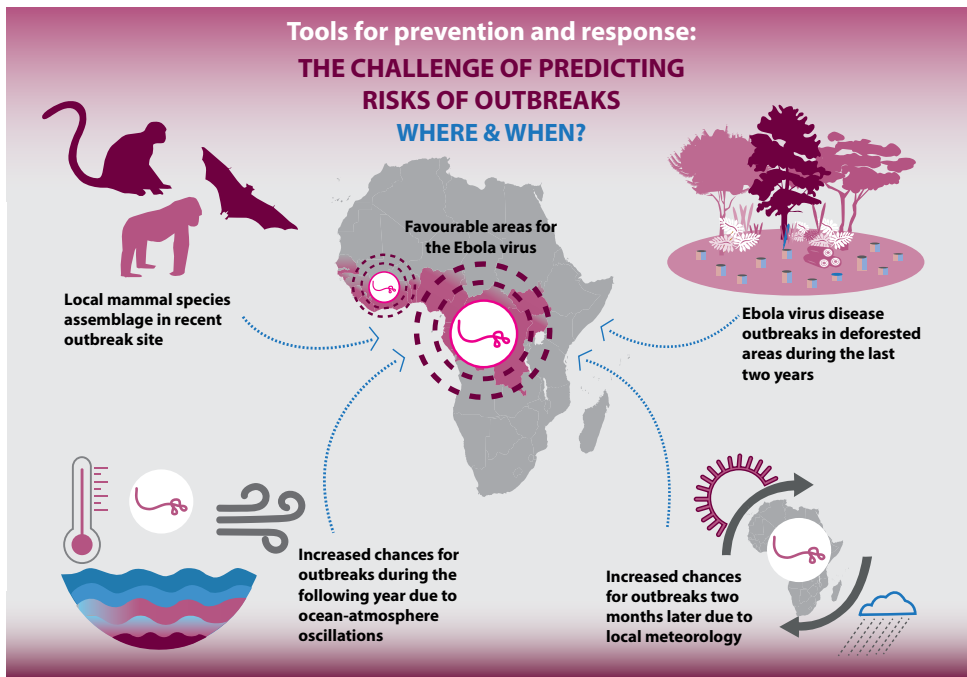
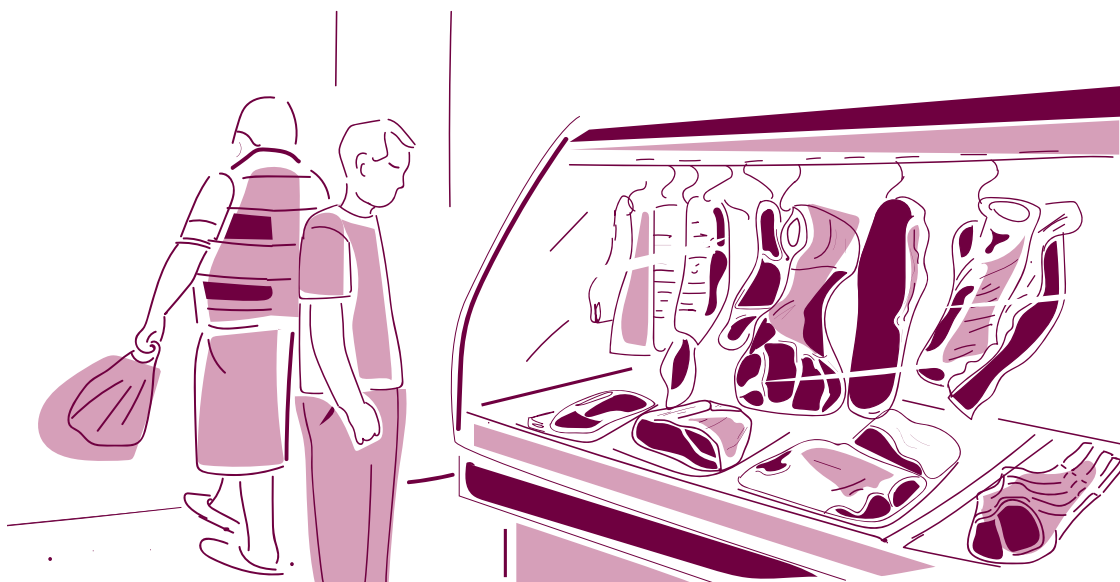


Figure 2. Summary of research undertaken by the BRI and partners to investigate the potential drivers associated with Ebola outbreaks

³ A reservoir is usually a living host of a certain species, such as an animal or a plant, inside of which a pathogen survives, often (though not always) without causing disease for the reservoir itself. https://en.wikipedia.org/wiki/Natural_reservoir



5.2 Supply and demand of wild meat from rural to urban settings

BRI scientists have worked extensively to study wild meat flows from rural to urban communities in Ecuador, Peru and Colombia. In Ecuador, the team concentrated on determining the impact of landscape connectivity and urban expansion on subsistence hunting in the Amazonian Napo and Pastaza provinces. Working within Kichwa and Waorani communities, the researchers aimed to understand the availability, consumption and trade of wild meat and how the market has evolved as urbanization has increased and these communities have become better connected by road networks (Cummins et al. 2015). Results indicated that Indigenous Peoples and non-Indigenous Amazonians are attracted to cities and towns, and that chicken and canned meat are becoming their main source of protein, but that wild meat is still hunted to provide household income. This region, like many other parts of the Amazon, is rapidly undergoing a transition between what was essentially a subsistence economy to one increasingly integrated into the wider market economy. See Figure 3.

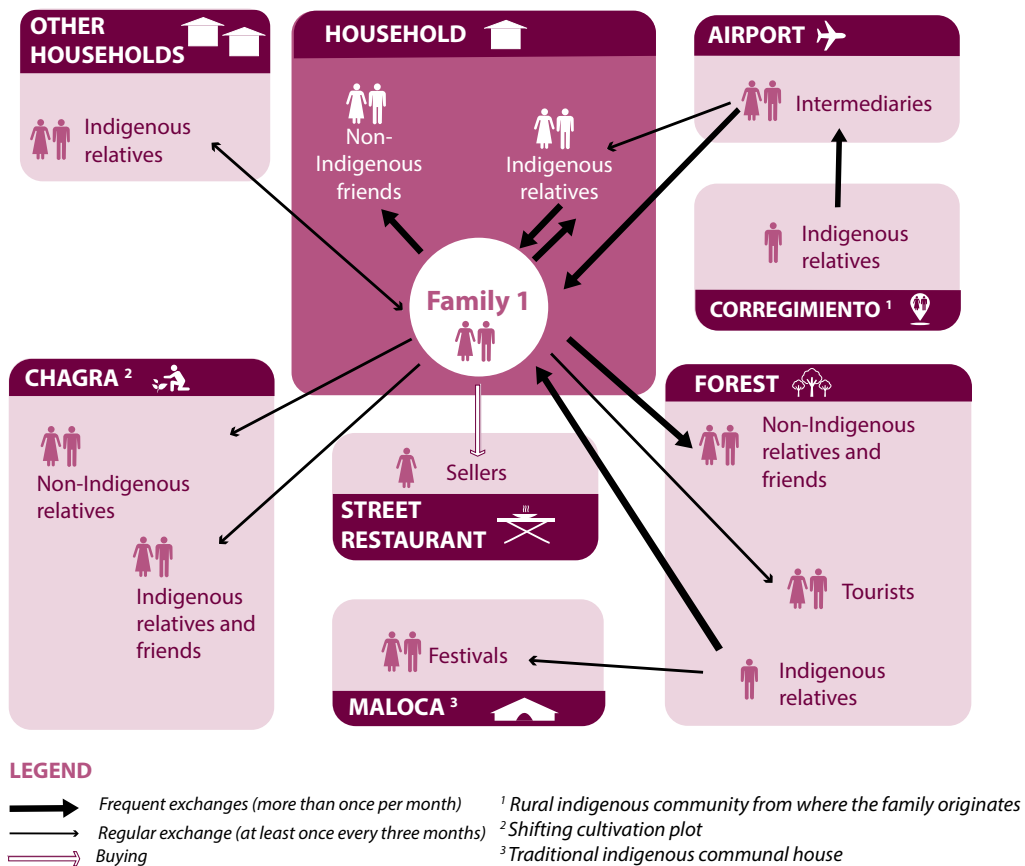



Figure 3. Wild meat network of a typical family in the Colombian Amazon

Note: This figure illustrates the variety of scenarios in wild meat exchanges. The most common way (several times a month) of receiving wild meat was through gifts sent from the community of origin, mainly by plane, or from other Indigenous families living in peri-urban areas. However, transportation of wild meat is subject to controls, fines and confiscations by local authorities. The family also obtained wild meat directly by hunting in the forest or in their fields. With neighbours, they would also exchange wild meat for agricultural products or be given wild meat as a gift. Wild meat can be offered to tourists when a member of the household acts as a tourist guide and to other Indigenous households, either by inviting them for a meal at home or sharing a piece of the animal when coming back from the fields used for shifting cultivation or from the forest. Source: van Vliet et al. (2015a).

In the past, the trade in urban wild meat in the Amazon basin was thought to be insignificant because of the perceived greater availability and affordability of domestic meats (Rushton et al. 2005). However, a BRI study of wild meat hunted and traded in the eight main frontier towns (just over 150,000 total inhabitants) along the Colombia, Brazil and Peru border in the Amazon estimated that as much as 473 tonnes of wild meat were traded each year (van Vliet et al. 2014). This amounts to 3.2 kg per inhabitant per year. In another study in the Brazilian Amazon, undertaken by the BRI-CIFOR team and its partners, as much as 10,691 tonnes of wild meat might be consumed annually in the 62 known urban centres within the State of Amazonas (El Bizri et al.

2020a). This amounts to 6.49 kg per inhabitant per year; in monetary terms it is USD 21.72 per person per year or USD 35.1 million total per year. The latter figure is comparable to the revenue from fishing and timber production in the region. With these data, the BRI team modelled the relationship between wild meat use and a selection of socioeconomic factors. Twenty-one taxa were consumed, mostly mammals (71.6%), followed by reptiles (23.2%) and birds (5.2%). The declared frequency of wild meat consumption was positively correlated with the proportion of rural population and with the per capita gross domestic product of the municipality (i.e., the administrative division) where the cities are located. Given the magnitude of wild meat trade found by these studies for the Amazon it is certain that the exploitation of wildlife to supply urban centres in this part of the world is not as insignificant as originally presumed. Moreover, as van Vliet et al. (2015a, b, c, d) show for Colombia, the wild meat trade to urban areas follows an organized but underground commodity chain (see Figure 3). In Colombia, the trade is underground, whereas in Peru and Brazil, wild meat is sold in open markets despite regulations against this, as indicated in the El Bizri et al. (2020a) study.


Further details of the flow of wild meat from rural areas to urban centres can be found in a more detailed study within the Jutai River Extractive Reserve, Amazonas, Brazil. Undertaken by the BRI-CIFOR team and partners, the study focused on assessing levels of wild meat consumption and trade and on the influence of social and biological factors. People from 51 households within 16 communities interviewed for the study declared that they consumed



Whilst the hunter sings the armadillo he trapped, a neighbour stops by to ask him what he plans to do with the meat.

Photo by Barbara Fraser/CIFOR

wild meat on an average of 3.2 ± 2.8 days per month per household. This amounts to 198.85 kg/month consumed by all the sampled households. Most respondents obtained wild meat by hunting it themselves or through having it given to them by their neighbours. The most consumed taxa were paca and collared peccary. Approximately two-thirds of respondents declared that they sold wild meat; meat destined for urban markets was more expensive and was sold primarily from the houses of relatives who lived in the city. Wild meat consumption was clearly determined by taste preferences, while prices were related to the body mass of the animal. Frequency of wild meat consumption and the probability of selling wild meat were positively associated with the number of hunters in the household. The study highlighted the value of wild meat for remote communities, and, significantly, the prominent links between these communities and urban markets. These findings are useful in developing strategies to ensure the sustainable use of wildlife in the Amazon. Further studies on what motivates consumers to eat wild meat, especially more vulnerable species such as primates, are also required. In a recent study, in which BRI participated, the reasons for eating or avoiding primate meat were explored in the city of Tefé in the Central Amazon. Results showed that there were differences between men and women, and that preference and custom positively affected primate consumption. Emotional, ethical and customary factors were an important part of avoiding primate meat. These findings provide insights into the reasons for primate consumption in the Amazon. These insights will be useful for designing tailored initiatives and for identifying the target audience in order to reduce hunting pressure on primates in rural settings and increase the effectiveness of outreach campaigns in urban centres.



Bushmeat sold in the local market at Ebolowa, Cameroon.

Photo by Colince Menel/CIFOR

Several BRI studies have aimed to understand the importance of wild meat in urban centres in West and Central Africa. Throughout sub-Saharan Africa, the meat of wild animals is a highly valuable NWFP. In Central Africa alone, the trade of wild meat is estimated to be worth US\$1–3 billion (Wilkie and Carpenter 1999). Such levels of extraction of terrestrial wildlife for food substantially exceed sustainable rates (Fa et al. 2002); also, the economic value is a short-term gain that will dwindle rapidly as wildlife populations are depleted (Coad et al. 2019). In particular, the desire of families in towns and cities to eat wild meat has already been recognized as a key factor that drives the overexploitation of wildlife in this region (Cowlshaw et al. 2004; Wilkie et al. 2005; Cronin et al. 2015). Urban consumers of wild meat live either in provincial towns or large metropolitan areas (Wilkie et al. 2005).

Provincial towns are often near sources of wildlife, and wild meat is often still cheaper and more readily available there than locally produced or imported alternatives. In large metropolitan cities, consumers usually have the choice of several sources of domestic animal protein, but many opt for wild meat for reasons other than its nutritional importance (Chausson et al. 2019). Since these consumers are far from sources of wildlife wild meat is no longer a dietary necessity; instead it reflects a cultural desire to connect to a rural past. City dwellers may eat wild meat as a means of culturally reconnecting to their place of origin, where they or their parents consumed wild meat, as shown from studies by the BRI-CIFOR team in cities in West Africa (Luiselli et al. 2017, 2018, 2019).

Although consumers in some provincial towns (particularly isolated communities) may buy wild meat because it is cheaper and more readily available (van Vliet et al. 2010; Fargeot et al. 2017), in metropolitan cities wild meat is more of a luxury item and status symbol than a necessity (Drury 2011; Ngoc and Wyatt 2013; Shairp et al. 2016; Wilkie et al. 2016). Since wild meat is a luxury commodity, city dwellers pay higher prices than rural consumers do for the same animal. Urban consumers' willingness to pay relatively high prices encourages rural hunters to increase the amount they take and the proportion that they sell for income (de Merode et al. 2004; Bennett et al. 2007; Grande-Vega et al. 2016). It also encourages non-local hunters to enter the market.

Given the size and geographic extent of the rapidly growing metropolitan cities throughout the tropics and subtropics it is not surprising that there has been no comprehensive investigation of the number and distribution of sales outlets for wild meat and alternative animal source foods in them (see Box 3, however).

Box 3. Study of wild meat consumption in Brazzaville and Kinshasa

A US Fish and Wildlife Service project, led by the Wildlife Conservation Society (WCS) and on which BRI collaborated, for the first time documented the distribution and abundance of outlets selling animal-source foods, including wild meat, for Brazzaville, in the Republic of the Congo (ROC), and Kinshasa, in the Democratic Republic of the Congo (DRC). These two Central African capital cities, separated by the Congo River, represent the third largest urban agglomeration on the African continent, behind Cairo, Egypt and Lagos, Nigeria. The main results of this work were published by Fa et al. (2019).

Although wild meat has been observed for sale in city supermarkets on occasion, the main outlets that sell wild meat are markets and restaurants. The study investigated a subsample of the markets and restaurants to determine the proportion that openly sell wild meat. The study mapped the distribution and numbers of meat outlets in the Kinshasa-Brazzaville metropolitan area. The two cities differ in the number and density of meat outlets, with more in Brazzaville. The number of meat outlets is related to human population densities; they are primarily concentrated along the banks of the Congo River, in the more affluent areas of the two cities. Across the two cities, roughly 22% of all sampled markets (50% of which were in Brazzaville and 19% in Kinshasa) and 24% of all visited restaurants (24% in each city) were selling wild meat during the survey. Even though few restaurants and shops offered wild meat for sale, extrapolating this amount to the entire area and population of both cities reveals that the overall amount of wild animal meat consumed each year in these large cities is likely to be significant. For example, if each person in Kinshasa and Brazzaville ate only 1 or 2 kg of wild meat annually (based on data for urban consumers in Wilkie and Carpenter 1999) that would mean 15–30 million kilograms are consumed annually in the two cities. The study also indicates that the number of domestic meat outlets may be adequate to supply urban dwellers with sufficient animal protein, without recourse to wild meat.

Africa's urban population is expected to more than triple over 40 years, from 395 million in 2010 to 1.339 billion in 2050, corresponding to 21% of the world's projected urban population (Güneralp et al. 2017). The supply of wild meat to these growing cities will have a strong impact on the animal populations that provide this meat.

5.3 Sustainable hunting practices

The trade of wild meat from rural areas to cities is a major conservation and livelihood concern. BRI scientists have worked with rural communities and Indigenous Peoples in Latin America, Africa and Asia to document and explore ways to achieve sustainable hunting. For these people in tropical and subtropical areas, wild meat is still the main form of meat they consume. Wild meat and fish can be plentiful in nearby areas, whereas livestock and farmed fish are expensive or unavailable. Hunted animals provide a cheap and relatively easy source of food. Ensuring that the local communities who depend on wild meat continue to use this resource sustainably rests on decisions made about the equitable use of natural resources by the communities themselves. The devolution of natural resource management to communities, which gives local people the rights and authority to manage their lands, is therefore crucial. To guarantee the sustainable exploitation of wildlife within these lands will require adequate information about the hunted species' numbers and distribution, and sufficient land must be allocated to the communities to ensure that they don't overhunt, and that they manage their own hunting, including the exclusion of outsiders.

A main concern of BRI, and for the international community, is to determine the ways by which hunting practices of wildlife can be made sustainable. This is also clear to the local communities themselves, who will argue that there is a need for game management, conservation of hunting grounds and access to multiple sources of food, including fish (both farmed and wild) and livestock, in order to maintain healthy populations of game species in the landscape. These perspectives indicate that participatory co-management of wildlife species is needed as part of the incentives to achieve sustainable resource use and the long-term provision of ecosystem services (Oldekop et al. 2012).



Boy selling iguanas.

Photo by Francois Sandrin/
CIFOR

The five-year project, Sustainable Management of Wildlife and the Bushmeat Sector in Central Africa, was launched in late 2012. It included the BRI-CIFOR team as a main consortium member, alongside CIRAD and FAO. The project, led by the FAO and the Global Environment Fund (GEF), operated through pilot sites in Gabon, Central African Republic, Republic of Congo and Democratic Republic of Congo. Within these sites, participatory wildlife and hunting management activities were undertaken. Lessons learned there could be rolled out to similar local communities in other parts of the Congo Basin. The sites represent the wide variety of socio-economic and ecological conditions found in the forest area of the countries in the region. The BRI-CIFOR team was responsible for producing documents detailing participatory methods for use in managing hunting at the village level (see, e.g., van Vliet et al. 2017a, b, e, g).

Together with FAO, CIRAD and WCS, CIFOR via the BRI became a consortium member in the SWM programme, tackling unsustainable levels of hunting for wild meat. This initiative, known as the Sustainable Wildlife Management (SWM) Programme (SWM 2021), is under the umbrella of the Organisation of African, Caribbean and Pacific States (OACPS); it is funded by the European Union, with co-funding from the French Facility for Global Environment. The programme started in August 2018 and runs until 2024. It is implementing projects in 13 African, Caribbean and Pacific countries, with the aim of improving both biodiversity conservation and food security. By developing innovative, collaborative and scalable new approaches to conserve wild animals and protect ecosystems, the programme will also improve the livelihoods of Indigenous Peoples and local communities who depend on these resources. The SWM Programme involves four main action areas: how wildlife hunting is regulated; how sustainably produced meat products and farmed fish can be supplied to replace wild meat; how the management capacities of Indigenous and local communities can be strengthened; and how the demand for wild meat, particularly in towns and cities, can be reduced.

The SWM Programme works closely with governments and local communities. The needs, rights and interests of local communities underpin all its activities, ensuring that the programme is culturally sensitive and sustainable. In each of the eight sites in which SWM is active, different operational models are implemented (Box 4). These eight models are guided by a comprehensive Theory of Change.⁴

⁴ Theory of Change is essentially a comprehensive description and illustration of how and why a desired change is expected to happen in a particular context. It focuses in particular on mapping out or “filling in” what has been described as the “missing middle” between what a program or change initiative does (its activities or interventions) and how these lead to desired goals being achieved. It does this by first identifying the desired long-term goals and then works back from these to identify all the conditions (outcomes) that must be in place (and how these related to one another causally) for the goals to occur.

Box 4. Intervention sites within the SWM Programme

- **Democratic Republic of the Congo (Ituri Landscape)** — Supporting two approaches to natural resource management: one within a national protected area (Okapi Faunal Reserve); and the other a community-based approach in local community forest concessions.
- **Gabon (Mulundu Department)** — Focusing on the sustainable management of village hunting and the local wild meat trade.
- **Guyana (Rupununi Savannas)** — Developing new models for sustainable wildlife and fisheries management in savannah and forest landscapes.
- **Madagascar (Makira Landscape)** — Promoting consumption and improving access to more resilient or domestic species through the development of backyard poultry raising and fish farming.
- **Papua New Guinea (Bismarck Forest Corridor)** — Working on sustainable wildlife consumption, for both cultural materials and food, at the village level.
- **Republic of the Congo (Ouesso Basin)** — Focusing on community management of hunting and fishing within logging concessions and reduction of wild meat consumption in logging towns and secondary cities.
- **Sahelian Wetlands Site:** Working on the sustainable management of migratory waterbirds in wetlands in Chad, Mali, Senegal and Sudan.
- **Zambia and Zimbabwe (Kavango–Zambezi Transfrontier Conservation Area):** Promoting local development through the sustainable use of natural resources, including wildlife and fisheries, in the Simalaha Conservancy (Zambia) and Mucheni Conservancy (Zimbabwe).

**SWM SUSTAINABLE
WILDLIFE
MANAGEMENT
PROGRAMME**

A significant product arising from the SWM Programme was a White Paper (FAO et al. 2020) focusing on why diseases spill over from wildlife to humans, and why these zoonotic outbreaks can spread and become epidemics or pandemics such as COVID-19. The White Paper also suggests what can be done to prevent, detect and respond to future spillover events. It has a particular focus on priority interventions in areas where humans, wildlife and livestock interact in order to contribute to further understanding and to support the One Health approach (see Section 5.1). The White Paper provides decision-makers with a set of feasible recommendations that can be implemented to prevent future epidemics.

5.4 Working with local communities

Longer-term projects undertaken by BRI combine research and engagement with local peoples to facilitate more sustainable ways of exploiting natural resources. Examples include BRI's commitment to the ATICOYA (*Asociación de Autoridades Indígenas*) hunter associations in Leticia and Puerto Nariño in Colombia (Sandrin et al. 2016; van Vliet et al. 2017c,f), the Yangambi project in DRC's Tshopo Province, and BRI's involvement with Baka Pygmies in the Djoum-Mintom area of southeast Cameroon. Details on the latter two initiatives are given below.



Yangambi, DRC

The Yangambi landscape covers an area of about 8,000 km² in northeast DRC. The main town is Yangambi, located about 100 km west of Kisangani City in Tshopo Province. Land tenure varies, including the Yangambi Biosphere Reserve (YBR), created in 1979; the Ngazi Forest Reserve, which belongs to the *Institut National des Etudes et Recherches Agronomiques* (INERA); a logging concession; and customary land. Due to the lack of human and financial resources, neither reserve has an official management plan, their limits are contested, and they are not under any specific form of management. Most of the landscape is covered by old secondary forests, semi-deciduous dense forests, young secondary forests and dense evergreen forests. The remaining land is occupied by a mosaic of agriculture, swamp forests and agroforestry systems. Data on the area's vegetation is available (Jacobsen et al. 2018), and more recently, information on medium and large mammals in the area was obtained from hunter interviews (van Vliet et al. 2018).

The number of people living around the YBR was estimated at 141,643 in 2016, based on data from the Yangambi Registry Office. During colonial times the community of Yangambi was a research campus of INERA and the *Institut Facultaire de Sciences Agronomiques* (IFA), where only staff and their families could live, but over the years it became a town, due to the in-migration of workers and people searching for job opportunities in what became an economic hub for the area. The population is composed of three groups:

- the urban population (37,997 inhabitants) who live in the 10 districts of the province: Bangala, Ekutsu, Likango, Lomboto, Lumumba, Lusambila, Moussa, N'Gazi, Okito and Yaekema;
- the Turumbo and Topoke populations who live in villages surrounding the reserve to the south, west and north along unpaved trails/roads (Yambau, Yawenda, Yelongo and Weko community groups); and
- the Bamanga (Bamanga Bengamisa and Bamanga Yambuya community groups) who live in the northeast part of the reserve, which belongs to the Bamanga and Mba tribes.

Traditional agriculture, including cultivation of cassava, banana, maize, rice, cowpeas, beans and groundnuts, is the main activity in all villages around the reserve and provides basic household livelihoods. The Bamanga people are more specialized in agriculture (particularly rice and peanuts) than the Turumbo, who hunt as their second most important livelihood activity. Agriculture is a complementary activity for the urban population

Spectacle Viande à Brousse (Weko). Theatre presentation to create awareness among traditional hunting communities on the importance of sustainable wildlife management.

Photo by Fiston Wasanga/CIFOR



of Yangambi, where most of the residents are state employees (researchers, technical and administrative staff from the INERA and IFA research centres, the Tshopo Province Administration and the YBR, which falls under the Ministry of Environment). Besides hunting and fishing, families also use many NWFPs for food and medicinal purposes and for crafts and building materials. In the villages, households keep small livestock (poultry, pigs, ducks, goats, sheep) in extensive traditional production systems, and use the resulting revenue to cover exceptional expenses, donations and dowries or to solve village conflicts.

During the last three decades, basic community infrastructure (roads, housing, educational and health facilities, etc.) has deteriorated significantly. Since the roads are in poor condition most basic necessities are supplied by canoes on the Congo River. Health establishments are insufficiently equipped, most urban and rural households have no access to drinking water, and the town of Yangambi is not electrified.

The Yangambi initiative, which is included within the *Formation, Recherche, Environnement dans la Tshopo* (FORETS) program coordinated by CIFOR, is a science, conservation and development project that focuses on how sustainably managed forests can drive local development. Research, restoration and climate-smart agriculture activities are central.

Yangambi's economy is strongly linked to scientific activities. In the past, Yangambi hosted a research centre that employed some of the population and created indirect economic opportunities for the rest of the community. The present research efforts, led by BRI, include faunal assessments using camera trapping; change campaigns (Figure 4), that target behaviours and develop strategies to reach people (communication, outreach, theatre, songs, commercials); and generating alternatives to hunting, with the support of various SME activities, micro-credit institutions, extension agencies and others.

Figure 4. Example of behavioural change campaigns undertaken in the Yangambi landscape.

Translation:

**Je chasse
Je nourri ma famille
Et je protège la forêt
Ensemble, nous réduisons la chasse commerciale**

*I hunt
I feed my family
And I protect the forest
Together, we reduce commercial hunting*

Conversation:

Je suis de retour ma femme, j'ai chassé du bon gibier
-I am back, my dear wife, I had a good hunt!

Merci papa Bienheureux, je vais préparer un délicieux repas pour toute la famille!
-I thank you Bienheureux, I am going to cook a delicious meal for the whole family!

Je ne comprends pas pourquoi Bienheureux ne vend pas son gibier pour venir boire avec nous.
-I don't understand why Bienheureux doesn't sell his catch to come and drink with us.

C'est moi qui paye la tournée aujourd'hui, mes amis.
-I'm paying for the round of drinks today, my friends.

Tu as aussi tout vendu, Innocent? Pourquoi tu ne peux pas être comme Bienheureux et me donner le gibier? Tes enfants ont faim!
-You also sold everything, Innocent? Why can't you be more like Bienheureux and give me the your catch? Your children are hungry!

Quelques jours plus tard, Innocent revient à la maison avec du gibier.
-A few days later, Innocent returns home with some bushmeat.

**JE CHASSE
JE NOURRI MA FAMILLE
ET JE PROTÈGE LA FORÊT
ENSEMBLE, RÉDUISONS LA CHASSE COMMERCIALE**





Nowadays, most households rely on the exploitation of natural resources for their livelihoods, including logging, slash-and-burn agriculture, hunting and fishing. Income-generating activities are limited, and local people often have no alternatives to over-exploitation. CIFOR, including the BRI team, has been working to create jobs in the landscape and to involve local communities in conservation and scientific activities that can improve their living conditions. These efforts focus on the sustainable management of forests.

A study of the market value chain (van Vliet et al. 2019) indicates that most of the wild meat hunted in the Yangambi Biosphere Reserve is sold in the city of Kisangani, a thriving market with around two million urban dwellers. Wild meat is the most frequently consumed meat, both in the main urban area and in the surrounding villages. According to the study, urban consumption generates a trade of about 103–145 tonnes of wild meat per year for a population of 37,997 inhabitants. This huge demand for wild meat has had devastating consequences on the large mammal fauna in Yangambi, although some emblematic species — such as chimpanzee, buffalo, okapi, red colobus and giant pangolin — are still present in the area. Typical of the situation in other African places, the wild meat trade in Yangambi has few barriers to participation and therefore numerous hunters and traders participate in supplying a significant number of consumers. Hunters, on average, earn a higher profit than traders, who bear the highest costs of transportation, fines and bribes. Reducing unsustainable trade in this context will require not using natural ecosystems as the main providers of animal protein. Hence, a crucial element of the Yangambi project is providing the local people with options for producing alternative sources of animal protein, through fish farming and domestic livestock rearing (CIFOR 2021). Recommendations to reduce unsustainable trade in urban areas need to be tailored to specific contexts. They must take into consideration whether markets are open (legal) or underground (illegal), the length of the trade chains (from local to international levels), the existence and types of barriers to entry, the number and types of stakeholders involved and the factors that influence supply and demand.

Djoum-Mintom, Cameroon

As in many other parts of the Congo Basin, wildlife in the tropical rainforests of southeast Cameroon faces increasing pressure from overexploitation, which is driven by a growing human population and uncontrolled outside commercial interests. In this region, rural poor people as well as Indigenous Peoples such as Baka Pygmies live precarious lives. The latter groups face a greater social and political disadvantage, since many of them have been displaced from the forest to settlements along the main roads. Pygmies continue to face huge political, economic, ecological and social pressures, both from modern state laws and from clashes with international development actors and agencies that impinge on their lands (Pyhälä 2012; Pemunta 2013). Inter-ethnic conflicts are also common (Rupp 2003). In many cases, Indigenous Peoples' traditional territories lie within the concession lands of extractive industry (logging, mining) or in protected areas; this drives evictions, displacement and human rights violations, as described by Pemunta (2014) and Ndameu (2001). Indigenous Peoples' lack of access to forest lands where they can hunt and gather directly affects their food security and livelihoods. The issue remains of whether hunting and gathering can be allowed to continue if they occur in a manner that ensures the long-term survival of animal and plant populations while meeting human needs. Even though some Central African countries have recognized the rights of Indigenous Peoples in national law, Pygmies are still marginalized. With the development of new economic activities, Pygmy groups have experienced the gradual reduction of their access to forest resources, especially game and edible wild plants. The expansion of protected areas has contributed to this reduction. The relationship between the use of forest products, subsistence agriculture and human health remains largely unstudied in these communities.

Often, assessments of the links between biodiversity and well-being centre on single issues — e.g., how wild meat hunting affects people's nutrition or income — without considering other intervening factors. A better understanding of the multiplicity of issues that affect people and wildlife will help generate interventions that result in long-term benefits for both. In an initiative supported by the Government of the UK's Darwin Initiative Fund, the BRI-CIFOR team, together with country partners, focused on supporting sustainable hunting practices and livelihoods as well as food production in 10 Baka villages. These are located along the Djoum-Mintom road south of the Dja Faunal Reserve and bordering the Dja Biosphere Reserve in southeast Cameroon. The project focused on understanding the use of domestic crops and wild foods to determine their relative importance in meeting peoples' nutritional needs. In parallel, team members assessed the

health status of a large sample of villagers to determine levels of malnutrition and disease, and where possible to establish links between these factors and the foods that people consumed. Based on the evidence collected, team members encouraged families to produce more and better grown local food crops, so that they could provide the nutrients that aren't provided by natural resources. Underpinning this work was the observation that reliance on wild meat is inversely related to other income, suggesting that it fills a gap. Thus, by enabling better domestic food production, alongside encouraging the sustainable extraction of wild resources (wild meat and food plants), the project aimed to improve local food security while protecting biodiversity. The project has worked to achieving this in four ways:

1. harmonizing local production and consumption of domestic and wild foods across seasons;
2. generating domestic produce surpluses, which can generate income to replace an over-reliance on wild meat trade, which will also support;
3. enabling hunting systems that encourage sustainable wildlife extraction; and
4. understanding the status of, and pressures on, threatened species.

The results of this project can serve as a model that can be scaled up to other Baka villages in the region and improve agri-food systems, and as a result reduce the impact on wildlife. These communities can become empowered to steward their lands and the biodiversity within them, thus enabling their long-term protection.

Figure 5. Baka hunters attending a presentation on data gathered on hunting territories, undertaken with their cooperation in the Djoum-Mintom project.

Photo by Rohan Fisher/CDU



By involving an estimated 77% of potential hunters in the 10 study villages, the project was able to amass a significant volume of information, not only on numbers of animals hunted, but also on the time invested in more than 1,000 hunting trips (Ávila Martin et al. 2020). In addition, hunters participated in mapping their hunting territories (Figure 6.; Fa et al. 2021b). As shown in other hunting studies of Baka communities in southern Cameroon, most hunters engage in short hunting events, target a low diversity of relatively abundant species, such as small duikers and large rodents (porcupines and rats), and hunt fewer large-bodied species. Around 50,000 kg of wild meat were estimated to be hunted per annum; as much as 7,000 kg (ranging from 2,000 to 19,000 kg per village) of wild meat were extracted annually per village. These figures represent as many as 12.3 ± 9.9 dairy cattle equivalents (based on a weight of dairy cattle of 617 kg, per Schubert et al. 2019) per village. The consumption of such relatively large amounts of animal protein is fundamental for people in area where meat from livestock rearing is absent. Moreover, hunting is a long-established part of their lives and has immense cultural value.

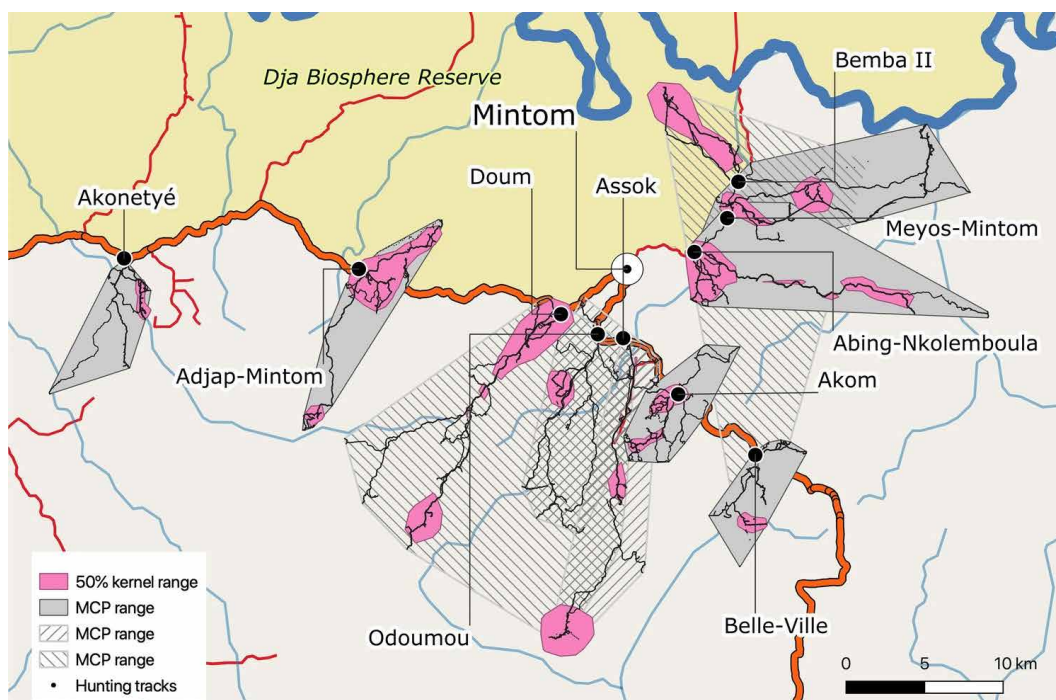


Figure 6. Hunting tracks, MCP (Minimum Convex Polygons) for home ranges and 50% kernel utilization distributions for hunters in the 10 Baka study villages in southeastern Cameroon (295 tracks recorded for 51 hunters). Source: Fa et al. 2021b; see Fa et al. 2021b for further details.

5.5 Understanding global wild meat issues and influencing policy and governance

BRI has been active in generating documentation to support the sustainable wild meat sector at international and local levels. Box 5 describes some examples of support of policies and governance.

Box 5. Summary of policy Interventions led by the BRI-CIFOR team

International level

World Conservation Union (IUCN)

A toolkit for implementing initiatives based on linkages between great ape conservation and poverty alleviation has been produced and circulated for comment. After revision, the document will be published as part of the “best practice” conservation series of IUCN.

Convention on Biological Diversity

CBD/SBSTTA/REC/XXI/2. Recommendation Adopted by The Subsidiary Body on Scientific, Technical and Technological Advice. XXI/2. Sustainable wildlife management: guidance for a sustainable wild meat sector. Montreal, Canada, 11–14 December 2017 (CBD 2017a).

CBD Fourteenth meeting

Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity 14/7. Sustainable wildlife management, Sharm el-Sheikh, Egypt, 17–29 November 2018 (CBD 2018).

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora)

In 2015, the General Secretariat of the Organization of American States and the CITES Secretariat developed a guide to the rapid assessment of the effects of implementing CITES provisions on the livelihoods of poor rural communities. The guide, published in 2016 (Gómez et al. 2016), provides tools for identifying mitigation or adaptation strategies that address the impacts of implementing the various CITES decisions.

Box 5. Continued...**National level***Peru*

At the regional level, an amendment to change the rules for environmental assessments to include the impact of plantations on game and wild meat. The aim was to effectively integrate the wild meat issue into environmental assessments. A technical plan for restoring biodiversity in abandoned logged forests is under discussion with the regional governments of Loreto and Ucayali. The plan includes information on managing small game species and on the hunting practised by women and children in defaunated timber concessions.

BRI's work on timber extraction in biodiversity rich forests — which includes the locally important non-wood product, Brazil nut — has been widely used by various stakeholders since its publication in 2011. The analysis shows that timber extraction in Brazil nut concessions had been carried out with little technical consideration and minimal regulation since 2004. CIFOR recently concluded an impact evaluation of this publication. The study demonstrated uptake by several bodies and processes:

1. The regional government of Madre de Dios, working to improve legal requirements and control of timber harvesting in these biodiversity-sensitive areas.
2. The Peruvian government's agency responsible for the legal use of forests and forest resource use, took measures to restrict uncontrolled timber harvesting in Brazil nut concessions.
3. Non-governmental organizations, notably World Wildlife Fund-Peru and ACCA.
4. The drafting process of the various laws and regulations pertaining to Brazil nut harvesting and management in the context of the new Forests and Wildlife Law (approved by the Peruvian Congress in 2011).

In 2012 BRI and its partner *Sociedad Peruana de Derecho Ambiental* published a report that illustrates the overlap between different land uses in Madre de Dios, in Peru's Amazon. The report shows that large areas of forest that were originally allocated for long-term extraction of timber and NWFPs are also being titled for non-forest uses such as farming and mining. Policymakers at the Ministry of Environment are making use of this publication as they draft new regulations for the

Box 5. Continued...

2011 *Forests and Wildlife Law*, which promotes the sustainable use of forest resources. The regional government of Madre de Dios is drafting policies on zoning, land-use planning, forest management and allocation of rights to farmland and forest resources and making use of the report as part of this process. The National Agency for Monitoring of Forest Resources and Wildlife is developing processes for GIS analysis and monitoring via remote sensing and validating the information with data from the field. The report is serving as a reference for this work.

Ecuador

As part of creating legal and financial support for the sustainable management of game species, incentives for managing game in forests and fallows as part of the Socio Bosque Program⁵ have been established at the provincial level in Napo and Pastaza. A framework on the impact of road building on wild meat and other forest resources will be included in environmental assessments on road building in the Ecuadorian Amazon.

Brazil

A range of hunting quota proposed for the states of Pará and Amapá and a technical document are being prepared by the team and experts from the Núcleo de Altos Estudos Amazônicos-Universidade Federal do Pará. A participatory wild meat monitoring system, based on BRI's research, was designed for district and provincial authorities in Brazil.

Colombia

Colombia is currently revising its wildlife policy through a participatory process. BRI-CIFOR team members were invited by the policy review team to provide recommendations based on the research results from Leticia. BRI's recommendations emphasize the role of wild meat in food security in the provision of nutrition. Based on these recommendations, local government institutions and Indigenous Peoples are ready to partner in an innovative pilot project for the sustainable use and the "legal/local and certified" trade of wild meat to maintain food security and livelihoods among Indigenous Peoples in the Amazon. The Instituto von Humboldt in Colombia will engage with CIFOR in developing national indicators of the use of wildlife to monitor its importance to people's livelihoods and food security and to biodiversity conservation.

⁵ The Socio Bosque Program started in September 2008. An initiative of the Ministry of the Environment of Ecuador, it provides economic incentives to owners of land with native forests to guarantee its protection over the medium to long term.



6. Moving forward

There is no doubt that in the last decade, BRI has been one of the most important contributors to wild meat research across the tropics and subtropics, adding to the knowledge of species used, volumes hunted and traded, and drivers of use. These investigations have helped confirm the importance of wild meat to millions of people, especially rural communities and Indigenous Peoples, and the integral and complex role of wild animals in the economies and ecologies of many countries across the globe.

At the start of the BRI program the issues affecting wild meat use were arguably simpler, and were primarily related to overexploitation. Since 2020, however, the trade in wild meat, and its role in diets, have been brought into focus because of discussions over the origins of COVID-19. As a result, the research context has changed dramatically. BRI must respond accordingly, including taking the One Health approach and addressing the concerns expressed during the preparation of the UN Food Systems Summit. The following three main research pillars are based on BRI's research and actions during the last decade. They can be instrumental in allowing CIFOR to make even more effective contributions to the wild meat issue.

Pillar 1: Help reduce urban use and supply of wild meat

The COVID-19 pandemic has triggered a systemic crisis that is likely to affect the supply of and demand for wild meat. It has had impacts on commodity prices and disrupted supply chains, and in some countries has caused a drop in international travel and tourism. Part of the response to this systemic crisis may be a reduction in consumption of wild meat due to concerns over the perceived health risks, as was the case in Liberia during the 2014–16 Ebola outbreak in West Africa (Dindé et al. 2017; Ordaz-Németh et al. 2017), and in Nigeria (Funk et al. 2021). The immediate ban on the wild meat trade during the COVID-19 outbreak in West and Central Africa had a limited and short-term impact on demand and on the associated hunting pressure (WCS Central Africa 2020). Thus, a key question for researchers involved in wild meat is to assess what direct effects COVID-19 has had on rural communities. Likewise, researchers should determine whether the immediate decline in wild meat consumption in urban centres can be prolonged. As part of a clear behavioural change campaign to reduce demand for wild meat in urban areas, understanding the drivers involved is crucial to guide interventions.

Although studies on drivers of urban wild meat consumption that can inform such campaigns have emerged and are increasing in some parts of the world (Shairp et al. 2016; FFI 2018; Chausson et al. 2019), the cultural and socio-psychological factors that affect consumer behaviour have not been studied sufficiently. As highlighted in McNamara et al. (2020), it is possible that the lockdown measures adopted all over the world to combat the COVID-19 pandemic could in fact increase the wild meat trade if rural households have fewer alternative sources of income and if supply chains for domestically reared meats are disrupted.

Wild meat is sold freely in different places, in stylish or popular restaurants, in bars, in private houses or on the roadside.

Photo by Manuel Lopez/CIFOR



For example, the shutdown of the tourism industry in countries in East Africa has triggered reduced funding and restrictions on the operations of conservation agencies, and has elevated human threats to nature, including increased poaching (Lindsey et al. 2020; Somerville 2020; ABC News 2020). BRI's research should focus on determining the long-term consequences of COVID-19 on the use of wild meat and its effects on consumers' food security and livelihoods. Understanding and predicting the complex dynamics of wild meat use in the new COVID-19 world will require increased collaboration between environmental and resource entities and the ecological and conservation sciences.

Any suggestion of outlawing the hunting and consumption of all terrestrial wild animals, as proposed for China (Koh et al. 2021) would force millions of people who depend on wild meat, often Indigenous or rural, to face the risk of malnutrition. As shown by the work of the BRI team, reducing the demand for wild meat from urban areas in the tropics and subtropics must remain a high priority in its research agenda. Finding ways to target social media campaigns to change consumer behaviour in large cities, to reduce both individual and aggregate demand for wild-caught animals, is crucial. BRI's experience in urban consumption and trade in the Amazon should be used to push forward a greater understanding of the issues and reduce the impact of urban consumption in the region. Further clarity on wild meat value chains will require extensive research, to make recommendations, improve practices and build capacities. BRI's focus on urban meat in Africa, particularly West Africa, should be expanded to include greater detail. Urban meat research in Central Africa is currently led by BRI partners such as the WCS, and collaboration with them is recommended.

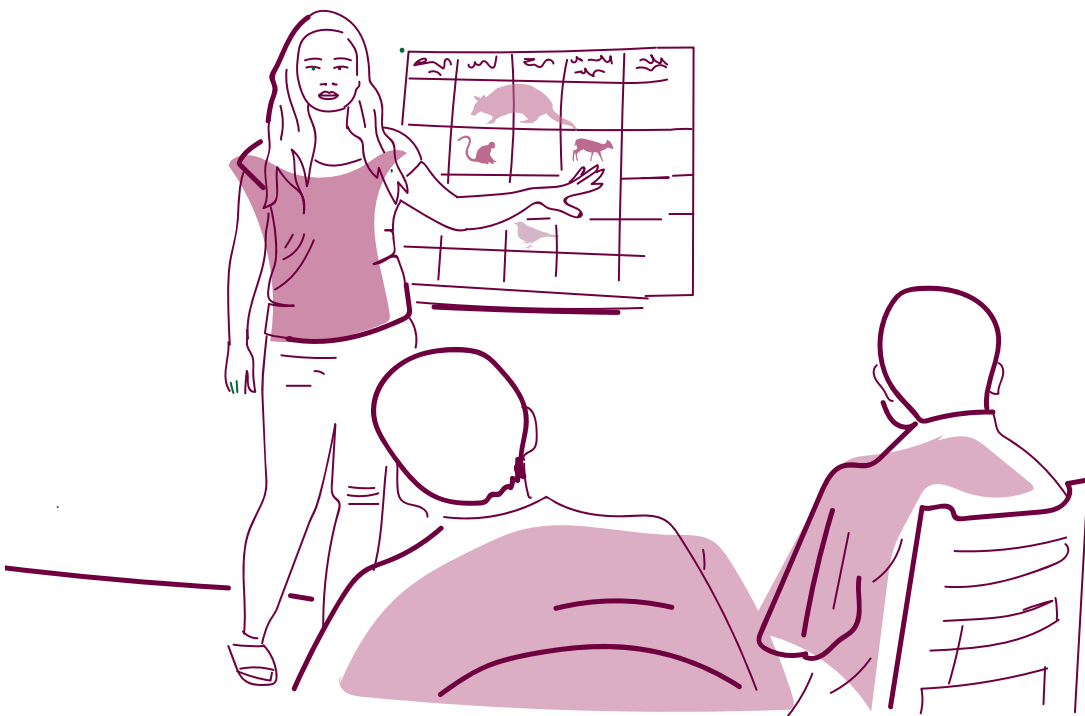
Pillar 2: Explore zoonotic diseases and wild meat

Hunting, processing, trade and consumption of wild meat pose major risks to global public health. There is evidence that disease risks increase along the wild meat supply chain, from hunting areas to urban consumers (Huong et al. 2020). The informal — or illegal — and/or unregulated character of wild meat and wildlife value chains worsens these risks and limits attempts to control them. Spillover events, where pathogens infect humans and cause epidemics, are relatively rare. However, risk mitigations are needed and justified given the huge impact of such events on public health, economies and society. Alongside these approaches, the value of spatial and temporal modelling cannot be underestimated. Based on the work already led by BRI on Ebola, further research on quantifying the potential zoonotic hazard levels for humans exposed to wild meat at the various stages of the supply

chain should be a priority. Predictive models that synthesize all the available information on disease processes and the factors affecting them can become a significant descriptive and prognostic tool for future outbreaks. Fine-scale predictive mapping of hotspots of zoonotic diseases can be used to mobilize efforts on the ground to prevent impacts on vulnerable human populations.

Pillar 3: Continue working with local communities

Where no alternative source of protein exists, people should be allowed to continue consuming wild meat, but it should be banned in places where other sources of protein exist. BRI's work with rural and Indigenous communities has assisted people to both determine ways of better managing the wildlife resources that provide them with food and produce alternative sources of food such as subsistence crops or domestic livestock. The expansion of such projects, to be led by BRI, must become an important part of the team's future objectives. Continuation of the existing community-based projects is essential, but expansion of similar projects in other parts of the world would generate a living portfolio of intervention sites, which would inform partners and other institutions. Such involvement would no doubt assist in recognizing and respecting the rights and authority of Indigenous Peoples and local communities to continue to preserve the ecological integrity of their traditional territories and use them wisely.





7. Final thoughts

These suggestions for BRI's future agenda must continue to be based on interconnected actions that link research and development institutions and must be followed up through true collaboration with local communities. The aim is to target both the management of rural supply and the reduction of urban demand, with long-term sustainability in mind. Although BRI's research into wild meat in the last decade has provided essential data on the users and uses, and on the drivers of unsustainable harvest, a shift in research is required, and efforts must focus on the three pillars discussed above. To achieve the main aims of these three pillars the BRI must attract more resources, especially given the new challenge of COVID-19. Furthermore, continuing human population growth, declining space for wildlife and even climate change will affect the likelihood of widespread sustainable offtakes. However, it is hoped that the value of the BRI's past performance — as well as its determination to make a greater difference in the future — will persuade governments and development agencies to recognize the urgent need to address the wild meat issue.

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Over the last decade, the CGIAR Program on Forests, Trees and Agroforestry (FTA) has undertaken innovative basic and applied research across different scientific disciplines, including the research and policy initiatives led by the Bushmeat Research Initiative, on the current levels and trends of wild meat extraction and of the importance of this wild meat to consumers. This publication presents key FTA outputs on wild meat from 2011 to 2021.



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