IMPACTS OF TAKING, TRADE AND CONSUMPTION OF TERRESTRIAL MIGRATORY SPECIES FOR WILD MEAT

CMS

Impacts of Taking, Trade and Consumption of Terrestrial Migratory Species for Wild Meat

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COVER IMAGE

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1 Executive Summary

This study looks for the first time at the extent to which terrestrial animals protected by the Convention on the Conservation of Migratory Species of Wild Animals (CMS) are being impacted by wild meat taking, trade and consumption. It contributes to the implementation of a decision adopted by the CMS Conference of the Parties in 2020 (CMS Decision 13.109). We assessed the direct and indirect impacts of wild meat taking, trade and consumption of 105 terrestrial mammal species listed in the CMS Appendices I and II and relevant CMS daughter agreements and initiatives. We first used a systematic review of the published literature, global database searches and the IUCN Red List to determine which CMS species are affected by wild meat hunting. We then reviewed the legislation applicable to the regulation of wild meat hunting and trade and explored the application of hunting legislation using a national case-study example. Finally, we examined the known linkages between zoonotic diseases and wild meat use and trade.

We concluded that a large proportion of the CMS species considered in this report are affected by wild meat hunting. The literature review found that 64% of the 105 reviewed CMS terrestrial mammal species are recorded as hunted. When Chiroptera (bat) species are removed from the analysis, this increases to 98% (47/48) of species. 70% of CMS terrestrial mammal species are hunted for wild meat consumption and 60% are recorded as traded (nationally and/or internationally; legally or illegally). Similarly, global database records of wild meat hunting and trade show that 51% of the CMS terrestrial mammal species are recorded as hunted or traded legally or illegally.

Taking (for all purposes) is reported as a key threat to the survival of many species. Of the 99 CMS species with an IUCN Red List assessment 50% of species and 98% of all non-bat species are threatened by hunting (including intentional or unintentional hunting and hunting for persecution/control), and 95% of the CMS species classified by IUCN as Endangered, Critically Endangered, or Extinct in the Wild are threatened by hunting.

For most CMS species studied, taking for domestic use has likely a greater impact than taking for international trade. When only meat for consumption was considered, 27 species were reported as consumed for subsistence in their IUCN Red List Assessment, 10 species used for national wild meat trade and only two species used for international wild meat trade.

There is strong evidence that zoonotic disease emergence is linked to human activities that bring wildlife, domestic animals, and humans into increasingly intense contact, including encroachment into remaining natural habitats and transport of wildlife to urban centres. CMS species used for wild meat can be a potential source of new zoonotic outbreaks. Data from (Johnson et al., 2020) suggests that 51% of the CMS terrestrial mammal species were known to host at least one of 60 pathogens that have been, or have the potential to be, transmitted to humans and cause disease.

Management of wild meat hunting generally is challenging; laws and regulations governing wild meat hunting and trade are often outdated, are based on insufficient scientific evidence, and often do not consider the land rights of local and indigenous peoples. Additionally, contradicting regulations, legal loopholes, lack of resources/capacity, and high levels of corruption make enforcement difficult. Migratory species are especially susceptible to over-hunting; national laws and regulations governing wildlife hunting and wild meat use, enforcement of these laws, and political and social conditions vary widely between nations, presenting a particular challenge for migratory species whose range may cross multiple international borders. Additionally, hunters can take advantage of predictable peaks in the abundance of species along migration routes.

In conclusion, there is strong evidence from the literature that wild meat use is a major driver of unsustainable hunting for numerous CMS species, especially under conditions of conflict, poverty, and land use change. However, additional research is needed for many species, as data on hunting offtakes and species abundance is limited and species may be targeted for multiple reasons.

We recommend several follow-up actions. First, we recommend that comparable and collatable data on hunting offtakes and species abundance are gathered on all the species studied to enable more complete assessments of impacts of hunting for wildlife consumption and trade. Second, a review of existing national hunting legislation and regulations, as well as the enforcement of these regulations, is needed. Third, capacity for monitoring and enforcement should also be examined. Fourth, the drivers contributing to the use of wildlife for domestic consumption, especially in urban areas, should be further identified and addressed. Finally, additional international cooperation will be needed to address wild meat taking, particularly for migratory species whose ranges may span vast areas that include various countries.

2 Introduction

2.1 Migratory species and hunting for wild meat: CMS Decision 13.109

Migratory species are hunted and eaten by humans in many regions of the world. However, the impact of this use on wild species populations is not well documented. Responding to this information gap, the 13th Meeting of the Conference of the Parties (COP13) of CMS directed the Secretariat to prepare an analysis on the direct and indirect impacts of wild meat taking, trade and consumption of terrestrial and avian species listed on CMS Appendices I and II (CMS Decision 13.109 on Addressing Unsustainable Use of Terrestrial and Avian Wild Meat of Migratory Species of Wild Animals). The Secretariat was also requested to to organise an assessement of the impact of direct use on the conservation status of species listed on Appendix I (CMS Decision 13.24 on Conservation Status of Migratory Species).

The aim of this report is to contribute to the implementation of CMS Decision 13.109, by assessing, to the extent possible, the direct and indirect impacts of wild meat taking, trade and consumption for each of the CMS terrestrial mammal species covered by CMS Appendices I and / or II, as well as the following species: *Gazella bennettii, Pantholops hodgsonii*, and *Procapra picticaudata* (all under CMS Central Asian Mammals Initiative); and *Myotis aurascens, Otonycteris hemprichii, Plecotus kolombatovici, Plecotus macrobullaris, Plecotus sardus, Rousettus aegyptiacus,* and *Taphozous nudiventris* (all listed under the Agreement on the Conservation of Populations of European Bats (EUROBATS)).

Considering the broad definition of 'taking' in CMS (Article I (1)(j)), covering 'taking, hunting, fishing, capturing, harassing, deliberate killing, or attempting to engage in any such conduct', a variety of scenarios need to be considered. In the frame of this study, any taking of the above-named species for the delivery of meat or other wildlife parts for human consumption (food or non-food, including for 'medicinal use'), legal or illegal, regulated, or unregulated by law is relevant. The analysis is also expected to provide input to an assessment of the impact of direct use on the conservation status of species listed on Appendix I as provided by CMS Decision 13.24.

2.2 Terms used in this report

In this report we use the following terminology:

- Hunting: The pursuit of wild animals often, but not always, ending in their killing or capture. This includes legal and illegal hunting activity. We use 'hunting' to cover the same broad CMS definition of 'taking' as outlined above.
- Sustainable hunting: Hunting in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations (adapted from the CBD definition of sustainable use (CBD, Article 2)).
- Threatened by hunting: We follow the IUCN Red List definition of a threat, which is "the proximate human activities or processes that have impacted, are impacting, or may impact the status of the taxon being assessed". In the context of the Red List, the 'status' refers to the Red List Extinction Risk Assessment status. More generally in this report a species threatened by hunting would be one that is experiencing significant population declines or is at risk from extinction, due to hunting offtakes.
- Wild meat: The meat of wild animals, used for food. Also referred to in the hunting literature as 'bushmeat'. For the purposes of this report, it does not include wild fish.
- Trade: The sale of wildlife or wild meat. This refers to all levels of trade, from local to international, unless otherwise stated in the text.

2.3 The use of wild animals as food

The meat from wild animals, obtained from a diversity of habitats (forests, savannas, aquatic environments, agricultural areas, deserts, glaciers etc.), is used as food around the world. Centuries of agricultural development have greatly diminished reliance on terrestrial wild meat in most temperate regions (Ramankutty et al., 2018), but wild meat is still used as a source of food and income in much of the tropics. Nielsen et al. (2018) examined the use and role of wild meat in 7978 households in 24 countries across Africa, Latin America and Asia, and found that 39% of households hunted wildlife for food at least once a year. Extrapolating from this sample they suggest that over 150 million households (between 230 and 833 million people) in the global south may hunt wildlife for food at least once a year. The number of people harvesting wild meat can vary significantly between regions; for example, Nielsen et al. (2018) found that 97% and 85% of sampled households hunted in Cameroon and Mozambique respectively, whereas none of the sampled households in India and Ecuador reported hunting.

In some rural communities – often those that are remote, where poverty levels are high, affordable alternatives to wild meat are scarce, and wildlife populations are still relatively abundant - wild meat can provide a significant proportion of daily protein, fat and micronutrient needs for rural peoples, and contribute to diversified diets (Alves & van Vliet, 2018; Cawthorn & Hoffman, 2015; Nasi et al., 2011). For example, Nasi et al., (2011) estimated that wild meat consumption could be providing between 60 and 80% of daily protein needs for 15 communities surveyed in the Congo Basin. Wild meat can also be an important source of household income and, due to urban demand for wild meat, the amount and proportion of hunting offtakes sold by hunters increases with proximity to urban markets, where bushmeat prices can be many times higher than in the villages within the areas where the animals were hunted (Brashares et al., 2011; Kümpel, 2006; Starkey, 2004).

Several site-level studies have found that wild meat can also provide a 'safety net' in times of economic hardship, civil unrest, drought or disruption in the supply of alternatives (Cawthorn & Hoffman, 2015; de Merode et al., 2004; Schulte-Herbrüggen et al., 2013, 2017; van Vliet et al., 2017; van Vliet et al., 2018), however, see Nielsen et al. (2018), who found no correlation between wild meat use and idiosyncratic income or food security shocks). While adequate data exists to show widespread use of wild meat by rural communities in the Global South, disentangling wild meat 'use' from 'dependence' on wild meat can be difficult, and has only been robustly assessed in a few cases (e.g., Allebone-Webb, 2009; Nunes et al., 2019). This has been identified as a major data gap by Ingram et al. (2021) in their recent review of progress in wild meat research, policy and practice from 2002-2020.

While wild meat can be an important source of nutrition for rural communities, wild meat does not often play a significant role in food security for urban dwellers, for whom relatively cheap alternative meats are available (Coad et al., 2019) and wild meat is generally consumed as a luxury item (Shairp et al., 2016; Wilkie et al., 2016). Population increases coupled with rural to urban migration has resulted in rapidly growing urban populations; In 2016, 54% of the world's people lived in urban areas, a rise from 34% in 1960 (World Bank, 2017). An estimated 83% of the population of South America lived in urban areas in 2014 (UNDESA, 2014), and Africa and Asia are urbanising rapidly (Cawthorn & Hoffman, 2015). As urban populations grow, so does the demand for wild meat. Even low per capita consumption rates can add up to large total quantities of wild meat consumed, and urban demand is fuelling increasing unsustainable offtakes in surrounding rural areas (Fa et al., 2003). This reduces wild species populations, and therefore meat availability, in the more wildlife-dependent rural communities surrounding these urban centres (Van Vliet & Mbazza, 2011).

Increasing urban demand incentivises external commercial hunters (as opposed to local village hunters), who are often primarily hunting for high-value wildlife products (such as ivory or skins; (UNODC, 2020) but will also respond to the lucrative profits to be made in urban and transborder sales of wild meat (Coad et al. 2019) and will move between hunting areas following target prey availability to maximise profits. External commercial hunters - especially those involved in the trade in ivory or in other high-value wildlife products - are often part of well-organised, well-armed hunting groups, sometimes ex-military, with strong direct links to urban and international traders (Coad et al., 2019; UNODC, 2020; Wutty & Simms, 2005). Due to the illegal nature of such wildlife trade, obtaining data on the activities of these groups can be difficult and dangerous, and therefore few estimates of offtake and incomes for these groups exist. However, it is thought that the number of groups and their activity is increasing with urban and global demand for wildlife products (UNODC, 2020).

Although transport of wild meat has been identified in Europe (Maisels et al., 2013), and the United States (Bair-Brake et al., 2014), long-distance intercontinental trade in wild meat from the tropics is poorly understood (Ingram et al. 2021). Estimates of annual inflows of illegal wild meat in passenger luggage to major airports in Europe at the start of the decade were up to 300 tons, with the bulk originating from Central and West African countries (Chaber et al., 2010; Falk et al., 2016). However, estimates of total wild meat harvest from Central Africa range between 1 and 5.5 million tonnes per year (Ingram, 2018). Comparison of these estimates suggests predominantly national use, with the caveat that investigation of the international trade in wild meat represents a key research gap.

2.4 Other forms of hunting and deliberate killing

Other forms of hunting and deliberate killings of wildlife were considered in this report to encompass the broad definition of 'taking' in CMS (Article I (1)(j)), which not only includes wild meat hunting, but also deliberate killing, and harvesting of other body parts for non-food human consumption or trade, such as for traditional medicines (Alves & van Vliet, 2018; Gomez, 2021) or for clothing or decorations and ornaments (Alves & van Vliet, 2018; Vander Velden, 2019). Other forms include direct hunting for sport/recreational purposes or trophy hunting (e.g., Batavia et al., 2019), indirect hunting (i.e., where the species was not the intended target, but was captured as bycatch or in snares and traps meant for other animals), killings resulting from human-wildlife conflict, retaliatory/nuisance killings, and opportunistic hunting and/or harvesting of body parts resulting from chance encounters.

Human-wildlife conflict includes the deliberate killing or harming of an animal as a retaliatory or pre-emptive measure to avoid financial losses (e.g., property or crop damage, or killing of livestock) or loss of human life (Dickman & Hazzah, 2016). Human-wildlife conflict is common where humans and wildlife come into frequent contact, such as where human settlements encroach on wildlife habitat or national parks, or large areas of wildlife habitat are converted to agriculture (Nicole, 2019). It is considered the primary motivation for the killing of species such as lions and jaguars where hunting for wild meat is a notable, but lesser threat (Bauer et al. 2016). Pests or nuisance animals are often larger species, such as elephants or jaguars, especially more aggressive young males, but can be smaller species; for example, bats may be considered pests when nesting in buildings. Trophy hunting is the deliberate killing of a species for sport or recreational purposes, after which the whole animal or a part of the animal is kept as a decorative object or souvenir to symbolise the hunter's success (Mitchell et al., 2021). Trophy hunting may occur as part of a legal commercial industry, where individuals (often international tourists) pay a fee to hunt a preferred species, or illegally. Similar to human-wildlife conflict, trophy or recreational hunting can have detrimental impacts on wildlife if offtake levels are unsustainable or if legal hunting encourages illegal hunting (Brink et al., 2016; Packer et al., 2011). It is therefore important to include trophy/recreational hunting and human-wildlife conflict when considering the impacts of hunting on CMS species.

2.5 Threats to wild animals from wild meat hunting

Hunting of wild species is widely recognised as a major threat to global biodiversity (Mazor et al., 2018). Nearly 20% of the IUCN Red List's threatened and near-threatened species are directly threatened by hunting (Mazor et al., 2018), including over 300 threatened mammal species (Ripple et al., 2015). Unsustainable hunting levels have been reported in many regions of the world, driven by increases in human populations, increased access to once remote areas, immigration to these areas following economic opportunities (i.e. logging or mining camps), demand for wild meat from growing urban populations, the higher catch-per-unit-effort (CPUE) possible from modern hunting technologies (e.g. wire/nylon snares and cheap firearms) and an unwillingness of national governments in some regions to devolve management responsibilities to local communities and support them to exclude external commercial hunters from their lands (for an in-depth discussion of the drivers of wild meat hunting see Coad et al. (2019); Ingram et al. (2021).

Hunting can be economically sustainable (i.e., can continue to provide local people with stable incomes into the foreseeable future) in 'post-depletion' scenarios, where large and medium-bodied species populations have been severely reduced or even driven to local extinction, but where small bodied species can persist under high levels of hunting pressure (Nielsen et al., 2018). However, post-depletion ecosystems lack many of their primate and large herbivore (Dirzo et al., 2014; Ripple et al., 2015, 2016). This has serious knock-on effects on ecosystem structure and function (Young et al., 2016).

2.6 Wild meat hunting and zoonotic diseases

While wild meat can provide an important source of nutrition for rural communities, there are also some serious health concerns associated with wild meat consumption. Zoonotic disease outbreaks have been increasing steadily since the 1940s, with over 70% of zoonotic emerging infectious disease events now originating in wildlife (Jones et al., 2008). There is strong evidence that zoonotic disease emergence is linked to human activities, which bring wildlife, domestic animals, and humans into more frequent and close contact. This includes destruction and degradation of natural areas (Allen et al., 2017), deforestation and reforestation (Morand & Lajaunie, 2021), intensive livestock rearing (Han et al., 2016), and hunting, trade, and consumption of wildlife (Swift et al., 2007). Considering predicted human population growth, compounded with other pressures on food security, there is a high likelihood that hunting for wild meat will increase. This will, in turn, increase human-wildlife contacts and, in the absence of better regulation and safety precautions, the risk of zoonotic spillover (McMichael, 2005).

2.7 Key questions asked in this report

To respond to CMS Decision 13.109, we focus on the following key questions regarding CMS terrestrial mammal species and their use as wild meat:

- Which of and how are the terrestrial mammal species listed on CMS Appendices I and II and relevant CMS Agreements and Initiatives directly impacted by wild meat hunting and trade (both legal and illegal) across their range? What information is available on levels of hunting offtake, types of use, trends, and drivers of hunting?
- What are the direct and indirect impacts of wild meat hunting, international trade, domestic trade/sale and consumption of the CMS terrestrial speciesacross their range? How does this compare with other drivers of decline?
- What are the key issues surrounding hunting legislation and its enforcement, especially where this pertains to use of wildlife as food?
- What are the linkages between hunting, trade and consumption of wild animals, in particular the CMS terrestrial species for consumptive purposes and the spread of zoonotic diseases?
- What are our knowledge gaps concerning the use of CMS species for wild meat and how could these be filled?

3 Methods

3.1 Species covered by this report.

We investigated wild meat use of all terrestrial mammal species covered by Appendix I and II of the Convention on Migratory Species. A review on CMS aquatic migratory mammal species has already been conducted, and can be accessed here: https://www.cms.int/en/document/report-aquatic-mammals-working-group-aquatic-wild-meat. Our review covers a total of 105 species from six orders (Table 1).

Table 1. The CMS terrestrial mammal species covered by this review, and their CMS appendices[1]. CAMI=Central Asian Mammals Initiative. EUROBATS = Agreement on the Conservation of Populations of European Bats.

Scientifc Name	Common Name	Order	Listing	Date
Acinonyx jubatus	Cheetah	Carnivora	I	**I** 05/03/2009
Addax nasomaculatus	Addax	Artiodactyla	I	**I** 01/01/1979
Ammotragus lervia	Barbary Sheep	Artiodactyla	II	**II** 05/03/2009
Barbastella barbastellus	Barbastelle Bat	Chiroptera	II	**II** 24/01/1986
Barbastella leucomelas	Asian barbastelle, Eastern barbastelle	Chiroptera	II	**II** 24/01/1986
Bos grunniens	Wild Yak, Yak	Artiodactyla	I	**I** 24/01/1986
Bos sauveli	Kouprey	Artiodactyla	I	**I** 01/01/1979
Camelus bactrianus	Wild or Bactrian Camel	Artiodactyla	I	**I** 23/12/2002
Cervus elaphus barbarus	Barbary deer	Artiodactyla	I	**I** 01/01/1979
Cervus elaphus yarkandensis	Bukhara Deer	Artiodactyla	I/II	**I** 23/02/2006 **II** 23/02/2006 **II** 01/01/1979
Eidolon helvum	Straw-Coloured Fruit Bat	Chiroptera	II	**II** 01/01/2001
Elephas maximus indicus	Asian Elephant	Proboscidea	I	**I** 22/05/2020
Eptesicus bottae	Botta's serotine	Chiroptera	II	**II** 24/01/1986
Eptesicus nilssonii	Northern Serotine Bat	Chiroptera	II	**II** 24/01/1986
Eptesicus serotinus	Serotine Bat	Chiroptera	II	**II** 24/01/1986
Equus africanus	African Wild Ass, Somali Wild Ass, Nubian Wild Ass	Perissodactyla	I	**I** 26/01/2018
Equus ferus przewalskii	Przewalski's Horse	Perissodactyla	I	**I** 26/01/2018
Equus grevyi	Grevy's Zebra	Perissodactyla	I	**I** 01/01/1979
Equus hemionus	Asiatic Wild Ass, Khulan	Perissodactyla	II	**II** 23/12/2002
Equus kiang	Kiang	Perissodactyla	II	**II** 23/12/2002
Eudorcas rufifrons	Red-fronted Gazelle	Artiodactyla	I	**I** 08/02/2015

[1] Appendix I & II of CMS: CMS has two Appendices. These appendices list migratory species to which the Convention applies. The text of the Convention defines the basic obligations of the Contracting Parties towards species listed on Appendix I and Appendix II. These obligations are quite distinct for the two Appendices, and a migratory species can be listed in both Appendices at the same time, if the circumstances so warrant.

Scientifc Name	Common Name	Order	Listing	Date
Gazella bennettii	Chinkara	Artiodactyla	CAMI	
Gazella cuvieri	Cuvier's Gazelle	Artiodactyla	I	**I** 01/01/1979
Gazella Dorcas	Dorcas Gazelle	Artiodactyla	I	**I** 01/01/1979
Gazella erlangeri	Neumann's Gazelle, Mountain Gazelle, Edmi Gazelle	Artiodactyla	II	**II** 01/01/1979
Gazella leptoceros	Slender-Horned Gazelle, Rhim	Artiodactyla	I	**I** 24/01/1986
Gazella subgutturosa	Goitered Gazelle, Black-Tailed Gazelle	Artiodactyla	II	**II** 23/12/2002
Giraffa camelopardalis	Giraffe	Artiodactyla	II	**II** 26/01/2018
Gorilla beringei beringei	Mountain Gorilla	Primates	I	**I** 1979
Gorilla beringei graueri	Eastern Lowland Gorilla	Primates	I	**I** 1979
Gorilla gorilla diehli	Cross River Gorilla	Primates	I	**I** 2005
Gorilla gorilla gorilla	Western Lowland Gorilla	Primates	I	**I** 2005
Hippocamelus bisulcus	Huemul, South Andean Deer	Artiodactyla	I	**I** 15/07/1997
Hypsugo savii	Savi's pipistrelle	Chiroptera	II	**II** 24/01/1986
Kobus kob leucotis	White-eared Kob	Artiodactyla	II	**II** 08/02/2015
Lasiurus blossevillii	Southern Red Bat, Western Red Bat, Desert Red Bat	Chiroptera	II	**II** 26/01/2018
Lasiurus borealis	Eastern Red Bat	Chiroptera	II	**II** 26/01/2018
Lasiurus cinereus	Hoary Bat	Chiroptera	II	**II** 26/01/2018
Lasiurus ega	Southern Yellow Bat	Chiroptera	II	**II** 26/01/2018
Loxodonta africana	African Elephant	Proboscidea	II	**II** 01/01/1979
Loxodonta cyclotis	Forest Elephant	Proboscidea	II	**II** 01/01/1979
Lycaon pictus	African Wild Dog, Painted Wolf, Cape hunting dog	Carnivora	II	**II** 05/03/2009
Miniopterus majori Formerly included in *Miniopterus schreibersii*	Major's long-fingered bat	Chiroptera	II	**II** 24/01/1986
Miniopterus natalensis Formerly included in *Miniopterus schreibersii*	Natal long-fingered bat	Chiroptera	II	**II** 24/01/1986
Miniopterus schreibersii	Schreibers' Bent-Winged Bat	Chiroptera	II	**II** 24/01/1986 **II** 24/01/1986
Myotis alcathoe	Alcathoe Myotis	Chiroptera	II	**II** 24/01/1986
Myotis aurascens	Steppe Whiskered Bat	Chiroptera	EUROBATS	
Myotis bechsteinii	Bechstein's Bat	Chiroptera	II	**II** 24/01/1986
Myotis blythii	Lesser Mouse-Eared Bat	Chiroptera	II	**II** 24/01/1986

Scientifc Name	Common Name	Order	Listing	Date
Myotis brandtii	Brandt's Bat	Chiroptera	II	**II** 24/01/1986
Myotis capaccinii	Long-Fingered Bat	Chiroptera	II	**II** 24/01/1986
Myotis dasycneme	Pond Bat	Chiroptera	II	**II** 24/01/1986
Myotis daubentonii	Daubenton's Bat	Chiroptera	II	**II** 24/01/1986
Myotis emarginatus	Geoffroy's Bat, Notch-Eared Bat	Chiroptera	II	**II** 24/01/1986
Myotis hajastanicus	Armenian whiskered bat, Hajastan myotis, Armenian myotis	Chiroptera	II	**II** 24/01/1986
Myotis myotis	Greater Mouse-Eared Bat	Chiroptera	II	**II** 24/01/1986
Myotis mystacinus	Whiskered Bat	Chiroptera	II	**II** 24/01/1986
Myotis nattereri	Natterer's Bat	Chiroptera	II	**II** 24/01/1986
Myotis nipalensis	Nepal myotis	Chiroptera	II	**II** 24/01/1986
Myotis punicus	Felton's myotis, Maghreb Mouse-eared Bat, Maghrebian Myotis	Chiroptera	II	**II** 24/01/1986
Myotis schaubi	Schaub's myotis	Chiroptera	II	**II** 24/01/1986
Nanger dama	Dama Gazelle	Artiodactyla	I	**I** 01/01/1979
Nyctalus lasiopterus	Greater Noctule Bat	Chiroptera	II	**II** 24/01/1986
Nyctalus leisleri	Leisler's Bat	Chiroptera	II	**II** 24/01/1986
Nyctalus noctule	Noctule Bat	Chiroptera	II	**II** 24/01/1986
Oryx dammah	Scimitar-Horned Oryx	Artiodactyla	I/II	**I** 01/01/1994 **II** 01/01/1979
Otomops madagascariensis	Madagascar free-tailed Bat	Chiroptera	II	**II** 01/01/1979
Otomops martiensseni	Large-Eared Free-Tailed Bat, Giant Mastiff Bat	Chiroptera	II	**II** 23/02/2006
Otonycteris hemprichii	Desert long-eared bat	Chiroptera	EUROBATS	
Ovis ammon	Argali Sheep	Artiodactyla	II	**II** 23/02/2012
Ovis vignei	Urial	Artiodactyla	II	**II** 22/05/2020
Pan troglodytes	Chimpanzee	Primates	I/II	**I** 26/01/2018 **II** 26/01/2018
Panthera leo	Lion	Carnivora	II	**II** 26/01/2018
Panthera onca	Jaguar	Carnivora	I/II	**I** 22/05/2020 **II** 22/05/2020
Panthera pardus	Leopard, Panther	Carnivora	II	**II** 26/01/2018
Pantholops hodgsonii	Chiru, Tibetan Antelope	Artiodactyla	CAMI	

Scientifc Name	Common Name	Order	Listing	Date
Pipistrellus kuhlii	Kuhl's Pipistrelle Bat	Chiroptera	II	**II** 24/01/1986
Pipistrellus nathusii	Nathusius's Pipistrelle Bat	Chiroptera	II	**II** 24/01/1986
Pipistrellus pipistrellus	Common Pipistrelle	Chiroptera	II	**II** 24/01/1986
Pipistrellus pygmaeus	Soprano pipistrelle, Brown pipistrelle	Chiroptera	II	**II** 24/01/1986
Plecotus auratus	Brown Long-Eared Bat	Chiroptera	II	**II** 24/01/1986
Plecotus austriacus	Grey Long-Eared Bat	Chiroptera	II	**II** 24/01/1986
Plecotus kolombatovici	Kolombatovic's Long-eared Bat	Chiroptera	II	**II** 24/01/1986
Plecotus macrobullaris	Alpine Long-eared Bat	Chiroptera	EUROBATS	
Plecotus sardus	Sardinian long-eared bat	Chiroptera	II	**II** 24/01/1986
Procapra gutturosa	Mongolian Gazelle, White-Tailed Gazelle	Artiodactyla	II	**II** 23/12/2002
Procapra picticaudata	Tibetan Gazelle	Artiodactyla	CAMI	
Rhinolophus blasii	Blasius' Horseshoe Bat	Chiroptera	II	**II** 24/01/1986
Rhinolophus euryale	Mediterranean Horseshoe Bat	Chiroptera	II	**II** 24/01/1986
Rhinolophus ferrumequinum	Greater Horseshoe Bat	Chiroptera	II	**II** 24/01/1986
Rhinolophus hipposideros	Lesser Horseshoe Bat	Chiroptera	II	**II** 24/01/1986
Rhinolophus mehelyi	Mehely's Horseshoe Bat	Chiroptera	II	**II** 24/01/1986
Rousettus aegyptiacus	Egyptian Fruit Bat	Chiroptera	EUROBATS	
Saiga borealis	Mongolian Saiga antelope, Saiga antelope	Artiodactyla	II	**II** 23/12/2002
Saiga tatarica	Saiga Antelope	Artiodactyla	II	**II** 23/12/2002
Tadarida brasiliensis	Mexican Free-Tailed Bat	Chiroptera	I	**I** 01/01/1979
Tadarida insignis	Oriental (or East Asian) Free-tailed Bat	Chiroptera	II	**II** 01/01/1979
Tadarida latouchei	La Touche's Free-tailed Bat	Chiroptera	II	**II** 01/01/1979
Tadarida teniotis	European Free-Tailed Bat	Chiroptera	II	**II** 01/01/1994
Taphozous nudiventris	Naked-rumped Tomb Bat	Chiroptera	EUROBATS	
Uncia uncia	Snow Leopard	Carnivora	I	**I** 24/01/1986
Ursus arctos isabellinus	Gobi Bear	Carnivora	I	**I** 26/01/2018
Ursus maritimus	Polar Bear	Carnivora	II	**II** 08/02/2015
Vespertilio murinus	Parti-Coloured Bat	Chiroptera	II	**II** 24/01/1986
Vicugna vicugna	Vicuña	Artiodactyla	I/II	**I** 01/01/1979 **II** 01/01/1979

Bushmeat for sale on an African market © Corinne Staley

3.2 IUCN Red List Assessments: Species uses and hunting threat

The IUCN Red List of Threatened Species is a checklist of taxa that have undergone an extinction risk assessment using the IUCN Red List Categories and Criteria. It divides species into nine categories: Not Evaluated, Data Deficient, Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild and Extinct. Of these, Vulnerable, Endangered, Critically Endangered are considered the "Threatened Categories" (IUCN, 2021). Most assessments appearing on the IUCN Red List are carried out by members of the IUCN Species Survival Commission (SSC), appointed Red List Authorities (RLAs), Red List Partners, or specialists working on IUCN-led assessment projects (IUCN, 2021). In addition to the Red List Categories, Red List assessments collect a range of information on the species. This includes the current trend of the population (declining, increasing, stable, not known), the threats facing the species (using a hierarchical Threat Classification Scheme), and the current use and trade of the species (using General Use and Trade Classification Scheme), which also records the scale of the use (subsistence, national, international).

We used the April 2021 download of the IUCN Red List (IUCN, 2021) to investigate the current Red List Classification and population trend for each of the 105 CMS terrestrial mammal species. We also used the IUCN Threat data to look at the number of CMS species that are threatened by hunting (IUCN Red List Threat classifications 5.1.1 – 5.1.4) and whether those species threatened by hunting are more likely to be at risk of extinction or are experiencing declines in their populations. We further investigated the current use and trade of CMS species, using the following seven Red List Use/Trade categories relevant to terrestrial mammal species: Food – human; Food – animal; Medicine – human & veterinary; Wearing apparel, accessories; Handicrafts, jewellery, etc; Pets/display animals, horticulture; Sport hunting/specimen collecting. We then recorded the number of species used/traded for subsistence, nationally and internationally.

3.3 Presence/absence of species in hunting and trade databases

There are at least seven global databases and four regional or national databases containing species-level records on illegal wildlife trade (Challender et al., 2021); see their supplementary materials for a useful review of known databases). Global databases include the UNODC World WISE (World Wildlife Seizures) database, TRAFFIC's Wildlife Trade Portal, the ETIS (Elephant Trade Information System), the World Customs Organization Customs Enforcement Network Database, the Great Apes Survival Partnership's Great Apes Seizure Database, the Environmental Investigation Agency (EIA) global database of seizures involving elephants, rhinos, pangolins and big cats, and the Wildlife

Justice Commission's global database of seizures on selected species (e.g., pangolins). National and regional databases include the EU-TWIX (European Union – Trade in Wildlife Information eXchange) database, the ASEAN-WEN (Association of Southeast Asian Nations-Wildlife Enforcement Network) Seizures database, the CITES Annual Illegal Trade Reports and the United States Fish and Wildlife Service's (USFWS) Law Enforcement Management Information System (LEMIS).

However, of these only two are open access (TRAFFIC's Wildlife Trade Portal, with prior approval from TRAFFIC and the USFWS LEMIS database, as provided by Eskew et al. (2020). In addition to these illegal trade databases, the CITES Trade Database provides open-access data on trade (imports and exports) of CITES-listed wildlife, and the WILDMEAT database provides soon-to-be open access data on legal and illegal wild meat hunting, consumption, and trade.

1. **The TRAFFIC Wildlife Trade Portal.** The Wildlife Trade portal (https://www.wildlifetradeportal.org/) presents a portion of TRAFFIC's open-source wildlife seizure and incident data. All information available on the Portal is obtained from publicly accessible or 'open' sources and consists of data relating to illegal wildlife trade. We extracted data for the last 5 years (2017 – 08/04/2021) and recorded the presence/absence of each CMS species in the database.
2. **The USFWS Law Enforcement Management Information System (LEMIS) database.** The USFWS LEMIS data are derived from legally mandated reports submitted to USFWS and contain information on US imports/exports of both live organisms and wildlife products. LEMIS data from 2000 – 2014 have been made publicly available by Eskew et al. (2020), who used a Freedom of Information Request[2] to obtain the data. Using this version of the database, we recorded the presence/absence of each CMS species in the database.
3. **The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)** Trade database. The CITES trade database (https://trade.cites.org/) is managed by the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) on behalf of the CITES Secretariat. It currently holds approximately 23 million records of trade in wildlife. Data predominantly covers the legal trade, as information on seized or confiscated specimens is often absent or provided in insufficient detail by Parties. (CITES Secretariat, 2013). Contracting Parties provide annual reports to the CITES Secretariat including full details of all export and import permits and certificates issued during the previous year. We extracted data from 2017 – 12/04/2021 and recorded the presence/absence of each CMS species in the database.
4. **The WILDMEAT database.** The WILDMEAT database (www.wildmeat.org) is managed by the Center for International Forestry Research (CIFOR), the Wildlife Conservation Society (WCS) and the University of Stirling. It collates available published and unpublished wild meat data within one database and in one standardised format. Three different types of data are held in the database:
    - Hunting offtakes. I.e., the number of individual animals harvested by hunters over a given period.
    - Wild meat consumption. I.e., the quantity of animal biomass consumed by individuals or within households over a given period.
    - Wild meat market sales. I.e., data on the price and number of individual animals, or pieces thereof, on offer at wild meat markets over a given period.

The WILDMEAT database currently holds data from Latin America and sub-Saharan Africa. In Latin America, this includes data from 65 references covering 10 countries: Bolivia, Brazil, Colombia, Ecuador, French Guyana, Mexico, Nicaragua, Peru, Suriname, and Venezuela. In sub-Saharan Africa, this includes data from 138 references covering 23 countries: Angola, Botswana, Cameroon, Central African Republic, Côte d'Ivoire, Democratic Republic of Congo, Equatorial Guinea, Gabon, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Morocco, Mozambique, Nigeria, Republic of Congo, Senegal, Tanzania, Togo, Uganda, Zambia, and Zimbabwe. Each reference can include multiple sites and data types. While this database will become open access in late 2021, until then it is only accessible to WILDMEAT partners. We have used the April 2021 version of the database to search for published records of hunting offtakes, wild meat consumption and wild meat sales for the 105 species. For each species we downloaded the units and number of units recorded as hunted, consumed, or sold, together with the geographic location of this use, and information on the publication that the data came from.

We interrogated these four databases to determine which of the 105 species were recorded as being hunted or traded over the periods that each database covers. As TRAFFIC make clear in their description of the Wildlife Trade Portal, *"while illegal wildlife trade incident data is a vital source of information, it should not be inferred that there is a direct correlation between seizures and the overall illegal wildlife trade, or that information across locations, species or time is consistent"* (TRAFFIC, 2021). As noted by Challender et al. (2021), unintentional misuse of the data provided in trade databases by several previous studies has led to mischaracterization of wildlife trade, which may in turn mislead policy processes, and

[2] The Freedom of Information Act, or FOIA, generally provides any person with the statutory right, enforceable in court, to obtain access to Government information in executive branch agency records. See https://www.archives.gov/foia for further information.

great care should be taken when trying to infer total trade volumes and trends from these data. For this reason, and due to the rapid nature of this review, we have simply recorded presence or absence for a species, and not attempted to calculate trade volumes. A detailed analysis of legal and illegal trade volumes of migratory species, heeding the advice of Challender et al. (2021) on the correct use of these trade databases, is a future research priority.

Information from these databases was used to determine, for each of the 105 species:

- Whether the species was recorded as illegally and legally traded globally, for wild meat and other purposes, using CITES, LEMIS and TRAFFIC data.
- Whether the species was recorded as being hunted, traded, or consumed as wild meat, using WILDMEAT data (but only for South America and sub-Saharan Africa, due to the current coverage of the WILDMEAT database).

3.4 Systematic online literature review

We conducted a systematic online literature review to search for publications containing information on reported hunting offtakes, types of use and hunting impacts for each of the 105 species.

We used Google Scholar as our main search platform. Before initiating our searches, we cleared all browsing history and cookies or used an incognito browser, to ensure that searches were equivalent between researchers. We created and used a list of pre-defined search terms (Appendix 1) to systematise our searches. We then searched the first 20 pages of results from Google Scholar to select the most relevant publications for each species, up to a total of 15 publications due to the time available for review and analysis of these publications. Publications were considered as relevant when they obtained data or information on the hunting, use or trade of the reviewed species. For species where few publications were available, studies were included irrespective of publication date. Where more than 15 references were available for a species, we selected those publications that were the most relevant and were the most recent. When Google Scholar returned too few relevant publications, we used the same search terms on Google (also using an incognito browser) and collected publications. We included peer-reviewed articles, peer-reviewed and published reports, and unpublished reports (i.e., 'grey literature'). We did not include news articles. Where a publication referenced primary data from another source, we located the publication containing the primary data when available and selected this as one of our 15 publications, rather than the publication referencing it.

In total we conducted searches using Google Scholar for all 105 CMS-listed terrestrial mammal species. In addition, we searched the IUCN Red List species assessments for information related to hunting in the longer written assessment documents (rather than the coded Red List database, as reported above) for all 105 species. Of the 105 species, 99 species are found in the IUCN Red List. We then entered information into a MS Access database. For each species we recorded the search terms used and the number of results returned in Google Scholar. For each publication we recorded information on:

1. The publication itself: authors, year of publication, countries covered in the publication, type of publication.
2. The type of data presented in the publication (for example, hunter surveys, seizures, patrols, questionnaires etc.).
3. The type of use or motivation of killing (for instance for consumption, trade, medicine, culture, bycatch, human-wildlife conflict etc.).
4. The geographic location of the use (at the scale given).
5. The legality of the use (legal or illegal, and any details on enforcement given).
6. Details of any trade, and the scale of the trade (i.e., national, international, transboundary; transboundary includes local scale trade that crosses international boundaries).
7. Details of any large-scale drivers, where given (i.e., the development of roads, civil conflict, or extractive industry development).
8. The amounts of the species used, where specified.
9. The impacts of the use (i.e., species population declines, local extinctions, indirect impacts) and the relative importance of the impacts of hunting in comparison with other threats (e.g., land use change, climate change), where specified.
10. Any record of zoonotic disease risks from the species.

A summary of the collated data was created for each species. The final database and summaries are provided with this report.

3.5 Review of the links between wild meat hunting and zoonotic disease risk

We investigated the link between species used for wild meat and known zoonotic pathogens, with special attention to CMS terrestrial mammal species, in two ways:

3.5.1 A review of the linkages between wild meat hunting and zoonotic disease risk, with special regard for CMS terrestrial mammal species.

To further understand the linkages between hunting, consumption and trade of CMS species and the spread of zoonotic diseases, we then conducted an online literature review, to include all types of zoonotic pathogens (bacteria and parasites, as well as viruses). We looked for evidence of zoonotic spillover (spillover being the transmission and subsequent replication of a disease agent that generates an immune response but can be asymptomatic) due to human contact through wild meat hunting, consumption, and trade, including handling, butchering, processing, and preparation of carcasses, and eating of wild meat.

3.5.2 An analysis of zoonotic viruses hosted by CMS species.

In 2020, Johnson et al. collated all published information in the scientific literature through to December 2013 on zoonotic viruses and their known terrestrial mammal hosts, examining data for 142 zoonotic viruses. They found that among IUCN Red List mammal species (using the 2014 IUCN Red List), those with population reductions owing to exploitation (Threat categories A1 – A4(d)) and loss of habitat share more viruses with humans. Using the data from (Johnson et al., 2020), which was published as supplementary materials (supplementary data file S1), we identified the known zoonotic viruses hosted by each CMS terrestrial mammal species as of December 2013.

4 Results

4.1 IUCN Red List: Species uses and threats from hunting

4.1.1 Species used for consumptive purposes

Of the 105 species investigated in this report, 99 had a Red List assessment. Of these, 38 were recorded as being "used" under the IUCN Use and Trade Classification scheme, under the following use categories:

- Food – human (27 species)
- Food – animal (2 species)
- Medicine - human & veterinary (15 species)
- Wearing apparel, accessories (9 species)
- Handicrafts, jewellery, etc. (8 species)
- Pets/display animals, horticulture (5 species)
- Sport hunting/specimen collecting (17 species)

Figure 1 presents the type of recorded use for the 99 study species, by order, and Table 2 provides the recorded use by species. Species within the Artiodactyla and Perissodactyla (ungulate) orders are most used for wild meat consumption (human food). Carnivore species have a range of recorded uses, and Proboscidea (elephant) species are used more for 'jewellery' - i.e., ivory - and for sport hunting/specimens. Bat species are recorded as having few uses by humans.

Figure 2 presents the scale of use – whether the use was at a local (subsistence) level, whether it was traded nationally, or whether it was traded internationally (and this is provided in Table 3 by species). Overall, 34 of the 99 species were reported as used at the subsistence level, 27 were traded nationally, and 22 were traded internationally, when all types of use were considered (and many were used at all three of these levels). When only meat for consumption was considered, 27 species were reported as consumed for subsistence, 10 species for national wild meat trade and two species, the straw-coloured fruit bat (*Eidolon helvum*) and Dorcas gazelle (*Gazella dorcas*), for international wild meat trade. Use of species for wild meat, rather than for other uses such as medicine, pets, clothing, jewellery, and sport, is generally local, with some trade nationally and very little internationally. The main species recorded as being eaten are ungulates.

4.1.1.1 Species threatened by hunting

The IUCN Red List documents whether a species is directly threatened by hunting under the IUCN Threats Classification Scheme (IUCN Threat category 5.1). The Scheme defines a direct threat as the proximate human activities or processes that have impacted, are impacting, or may impact the status of the taxon being assessed. In this context, if a species is not classified as threatened by hunting, it may still be used for consumption or commercial purposes, but not at a scale that is considered a threat, or because there is insufficient information available to class the level

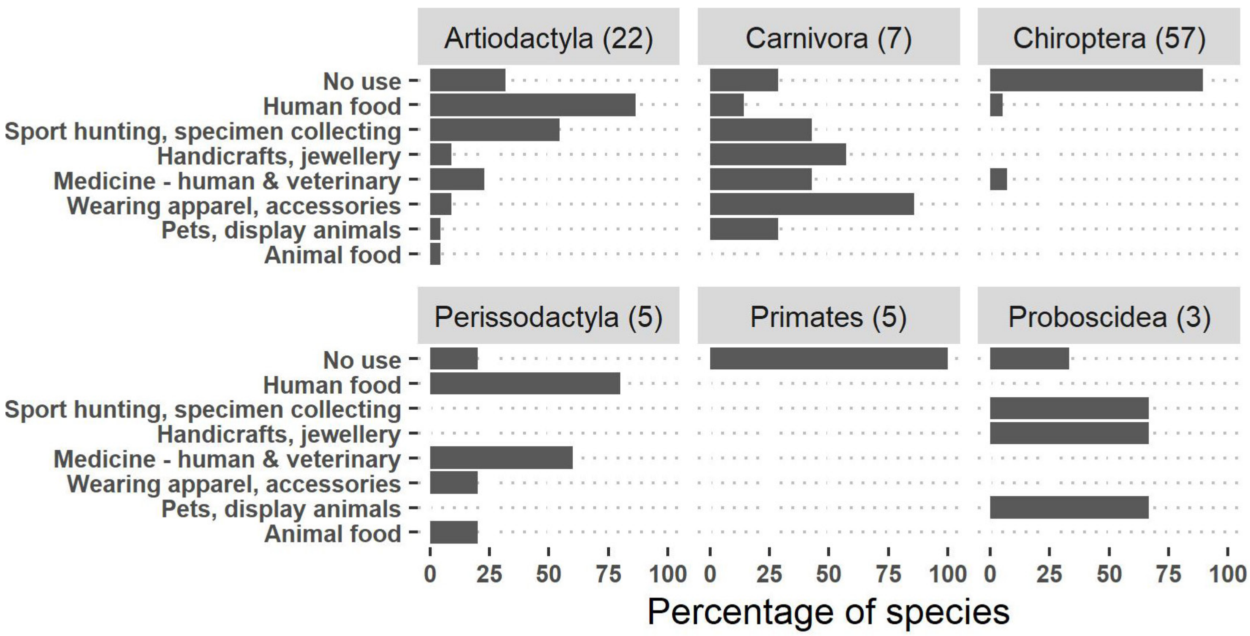

Figure 1. The use of the 99 CMS terrestrial mammal species, by scientific order. The figure shows the percentage of species, by scientific Order, that are recorded as being used under each IUCN Red List Use Category. Numbers in parentheses give the number of species in each order.

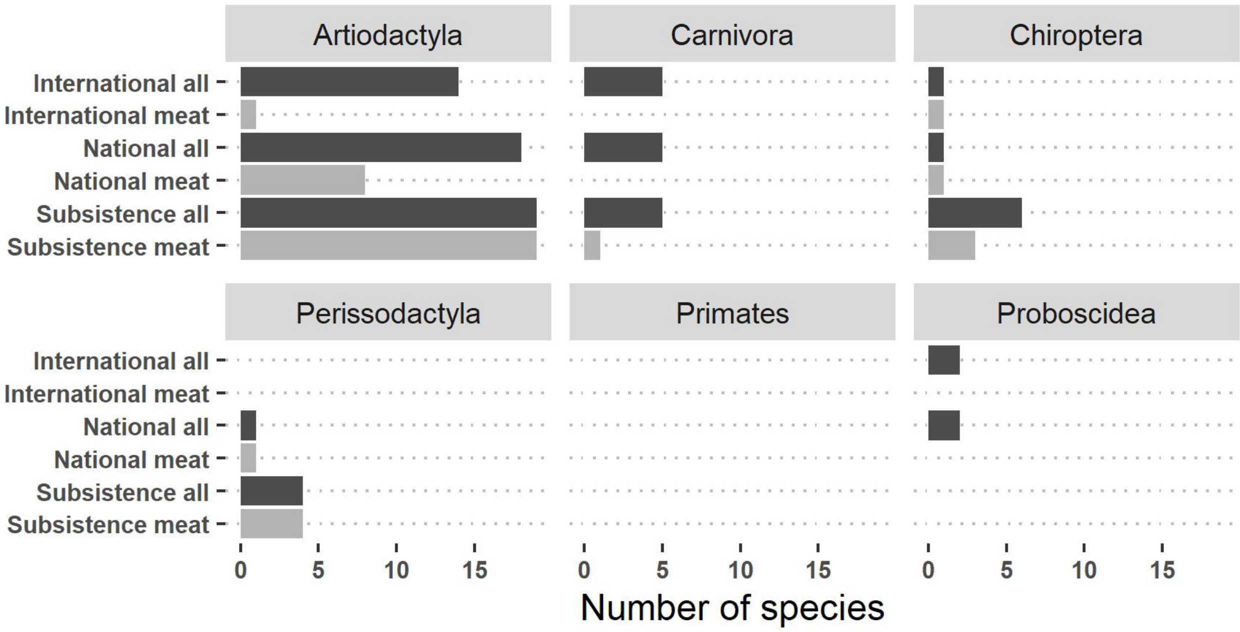

Figure 2: The scale of the use of the 99 CMS terrestrial mammal species, by scientific order. Darker shaded bars show the scale of all uses, and lighter shaded bars show the scale of use where species are used for human consumption ('International', 'National' and 'Subsistence' categories are those used by the IUCN Red List). Bars represent the number of species.

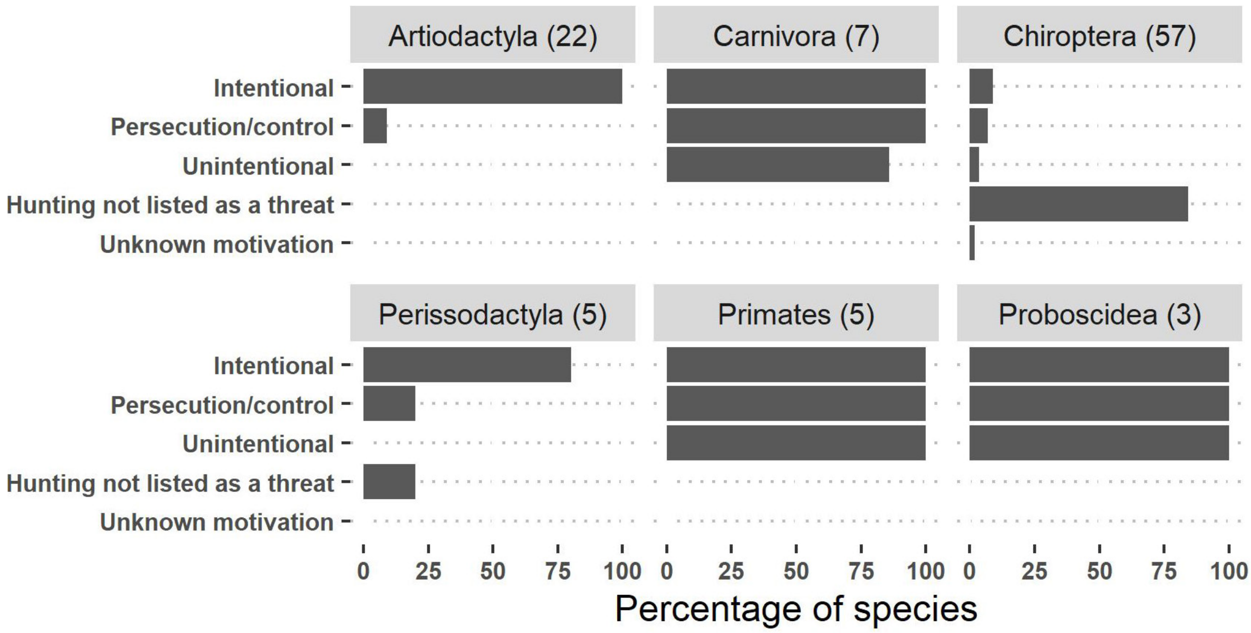

Figure 3: The percentage of the 99 CMS terrestrial mammal species recorded by the IUCN Red List as being threatened by hunting (Threat 5.1 and associated sub-categories), by scientific order. Numbers in parentheses give the number of CMS terrestrial mammal species in each order.

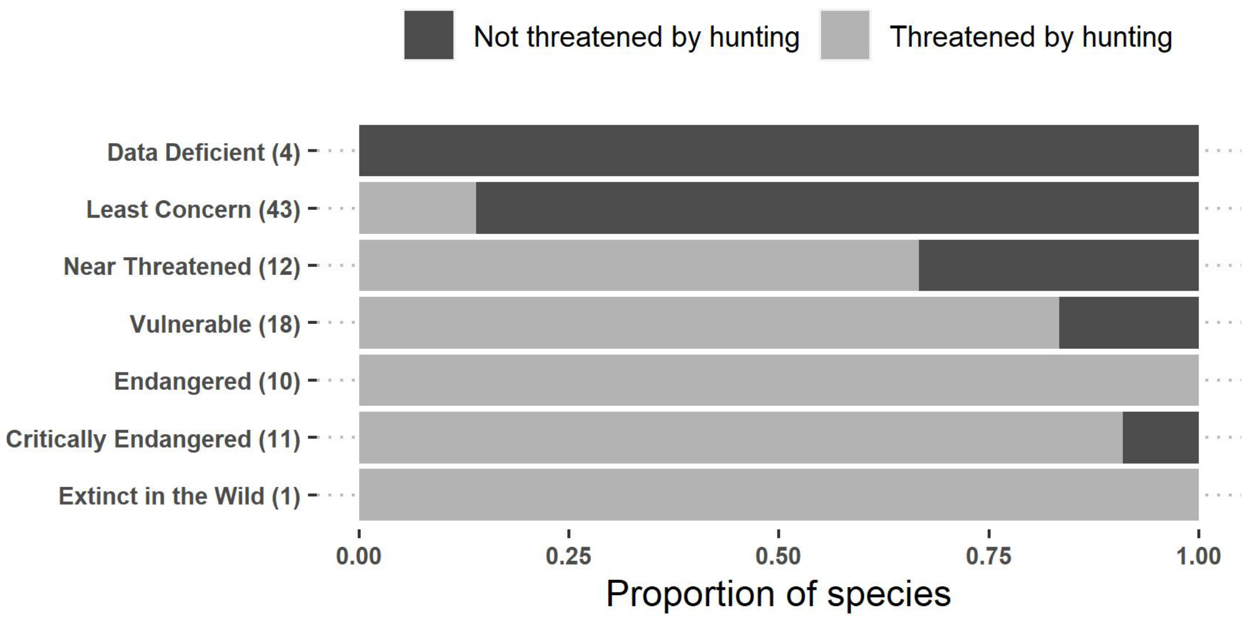

Figure 4: The proportion of the 99 CMS terrestrial mammal species in each IUCN Red List Assessment Category that are listed as being threatened by hunting.

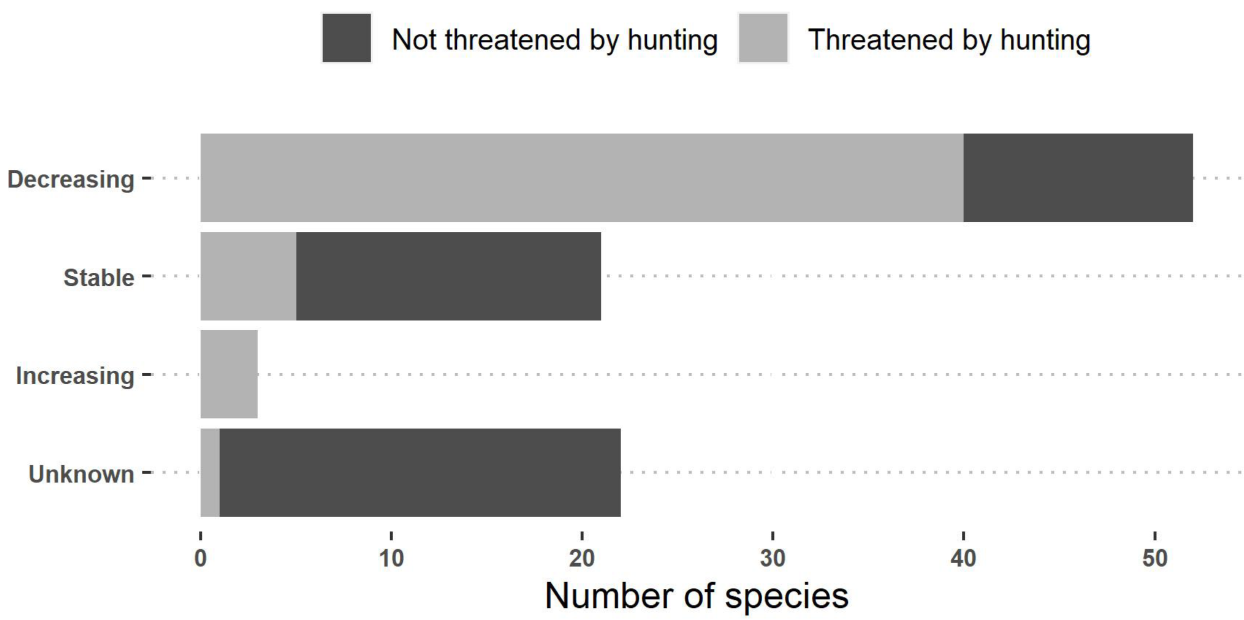

Figure 5: The number of the 99 CMS terrestrial mammal species listed as being threatened by hunting, by population trend (as recorded in their IUCN Red List assessment).

of use as a threat to the species. The scheme does not differentiate between whether the threat comes from legal or illegal hunting. Within the general threat category of 'hunting', assessors then classify the hunting threat into four sub-categories:

- 5.1.1 Intentional use (species being assessed is the target)
- 5.1.2 Unintentional effects (species being assessed is not the target)
- 5.1.3 Persecution/control
- 5.1.4 Motivation Unknown/Unrecorded

Of the 99 study species, 50 species are listed as being threatened by hunting (Table 2). Of these 50 species, 46 are threatened by intentional hunting, 16 by unintentional hunting, 22 by hunting for persecution/control and for one species the motivation was unknown.

Of the 50 species threatened by hunting, 41 were non-bat species. All but one (*Equus kiang*) of the 42 non-bat species are listed as threatened by hunting. Most bat species (*Chiroptera*) are not threatened by hunting (48 of 57 species). Key exceptions include the straw-coloured fruit bat (*Eidolon helvum*), which is classed under threat category '5.1.1 Intentional use', and the Schreiber's Bent-winged Bat (*Miniopterus schreibersii*), which is categorised under threat categories '5.1.3. Persecution/control' (this is because of deliberate roost disturbance and not for consumption of any kind). Figure 3 illustrates the number of species threatened by different sub-categories of hunting, by scientific order.

Of the 22 CMS species that are Endangered, Critically Endangered, or Extinct in the Wild, 21 are threatened by hunting (Figure 4). Of the 52 CMS species that were assessed as having decreasing populations, 40 species were recorded as threatened by hunting (Figure 5). However, the correlations between hunting as a threat and Red List status/population status for CMS species should be interpreted with caution. As mentioned above, when bat species are removed from the analysis, all species apart from one are reported as threatened by hunting. The 'not threatened' columns in these graphs are therefore almost completely bat species. Most of these bat species have a European distribution, and therefore this also creates a geographical bias.

Table 2: Information from the IUCN Red List Assessment for each CMS terrestrial mammal species[3].

- Red List: The current Red List assessment.
- Pop. Trend: Population trend (increasing, decreasing stable, unknown) as given by the Red List assessment
- Hunt Threat: Whether hunting is listed as a threat in the IUCN Red List assessment
- Hunt Type: Whether hunting is listed as Intentional (I), Persecution/Control (P) and/or Unintentional (U) in the Red List assessment
- Use Type: Which Use categories are listed in the Red List assessment, using the Red List numbering system. 1 = Food – human; 2 = Food – animal; 3 = Medicine, human & veterinary; 10 = Wearing apparel, accessories; 12 = Handicrafts, jewellery, etc; 13 = Pets/display animals, horticulture; 15 = Sport hunting/specimen collecting. If no specific listing has been entered in the Red List, we have filled it in from our knowledge of the region or from the other relevant fields in the IUCN Red List, and this is in italics.
- Trade scale: Whether trade for wild meat is at the Subsistence (S), National (N) and/or International (I) level.

Scientifc Name	Common Name	Red List	Pop. Trend	Hunt Threat	Hunt Type	Use Type	Trade Scale
Acinonyx jubatus	Cheetah	Vulnerable	Decreasing	1	I,P,U	10;12;13;15	
Addax nasomaculatus	Addax	Critically Endangered	Decreasing	1	I	1;15	S
Ammotragus lervia	Barbary sheep	Vulnerable	Decreasing	1	I	1	S
Barbastella barbastellus	Barbastelle bat	Near Threatened	Decreasing				
Barbastella leucomelas	Asian barbastelle, eastern barbastelle	Least Concern	Unknown				
Bos grunniens (now Bos mutus)	Wild yak, yak	Vulnerable	Decreasing	1	I,P	1	S,N

Scientifc Name	Common Name	Red List	Pop. Trend	Hunt Threat	Hunt Type	Use Type	Trade Scale
Bos sauveli	Kouprey	Critically Endangered	Decreasing	1	I	1;3;12;15	S,N
Camelus bactrianus	Wild camel, bactrian camel	Critically Endangered	Decreasing	1	I,P	1;15	S
Cervus elaphus barbarus[4]	Barbary deer	Least Concern (at species level)					
Cervus elaphus yarkandensis	Bukhara deer, Tarim Red Deer	Least Concern (at species level)					
Eidolon helvum	Straw-coloured fruit bat	Near Threatened	Decreasing	1	I	1;3	S,N,I
Elephas maximus indicus	Asian elephant (the taxon on the mainland)	Endangered	Decreasing	1	I,P,U	1;10;12;13	L,N,I
Eptesicus bottae	Botta's serotine	Least Concern	Stable				
Eptesicus nilssonii	Northern serotine bat	Least Concern	Stable				
Eptesicus serotinus	Serotine bat	Least Concern	Stable				
Equus africanus	African wild ass	Critically Endangered	Decreasing	1	I	1;2;3	S
Equus ferus prze-walskii	Przewalski's horse	Endangered	Increasing	1	I		
Equus grevyi	Grevy's zebra	Endangered	Stable	1	I	1;3	S
Equus hemionus	Asiatic wild ass	Near Threatened	Stable	1	I,P	1;3;10	S,N
Equus kiang	Kiang	Least Concern	Stable	1	I	1	S
Eudorcas rufifrons	Red-fronted gazelle	Vulnerable	Decreasing	1	I	1;10;13	S,N
Gazella bennettii	Chinkara	Least Concern	Decreasing	1	I	1;15	S
Gazella cuvieri	Cuvier's gazelle	Vulnerable	Decreasing	1	I	1;15	S
Gazella dorcas	Dorcas gazelle	Vulnerable	Decreasing	1	I	1;15	S,N,I
Gazella erlangeri[5]	Neumann's gazelle	No listing					

[3] It should, however, be recognised that for some species, such as the African great apes (two gorilla species, and four subspecies, plus four subspecies of chimpanzee), recorded "uses" in their IUCN Red List page did not include those where the use would be illegal. Typically, the sentence *"Gorillas are completely protected by national and international laws in all countries of their range, and it is, therefore, illegal to kill, capture or trade in live Gorillas or their body parts"* appears in that section. For example, it is illegal in all range states to kill, capture or trade in live gorillas or their body parts. Instead, the fact that these species are hunted and eaten by humans appears in the narrative of the Red List Assessments (in the Justification and Threats sections) and in the "Biological Resource Use" field ("Hunting & trapping terrestrial animals"). The same reasoning has not been applied to other species, such as forest elephants, where the IUCN Use and Trade section details the use of forest elephants for ivory and bushmeat hunting, both of which are illegal. Noting these inconsistencies, for each species we also searched for further information on use, scale of use and threats from hunting within the wiser Red List Assessment text. Where we found reference to a particular use, we have added it to Table 4 in italics. To be conservative however, we have based our analyses only on the data provided within the IUCN Use and Trade Classification scheme.

[4] There is an IUCN Red List assessment for *Cervus elaphus*, but not *Cervus elaphus barbarus* or *Cervus elaphus yarkandensis*. The assessment text for Cervus elaphus mentions that "In Algeria and Tunisia, the species has declined due to overhunting"

[5] Possibly a captive/ domesticated form of Gazella arabica (Wronski et al., 2017)

Scientifc Name	Common Name	Red List	Pop. Trend	Hunt Threat	Hunt Type	Use Type	Trade Scale
Gazella leptoceros	Slender-horned gazelle, rhim	Endangered	Decreasing	1	I	1;15	S
Gazella subgutturosa	Goitered gazelle, black-tailed gazelle	Vulnerable	Decreasing	1	I	1;15	S,N
Giraffa camelopardalis	Giraffe	Vulnerable	Decreasing	1	I	1;15	S
Gorilla beringei beringei	Mountain gorilla	Critically Endangered	Decreasing	1	I,P,U		
Gorilla beringei graueri	Eastern lowland gorilla	Critically Endangered	Decreasing	1	I,P,U	1	S
Gorilla gorilla diehli	Cross river gorilla	Critically Endangered	Decreasing	1	I,P,U	1	S
Gorilla gorilla gorilla	Western lowland gorilla	Critically Endangered	Decreasing	1	I,P,U	1	S,N
Hippocamelus bisulcus	Huemul, south andean deer	Endangered	Decreasing	1	I	1;2;15	S
Hypsugo savii	Savi's pipistrelle	Least Concern	Stable				
Kobus kob[6] *leucotis*	White-eared kob	Least Concern	Decreasing	1	I	I	S, N
Lasiurus blossevillii	Southern red bat, western red bat, desert red bat	Least Concern	Unknown				
Lasiurus borealis	Eastern red bat	Least Concern	Stable				
Lasiurus cinereus	Hoary bat	Least Concern	Unknown				
Lasiurus ega	Southern yellow bat	Least Concern	Unknown				
Loxodonta africana	African elephant	Endangered	Decreasing	1	I,P,U	1; 12;13;15	S
Loxodonta cyclotis	Forest elephant	Endangered	Decreasing	1	I,P,U	1; 12;13;15	S
Lycaon pictus	African wild dog	Endangered	Decreasing	1	I,P,U		
Miniopterus majori	Major's long-fingered bat	Least Concern	Unknown	1	I[7]		
Miniopterus schreibersii	Schreibers' bent-winged bat	Vulnerable	Decreasing	1	P		
Myotis alcathoe	Alcathoe myotis	Data Deficient	Unknown				
Myotis aurascens	Steppe whiskered bat	Least Concern	Stable				

6 IUCN Red List Assessment only available at species, and not sub-species level

7 IUCN Red List Assessment: "The major threats to this species are not known. It could be susceptible to cave disturbance in some sites and it could perhaps be hunted in some areas."

Scientifc Name	Common Name	Red List	Pop. Trend	Hunt Threat	Hunt Type	Use Type	Trade Scale
Myotis bechsteinii	Bechstein's bat	Near Threatened	Decreasing				
Myotis blythii	Lesser mouse-eared bat	Least Concern	Decreasing	1	P		
Myotis brandtii	Brandt's bat	Least Concern	Stable				
Myotis capaccinii	Long-fingered bat	Vulnerable	Decreasing	1	I		
Myotis dasycneme	Pond bat	Near Threatened	Decreasing	1	U		
Myotis daubentonii	Daubenton's bat	Least Concern	Stable				
Myotis emarginatus	Geoffroy's bat, notch-eared bat	Least Concern	Stable	1	I,P	3	
Myotis hajastanicus	Armenian whiskered bat	Critically Endangered	Unknown				
Myotis myotis	Greater mouse-eared bat	Least Concern	Stable				
Myotis mystacinus	Whiskered bat	Least Concern	Unknown		I	3	S
Myotis nattereri	Natterer's bat	Least Concern	Stable		I	3	S
Myotis nipalensis	Nepal myotis	Least Concern	Unknown				
Myotis punicus	Felton's myotis	Data Deficient	Unknown		I	3[8]	S
Myotis schaubi	Schaub's myotis	Data Deficient	Unknown				
Nanger dama	Dama gazelle	Critically Endangered	Decreasing	1	I	1;12;15	S
Nyctalus lasiopterus	Greater noctule bat	Vulnerable	Decreasing				
Nyctalus leisleri	Leisler's bat	Least Concern	Unknown				
Nyctalus noctula	Noctule bat	Least Concern	Unknown				
Oryx dammah	Scimitar-horned oryx	Extinct in the Wild		1	I	1;10;12[9]	
Otomops madagascariensis	Madagascar free-tailed bat	Least Concern	Unknown				
Otomops martiensseni	Large-eared free-tailed bat	Near Threatened	Decreasing				
Otonycteris hemprichii	Desert long-eared bat	Least Concern	Unknown				
Ovis ammon	Argali sheep	Near Threatened	Decreasing	1	I	1;3;15	S

[8] Red List Assessment Threat text: “Species are collected for medicine”.

[9] Red List Assessment Threat text: “Overhunting and habitat loss, including competition with domestic livestock, have been reported as the main reasons for the extinction of the wild population of Scimitar-horned Oryx. Prior to their extinction in the wild Scimitar-horned Oryx were prized by local people for their meat and hide (Morrow et al. 2013). Their thick hide was used for ropes, bags, shoes and shield coverings and they were targeted by trophy hunters for their horns (Morrow et al. 2013).”

Scientifc Name	Common Name	Red List	Pop. Trend	Hunt Threat	Hunt Type	Use Type	Trade Scale
Ovis vignei	Urial	Vulnerable	Decreasing	1	I	15	
Pan troglodytes	Chimpanzee	Endangered	Decreasing	1	I,P,U	1;13	S,N
Panthera leo	Lion	Vulnerable	Decreasing	1	I,P,U	3;10;12;15	
Panthera onca	Jaguar	Near Threatened	Decreasing	1	I,P,U	3;10;12	
Panthera pardus	Leopard, panther	Vulnerable	Decreasing	1	I,P,U	3;10;15	
Pantholops hodgsonii	Chiru	Near Threatened	Increasing	1	I	1;3;10	S
Pipistrellus kuhlii	Kuhl's pipistrelle bat	Least Concern	Unknown				
Pipistrellus nathusii	Nathusius's pipistrelle bat	Least Concern	Unknown				
Pipistrellus pipistrellus	Common pipistrelle	Least Concern	Stable				
Pipistrellus pygmaeus	Soprano pipistrelle	Least Concern	Unknown				
Plecotus auritus	Brown long-eared bat	Least Concern	Stable				
Plecotus austriacus	Grey long-eared bat	Near Threatened	Decreasing				
Plecotus kolombatovici	Kolombatovic's long-eared bat	Least Concern	Decreasing				
Plecotus macrobullaris	Alpine long-eared bat	Least Concern	Decreasing				
Plecotus sardus	Sardinian long-eared bat	Vulnerable	Decreasing				
Procapra gutturosa	Mongolian gazelle	Least Concern	Stable	1	I	1;3;10;12	S,N
Procapra picticaudata	Tibetan gazelle	Near Threatened	Decreasing	1	I	1;10;12	S,N
Rhinolophus blasii	Blasius' horseshoe bat	Least Concern	Decreasing				
Rhinolophus euryale	Mediterranean horseshoe bat	Near Threatened	Decreasing	1	U		
Rhinolophus ferrumequinum	Greater hor-seshoe bat	Least Concern	Decreasing				
Rhinolophus hipposideros	Lesser horseshoe bat	Least Concern	Decreasing				
Rhinolophus mehelyi	Mehely's horseshoe bat	Vulnerable	Decreasing				
Rousettus aegyptiacus	Egyptian fruit bat	Least concern	Stable	1	I,P	1	S
Saiga tatarica, Saiga borealis	Saiga antelope	Critically Endangered	Decreasing	1	I	1;3	S,N

Scientifc Name	Common Name	Red List	Pop. Trend	Hunt Threat	Hunt Type	Use Type	Trade Scale
Tadarida brasiliensis	Mexican free-tailed bat	Least Concern	Stable				
Tadarida insignis	Oriental free-tailed bat	Data Deficient	Unknown				
Tadarida latouchei	La touche's free-tailed bat	Endangered	Decreasing	1	I	1	S
Tadarida teniotis	European free-tailed bat	Least Concern	Unknown				
Taphozous nudiventris	Naked-rumped tomb bat	Least Concern	Stable				
Uncia uncia	Snow leopard	Vulnerable	Decreasing	1	I,P,U	3;10;12;13	
Ursus arctos isabellinus	Himalayan brown bear *U. a. isabellinus* in China	CR (Mongolia); VU (Tian Shan Mountains, Karakorum); LC (Western China)	Stable (Mongolia); Possible decline (Tian Shan Mountains, Karakorum); Unknown (Western China)				
Ursus maritimus	Polar bear	Vulnerable	Unknown	1	I,P	1;10;12	S
Vespertilio murinus	Parti-coloured bat	Least Concern	Stable				
Vicugna vicugna	Vicuña	Least Concern	Increasing	1	I	1;10	I

4.2 Global database records of wild meat hunting and trade

Of the 105 CMS terrestrial mammal species, 54 are recorded as hunted or traded legally or illegally in one or more of the LEMIS, TRAFFIC, WILDMEAT and CITES databases. Figure 6 provides a summary by scientific order, and Table 3 provides information on the presence/absence of each species in the four databases. Notably, bat species are mainly absent from trade, with only 12 of 57 species recorded as hunted in trade/hunting databases.

As discussed previously, trade database records must be interpreted carefully, and the presence of each species in these databases for each species will depend on levels and quality of national reporting, enforcement activity, detectability of legal and illegal hunting events, and the scale of the trade in the species. Species that are solely traded locally or nationally will not be recorded in international trade databases, and the WILDMEAT database, which reports on local/national-level hunting, has restricted geographical coverage.

4.3 Literature review: hunting offtakes, trends and impacts

4.3.1 Availability of information

Our literature review resulted in 636 relevant publications, of which 51% were peer-reviewed articles and 49% were reports and other grey literature. All publications have been added to a Mendeley library, which can be accessed here: https://www.mendeley.com/community/cms-hunting-impacts/. Appendix 2 details the searches carried out per species and the data on hunting found in each publication (with a link to the relevant Mendeley library page). This includes information (where available) on species use/hunting purpose, hunted amounts, trade purposes and scales (i.e., whether trade is local, national, international), trade prices, large-scale drivers of hunting, hunting impacts, hunting legality and enforcement and associated zoonotic diseases. A summary of the information found per species is provided in Appendix 3, which is attached to this report. While the following section summarises the main findings from our literature review, we would invite anyone wishing for further detailed information on each CMS species to consult these appendices.

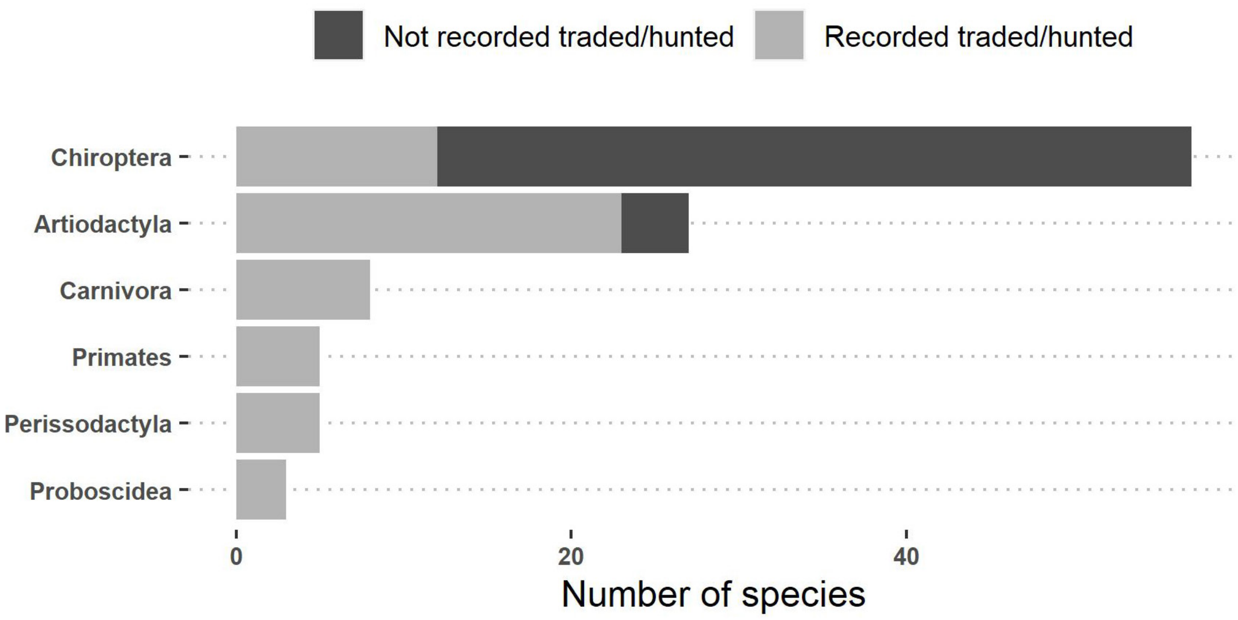

Figure 6: The number of CMS terrestrial mammal species recorded in at least one of the four trade/hunting databases, by scientific order.

Table 3: The presence/absence of each CMS terrestrial mammal species recorded as having been hunted/traded in the four databases.

Scientifc Name	Overall	LEMIS[10]	TRAFFIC	WILDMEAT[11]	CITES
Acinonyx jubatus	y	y	y	y	Y
Addax nasomaculatus	y	y			Y
Ammotragus lervia	y	y			Y
Barbastella barbastellus					
Barbastella leucomelas					
Bos grunniens	y	y			
Bos sauveli	y				Y
Camelus bactrianus	y	y			
Cervus elaphus barbarus	y	y		y	Y
Cervus elaphus yarkandensis	y	y			
Eidolon helvum	y	y		y	
Elephas maximus indicus	y				Y
Eptesicus bottae					

10 USA only

11 Selected countries in Africa and South America only; see methods section for full list of countries

Scientifc Name	Overall	LEMIS[10]	TRAFFIC	WILDMEAT[11]	CITES
Eptesicus nilssonii					
Eptesicus serotinus					
Equus africanus	y	y			Y
Equus ferus przewalskii	y	y			Y
Equus grevyi	y	y			Y
Equus hemionus	y				Y
Equus kiang	y	y			Y
Eudorcas rufifrons					
Gazella bennettii	y	y			Y
Gazella cuvieri	y				Y
Gazella dorcas	y	y		y	Y
Gazella erlangeri					
Gazella leptoceros	y				Y
Gazella subgutturosa	y	y			
Giraffa camelopardalis	y	y	y	y	Y
Gorilla beringei beringei	y	y	y		Y
Gorilla beringei graueri	y	y	y		Y
Gorilla gorilla diehli	y	y			Y
Gorilla gorilla gorilla	y	y		y	y
Hippocamelus bisulcus	y	y			Y
Hypsugo savii					
Kobus kob leucotis					
Lasiurus blossevillii					
Lasiurus borealis					
Lasiurus cinereus	y	y			
Lasiurus ega	y	y			
Loxodonta africana	y	y	y	y	Y
Loxodonta cyclotis	y			y	Y
Lycaon pictus	y	y	y		
Miniopterus majori					

Scientifc Name	Overall	LEMIS[10]	TRAFFIC	WILDMEAT[11]	CITES
Miniopterus natalensis	y	y			
Miniopterus schreibersii					
Myotis alcathoe					
Myotis aurascens					
Myotis bechsteinii					
Myotis blythii					
Myotis brandtii					
Myotis capaccinii					
Myotis dasycneme					
Myotis daubentonii					
Myotis emarginatus					
Myotis hajastanicus					
Myotis myotis					
Myotis mystacinus	y	y			
Myotis nattereri					
Myotis nipalensis					
Myotis punicus					
Myotis schaubi					
Nanger dama	y			y	Y
Nyctalus lasiopterus					
Nyctalus leisleri					
Nyctalus noctula					
Oryx dammah	y	y	y		Y
Otomops madagascariensis					
Otomops martiensseni					
Otonycteris hemprichii					
Ovis ammon	y	y	y		Y
Ovis vignei	y	y			
Pan troglodytes	y	y	y	y	Y
Panthera leo	y	y	y	y	Y
Panthera onca	y	y	y		Y

Scientifc Name	Overall	LEMIS[10]	TRAFFIC	WILDMEAT[11]	CITES
Panthera pardus	y	y	y	y	Y
Pantholops hodgsonii	y	y	y		Y
Pipistrellus kuhlii	y	y			
Pipistrellus nathusii					
Pipistrellus pipistrellus	y	y			
Pipistrellus pygmaeus					
Plecotus auritus					
Plecotus austriacus					
Plecotus kolombatovici					
Plecotus macrobullaris					
Plecotus sardus					
Procapra gutturosa					
Procapra picticaudata	y	y	y		
Rhinolophus blasii					
Rhinolophus euryale					
Rhinolophus ferrumequinum	y	y			
Rhinolophus hipposideros	y	y			
Rhinolophus mehelyi					
Rousettus aegyptiacus	y	y		y	
Saiga borealis	y				Y
Saiga tatarica	y	y	y		Y
Tadarida brasiliensis	y	y			
Tadarida insignis					
Tadarida latouchei					
Tadarida teniotis					
Taphozous nudiventris					
Uncia uncia	y	y	y		
Ursus arctos isabellinus	y	y	y		Y
Ursus maritimus	y	y			Y
Vespertilio murinus	y	y			
Vicugna vicugna	y	y			Y

4.3.2 Types of use

Of the 105 species studied, 67 species were recorded as hunted in the publications found from our literature review (which included a review of Red List assessments for each species). Of these, 47 (70%) were hunted for wild meat consumption, 29 for cultural reasons, 33 for medicinal use, 26 due to human-wildlife conflict, 13 as bycatch and 37 for sport/trophy hunting/fashion. Of the 67 hunted species, 40 species (60%) were recorded as traded. Figure 7 illustrates the different types of use by scientific order, and a summary of use per species is provided in Appendix 3.

Artiodactyls are the group that are the most frequently used for consumption ('wild meat' - 96% of all species), whereas other groups are used for a wider range of uses. CMS listed bat species were not as frequently recorded as being hunted, with references to hunting found for only 20 of the 57 bat species (35% of species). Aside from Chiroptera, only one other CMS species was not recorded as hunted. This was Neumann's Gazelle *Gazella erlangeri*, which is not listed in the IUCN Red List. It has been suggested that this animal - sometimes kept as a pet in the Middle East - is not a true species at all but is in fact a captive form of Arabian Gazelle *Gazella arabica* (Wronski et al., 2017).

The only ungulate species not listed as threatened by hunting in the IUCN Red List (where it is listed as 'Least Concern') is the kiang (*Equus kiang*). However, the narrative of the Red List Assessment "Threats" section for this species clearly mentions hunting as a past and present threat, and there is further evidence of hunting for consumption and medicinal use from multiple sources from our literature review. The Red List Assessment states that "the status and trends of Kiang populations are poorly known" although the overall trend is assessed as "stable".

4.3.3 Levels of hunting offtake

From the literature review, we found publications that provided data on hunting offtakes, levels of hunting, or hunting trends, for 45 of the 105 species (21 Artiodactyla, 8 Carnivora, 4 Chiroptera, 4 Perissodactyla, 5 Primates and 3 Proboscidea (elephant species); see Appendix 3). In general, while some estimates of offtake levels (legal and illegal) are available for species, many come from single-site case studies, with varying methods and sampling effort, which cannot easily be extrapolated.

Table 4 provides the information on amounts hunted for dorcas gazelle (*Gazella dorcas*), by way of illustration. Hunting data comes from market surveys in Morocco; Bergin & Nijman (2015) surveyed the markets of 22 Moroccan cities from May – June 2013, May 2014 and December 2014, and 137 specimens (representing approximately 98 individuals) of dorcas gazelle were recorded. However, this cannot be extrapolated into numbers of dorcas gazelle hunted across Morocco, as we do not know the sampling effort and detection rates for these markets, the total number of markets in Morocco, or the proportion of hunted gazelle that end up in a market. Nevertheless, the authors point out that the given population size for this species in Morocco was

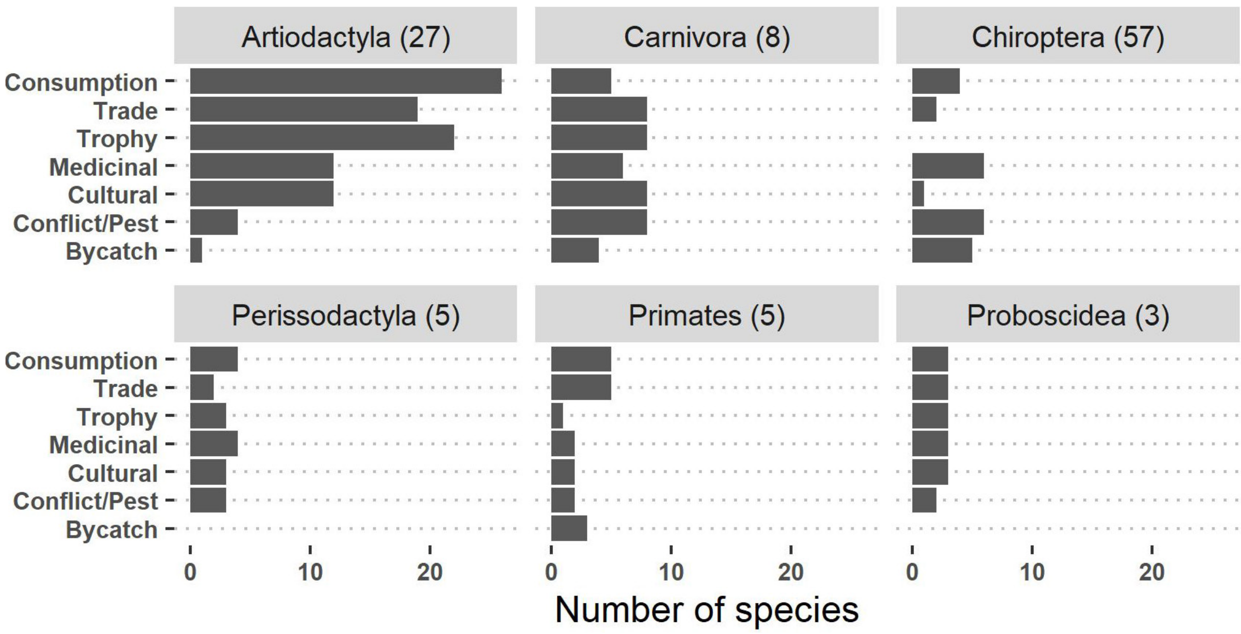

Figure 7: The number of species in each order that are reported as used for different purposes from the literature review. Numbers in parenthesis are the number of CMS terrestrial mammal species in each order.

Table 4: An example of hunting offtake and trade data gaps: the amount of dorcas gazelle (Gazella dorcas) hunted and traded, from our literature review.

Amount	Location and Year	Reference
5 whole animals, 15 skins, 48 heads/horns	Markets in 17 towns/cities in Morocco, Year?	(Bergin & Nijman, 2014b)
137 specimens; authors believe this amounts to 98 individual dorcas gazelles	Markets in 11 different cities in Morocco 2013-2014	(Bergin & Nijman, 2014a)
Approximately 100 killed in 2012 and 125 killed in 2015. Data gathered through questionnaires to 40 international experts and from interviews made in September 2015 to c. 200 Libyan residents	Libya 2012-2015	(Brito et al., 2018)
372 gazelles recorded hunted between 1964 and 2016 (almost half of which were before 1990), from 13 completed questionnaire surveys from experts in Libya	Various locations in Libya, detailed listed in Table 4.17 in thesis. 1964-2016	(Algadafi, 2019)

approximately 200-800 individuals, and therefore the 98 specimens observed at markets could represent 8-30% of the entire population in Morocco, highlighting that sometimes exact offtakes are not needed to determine a significant hunting impact. Nationwide estimates are available for Libya (Algadafi et al., 2017; Brito et al., 2018) but are based on limited questionnaire surveys rather than observations. Dorcas gazelle ranges across most of the Sahel and hunting data and dorcas gazelle population data are unavailable for most of its range. While the investigations documented here represent substantial and high-quality research efforts on the behalf of the investigators, they do not provide adequate data to estimate hunting pressure on dorcas gazelle across its range.

The low number of hunting offtake studies is a greater issue for species whose ranges cover many countries, as research effort can vary widely by country, as can hunting pressure. Research effort tends also to be focussed on areas surrounding protected areas (PAs), with the aim of understanding threats to these PAs. This leads to very patchy data on hunting offtakes in non-protected landscapes.

A lack of systematic sampling makes extrapolation to a national level, or across a species' range, challenging, and therefore these numbers on their own are of little use in estimating overall offtake levels. This is comparable to some of the limitations of trade database records (Challender et al. 2021). Elephants are a well-known exception to this problem, as a systematic method for documenting the illegal killing of elephants across Africa and Asia has been in use since 1996, as described in Box 1. However, detailed data are not made publicly available at the request of elephant range States/CITES Parties, and it is therefore not possible to determine the number of individuals killed for ivory or for meat or used for both purposes, even when the total number of individuals killed is known. Similarly, a Snow Leopard Crime Database exists (https://globalsnowleopard.org/capacity-center/illegal-wildlife-data/), containing records of seizures (legal actions taken by government authorities) and observations (reports of snow leopard [Uncia uncia] killing, capture or trade, including market surveys) dating back to 1989 (Nowell et al., 2016a). Between 221 – 450 snow leopards are estimated to have been poached across their range between 2008 – 2016, using data from the database. Of these, 55% were killed in retaliation for livestock depredation, 21% killed for trade and 18% taken by non-targeted methods such as snares. However, with the average rate of illegal hunting detection estimated at less than 38%, numbers are probably much higher (Nowell et al., 2016). A recent review of illegal hunting and trafficking in cheetahs (Tricorache et al., 2018) also provides estimates of the global illegal trade in cheetahs from 2005 - 2015, estimating that a minimum of 1108 cheetah were trafficked in those 10 years, of which over 80% were recorded in East Africa, for use as pets or for their pelts.

Illegal hunting offtakes may also be more quantifiable in circumstances where the hunting of an individual animal is unlikely to stay unnoticed – for large-bodied species, where the number of individuals in a specific area are low, or in open habitats where censuses are relatively straightforward, and where conservation and law enforcement efforts (and therefore detectability) are high. Examples of this include mountain gorillas (*Gorilla beringei beringei*), where the number of gorillas hunted per year is well-known, due to the small area in which the species is found (Virunga Transboundary Protected Area in Uganda, DRC and Rwanda and Bwindi Impenetrable National Park in Uganda), and there is high conservation and enforcement effort in the two protected areas. (Arcus Foundation, 2021) document the killing of 26 habituated gorillas from 1967 – 2008 (3 snared unintentionally, 15 shot by militia and 8 for the pet trade, wild meat trade

Box 1: Systematic monitoring of elephant killing through the MIKE programme (reproduced, with permission, from the CITES secretariat)

The CITES programme for Monitoring the Illegal Killing of Elephants, commonly known as MIKE, was established by the Conference of the Parties (CoP) to CITES at its 10th Meeting (Harare, 1997), and is conducted in accordance with the provisions in Resolution Conf. 10.10 (Rev. CoP18) on Trade in elephant specimens. The MIKE Programme is managed by the CITES Secretariat under the supervision of the CITES Standing Committee. Since implementation began in 2001, the operation of the MIKE Programme in Africa has been possible thanks to the support from range States implementing the MIKE programme and submitting data on an annual basis as well as the generous financial support of the European Union (EU) and other donors.

MIKE aims to inform and improve decision-making on elephants by measuring trends in levels of illegal killing of elephants, identifying factors associated with those trends, and building capacity for elephant management in range States. MIKE operates in a large sample of sites spread across African and Asian elephant range in 32 countries in Africa and 13 countries in Asia. The total number of MIKE sites in Africa is 69, representing more than 50% of the African elephant population on the continent. There are 29 sites in Asia.

MIKE data is collected by law enforcement and ranger patrols in the field, and through other means in designated MIKE sites. When an elephant carcass is found, site personnel try to establish the cause of death and other details, such as sex and age of the animal, status of ivory and stage of decomposition of the carcass. This minimum set of standardized information relating to each carcass detected at MIKE sites is then submitted to the MIKE Programme.

The CITES MIKE Programme, in collaboration with UNEP's Science Division and with funding provided by the EU, developed a web-based (online) database management and reporting system. The new MIKE Online Database contains more than 23,000 records submitted by participating range States. This provides the most substantial information base available for making a statistical analysis of the levels of illegal killing of elephants in the world.

The CITES MIKE programme evaluates relative illegal hunting levels based on the Proportion of Illegally Killed Elephants (PIKE), which is calculated as the number of illegally killed elephants found, divided by the total number of elephant carcasses encountered by patrols or other means, aggregated by year for each site.

PIKE is an index of illegal hunting pressure and provides trends relating to the levels of illegal hunting, but it may be affected by several potential biases related to data quality, the fact that MIKE sites are not randomly selected, the reporting rate, the carcass detection probabilities, and the variation in natural mortality rates across MIKE sites, including increases in natural mortality caused by drought and other factors. PIKE however remains a reliable indicator to monitor and study changes in illegal hunting pressure over time. To determine the trends in PIKE at a continental and subregional scale, the MIKE Programme uses a generalized linear mixed model (GLMM): PIKE generally increased from 2003 to 2010, peaked in 2011, and decreased from 2011 to 2019. The trendline for the unweighted Bayesian GLMM PIKE estimates shows that there is sufficient evidence to confirm an upward trend (increase in PIKE) from 2003 to 2011, and a downward trend (decrease in PIKE) from 2011 to 2019. Over the last five years (2015 to 2019), the unweighted continental PIKE estimate shows a downward trend with a level of certainty over 95%.

and crop raiding) in Virunga and a further six live young gorillas confiscated from poachers from 2004 – 2017. In Bwindi four young gorillas were killed intentionally by poachers in the 1990's for the purposes of obtaining a live infant, a blackback male was speared by a poacher hunting for other wildlife in 2011 and a female (and her unweaned baby) was killed unintentionally while crop raiding in 2012. Further killings are possible but large additional numbers are unlikely as word of major killings spread quickly. While these are relatively low numbers of mountain gorillas killed, the killings of the habituated gorillas represented 12% of all mortality of Virunga gorillas at the time, and probably reduced the growth rate of the habituated groups by about 1% annually. The seven gorillas killed in Bwindi represented 1.5 – 2% of the total gorilla population of the park. Similarly, offtakes for the Cross River gorilla, of which most of the remaining individuals are found in a few key Protected Areas in Nigeria and Cameroon, are thought to be in the range of 1 – 3 per year (Bergl et al., 2016). However, this could represent 0.4 -3% of the total global population.

For western lowland gorillas (*Gorilla gorilla gorilla*) and chimpanzees (*Pan troglodytes*), where global populations and ranges are much greater, estimates of hunting offtakes are much less precise. Stiles et al. (2013) estimate that from 2005 -2011 more than 2000 chimpanzees and 420 gorillas (all subspecies) were hunted each year. Market surveys covering 89 urban and rural markets in a 35,000-km^2 area between the Cross River in Nigeria and the Sanaga River in Cameroon (Fa et al., 2006) found that more than 2,000 chimpanzees and more than 600 gorillas (all subspecies) are traded annually.

While there is a general lack of available information on bat hunting, an exception is the straw-coloured bat (*Eidolon helvum*), thought to be Africa's most hunted bat (Box 3). While available site-level estimates of offtakes suggest a large offtake of *Eidolon helvum* is probable across Africa, these case-study estimates do not yet allow for an overall global, regional or even national offtake to be calculated, or the impact of this offtake to be assessed. This is the situation for most wild meat species globally (Coad et al., 2019) and is not limited to migratory species.

Box 2: African Elephants: two species, principal threats, and trends

In 2021, African elephants were recognised as two separate species by the IUCN: African savanna elephants (*Loxodonta africana*) and African forest elephants (*Loxodonta cyclotis*) (Hart et al., 2021). Prior to this, IUCN considered African elephants as a single species, with two subspecies (*L. a. africana* and *L. a. cyclotis*). Both species are in threatened categories on the IUCN Red List: African savanna elephants are listed as Endangered and African forest elephants as Critically Endangered (Gobush et al., 2021a; Gobush et al., 2021b). The principal threat for both species is illegal hunting for ivory, although there are other significant threats, dependent on location: human-elephant conflict, habitat loss and fragmentation, and climate change (Gobush et al., 2021a,b). Elephant ivory has long been a desirable luxury item across the Far East and in the Chinese diaspora (Gao & Clark, 2014). It is used in trinkets, jewellery, furniture, as a show of wealth/status, and in religious totems among other uses. After about 2010, the principal destination of ivory was China, where the extraordinary economic boom allowed people to purchase ivory for the first time (Vigne, 2021). Once an elephant is killed, poachers typically take the tusks, and occasionally other body parts that have a high ratio of profit to weight - the tail (or tail hairs) and parts of the skin that can be sold or used as bribes to avoid law enforcement attention; occasionally the meat is also taken as well, especially in Central Africa (Gobush et al., 2021b; Stiles, 2011). Elephant meat, in contrast to ivory, is logistically complex to transport, rots unless smoked, and normally attracts the same price per kilo as other types of bushmeat, so is not very attractive to ivory poachers (Stiles, 2011).

Box 3: Bat hunting: a lack of data or a lack of threat?

Of the 57 bat species listed on the Convention on Migratory Species, there is little evidence of hunting or bushmeat consumption. However, it is unclear whether this absence of evidence is due to a lack of research or a lack of use. The IUCN Red List lists hunting, trade and consumption as threats to some CMS bat species and a global review by (Mickleburgh et al., 2009) found that bat species are hunted and consumed for their meat, particularly throughout Asia and Africa. In addition, bats can be killed by children as a pastime or to build hunting skills, as bycatch, or as a nuisance pest (Coad, pers. obs.; Fattah et al., 2019). However, whilst there is a high volume of literature on wild meat hunting, consumption of bats is rarely discussed or documented (Mickleburgh et al., 2009; (CIFOR et al., 2021). The absence may be because hunting studies often record hunted bats generically as 'bats', or record hunting offtakes at the order or genus level due to difficulties in bat identification. Bat species may therefore not show up in the results of traditional wild meat hunting offtake studies. The little or limited evidence of whether or which bats are hunted or consumed as wild meat therefore presents a big data gap.

In Europe, there is no evidence of bat species being hunted for consumption, however there are incidences of bats being deliberately killed as nuisance pests or accidentally killed during construction activities, by chemical wood treatments, as roadkill, or by wind turbines. For example, (Stebbings, 1995) recorded four instances of illegal killings of the greater horseshoe bat (*Rhinolophus ferrumequinum*) using pesticides in the UK. Similarly, hunting for persecution/control is a threat to the common bent-wing bat (*Miniopterus schreibersii*) (Stebbings, 1995) and the lesser Mouse-eared bat (*Myotis blythii*) (Juste & Paunović, 2016a) according to the IUCN Red List, but no information is given on the drivers and frequency. Some European species are hunted in the North African part of their range and used for medicinal purposes, including *Myotis capaccinii* (Paunović, 2016), *Myotis emarginatus* (Piraccini, 2016b) and *Myotis punicus* (Juste & Paunović, 2016c). However, there is no information on amounts, prices and trade levels. In Asia, there is some evidence that *Tadarida insignis* and *Tadarida latouchei* are hunted (UNEP-WCMC, 2011). *T. latouchei* is hunted locally for wild meat consumption in Lao PDR and Viet Nam, however this is classified as a low impact threat (Thong & Loi, 2020).

One exception to the lack of available information is the straw-coloured bat (*Eidolon helvum*), thought to be Africa's most hunted bat. This species is hunted and consumed as bushmeat in West and Central Africa, likely due to its large body size (Mickleburgh et al., 2009b). Estimates of hunting offtakes (predominantly for consumption) were available from 7 different publications. It has recently been estimated (Nnamuka et al., 2020) that 128,000 individuals are sold in Accra and Kumasi, Ghana, every year. In the Plateau of Abijan, Cote d'Ivoire, 306,000 bats were killed between August 2005 and July 2006 (Niamien et al., 2015a). (Fa et al., 2006) estimated a regional offtake per year of 434 individuals for urban consumption and 1380 carcasses extracted for rural consumption in Nigeria, and 214 extracted for rural consumption respectively in Cameroon, across the Cross-Sanaga rivers region.

While offtake rates for Eidolon helvum in West and Central Africa seem high, it is not easy to know the impact on the global population, as neither national nor range-wide population estimates of *Eidolon helvum* currently exist. However, the size of individual roosts can sometimes reach millions of bats, and the species has been recorded across most of sub-Saharan Africa (Peel et al., 2017). While (Mickleburgh et al., 2009b) suggest that consumption levels only constitute a serious threat in Tanzania, in Uganda a well-known colony in Kampala declined over a forty-year period from ca 250,000 animals to 40,000 in 2007, with hunting thought to be a major factor in these declines (Monadjem et al., 2007). This suggests there may be regional variations in hunting pressure and preferences for *Eidolon helvum*. The IUCN Red List for Eidolon helvum classifies hunting and trapping as a low impact threat (Cooper-Bohannon et al., 2020).

The IUCN similarly classifies hunting as a low-level threat for *Myotis blythii* (Juste & Paunović, 2016b), *Myotis capaccinii* (Paunović 2016) and *Myotis dasycneme* (Piraccini, 2016a). For other CMS bat species, little information is available on the impact hunting has on populations. The knowledge gap regarding hunting and consumption of bats means it is unclear whether these threats are having little or no impact on CMS bat species or whether the data is incomplete.

4.3.4 Trends in hunting offtakes

While many of the publications in our literature highlight that the threat of hunting is a key driver of species declines, few were able to provide good estimates of hunting offtakes, either at a national level or a range-wide level. Therefore, documentation of trends in hunting activity are also scarce. Where information was available, it tended to highlight large-scale historical trends, rather than current trends. Examples include:

- Uncontrolled hunting of dorcas Gazelle (*Gazella dorcas*), dama Gazelle (*Nanger dama*) and slender-horned gazelle (*G. leptoceros*) in the 19th century to the late 20th century has led to drastic population declines. These declines were accelerated in the late 20th century due to the use of automatic weapons and motorised desert vehicles (Mallon & Kingswood, 2001). Dorcas gazelle hunting may be increasing in Libya, potentially because of the recent civil conflict (Table 4).
- For both species of African elephant (*Loxodonta africana* and *L. cyclotis*), illegal hunting is considered the principal threat. Although some savanna elephant populations (e.g., in Kenya, Tanzania, Zambia, Uganda) experienced a couple of decades of recovery from earlier illegal hunting waves, more recent data recorded by the MIKE project (since 2002) showed that illegal hunting significantly intensified across the continent, starting in 2008, peaking in 2011. The metric of illegal hunting pressure used, PIKE (see Box 1), although slowly declining, remains above 0.5, (the threshold above which elephant populations are very likely to be in net decline) in Central and West Africa (CITES, 2019b). A few populations of both species are stable, and more so in southern Africa, but unsustainably high levels of illegal hunting across much of the continent continues (Gobush et al., 2021a,b).
- Chiru (*Pantholops hodgsonii*) hunting escalated to a commercial scale in the late 1980s and 1990s when, according to the Chinese government, about 20,000 chirus were hunted annually, primarily for their shahtoosh (hair) (Du et al., 2016). However, the status of the chiru seems to be improving, with the IUCN Red List reporting an increase in populations to between 100 - 150,000 individuals, and that this in part reflects

significant effort by range and consumer States to address illegal killing and sales of chiru (IUCN SSC Antelope Specialist Group, 2016b).

- Vicuña (*Vicugna vicugna*) began a sharp decline due to over-exploitation of their meat, skin and fibre, and populations dropped until they faced a real threat of extinction, falling from 2 million individuals to under 10,000 by 1964. After 30 years of proactive, effective protection and management, vicuña populations have recovered sufficiently (to 350,000 individuals) to make sustainable management projects viable, and now vicuña are live sheared for their fleece (Box 6). However, the Red List entry for this species states that "According to the Technical Meeting of the Vicuña Convention (2015) there has been, with the exception of Ecuador, an alarming increase in Vicuña poaching throughout its range, especially affecting isolated Chilean and relict populations whose marginal distribution increases their vulnerability".
- Saiga antelope (*Saiga tatarica*) recovered from a low of a few thousand individuals in the first few decades of the Soviet Union, after being over-hunted for meat and horns in the 19th and early 20th century. High levels of illegal hunting after the collapse of the Soviet Union, coupled with disease outbreaks, have again decimated Saiga populations which are still at risk from overhunting (Box 5).

Box 4: Trade in jaguars – multiple uses and potentially increasing impacts

Jaguars (*Panthera onca*) and their body parts are used locally and traded internationally. Jaguars were historically killed for their skins, which were used in the fashion industry. This legal trade was halted with the CITES listing of jaguars on Appendix I in 1975. However, jaguars are still killed because of conflict in response to predation events on livestock or other domestic animals, or out of perception that jaguars are a potential threat (Cavalcanti, 2010). Jaguar body parts are used for various purposes, including for personal use, or traded on local or international markets.

Locally, jaguar body parts may be used in decoration, traditional remedies or cultural practices (Arias et al., 2021). For example, amulets with jaguar teeth are worn as spiritual symbols, skins serve as home decoration or costumes, and jaguar fat is used to treat arthritis and other pains. Live animals are also kept as pets or attractions (Arias et al., 2021). For international trade, seizure reports suggest that canines, skins and heads are the more popular items (Morcatty et al., 2020a). In Suriname, reports exist of a jaguar paste, created by boiling down the entire jaguar carcass over several days, that is in demand from local buyers as a general and sexual health tonic that is diluted in alcohol; an international market in China may exist as well, but is largely unknown (Lemieux & Bruschi, 2019a; Arias pers comms. 2021). This paste would be nearly impossible to detect in seizures and therefore it is difficult to quantify trade volumes.

The international market for jaguar products also includes tourists, who purchase souvenirs, such as jaguar skin leather products or necklaces with canines. In a more recent trend of Ayahuasca tourism, jaguar parts are promoted to tourists by 'shamans' under the claim that these trinkets augment the psychedelic experience (Braczkowski et al., 2019). Additionally, drug and arms traffickers have been found in possession of a taxidermied jaguar (Melissa Arias et al., 2020), and there is evidence of illegal trophy hunting in Brazil (Arias pers comms. 2021).

The Chinese market for medicine and status symbols has been a recent focal point of concern for jaguars. Morcatty et al., (2020) found that illegal trade in jaguar parts was positively correlated with the amount of private Chinese investment and levels of corruption in the range countries. Demand of jaguar parts for the Chinese market have been attributed to the booming Chinese economy, increasing the demand for status symbols, and the increased prices of tiger parts due to stricter enforcement on tiger (*Panthera tigris*) part trade (Morcatty et al., 2020). Traditional Chinese medicine may play a role too (Lemieux & Bruschi, 2019b; Morcatty et al., 2020b). Chinese business connections facilitate a link between market and supplier through combining illegal trade with a legal market chain, but evidence suggests that a market also exists for newly established Chinese communities in the jaguar range (Lemieux & Bruschi, 2019c). However, the relative contribution of the Chinese market to illegal international trade in general is not clear as official seizures of jaguar body parts in China are rare (Arias 2021, pers. comm.). The market for jaguar body parts is likely diverse, with domestic and international markets in countries such as in the US and EU, where more seizures have occurred than in China (Arias pers comms. 2021).

Widespread use and trade of jaguars has long existed at a domestic scale; however, it has only recently received attention. Use and trade of jaguars has largely resulted from opportunistic encounters and conflict between humans and jaguars (Arias et al., 2021). There is a risk that the opportunity to sell parts of jaguars – an animal with an already poor reputation relating to human-wildlife conflict – may give local people additional incentive to kill, which may be compounded by poverty and opportunities to quickly earn cash in countries with poor enforcement and culture where the killing of jaguars is accepted (Kerman, 2010; Lemieux and Bruschi 2019; Morcatty et al., 2020).

The number of jaguars killed annually is not known and it is difficult to measure trends over time due to a lack of baseline data. Morcatty et al. (2020) reviewed data on confiscated jaguar parts between 2012 and 2018 from 19 Central and South American countries and China and found that 857 individuals were seized. These data revealed a 200-fold increase in the number of jaguars traded in the last 10 years, and a 5-fold increase in seizure reports. The data from this study suggests an increase in jaguar trade, however the increase may not be due to a direct increase in jaguar killings, but may be linked to improved reporting, detection and an increase in media and conservation interest in recent years (Arias pers comm. 2021). More baseline information is needed before trends in jaguar hunting and trade over time can be estimated.

4.3.5 Impacts of hunting on species populations and ecosystems

4.3.5.1 Direct Impacts

Migratory species are especially susceptible to over-hunting (Datta, 2021; Dolman et al., 2021; Epstein et al., 2009; Sarwar et al., 2021). Predictable spatio-temporal peaks in abundance along migration routes can be targeted by human hunters, and the hunting of migratory species can be celebrated, as they represent a seasonal bounty (Datta 2021).

However, a lack of systematically collected data on hunting offtakes for each species makes quantitative assessment of hunting impacts extremely challenging. When species are impacted by multiple threats (as is the norm) and estimates of hunting offtakes do not exist, it is hard to formally attribute population declines to hunting, as opposed to another threat (for example, habitat loss). It is even more challenging to attribute impacts to use, such as hunting for meat as opposed to medicine or conflict for example, where (as is also the norm) hunted species have multiple uses. Nevertheless, for many species where hunting is known to be a major or the main threat, population declines have been precipitous, and as published literature makes the connection between hunting and these declines, it seems fair to draw some informed assumptions on hunting impacts.

Several publications have used a modelling approach to attribute the effect of hunting and other variables to animal density (and/or decline), not by using offtakes, but by using either directly observable evidence of hunting within systematically surveyed sites (signs such as snares, spent cartridges, hunting camps and so on), or by using a proxy for hunting, such as the distance to the closest roads and villages, or an index of accessibility which combines slope, vegetation type, remoteness from human settlements (often weighted by population size) and modelling the effect of that proxy across a much larger landscape - sometimes an entire range of a species. Examples of the former include (Stokes et al., 2010) for elephants and great apes; examples of the latter for the same broad taxa include Heinicke et al. (2019); Maisels et al. (2013); Plumptre et al. (2021) and Strindberg et al. (2018).

Of the 105 species reviewed, we found information on direct impacts of hunting for 58 species: 24 Artiodactyla, 8 Carnivora, 13 Chiroptera, 5 Perissodactyla, 5 Primates and 3 Proboscidea. Of these 58 species, published information suggests that hunting impacts have been/are currently high for at least 40 species. A summary of the impacts of hunting for each of the species is provided in Appendix 3.

Migratory ungulates are almost all reported as significantly threatened by hunting and are experiencing population declines (where information was available). While ungulates are hunted for a range of uses - including meat, medicine, trophies, conflict with livestock and skins – meat is often a key use, especially during times of conflict or famine. The scimitar horned oryx (*Oryx dammah*) is already extinct in the wild, and published literature suggests that overhunting was the main cause of extinction, partly for meat and partly to produce leather goods (Gilbert & Woodfine, 2016). High levels of hunting of kouprey (*Bos sauveli*) in the last 30 years have resulted in at least an 80% decline in population numbers, due to hunting for meat, horns and medicine, and this species may now be extinct in the wild (Timmins et al., 2016). Most other migratory ungulates still extant in the wild have experienced significant population declines that can be attributed to hunting. Examples include:

- Bukhara deer (*Cervus elaphus bactrianus*) were almost hunted to extinction for meat, skins and skulls, declining to 400 individuals before a reintroduction programme brought about an increase in numbers (Karlstetter & Mallon, 2014).
- The red-fronted gazelle (*Eudorcas rufifrons*),

where hunting is thought to affect most populations (50%-90%) across its range (IUCN SSC Antelope Specialist Group, 2017)

- The wild yak (*Bos mutus*), where hunting for meat, medicine, horns, conflict and skins have greatly reduced wild yak populations, resulting in severe range contractions and population reductions (Shi et al., 2016).
- The urial (*Ovis vignei*), where hunting for meat is the main use, has seen drastic population declines across its range, with a 56% population decline recorded in Pakistan between 1976-2004 (Awan, 2006).
- The addax (*Addax nasomaculatus*), which was present in West Africa in good numbers until the 1970's, when uncontrolled hunting for meat, horns and hide accelerated with the introduction of motor vehicles and modern weapons. The primary factor in the decline of Addax has been uncontrolled hunting over many years. Drought and the extension of pastoralism into desert lands, due to an increase in wells, have also increased hunting pressure, particularly during the 1980s and 1990s (Beudels et al., 2005; Newby, 1984). In recent years, the only near-viable population in Termit Tin Toumma NNR in Niger has been subject to disturbance by oil exploration and production and to hunting by military escorts of oil workers (Duncan et al., 2014). Finally, political instability in Libya has caused an increase in human traffic, and opportunistic hunting, in Termit Tin Toumma (IUCN SSC Antelope Specialist Group, 2016a). In 2019 the size of the global wild population was estimated to be between 85 and 120 adults (IUCN SSC Antelope Specialist Group, 2016a).
- Both the vicuña (*Vicugna vicugna*) and the Chiru (*Pantholops hodgsonii*) have experienced severe population declines due to overhunting. The creation of strict protections for both species (the creation of protected areas and legislation to outlaw or manage hunting) have been credited for their recovery (Cooke, 2016; CITES, 2019a; Box 6)., although there has been "an alarming increase in Vicuña poaching throughout its range" (Acebes et al., 2019) and some poaching of chiru continues, requiring strict anti poaching measures (IUCN, 2016b).

Some species lack enough data to make informed judgements; for example, the argali sheep is threatened by illegal hunting across its range, but also by land-use change and competition with domestic livestock. There is currently inadequate data to assess the impact of hunting alone. Similarly, there seems to be little available information for Neumann's gazelle (*Gazella erlangeri*), where there is no recent information on wild populations.

Hunting impacts can be disproportionate to hunting offtakes. A good example of this is the saiga antelope (*Saiga tatarica* and *Saiga borealis*), where hunting has been a key driver of population declines. Hunters preferentially target male saiga for their horns, resulting in a sex-biased population with fewer males than in unhunted populations, which results in lower overall fecundity and faster population declines (Box 5). This is likely to be an issue for other migratory ungulate species where males are targeted for their horns (and for elephants - see below). Hunting can also reduce species populations to a point where they are more vulnerable to other threats and shocks – saiga are again a good illustration of this issue (Box 5).

Box 5: Saiga antelopes: The dual impacts of sex-biased hunting and disease

Saiga antelopes are recognized as two separate species by CMS, *Saiga tatarica* and *Saiga borealis* (CMS, 2021). Both species face similar threats, including illegal hunting, disease, infrastructure development, weather and climate, and predation. This box refers to saiga antelopes inclusive of both species; though at the population level, the circumstances vary (Milner-Gulland et al., 2001).

By the creation of the Soviet Union, Saiga numbers were down to a few thousand, due to overhunting within the Russian Empire, and demand for Saiga horn from China. In the first few decades of the Soviet Union the species recovered due to a ban on hunting, strong border controls, the limitation of firearm possession by local people, the emptying of the steppe due to collectivization, and strong law enforcement (Milner-Gulland et al., 2001). During the 1950's and 1960s a well-organised hunting system was put in place, using trucks and a team of up to 20 hunters on each. For example, on the west of the Volga River, 120,000-150,000 saiga were hunted per year during 1957-1962 (IUCN, 2018).

With the collapse of the Soviet Union, the strict hunting control system became dysfunctional. Illegal hunting began to gain momentum. From the mid-1990s until mid-2000s, saiga's population declined by more than 90%, which was mainly driven by illegal international horns trade and local meat consumption (Milner-Gulland et al. 2001; Kühl et al., 2009). Only male saigas have horns, which are used in traditional Chinese medicine, therefore the illegal hunting of saigas is male-oriented. Male saigas are limited in their absolute ability to inseminate females, and as a result hunting not only directly reduces saiga numbers but also reduces female fecundity. (Ginsberg & Milner-Gulland, 1994) found that severely sex-skewed harvests can precipitate population collapse much more quickly than where both sexes are targeted (Milner-Gulland et al., 2001). Illegal hunting is still a major threat to all saiga populations today.

In addition to the hunting pressure, saiga's population has been further reduced by Mass Mortality Events (MME's). In 2015, more than 200,000 saiga antelopes (*Saiga tatarica tatarica*) died in 3 weeks in central Kazakhstan, from hemorrhagic septicemia caused by the bacterium *Pasteurella multocida* type B (Kock et al., 2018). Adult numbers were reduced to around 15% of the pre-calving numbers of this population, representing a loss of around 62% of the global population. Saigas may be vulnerable to mass disease-induced mortality, as previous mass mortality events were also recorded in 2010 and 2011.

In 2016, an outbreak of peste des petits ruminants virus (PPRV) into livestock in Mongolia (probably originating from uncontrolled transboundary livestock movements) was followed by the death of 1000s of saiga from PPRV and a confirmed fall in saiga populations in from 25,699 in January 2017 to 8,806 by May 2017 (Pruvot et al., 2020), raising concerns for the species survival. This MME illustrates the threat of disease spillover from livestock for wild species populations.

Hunting can increase the risk of local extinctions if species are affected by additional threats (such as disease or fluctuations in climate) as populations are already depressed and closer to their minimum viable population level. Additional threats need not therefore cause high levels of mortality to push the population to local extinction.

Box 6: Sustainable use initiatives for the hunting of CMS species

A few CMS species are managed for sustainable use with varying levels of success, either for subsistence use or for international trade. Here we describe two examples of sustainable use initiatives: One is based on the sustainable use of vicuña for the international trade of its fur in the Southern Andes region, and the other on the polar bear (*Ursus maritimus*), mostly used for subsistence among the Inuit people in Canada.

Vicuña

The vicuña is a South American Camelid (Osgood, 1943; Wheeler, 1995), with a 300,000km^2 range extending across Perú, Bolivia, Chile and Argentina. Overhunting of the vicuña for their meat, skin and fibre began as long ago as the Spanish conquests, and by the 1960's they were one of the most threatened species in South America, declining from a population of approx. 2 million to only 10,000 individuals (Lichtenstein, 2009). Vicuña were protected under the Convention for the International Trade of Endangered Species (CITES) Annexe I in 1975, and under the CMS (Appendices I and II) and the Vicuña Convention (signed by Argentina, Bolivia, Chile and Perú) in 1979. All vicuña are on CMS Appendix I except the Peruvian population, which is on CMS Appendix II (CMS 2020). These protections are credited as resulting in the species' recovery (Lichtenstein, 2009) and there are now thought to be over 350,000 mature individuals.

In 1995, the entire Peruvian vicuña population and the north Chilean populations were downlisted from CITES Appendix I to Appendix II as part of policies to promote a more sustainable use approach, permitting international sale of fibre and cloth from live shorn animals. All other populations were included in Appendix I (Acebes et al., 2019). Today (2021), the vicuna on CITES Appendix II include all the animals in Peru, Ecuador and Bolivia, some animals in Argentina (the populations of the Provinces of Jujuy, Catamarca and Salta, and the semi-captive populations of the Provinces of Jujuy, Salta, Catamarca, La Rioja and San Juan), and Chile (populations of the region of Tarapacá and of the region of Arica and Parinacota) (CITES Appendices I, II and III 2021).

Fibre is harvested from live-captured animals, and fibre export and import and the trade of products derived therefrom are allowed under strict regulations (Acebes et al., 2019). Communities are involved in the sustainable management of vicuñas and their traditional knowledge is integrated with scientific research. For example, in the Puna community, Argentina, members of the community assume responsibility for taking care of vicuñas in their territory. A vicuña management committee is endorsed by a community assembly formed from Law N° 5634, which then sets rules (re. e.g. caring for the vicuñas, preventing attacks by dogs, alerting of illegal hunting events, eliminating fences from waterholes to facilitate access to vicuñas. Some community groups have decided to reserve part of the community grassland area for exclusive grazing of vicuñas (Cowan Ros, 2020). Currently, Peru harvests fibre from wild vicuñas maintained in extensive plots, and Bolivia and Chile have developed capture and release methods and harvest systems for large-scale exploitation of wild populations. From 2007-2016, trade in vicuña fibre increased by 78%. The annual value of these exports, largely from Peru, is approximately $3.2 million, and Italy is the main destination market, then re-exporting to China, Switzerland and the US (Kasterine & Lichtenstein, 2018).

Unfortunately, although the species is now listed as 'least concern' across its range on the IUCN Red List (Acebes et al., 2019), there has been "a troubling increase of poaching during the last decade" (Acebes et al., 2019). As this species has IUCN National Red Listings as well as an overall one, it is instructive to note that the Peruvian vicuñas (with just under half of the world population) is now Near-Threatened and the Chilean population (with just 3% of the world population) is Endangered (Acebes et al., 2019). In Bolivia an estimated 1% of the population is killed illegally for the fibre trade (Kasterine & Lichtenstein, 2018). This increase in illegal hunting is thought to be due to the logistical difficulty of patrolling large areas, lack of financial means by local and national authorities to initiate patrols, insufficient legal frameworks, difficulties in law enforcement and extreme poverty. In addition, the number of people benefitting from sustainable management of vicuña, and their profits, can be low or even non-existent (García-Huamaní, 2020). This compares with the high prices of garments that are made from vicuña fibres and sold within Europe (Lichtenstein, 2009), which drives an illegal market for vicuña fibres (Acebes et al., 2019), which continues to put pressure on the species.

Polar bear

Polar bears are a prominent example of sustainable use of CMS species for the subsistence and cultural reproduction of indigenous and local communities. Polar bears are one of the most sensitive marine mammals in the Arctic to climate-induced habitat change (Laidre et al., 2008). Climate change and resulting declines in the quality and quantity of sea ice have reduced the available habitat and prey availability for polar bears and this is seen as the biggest threat to their survival (Lam et al., 2021).

Polar bears have been used by the Inuit people for millennia for their meat and pelts. Polar bear hunting is of high cultural importance to many Inuit communities, and the sale of pelts provides an important source of income. The US, Canada, and Greenland allow and manage a subsistence harvest of Polar Bears; harvest is prohibited in Norway and Russia (Wiig et al., 2015). In Canada, land claims and treaty agreements have formalized polar bear harvesting by aboriginals (Natural Resources Transfer Agreement of the Constitution Act (Manitoba) 1930; James Bay and Northern Quebec Agreement 1975; The James Bay Treaty – Treaty No. 9, 1905; Inuvialuit Final Agreement 1984; Nunavut Land Claims Agreement (NLCA) 1993; Labrador Inuit Land Claims Agreement 2005). These agreements call for wise use of wildlife based on the principles of conservation and provide for the aboriginal public to be participants in wildlife management. The Nunavut Land claims agreement, for example, aims to create a wildlife management system that promotes the involvement of aboriginal communities in polar bear harvest management and research. Aboriginal communities, particularly in Nunavut and the Northwest Territories, participate in decisions on harvest levels, protected areas, what kind of information decisions should be based on, and the nature and funding levels of research projects (Gilchrist and Mallory 2007). Polar Bears were included in CITES Appendix II in 1992 and remain there today (CITES 2021). Of the wild-caught Polar Bears on the CITES Trade database examined in this report (2017-2021), 80% of the consignments originated in Canada.

The IUCN Red List assessment, last completed in 2015 (Wiig et al., 2015), reports that the annual legal harvest of Polar Bears is between 700 and 800 or 3-4% of the estimated size of the total population of about 20-25,000 animals. This harvest level is thought to be sustainable in most subpopulations (Wiig et al., 2015). Although illegal hunting of Polar Bears is not thought to be of major concern, illegal hunting of polar bears in Russia (estimated at 100 - 200 bears per year), combined with legal subsistence harvest in the U.S., may exceed sustainable limits for the Chukchi subpopulation (Wiig et al., 2015). In addition, as polar bear populations decline because of climate change impacts, current harvesting levels will become less sustainable. As for many CMS species, there is a need for more rigorous documentation of legal and illegal harvest levels, and population numbers, to allow managers to adaptively manage polar bear quotas.

Carnivores are not often intentionally hunted for food, but are highly threatened by hunting for medicinal use, skins, trophies, and due to human-wildlife conflict or opportunistic encounters. As the hunting of carnivore species is for many purposes, it is hard to disentangle the impact of each use. However, it seems that direct consumption for meat is not a principal driver of population declines, with human-wildlife conflict, trophy hunting and skins, and the indirect effects of reductions in their prey base being more impactful (see section on indirect impacts below).

Large declines in carnivore populations have occurred globally. For example, the African lion (*Panthera leo*) has declined by 38% over 21 years (1993 - 2014) to <35,000 individuals occupying 25% of its historic range (Henschel et al., 2014; Bauer et al., 2016). The main drivers of lion declines are large-scale habitat conversion, prey base depletion through unsustainable hunting (see 'Indirect impacts' below), and the retaliatory killing of lions due to human-lion conflict. Lion bones are also used as a substitute for tiger bone in SE Asian traditional medicines, as tiger populations decline (Creel et al., 2016; Bauer et al., 2016). The situation is most critical in West Africa, where lions have been considered regionally endangered since 2004, and where <500 individuals may persist (Henschel et al., 2014). While the Red List assessment (Bauer et al. 2016) classifies habitat loss and human development as higher threats than hunting to the global lion population, this may vary between regions. In Southern Africa, Everatt et al. (2019) found that illegal hunting was the biggest driver of population declines in the Greater Limpopo Lion Conservation Unit, one of eleven lion 'strongholds'.

Leopards (*Panthera pardus*) have suffered similar declines. Leopards historically lived across nearly 35,000,000 km2 but are now confirmed present in only 25% of this area, in 173 extant patches covering ~8,500,000 km^2 (Jacobson et al., 2016), and have suffered range loss of 63–75%, with highest losses in Asia. Four subspecies have lost more than 90% of their historic range and six are spread across less than 100,000 km2. Leopards are threatened by illegal hunting due to human-wildlife conflict, for their skins, as traditional medicine (and as a tiger bone substitute), due to bycatch in snares, due to prey depletion from wild meat hunting and due to legal and illegal trophy hunting (Naude, 2020). As with lions they are also threatened by habitat destruction. The lack of data on leopard offtakes makes it difficult to disentangle the impacts of these different threats (Stein, 2020), and the relative impact of different threats is likely to vary between region and subspecies. The Javan leopard is thought to be threatened primarily by habitat loss (Gomez and Shepherd, 2021), whereas illegal hunting is reported to be the biggest threat to the Indo-Chinese leopard (Rostro-García et al., 2016), and in South Africa (Balme et al., 2010). In Saudi-Arabia the decline of the leopard's prey base and retaliatory killings were reported as the biggest threats (Islam et al., 2018). Similarly, hunting is known to be a key threat to snow leopards (*Uncia uncia*), however despite the existence of the Snow Leopard Crime Database, a lack of data on snow leopard populations and hunting offtakes makes it difficult to estimate the extent to which population declines are due to direct illegal hunting (primarily due to human wildlife conflict and for trade in hides and bones) or due to prey population declines and habitat destruction (Nowell et al., 2016).

Elephants are one of the few species where hunting data has been collected systematically across their range; this has been done since 2002 through the MIKE programme in both Africa and Asia (see Box 1; Box 2). Poaching rates (overwhelmingly for ivory, not meat) have climbed and remained high for African elephants in the 21st Century, and elephant populations have declined drastically, and continue to fall. Forest elephant populations fell by 62% between 2002 and 2011 (Maisels et al., 2013; Wittemyer et al., 2014) and on a longer time frame, by 86% between 1983 and 2015 (Gobush et al., 2021b). Savanna elephant populations declined by 60% between 1964 and 2015 (Gobush et al., 2021b). In both Asia and Africa, ivory poachers deliberately choose to kill adult male elephants: in Asia, only the males have tusks, and in Africa, the males' tusks are thicker and often longer than those of the females, meaning there is a higher volume of ivory on an adult male than on an adult female. The selection of males in all three species has led to skewed sex ratios where adult females outnumber adult males in African Forest Elephant and African Savanna Elephant populations (Mondol et al., 2014; Turkalo et al., 2018) and in Asian Elephants; here, the sex ratio skew can be very high (Paulraj & Subramanian, 2000; Vidya et al., 2004). Interestingly in Sri Lanka, past ivory poaching had led to an overwhelmingly tuskless male population (Kurt et al., 1995).

Bats are rarely reported as hunted to species level, and therefore nearly all the bats in this review were reported as having low direct impacts from hunting. The exception is the Straw-coloured Fruit Bat (*Eidolon helvum*), which is hunted for food and medicine, and where population declines have been recorded, especially in Central and West Africa (Box 3). However, the degree of hunting threat varies significantly across its range, due to varying perceptions of the bat and its use as food (Niamien et al., 2015).

Impacts of hunting on gorilla species vary significantly between subspecies, though all are threatened by hunting. Mountain Gorillas (*Gorilla beringei beringei*) exist in two populations in the Virunga Transboundary Park and Bwindi Impenetrable National Park. In both these areas, gorilla consumption is taboo among local communities. Gorilla killing generally occurs due to retaliatory human-wildlife conflict (crop-raiding or fear), or by militarised groups engaged in the civil conflict (sometimes to eat their meat), or as bycatch in snares set for ungulates (see section 4.1.3.3). There is strong law enforcement activity within both protected areas (e.g. Robbins et al., 2011), and gorilla-based ecotourism is highly profitable, with 10% of revenues going to a local community development fund. As a result, Mountain Gorilla populations are slowly increasing (the only gorilla taxon to be doing so), albeit still listed as Endangered by the IUCN Red List due to the increasingly small area, and fragmented nature, of its extent of occurrence (Hickey et al., 2020).

In comparison, the primary threat to the other three gorilla subspecies, Western Lowland Gorillas (*Gorilla gorilla gorilla*), Grauer's Gorilla (*Gorilla beringei graueri*) and the Cross River Gorilla (*Gorilla gorilla diehli*), is illegal hunting for meat. All are now listed as Critically Endangered by IUCN.

Grauer's Gorillas are estimated to have declined by 60% since the mid 1990's (or equivalent to 82% decline in two gorilla generations) (Plumptre et al., 2021) due to hunting, driven by human demographic growth in the region and illegal hunting by armed militias and rebel groups in the artisanal mining camps, meaning that access to arms is easy and demand for meat is high (Humle et al., 2016; Plumptre et al., 2016, 2021). The last remaining strongholds of this taxon are the contiguous Kahuzi-Biega National Park and the Oku Community Reserve (Plumptre et al., 2021).

Only about 200-250 Cross River Gorillas exist in the wild. The threat of illegal hunting for meat – albeit opportunistic – is exacerbated by the fact that their remaining habitat is under threat for farming and firewood by the very high human population density within its range, the Cameroon-Nigeria transborder area (Bergl et al., 2016). It is estimated that opportunistic hunting removes 1–3 individuals from the population annually, and gorillas are also injured and killed as "bycatch" in snares targeting ungulate species (Bergl et al., 2016). Although hunting events are rare, with such a small population the current level of offtake is unsustainable (Bergl, 2006; Bergl et al., 2016).

Unlike Mountain, Grauer's and Cross River Gorillas, which all have relatively small ranges, Western Lowland Gorilla (*Gorilla gorilla gorilla*) range extends from the Atlantic coast of Central West Africa to the Congo and Oubangui Rivers and covers about 700,000 km^2 (Maisels et al., 2018). The primary threats to this taxon are- in descending order - hunting (by far the most important threat), disease, and habitat loss (Maisels et al., 2018). The specific drivers of hunting, again in descending order of importance, the presence of anti-poaching teams, distance to the nearest road, human population density, whether gorillas were eaten in the immediate area, and elevation (it is easier to hunt in flatter areas) (also see Table 7) (Strindberg et al., 2018). The population in 2013 was estimated at around 361,000 individuals, decreasing at a rate of around 2.7% a year (Strindberg et al., 2018).

Chimpanzees (Pan troglodytes; four subspecies) are found across Africa from the Atlantic Coast of West Africa across to the Albertine Rift and western Tanzania and western Uganda (Humle et al., 2016). Estimates of population numbers vary in their precision and accuracy depending on subspecies; estimates of decline are available, but the proportion of decline due to hunting is not well understood. Nevertheless, hunting is known to be a key threat, and chimpanzees are primarily targeted by hunters for their meat.

Western Chimpanzees Pan troglodytes verus: in a recent study that examined all 59 Western Chimpanzee sites for which data exists (in the IUCN A.P.E.S. Wiki database), the top-ranked threat (mentioned for 50 sites) was hunting (Heinicke et al., 2019), followed by agriculture (47 sites) and logging/wood harvesting (42 sites). Thus, although hunting is the most important threat for this taxon, habitat loss and modification is close behind.

Cameroon-Nigeria Chimpanzees (Pan troglodytes ellioti) are found from the Nigeria-Cameroon highlands across to the Sanaga River in Cameroon, and population size is only about 6000-9000 individuals (Humle et al., 2016). The rate of decline is not known but is caused by a combination of hunting and habitat loss, which is worsening as the already high human population density within the range of this taxon increases, along with the increasing demand for meat and for agricultural land.

For Central Chimpanzees (*Pan troglodytes troglodytes*) the principal threat is hunting. Declines over the period 2003-2013 were not nearly as steep as for Western Lowland Gorillas, with which it is broadly sympatric. The principal drivers related specifically to hunting for Central Chimpanzee density across its range were – again in decreasing order of importance – whether chimpanzees were eaten in the immediate area, Human Influence Index, the presence of anti poaching teams, and then slope and elevation (as hunters dislike expending effort on steep mountainous terrain when flatter land is available) (Strindberg et al., 2018).

Finally, the estimated decline of Eastern Chimpanzees *Pan troglodytes* schweinfurthii across their range from 1980 to 2055 is estimated at over 50% (putting them into the Endangered category); the greatest threat to this taxon is hunting for meat, either intentionally or as a bycatch in snares set for other species, such as ungulates (Plumptre et al., 2016). This taxon has a very large geographical distribution. Drivers of hunting include artisanal mining, which attracts large numbers of people into chimpanzee habitat (it is essentially the same story as for Grauer's Gorillas, with which it is sympatric where these gorillas occur); these people hunt for meat, or engage others to hunt for them, or have money from their mining activities with which to buy bushmeat.

4.3.5.2 Indirect Impacts of hunting on CMS species

Indirect impacts of hunting refer to the cascade effects of changing ecological function across the trophic web, as species declining under extreme hunting pressure change their ecological interactions with others (Abernethy et al., 2013; Young et al., 2016). A review of over 160 papers in 2013 examined the direct and indirect impacts of hunting in Central Africa (Abernethy et al., 2013); here we reprise key points from that paper and add others published since then for Central Africa and other regions supporting CMS species, gleaned from our Google and Google Scholar search.

Indirect impacts of hunting can profoundly affect the wider ecological system when the hunted species is an 'ecosystem engineer' or 'keystone species'. Several CMS species can be described as such, including elephants, gorillas and bats, and top predators such as lions, leopards, and bears. These species are often large-bodied and slow-reproducing, and so therefore also vulnerable to hunting (Abernethy et al., 2013).

- African forest elephants (*Loxodonta cyclotis*) can make up between 33 and 89% of the animal biomass of intact Central African forests (Abernethy et al., 2013). The loss of these species from an ecosystem can thus be profound. They have been described as 'forest gardeners', consuming more seeds from more species than any other taxon of large vertebrate dispersers (Campos-Arceiz & Blake, 2011), which they disperse over a wide area and often very far from their parent plant. Certain plant species which require elephants for their dispersal may suffer increased density dependent seed or seedling mortality (Bollache et al., 2013; Jansen & Zuidema, 2001; Wright, 2003). The largest trees that dominate African forests tend to have higher wood density than other tree species (Reich et al., 1997) and these are the trees that tend to be elephant-dispersed (Berzaghi et al., 2019). A large tree can sequester proportionally more carbon than a smaller tree in a year (Stephenson et al., 2014), so loss of Forest Elephants in Central Africa will reduce the recruitment of large trees, increase stem density of smaller trees, and decrease overall carbon stocks and the rate of carbon sequestration. As much as 96% of Central African forests could have modified species composition and structure as elephants are compressed into remaining protected areas (Poulsen et al., 2017).
- Recent work has suggested that the removal of megaherbivores - by humans - in the Americas 13,000 years ago, in Egypt 5000 years ago, Mesopotamia and China over 3000 years ago, and the Indus valley 1000 years ago has had the indirect effect of greatly reducing lateral nutrient transportation - especially phosphorus, a key plant nutrient - across huge areas of land, leaving vast areas with low soil nutrient levels, and the hypothesised collapse of river valley civilisations (Doughty et al., 2013, 2016; Wolf et al., 2013). This could also happen in sub-Saharan Africa if elephants are lost (Doughty et al., 2016) and may have already happened across much of the rest of Asia, but this remains to be seen.
- Gorillas (*Gorilla beringei* and *G. gorilla*) are among the largest frugivores in African forests and play similar seed dispersal roles, being particularly important dispersers of large-seeded plants. In some cases, gorillas may be the sole disperser of some tree species, such as the Cola lizae tree (Tutin et al., 1991), which is endemic to Gabon (Halle, 1987) - it is only dispersed by Western Lowland Gorillas (*G. gorilla*). This means that, as with forest elephants, reduction of gorilla populations through over-hunting can have profound impacts on forest structure and function.
- The straw-coloured fruit bat (*Eidolon helvum*) is one of Africa's most hunted bat species, thought to be an important long distance seed disperser in tropical Africa, maintaining genetic connectivity and colonizing new sites for plant species, as it travels long distances (over 2000km) across fragmented landscapes in Ghana, and from savannas in Zambia to the heart of the Central African forest block in DRC (Abedi-Lartey et al., 2016; Richter & Cumming, 2006, 2008).
- Reductions of key prey species, such as many of the listed ungulate species, can result in reductions in predators such as leopards, lions and jaguars. Indirect hunting impacts are well-documented for leopards (*Panthera pardus*). Leopards are intentionally hunted for trophies and skins. However, even in areas where illegal leopard hunting is not practiced due to cultural taboos, hunting of ungulate species can cause local extinctions of leopard populations due to large reductions in their main food resources. In Gabon, Henschel et al. (2011) documented decreasing leopard populations and an increasing use of smaller prey species by leopards with proximity to human settlements, and high dietary niche overlap between leopards and human hunters at sites situated at similar distances from settlements. These authors suggested that wild meat hunting may precipitate the decline in leopard numbers through exploitative competition and that intensively hunted areas are unlikely to support resident leopard populations. Exploitative competition also exists between human hunters and other carnivore species. Modelling of lion distributions in the Greater Limpopo Lion Conservation Unit (GLLCU) of South Africa found that lion densities were positively correlated with

the availability of key prey species and negatively affected by the occurrence of bushmeat illegal hunting activities (Everatt et al., 2019); the authors suggest that exploitative competition with human hunters for prey was a significant factor determining the presence of lions. Moyer et al. (2014) found that the preferred prey species of human hunters and jaguars in the province of Colón, Panama, was the same – lowland paca (*Cuniculus paca*). Similarly, Foster et al. (2016) found high dietary overlap between human hunting offtakes and jaguar and puma diets in Belize.

- The use of snares, often used for capturing ungulates, can also result in the unintentional trapping of species that might otherwise not be targeted by local subsistence hunters, including animals (such as carnivores) which are seldom targeted for their meat (Coad et al., 2010). Our review highlighted that mortality through bycatch was a particular issue for gorilla species, leopard species and lions (e.g. Everatt et al., 2019). It should be noted that there can be a very high proportion of snare wastage (where snared animals die and rot before the snare owner can collect them), which greatly increases the removal of potential prey species for carnivores, even if the meat is not consumed by humans in the end (e.g., (Noss, 1998; Yamazaki et al., 2020). Even if animals do not die, their fitness can be gravely compromised by losing a limb or foot (e.g. Haggblade et al., 2019; Quiatt et al., 2002).
- Reductions of apex predators, such as lions, leopards and bears, can result in increases in populations of smaller predators, known as 'competitive release'. One example of competitive release includes three CMS species. Lions (*Panthera leo*) keep wild dogs (*Lycaon pictus*) and cheetahs (*Acinonyx jubatus*) at low densities (Durant, 1998, 2000; Ritchie & Johnson, 2009), both by direct killing and by wild dogs and cheetahs avoiding areas with high lion densities. Reduction in lion densities can therefore result in increased numbers of both these predator species. There has also been evidence of competitive release for puma (*Puma concolor*) and ocelot (*Leopardus pardalis*), following the decline of jaguars (Moreno et al., 2006).
- Reductions in apex and meso-predators through hunting can also result in hyperabundance of smaller prey species (e.g., some species of birds, bats, small primates, and rodents) released from predation pressure and yet not targeted by human hunters, with knock-on consequences for the ecology of the area (Olsson et al., 2019; Terborgh et al., 2001, 2008). In particular, seed predation can rise, following predator elimination (e.g., Effiom et al., 2013; Nuñez-Iturri & Howe, 2007)

4.3.6 Large-scale drivers of hunting of CMS species

While the immediate driver of wildlife hunting is generally to provide food and income (or control a pest species) the scale of use is often affected by larger-scale political, demographic or environmental drivers. We found information from our literature review on large-scale drivers of hunting for 28 species (Table 5).

War, armed conflict, or civil unrest as one of the important large-scale drivers of hunting for 12 species. Conflict can reduce access to food, jobs and medical care and increase poverty, due lack of access to local markets, breakdown in governance systems, and when armed forces or militia groups steal livestock and goods from local people (Jambiya et al., 2007; Loucks et al., 2009; van Vliet et al., 2018). Faced with a lack of alternatives, people are therefore driven to increase their hunting of animals for food and income. Armed groups also hunt wildlife to feed combatants and make money (Plumptre et al., 2016). Examples include: an increase in hunting of the barbary sheep (*Ammotragus lervia*) and barbary deer (*Cervus elaphus barbarus*) following civil conflict in Tunisia (DGF and IUCN, 2017); the dorcas gazelle (*Gazella dorcas*), following armed conflict in Libya and Mali, and Grauer's gorillas (*Gorilla beringei graueri*), to provision armed militia groups in mining camps in the Democratic Republic of the Congo (DRC) (Plumptre et al., 2021, 2016). In northern DRC, during the civil conflict of the 1990s and 2000s, there was an estimated 500% increase in urban sales of protected wildlife (de Merode and Cowlishaw, 2006), helped by the increased availability of firearms, and a catastrophic drop in forest elephant *Loxodonta cyclotis* numbers in a well-studied population in the Ituri landscape (Beyers et al., 2011). In Mozambique, the period of civil conflict from 1980–1992 saw substantial declines in the wildlife of the Gorongosa National Park: elephant (*Loxodonta africana*) populations fell from 3000 individuals in 1979 to 108 in 1994 (Hatton, 2001). Armed conflict also continues to affect hunting pressure after its end, due to an increase in the availability of weapons. This has been the case for the African wild ass (*Equus africanus*) and giraffe (*Giraffa camelopardalis*) following the Ethiopian war (Abate & Abate, 2017; Moehlman et al., 1998), and the white-eared kob (*Kobus kob*) in Sudan (Marjan, 2014). In the Tibetan Plateau, the confiscation of weapons resulted in a decline in wild yak (*Bos mutus* or *Bos grunniens*) hunting (Shi et al., 2016).

Poverty and famine (which can also arise because of conflict) were mentioned as drivers of hunting. During the famine years of 1959-1960 in China, wildlife was killed systematically for food. This reliance on wildlife then persisted into the 1990s and affected the wild yak and kiang populations (Shi et al., 2016). Similarly, changing climate can affect food supplies, creating a new reliance on wildlife. This has occurred for Sahelian species such as the red-fronted gazelle (*Eudorcas rufifrons*), where

Argali Sheep (*Ovis Ammon*) © Askar Davletbakov

desertification and declining crop yields have resulted in human migration into the gazelle's range, bringing with it increased hunting pressure (Abiodun et al., 2020). In the Patagonian Pacific, toxic algal blooms resulted in lower fishing returns and resulted in fishermen using dogs to hunt huemul (*Hippocamelus bisulcus*) (Berger et al., 2020).

Broad socio-economic and political changes in a region or country can also have impacts on hunting pressure. An example from this review is the impact of the breakup of the Soviet Union, which is cited as a driver of hunting for argali sheep (*Ovis ammon*) (Rosen, 2012), black-tailed gazelle (*Gazella subgutturosa*) (Blank, 2018) and saiga antelope (*Saiga tatarica*; Box 5), due to a breakdown in the governance systems controlling hunting, and increased poverty and food shortages.

Agricultural expansion, mining and land use change are mentioned as drivers for 11 of the 28 CMS species, and in the broader hunting literature is widely cited as a factor influencing hunting activity. Agricultural and mining concessions open-up previously inaccessible habitats and often results in the development of road networks (Abernethy et al., 2013; Laurance & Arrea, 2017). Concessions also provide local employment opportunities, attracting more people into an area. This results in an increase in both the availability and demand for wildlife, incentivising commercial hunting and increasing pressure on wildlife (Poulsen et al., 2009). In addition, the fragmentation of habitats and increasing human populations surrounding these habitats bring humans and wildlife into increased contact with each other, which can result in human-wildlife conflict and killing of wildlife as a pest species, and this increased contact also increases the potential for zoonotic disease transmission (Wilkinson et al., 2018). Direct drivers of gorilla and forest elephant abundance are the ease of road access in Central Africa (Maisels et al., 2018; Strindberg et al., 2018).

Finally, economic immigration and changes in demand for wildlife products from countries where demand for wildlife products is high can also stimulate wildlife trade. Chinese investment in jaguar range countries may have stimulated the demand for jaguar paste to supply Chinese nationals in jaguar range states, such as Suriname, and potentially to supply mainland China (Box 3) (Lemieux and Bruschi, 2019). This trade is believed to be rare but increasing; more research into this international market and its impact on jaguar numbers is needed. Increases in ivory poaching have been shown to be linked to the boom in the Chinese economy, and to Chinese household income (Wittemyer et al., 2014).

Table 5: Reported large-scale drivers of hunting for CMS terrestrial mammal species, from literature review.

Scientifc Name	Common Name	Summary of Large-Scale Drivers of Hunting
Acinonyx jubatus	Cheetah	Poverty (Tricorache et al., 2018). Growing human populations and habitat loss (also leading to cheetah prey loss), which both increase human-cheetah conflicts such as livestock depredation (Wykstra et al., 2018). Civil conflict across the Sahelo–Saharan region (Durant et al., 2015).
Addax nasomaculatus	Addax	Increase in access to weapons and motor vehicles since the 1970's. Drought and the extension of pastoralism into desert lands in the 1980s and 1990s (Beudels R. C. et al., 2005, (Newby, 2014). Oil exploration in Niger since 2008, with armed military groups, brought in to protect oil workers, engaging in hunting, and disturbance from oil infrastructure. Refugees from Libya into Niger in 2011, and increased illegal trading between Niger and Libya, following civil conflict (Hall, 2016, IUCN SSC Antelope Specialist Group, 2016).
Ammotragus lervia	Barbary sheep	Poverty and civil unrest 1960-'present' (1997), following Chad's independence from France and civil war (Keith & Plowes, 1997). Civil unrest in Tunisia (DGF and IUCN, 2017). Conflict and war in the Sahara-Sahel Region (Brito et al., 2018).
Bos grunniens	Wild yak, yak	Access to weapons: with the confiscation of weapons in most areas of the Tibetan Plateau in the 21st Century, the extent of the threat of hunting to wild yaks has declined (Shi et al., 2016). Famine: During the famine years of 1959-1960 wildlife was killed systematically for food. Access: Since the mid-1950s, the construction of highways has facilitated the access of commercial poachers to wild yak's populations, increasing the hunting pressure and the threats to wild yaks (Shi et al., 2016).
Eidolon helvum	Straw-coloured fruit bat	Hunting linked to socio-economic situation (income resource and food source) (Niamien et al., 2015).
Equus africanus	African wild ass	Poverty. Access to and high ownership of automatic rifles (AK47) and cheap bullets (Moehlman et al., 1998). Drought, bringing pastoralists (who also hunt wild ass for food and income) and wild ass into conflict for resources (Kebede et al., 2014).
Equus grevyi	Grevy's zebra	Hunting for meat by combatants during the 'shifta' War of 1963–1968, Kenya (Lelenguyah et al., 2010).
Eudorcas rufifrons	Red-fronted Gazelle	Adverse climatic conditions and conflict in the Sahel region, leading to food insecurity (Abiodun et al., 2020). Conflict in Sudan has led to a lack of funding for wildlife law enforcement in protected areas and an increase in illegal hunting (Mcneely et al., 2004)
Gazella dorcas	Dorcas gazelle	Armed conflict in Libya and Mali. Increase in illegal killing of dorcas gazelle occurred two years after the start of armed conflict in the region (Brito et al., 2018).
Gazella subgutturosa	Goitered gazlle, black-tailed gazelle	Food supply shortage due to the collapse of Soviet Union (Blank, 2018).
Giraffa camelopardalis	Giraffe	Intense human population growth in giraffe range states (Muller, 2018). The hunting of giraffes for wild meat within communities that are affected by conflict (e.g., in Central and East Africa) (Dunn et al., 2021). Proliferation of firearms during civil conflict in Ethiopia (Abate & Abate, 2017). Drought in Northern Kenya, in communities that consume giraffe meat, has led to fluctuations in food security, which may have increased wild meat consumption in the area (Ruppert et al., 2020).
Gorilla beringei graueri	Grauer's gorilla	Civil unrest, mining, climate change, human population growth. During the war in DRC, armed groups in mining camps relied on hunting wild meat, including gorillas (Plumptre et al., 2021, Plumptre et al., 2016).

Scientifc Name	Common Name	Summary of Large-Scale Drivers of Hunting
Gorilla gorilla diehli	Cross river gorilla	Growing human interactions due to high forest conversion to farms and illegal hunting (African Conservation Foundation, 2013). Dense human populations surrounding remaining habitat (Bergl et al., 2016).
Gorilla gorilla gorilla	Western lowland gorilla	The principal threat to this taxon is illegal hunting for meat, followed by disease (especially Ebola), and then habitat degradation and destruction (Maisels et al., 2018). The principal drivers of gorilla density that are related to hunting - in descending order - were the absence of guards, distance to the nearest road, human population density, whether people ate gorillas locally, and elevation (hunting is more difficult in mountainous terrain) (Strindberg et al., 2018).
Hippocamelus bisulcus	Huemul	Toxic algal blooms in the Patagonian Pacific diminished the harvest of fish and resulted in fishermen using dogs to hunt huemul (Berger et al., 2020). Colonization and expansion of the agriculture frontier increased human populations and access for hunters (C. Silva et al., 2011).
Kobus kob leucotis	White-eared kob	Hunting in Sudan has risen in the recent decades due to the widespread use of illegally acquired firearms and supply of ammunition, the result of decades-long civil war and insecurity (Marjan, 2014).
Loxodonta africana	African savanna elephant	The illegal hunting rates of African savanna elephants to 2014 was driven by corruption and by economic living standards in China (as more people could afford to buy ivory (Wittemyer et al., 2014). A more recent analysis showed that illegal hunting was (again) driven by corruption, ivory price (in the far East), poverty density and adequacy of law enforcement (CITES, 2019b; Hauenstein et al., 2019).
Loxodonta cyclotis	African forest elephant	Forest elephant density is most strongly predicted by high human population density, hunting intensity, absence of law enforcement, poor governance, and proximity to expanding infrastructure, all of which facilitate ivory poaching (Maisels et al. 2013).
Lycaon pictus	African wild dog	30 years of intense civil unrest in Angola, 1975–2002 (Monterroso et al., 2020). Human development and encroachment on wild spaces (Mohamed bin Zayed Species Conservation Fund, 2011). Habitat fragmentation due to human development bringing humans and wild dogs closer together (Woodroffe & Sillero-Zubiri, 2020).
Oryx dammah	Scimitar-horned oryx	Human development and access to advanced weapons (Jackson, 1978). Introduction of firearms and vehicles has intensified hunting pressure (Wakefield et al., 2002).
Ovis ammon	Argali sheep	Soviet Union breakdown and economic hardship (Rosen, 2012).
Pan troglodytes	Chimpanzee	The principal threats to this species (and the order differs depending on subspecies) are illegal hunting for meat, disease and habitat degradation and destruction (Humle et al., 2016). The principal drivers of Western Chimpanzee (Pan t. verus) density that are related to poaching are accessibility (i.e. reflected by protection afforded by guards) and hunting taboos (Heinicke et al., 2019). The principal drivers of the Cameroon-Nigerian Chimpanzee (Pan t. ellioti) poaching are human population growth within its range, easy access to arms, improved transport systems, and high financial incentives for supplying urban markets with bushmeat (Humle et al., 2016). The principal drivers of Central Chimpanzee (Pan t. troglodytes) density that are related to poaching -in descending order - are whether people actually eat chimpanzees locally, human impact index, the absence of guards, slope, and elevation (hunting is more difficult in mountainous terrain) (Strindberg et al., 2018). Finally, principal drivers of Eastern Chimpanzee (Pan t. schweinfurthii) poaching is the demand from people living in the logging and mining camps, where all wildlife is intensively hunted for meat. The camps are often guarded by militias which facilitates access to firearms (Plumptre et al., 2016), (Plumptre et al., 2021)).

Scientifc Name	Common Name	Summary of Large-Scale Drivers of Hunting
Panthera onca	Jaguar	The proliferation of extractive industries, such as logging and mining, which create opportunities to illegally hunt jaguars by bringing humans in contact with wildlife and/or making it easier to access wild areas. The ayahuasca tourism boom, which includes the use of Jaguar parts (Braczkowski et al., 2019). Chinese investment in Suriname may be increasing demand for jaguar products (Lemieux & Bruschi, 2019).
Procapra gutturosa	Mongolian gazelle, white-tailed gazelle	During World War II large numbers were killed by the state, who used the meat to provision soldiers. Between 1941 and 1945 100,000 gazelles were killed each year (Bannikov, 1954).
Equus kiang	Kiang	In recent years, the kiang in the Arjin Mountain Nature Reserve have become increasingly vulnerable to illegal hunting and habitat alteration as human populations in nearby areas have increased and as new roads have improved access. The Arjin Mountain Nature Reserve has witnessed a continuing influx of iron and asbestos miners from Qinghai Province to move into the reserve (Turghan et al., 2013).
Saiga tatarica	Saiga antelope	With the collapse of the Soviet Union, the strict hunting control system for saiga became dysfunctional and illegal hunting began to gain momentum (Milner-Gulland et al., 2001).
Pantholops hodgsonii	Chiru, Tibetan antelope	Gold prospecting and increases in modern weapons and motor transport. chirus are often killed by gold prospectors in China; 1000's of prospectors may rapidly immigrate into an area if a strike is made (Wright & Kumar, 1997).
Ursus maritimus	Polar bear	The 1983 collapse of the sealskin market reduced Inuit hunter incomes at the same time as the price of imported goods was rapidly increasing and wage employment opportunities were limited. This resulted in inuit hunters deciding to use a portion of their polar bear quota for guided tourist hunts. This did not increase hunting, but altered its purpose (Freeman & Foote, 2009).

4.4 Governance of wild meat hunting and use

4.4.1 International conventions addressing wild meat hunting and use

International conventions are the most frequent platform for intergovernmental policy outcomes relating to curbing the illegal wildlife trade. In addition to the CMS, the UN Convention on Biological Diversity (CBD), the Convention on Trade in Endangered Species (CITES) and the UN Declaration on the Rights of Indigenous Peoples (UNDRIP) all have Decisions related to wild meat hunting and use. The following section describes these four main conventions and the relevant Decisions, building on Coad et al. (2019)[12].

4.4.1.1 The Convention on Migratory Species: Decisions relevant to wild meat taking, trade and consumption

At the 12th meeting of the Conference of the Parties of the Convention on Migratory Species (August 2017), a Meeting Document titled 'Addressing Unsustainable Use of Terrestrial and Avian Wild Meat' was published by the CMS, highlighting the increasing concern that decision makers, conservationists and human development agencies have regarding the increase in consumption and the unregulated trade of wild meat. This document outlines the main issues regarding wild meat use, and contains draft decisions, which were formalised as CMS Decision 13.109 on Addressing Unsustainable Use of Terrestrial and Avian Wild Meat of Migratory Species of Wild Animals. Decision 13.109 asks the Secretariat to *prepare an analysis on the direct and indirect impacts of wild meat taking, trade and consumption of terrestrial and avian species listed on CMS Appendices I and II.* The document also outlines the CMS provisions relevant to wild meat, namely:

- CMS lists species that are endangered on Appendix I (Article III), while Appendix II lists species that have an unfavourable conservation status and require an international agreement for their conservation and management or whose conservation status would significantly benefit

[12] Further information on regional governance of wildmeat and voluntary intergovernmental and multi-stakeholder initiatives relevant to wild meat use in the tropics and sub-tropics is provided by Coad et al (2019).

from international cooperation (Article IV). With respect to Appendix I-listed species Parties are required to prohibit their taking (i.e. *taking, hunting, fishing capturing, harassing, deliberate killing, or attempting to engage in any such conduct*), except if one of four exceptions applies, including if the taking is to accommodate the needs of traditional subsistence users of such species (Article III, 5. c)). Furthermore, if a Party makes use of this exception, it shall, as soon as possible, inform the Secretariat accordingly (Article III. 7.).

- Appendix II-listed species should be protected through international agreements, which should, amongst others, *provide for measures based on sound ecological principles to control and manage the taking of the migratory species* (Article V, 5. j)). Since it is within the prerogative of the Parties to agreements or Signatories to Memoranda of Understanding (MOU) concluded for Appendix II-listed species to provide for measures to control and manage the taking of species, each agreement and MOU might differ on that point.
- In addition, Goal 1 of the Strategic Plan for Migratory Species (2015-2023) (Resolution 11.2), requests Parties to *Address the underlying causes of decline of migratory species by mainstreaming relevant conservation and sustainable use priorities across government and society, while Target 6 provides that Fisheries and hunting have no significant direct or indirect adverse impacts on migratory species, their habitats or their migration routes, and impacts of fisheries and hunting are within safe ecological limits.*

4.4.1.2 The Convention on Biological Diversity

The Convention on Biological Diversity has adopted several Decisions regarding the sustainable use of wild meat. In 2008 the CBD established a Liaison Group on Bushmeat. The Liaison Group provided recommendations for the sustainable use of wild meat which were adopted by the CBD COP 11 in 2012 (Decision XI/25), with further recommendations adopted by the CBD COP 12 in 2014 (Decision XII/18). In addition, the CBD Action Plan on Customary Sustainable Use (UNEP/CBD/COP/DEC/XII/12, B, Annex) was adopted in 2014.

During the World Forestry Congress in Durban (2015), the Center for International Forestry Research (CIFOR) presented a roadmap for securing wildlife and food security (Fa & Nasi, 2015). Subsequently, the Conference of the Parties (COP) to the Convention on Biological Diversity held their thirteenth meeting (CoP 13), in Cancun in 2016, and adopted a decision to elaborate technical guidance building on the roadmap presented in Durban (UNEP/CBD/COP/DEC/XIII/8) (CBD, 2016). This Decision encouraged *"Parties and other Governments, as well as relevant organizations, to consider and implement, as appropriate, the road map for better governance towards a more sustainable bushmeat sector, presented to the XIV World Forestry Congress in Durban, South Africa, in September 2015".* It also requested that the Executive Secretary "further elaborate technical guidance for better governance towards a more sustainable bushmeat sector, with a view to supporting Parties' implementation of the Strategic Plan for Biodiversity 2011-2020, building on the road map".

This resulted in the publication of two guidance documents. Firstly, a *"Voluntary guidance for a sustainable wild meat sector: wild meat, food security, and livelihoods",* which was published Annex to Decision XIV/7 on Sustainable wildlife management adopted at the 14th Meeting of Conference of the Parties to the Convention on Biological Diversity (Sharm El Sheikh, November 2018). A more comprehensive version of the guidance was then published as a joint CBD/CIFOR report: *"Towards a sustainable, participatory and inclusive wild meat sector"* (Coad et al., 2019). The report offers technical information on governance and management approaches to improve sustainability of wild meat use and food security in the long term.

4.4.1.3 Convention on Trade in Endangered Species (CITES or Washington Convention)

CITES monitors and authorizes the international trade among its parties of all species listed in its appendices. The current CITES position on wild meat is explained in Resolution Conf. 13. 11 (Rev. CoP 18) and encourages Parties to implement CBD Decisions XI/25 and XII/18 where appropriate and take advantage of the *Voluntary guidance for a sustainable wild meat* sector found in the Annex to Decision XIV/7.

In 2016, the COP adopted Resolution Conf. 16.6 (Rev. CoP17) on 'CITES and livelihoods', recognizing that the implementation of CITES is better achieved when the national governments of the parties seek the engagement of rural communities, especially those traditionally dependent on CITES-listed species for their livelihoods.

The wild meat trade impacts many CITES-listed species (for example, elephants and gorilla species), but international trade for these species is generally for wildlife products (such as ivory, scales etc) rather than meat, which is mainly traded at a domestic level.

4.4.1.4 The UN Declaration on the Rights of Indigenous Peoples (UNDRIP)

The UNDRIP, passed in 2007, elaborates on existing human rights standards and fundamental freedoms as they apply to the specific situation of indigenous peoples. Articles particularly relevant to wild meat management are Article 8 on preventing dispossession from territories,

Bushmeat sold in the local market at Ebolowa, Cameroon, Africa. © Colince Menel/CIFOR

Article 18 on the right to participate in decision making, Article 19 relating to free, prior and informed consent (FPIC) and Article 26 on the right to own, use, develop and control traditional territories.

4.4.2 National governance of wild meat hunting and use

With guidance on the sustainable governance and management of the wild meat sector recently created by the CBD, we do not seek to provide separate guidance on wildmeat governance and management in this report and refer readers to Coad et al. (2019).

In the following section we therefore provide a brief synopsis of the key issues surrounding national wild meat legislation and enforcement, drawing from Coad et al. (2019) with updates from the recent literature, a focus on issues concerning migratory species and case-study examples from CMS species. We then introduce the newly create Legal Hub Toolbox, a set of legal diagnostic tools and methodologies created by the EU Sustainable Management Programme to map and analyse relevant statutory legal frameworks and demonstrate the use of the toolbox using the Democratic Republic of Congo as a case-study.

4.4.2.1 Key issues surrounding the national regulation of wild meat hunting and use

While the international and regional resolve to sustainably manage wildlife resources is clear, ultimately it is national action that will lead to sustainable management of national resources. National laws and regulations governing wildlife meat hunting and wild meat use vary widely between nations, and this can be a particular challenge for the sustainable management and conservation of migratory species (Box 7). In many tropical countries, urgent reform of current hunting legislation is needed for sustainable management to occur (van Vliet et al., 2019). In these countries, hunting legislation can be very old (e.g., created in the 1960's and 1970's) and based on English or French law from the colonial era. These laws were originally drawn up for mainly sport hunting of temperate species and are therefore poorly suited for the regulation of subsistence hunting of tropical species.

For example, temperate species reproduce each year at a given time, and which is roughly synchronised for most birds and mammals. Therefore, European hunting laws usually defined a six-month closed hunting season to allow the various taxa to conceive, gestate, give birth, and bring up their young to independence. However, in the forested humid tropics, the typical game species - primates and ungulates, and some game birds - reproduction is much less predictable and a set six-month closed season is not biologically relevant. In the forested humid tropics, especially in Central Africa, many of these laws need revision. In particular, the closed hunting season is impossible for subsistence hunters to adhere to, and indeed has just been rescinded for three small-bodied, fat-reproducing species in Gabon (blue duiker, cane rat, and brush-tailed porcupine) (Government of Gabon, 2020).

In most countries the commercial sale of wild meat trade is illegal, or highly restricted subject to permits, and in some countries this illegality has pushed the sector to hidden channels, making the scale of the illegal trade in wild meat difficult to quantify. While many countries acknowledge and allow for legal subsistence hunting, subsistence hunting practices can still end up contravening hunting regulations (Sartoretto et al., 2017). For example, in Central Africa, Gabon and Congo recognize customary use rights for local communities, which cover the use of timber and non-timber forest products to meet subsistence needs. However, it is often unclear which general hunting restrictions (for example, restrictions concerning hunting methods, quotas, seasons, and sales of meat) also apply to subsistence hunters with these customary use rights. Applying for required hunting permits and licenses (which may require travel in major cities with associated costs) is also outside the capacities of many rural subsistence hunters (van Vliet et al., 2019). Additionally, contradictions in legislation can occur where newer legislation overlaps older legislation, creating confusion and legal loopholes and making enforcement challenging (Coad et al., 2019). As a result, regulations are largely unrespected. For example, van Vliet & Nasi (2008) showed in villages from north-east Gabon, that 30% of the animals were hunted using illegal methods, 34% were hunted in banned periods, and not a single hunter had a legal hunting permit.

Another key issue undermining the governance and management of hunting in many countries is the lack of land rights for local and indigenous peoples (Coad et al., 2019). For example, there has been almost no devolution of forest tenure rights in Africa where in 2013 national governments were found to still own 98% of forest land (Anderson & Mehta, 2013). Where local people have few rights over their wildlife, and have no power to exclude external hunters, there is little incentive for sustainable management (Kabiri & Child, 2014). Additionally, conflicts between national hunting laws and customary laws, even where national laws are unenforced, can erode the authority of local, traditional power structures, further weakening the local governance of wildlife resources (Walters et al., 2015).

Without legislation that allows local hunting of resilient species and community co-management of wildlife resources, many community and NGO projects aiming for sustainable hunting management find themselves acting outside of national hunting laws (Coad et al., 2019). This is likely to impede projects from achieving positive long-term impacts (Asare et al., 2013; Roe et al., 2009). Calls for revisions to national legislation to better regulate the wild meat trade to prevent the emergence and spread of novel zoonotic pathogens and future epidemics have also followed the outbreak of the Covid-19 pandemic (Borzée et al., 2020).

As part of their guidance to CBD Parties, Coad et al. (2019) recommend review and revision of existing hunting and wildlife trade legislation, looking in particular at:

- A rationalization of wildlife laws to focus on sustainability (for a 10+ year horizon) and to ensure that they are fit for purpose and can be properly applied enforced, with due consideration of both food security and conservation concerns.
- Development of guidelines distinguishing species that are resilient to hunting and those that are not, to orient offtakes to those species that can be hunted sustainably.
- Devolution of wildlife rights to local populations, with clear membership criteria, where appropriate, and in line with the Plan of Action on Customary Sustainable Use under the CBD and UNDRIP.

Box 7: Governance challenges specific to migratory species

Migratory animals present specific governance challenges because the pressures subjected to the species and their habitats, and the protections afforded to them through national hunting legislation, vary across their geographic range (Moreno-Zarate et al., 2021). The range of migratory species will often extend across different land use types and national and regional jurisdictions. This means that while they may be protected at one time of year or life stage, they may be vulnerable to hunting at others, and cannot be effectively conserved by protected landscapes or hunting laws that do not cover their entire migratory range. Setting sustainable harvest quotas in one jurisdiction for a species, which may also be harvested in other jurisdictions, is complex, and the monitoring of offtake levels and population abundance needed for sustainable management requires cooperation across countries, which is often lacking, but key to sustainable use (Dolman et al. 2021).

4.4.3 EU-SWM Legal Hub tools and methodologies for analysing legal and institutional frameworks

The Sustainable Wildlife Management (SWM) Programme is a 7-year initiative (2017-2024) of the Organisation of African, Caribbean and Pacific States (OACPS)[13] implemented in 15 countries[14] which aims at conserving biodiversity, whilst at the same time improving food security and livelihoods of the people who depend on these resources. To this purpose, the SWM Programme supports participatory and evidence-based processes to strengthen normative frameworks, statutory and customary, for enabling and supporting effective management and sustainable use of wildlife as well as sustainable food and agriculture production as a viable alternative to wildlife use.

As part of this work, a cross-sectoral review of legal frameworks that regulate different aspects of both wild and farmed meat and fish value chains in the SWM Programme partner countries has been carried out, with the support of national experts. These results are compiled into legal country profiles and further displayed on a Legal Hub section of the SWM Programme website. To guide this process, a comprehensive set of legal diagnostic tools and methodologies were produced, namely for:

- Mapping the relevant statutory legal framework (Tool), (Methodology). This tool facilitates the identification of potential obstacles to legal certainty (ambiguities deriving from legislative drafting techniques, existence of obsolete normative texts, etc.).
- Reviewing domestication of relevant international instruments (T), (M). This tool helps to understand how State obligations arising from international agreements and conventions are reflected in the national legal framework. The tool currently focuses on six international instruments[15], including the Convention on the Conservation of Migratory Species of Wild Animals (CMS), but its conceptual framework can be adapted to other instruments, including regional and non-binding ones.
- Analyzing consistency across sectoral legislations and identifying potential gaps (T), (M). This tool provides a cross-sectoral analysis of the strengths and weaknesses of national legal framework applicable to wildlife management, ranging from land tenure to food safety, but also including hunting and fishing as well as animal production and animal health.
- Clarifying the relationships between statutory and customary law (T), (M). This tool aims at identifying, understanding and documenting the rights of indigenous peoples and local communities to land and associated natural resources, such as wildlife, as well as the multiple challenges associated with promoting the recognition of customary rights to support creation of synergies between statutory law and customary law.
- Identifying the barriers to implementation and/or enforcement of laws (T), (M). The tool helps identify the structural and conjunctural factors that explain the insufficient or lack of implementation and enforcement of certain legal instruments in a jurisdiction.

These tools can be adapted for use in any country to support national efforts to promote conservation and sustainable use of wildlife. For example, the tool for reviewing domestication of international instruments is currently used in Egypt, Mali, Senegal, Sudan and Chad in the framework of the RESSOURCE project[16] to review the domestication of both the Ramsar Convention on Wetlands and the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA). The results of these tools can help co-identify priorities for actions in terms of legal development/reform or capacity building for law application and enforcement adapted to each country. An example of the results offered by the joint use of these tools follows, using the Democratic Republic of Congo (DRC) as a case study. As part of this review, the level of domestication of CMS has been particularly highlighted.

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13 Funded by the European Union with co-funding from the French Facility for Global Environment (FFEM) and the Agence Française de Développement (AFD). The SWM Programme is implemented by a consortium of partners led by the Food and Agriculture Organization (FAO) and including the French Agricultural Research Centre for International Development (CIRAD), the Center for International Forestry Research (CIFOR) and the Wildlife Conservation Society (WCS).

14 The SWM Programme is working in Botswana, Chad, Democratic Republic of the Congo, Egypt, Gabon, Guyana, Madagascar, Mali, Namibia, Papua New Guinea, Republic of the Congo, Senegal, Sudan, Zambia and Zimbabwe.

15 Convention on the Conservation of Migratory Species of Wild Animals (CMS), Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), Convention on Wetlands of International Importance especially as Waterfowl Habitat (RAMSAR), Convention on Biological Diversity (CBD) and its two Protocols (Nagoya and Cartagena); Convention Concerning the Protection of the World Cultural and Natural Heritage (WHC); United Nations Convention Against Corruption (UNCAC).

16 The RESSOURCE project, namely «Renforcement d'expertise au sud du Sahara sur les oiseaux et leur utilisation rationnelle en faveur des communautés et de leur environnement», is a French Facility for Global Environment (FFEM) funded initiative supporting efforts to improve the sustainable use of natural resources, particularly waterbirds, in the wetlands of Egypt, Mali, Senegal, Sudan and Chad.

4.4.3.1 Assessment of normative framework in Democratic Republic of Congo (DRC), using the SWM Legal Hub Toolkit

Legal and Institutional framework. More than 200 normative texts[17] have been gathered by SWM to inform a comprehensive legal analysis on sustainable wildlife management in the country, including regarding the production of alternative sources of proteins. The mapping of these texts highlighted structural as well as conjunctural concerns affecting both the wild meat and animal production value chains and related governance. These include the lack of clear distribution of responsibilities across the relevant administrative bodies, some of which date from the colonial period, as well as the obsolescence of several normative texts, some of which still include sanctions in currencies that are no longer in use.

Consistency across sectoral legislations and potential gaps. In the DRC, the main laws governing wildlife are Law No. 082-002 of May 28, 1982, regulating hunting and Law No. 14/003 of February 11, 2014, on nature conservation, together with the Land Law from 1973 and the Forestry Code from 2002. Important aspects for sustainable wildlife management are however not systematically covered. For example, while a comprehensive system of hunting permits with multiple categories is in place, the exact scope of each permit is not always clear, including regarding the right to hold, transport, and dispose of hunted game. Wildlife trade regulations also remain unclear at least to the extent to which it relates to wild meat. The opening and closing dates for hunting seasons are to be set by the provincial governors on an annual basis, yet the law provides no criteria to inform these decisions in a sustainable way. Finally, despite Constitutional recognition of collective ownership and customary land rights, sector specific legislation is not yet aligned with these principles. This negatively affects indigenous people and local communities (IPLC) access to natural resources and wildlife. However, the ongoing reform of these laws offers the opportunity to improve this situation.

Customary law. Customary law is recognized as an auxiliary source of law in the DRC Constitution insofar as it is not contrary to public order or morality. The Constitution provides for these same limits on the recognition of customary authority. A specific instrument – the Law No. 15/015 of 25 August 2015 « fixant le statut des chefs coutumiers » was promulgated in 2015 in accordance with Article 207 of the Constitution. Hence, customary law continues to govern the actions and behavior of most members of rural communities dependent on wildlife for food, land and other natural resources which sustain their livelihoods. At the same time, customary law is not harnessed to support implementation of statutory laws when it comes to access and use of wildlife resources.

Barriers to implementation and/or enforcement of laws. The main underlying factors identified during the field surveys conducted in the Okapi Wildlife Reserve in the Ituri Province where the SWM Program operates are the lack of human, technical and financial resources to enforce the laws. The poor knowledge both duty bearers and rights holders have of the relevant legal texts and the deriving rights and duties was also identified as a major challenge along with the gap between statutory law and local cultural and socio-economic context.

Domestication of international instruments (with a focus on CMS). There are no texts that deal specifically with the protection of migratory species and their habitats in DRC, but species listed in Appendix I and Appendix II of the CMS can be protected under the general biodiversity conservation regime organized by Law No. 14/003 of February 11, 2014, on nature conservation. Indeed, the protected species status under national law ensures protection for both species and habitats by prohibiting any taking (hunting, capture, fishing) and intentional disturbance (especially during reproduction and migration) of protected species, as well as any destruction of breeding sites, resting places or natural habitat where protected species live[18].

This law also provides for the establishment of a list of species fully or partially protected, by a decree deliberated in the Council of Ministers (Article 13). However, the text has not been adopted yet and is currently under discussion. This process is led by the «Institut Congolais pour la Conservation de la Nature» (ICCN). Until its completion, the protection status of CMS species is defined by Ministerial Order No. 020/CAB/MIN/ECN-EF/2006 of May 20, 2006, which approves the list of protected animal species in the Democratic Republic of Congo (hereafter, the Order No. 020). However, this latter coexists with other lists previously established by hunting legislation[19] which do not necessarily contain the same species. This situation is likely to create uncertainty as to the status of certain species and therefore their harvesting.

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17 For the purposes of the SWM Programme, this collection is mainly focused on the normative texts relating to the following areas: land tenure, land-use planning, forestry, wildlife, protected areas, hunting, fishing, as well as animal health and production (including aquaculture) and other relevant sectors, particularly food security and public health, among others.

18 Article 14, Law No. 14/003 of February 11, 2014, on nature conservation.

19 Appendixes of Law No. 082-002 of May 28, 1982, regulating hunting and Order n° 014/CAB/MIN/ENV/2004 of April 29, 2004, concerning the measures for the execution of the Law n° 82-002 of May 28, 1982 regulating hunting

While the Order No. 020 list has not been updated since 2006, there is a general consistency between the level of protection granted by the CMS and the status granted by Order No. 020 in as far as terrestrial mammal species listed in Appendix I (endangered migratory species) are concerned. Yet some discrepancies have been reported for marine species and birds from the same Appendix. For example, some species present in the DRC do not have a protected status[20] or have only a partially protected status[21] .

The protection and conservation of certain migratory species is also organized at the inter-regional level through more specific initiatives and agreements. Among those we can mention the Gorilla Agreement of 2007 concluded under the auspices of the CMS, for which the DRC had a leading role, and the Great Virunga Transboundary Collaboration Treaty on Wildlife Conservation and Tourism Development (GVTCT) of 2015 between the DRC, Rwanda, and Uganda, which aims at promoting the conservation of gorillas in transboundary protected areas.

4.4.4 Enforcement of national hunting laws

The most recent report by the International Consortium on Combating Wildlife Crime (ICCWC) (ICCWC, 2021) reports that *"Exacerbated by poverty and facilitated by corruption, wildlife crime flourishes when detection rates and arrests are low, when penalties are weak and when prosecutions are rare"*. Wildlife crime includes international and national trafficking of body parts and live animals; it may also be used for money-laundering (FATF, 2020).

Legislation can be irrelevant unless enforced, and the enforcement of hunting laws in many countries is often extremely weak (Gore et al., 2013). Lindsey et al. (2015) found that poor law enforcement was the most frequently cited driver of illegal wild meat hunting in savannah ecosystems. A review of 82 wildlife cases from the Northern Zone Anti-Poaching Unit, Arusha, Tanzania found that only 16% of these resulted in prosecution. Lindsey et al. (2015) also found that of the 64 suspects arrested for illegal hunting in the NG26 concession in northern Botswana over 30 months, none were convicted. Similarly, in a review of the illegal trade in orangutans as pets, Freund et al. (2017) found 145 cases of orangutans being illegally held between 2004-2014, but only one prosecution of orangutan trading in West Kalimantan; the authors suggest that weak law enforcement in the region remains the most significant challenge in addressing wildlife trade in general. There are many factors that can lead to weak law enforcement, including:

- **Perceived illegitimacy of hunting regulations.** When wildlife laws are seen as not reflecting the interests and concerns of hunters dependent on the resource for their livelihood security, and when they conflict with customary rules and norms, they can be perceived as illegitimate and ignored (Coad et al., 2019). As discussed in section 4.4.2, in many countries hunting legislation need revision and currently include rules that are impossible for subsistence hunters to adhere to (for instance long seasonal hunting closures). Wildlife, hunted for wild meat, is often perceived as a free resource to which access should not be regulated by the state. In many countries wildlife laws are not enforced, because enforcement officials (police, lawyers, judges) may be unwilling to punish people for hunting wildlife. Judiciary uncertainty over the legitimacy of wildlife protection has often led to the use of very low fines and penalties, leaving the potential revenues to be made from illegal hunting higher than the potential risks of breaking the law.
- **High levels of corruption/'rent seeking'.** The trade in wildlife products – even wild meat - can be a high-profit enterprise. This leaves (often low-paid) officials responsible for regulating trade in these species vulnerable to corruption (Zain, 2020). The United Nations Office on Drugs and Crime (UNODC) and the United Nations Environment Programme (UNEP) report corruption as a critical enabler of the illegal wildlife trade (UNODC, 2020). The Last Great Ape Organization (LAGA) recorded that *"Bribing attempts are documented in 85% of our field arrest operations, and 80% of all court cases within the legal system"* (LAGA, 2013). In some cases, government employees/ officials are actively involved in illegal hunting or the wild meat trade (Lindsey et al., 2015; Stiles, 2011b; Stiles, 2011).
- **Low knowledge of wildlife laws by both law enforcement officials and the public.** For example, in a survey of 180 park officials in Okomu and Old Oyo National Parks, Nigeria, 34% could name one of Nigeria's wildlife laws, and only 1.7% knew the correct fine for killing an elephant in the parks (Coker et al., 2020).
- **Low resources allocated to law enforcement.** In many countries, hunting law enforcement capacity (in terms of money, equipment, vehicles, and numbers of well-trained staff) is low (Harrison et al., 2016; Lindsey et al., 2015; Parry et al.,

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[20] *Sousa teuszii, Hirundo atrocaerulea, Lepidochelys olivacea, Coracias garrulus, Ardeola idea, Pristis pectinate, Pristis pristis*

[21] *Aquila nipalensis, Gyps africanus, Gyps coprotheres, Gyps rueppelli, Necrosyrtes monachus, Neophron percnopterus, Torgos tracheliotos, Carcharodon carcharias, Rhincodon typus, Falco naumanni, Falco vespertinus*

2014). This may be due to wildlife crime being seen as a low priority by national governments, or due to a lack of funding.

Aside from the seizure data held in global trade databases, there is scant open-access information on the levels of enforcement and enforcement capacity and activity globally. National data does exist, such as those collected through the Spatial Monitoring and Enforcement Tool (SMART; https://smartconservationtools.org/), which records patrol data in real time using handheld tablet computers or smartphones. However, because these data are Government property (they are typically collected by law enforcement agents - wildlife rangers or "Ecoguards") these data are not generally available to either civil society or to neighbouring countries' wildlife authorities. To ensure that enforcement activity is not visible by wildlife traffickers or wildlife crime facilitators, this type of data is only analysed at the national level, and the resulting reports are available only within the relevant Ministries.

4.4.4.1 Enforcement of national legislation: examples for CMS species

We identified case-study examples of the impact of the enforcement of hunting legislation on CMS species populations from our literature review. Two themes emerge: One is that while CMS species may be protected under national and international laws and conventions, in many countries enforcement capacity and effort is low, and hunting therefore continues unabated. The second is that species populations that experienced sharp declines due to over-hunting have recovered after legal protection and enforcement of laws.

The following species provide examples of where enforcement efforts have succeeded:

- While hunting has caused significant population declines for Cuvier's gazelle (*Gazella cuvieri*), better protection in reserves and stricter laws have led to a decrease in consumption of meat on a local scale in Algeria (IUCN, 2018a). Additionally, the species has been offered some protection in some areas of Morocco and Algeria as it has a 'special status' with the local communities and is therefore not hunted (Bounaceur et al., 2016; IUCN, 2018a). Unfortunately, since 2013, its stronghold in Tunisia (Chambi NP) has now been severely affected by military operations (IUCN, 2016).
- The Kapchagaj National Park population of black-tailed gazelle (*Gazella subgutturosa*) is protected from illegal hunting and has the highest population densities in Kazakhstan. Other populations in Kazakhstan have virtually no protection from illegal hunting and have suffered substantial losses, and as a result, they occur at very low densities (Blank et al., 2012).
- In Afghanistan, illegal hunting of urial (*Ovis vignei*) varies significantly between management regimes. The state managed Eastern Salt Range (ESR) covers 518km^2 and contains about 160 urial. Law enforcement is lacking, lamb captures are common and adult urials are illegally hunted. In comparison, the community managed Kalabagh Game Reserve (KGR) extends over 137km^2 and supports about 500 urials. Protection against illegal hunters is strictly enforced in the KGR, where urials have been protected for the last 70 years. Livestock grazing within the KGR is strictly prohibited in the core area of about 20km^2 with the greatest urial density, and only a few head of cattle and sheep are allowed in other parts within the reserve where urial occurs. Human access is limited to a few unpaved roads. Outside the KGR, in most of the Salt Range, most mature males were shot. When interviewed, local people noted that urial poaching occurs with the tacit accord of wildlife officials (Awan, 2006).
- In China, illegal hunting of argali (*Ovis ammon*) has been a substantial threat. In the mid-1990s however, a nationwide effort to confiscate illegal weapons substantially reduced the weaponry available for illegal hunting. This, together with continued efforts to publicize the national law prohibiting killing protected species, appears to have reduced illegal hunting during the last decade (Rosen, 2012).
- In 1993, the Chang Tang Wildlife Reserve in Tibet, China, was established to counteract high levels of illegal hunting of chiru (*Pantholops hodgsonii*). The 334,000 km^2 protects most of the surviving chiru populations. Many middlemen who transport chiru wool have been arrested by the Tibet Forest Department, thousands of chiru hides have been confiscated, and individuals who have illegally hunted chiru have been jailed. In mid-1996, China's State Council issued an order that chiru protection be given high priority for protection. These actions are credited with a recovery of chiru populations (CITES, 2019a). However, although protected under the law, the vast area across which chiru are illegally hunted makes law enforcement challenging (Zhen, 1999).
- Creation of the Chang Tang and Seling Lake Nature Reserves in Tibet, China, and improved enforcement of illegal hunting of kiang (*Equus kiang*) in these reserves, is reported to have reduced illegal hunting and improved population numbers of kiang since the 1990s, so much so that in December of 2000, the Nyima County government filed a request to cull 4000 kiang annually, citing grazing competition with livestock and grassland degradation as the justification.

Kiang (*Equus kiang*) © RobertHarding.com

The request was denied (Tsering et al., 2013).

- For saiga antelope, the creation of the USSR brought with it a rapid recovery of populations thanks to border controls, the limitation of firearm possession by local people, the emptying of the steppe due to collectivization, and strong law enforcement. The breakdown of the USSR and resulting breakdown in enforcement of hunting regulations resulted in an explosion in hunting of saiga and population declines (Box 5.).
- Despite these examples, for most of the species reviewed in this report our review suggests that enforcement effort/capacity is not high enough to effectively enforce hunting laws and sustainably manage hunting activity. In some cases, the areas to patrol are so large that the number of available enforcement officers is inadequate to the task. For species such as elephants, the potential revenues to be made from wildlife products are higher than the potential risks of breaking the law (generally the chance of being fined or given prison time).

4.5 Zoonotic diseases and wild meat hunting and use

A zoonosis is any disease or infection that is naturally transmissible from vertebrate animals to humans (WHO, 2020). A total of 1,415 species of infectious organisms affecting humans have been described, of which 61% are zoonoses (Taylor et al., 2001). Examples of zoonotic diseases include Severe Acute Respiratory Syndrome (SARS), Ebola Virus Disease, Nipah, Human Immunodeficiency Virus infection and Acquired Immunodeficiency Syndrome (HIV/AIDS), human 'mad cow disease' (variant Creutzfeldt–Jakob disease, CJD) and West Nile fever.

Of the described species of infectious organisms, 175 are emerging, of which 75% are zoonotic (Taylor et al., 2001). An emergent disease is an "infectious disease whose incidence is increasing following its first introduction into a new host population" (Woolhouse & Dye, 2001). Rapidly increasing human population densities, social-economic and behavioural changes, a globalized economy, increased mobility, increasing encroachment into and modification of the natural environment, and ecological changes all increase the potential for emergent diseases (McMichael, 2005). The total number and diversity of zoonotic outbreaks, and richness of causal diseases increased significantly since 1980 even after controlling for disease surveillance, communications, geography and host availability (Smith et al., 2014).

Impacts can be global, as the rapid pandemic spread of COVID-19 or the 2009 H1N1 swine-flu clearly demonstrate. After the original zoonotic transmission, their viral pathogens caused diseases that then spread human to human and became pandemics. A pandemic is "an epidemic occurring over a very wide geographic area, crossing international boundaries, and usually affecting many people. The agent must be able to infect humans,

Box 8: Transmission of coronaviruses from bats to humans

SARS was first recognized at the end of February 2003 in Hanoi, Viet Nam, in a patient that had extensively travelled in Southeast Asia (WHO, 2003). In the same year, SARS spread to more than 30 countries across five continents (Guan et al., 2003). The coronavirus SARS-CoV-1 was identified as the causative agent (Drosten et al., 2003). The virus was traced back to a live-animal market in Guangdong, southwest China, where it appears to have jumped from traded Himalayan palm civets that tested positive for a virus highly similar (99.8%) to SARS-CoV-1. Evidence of virus infection was also detected in other animals including a raccoon dog and Chinese ferret badger and in humans working at the same market (Guan et al., 2003). Furthermore, 40% of animal traders and 20% of animal slaughterers had detectable serum antibodies, compared to only 5% of vegetable traders. Subsequently, genetically diversified CoVs related to SARS-CoV-1 were then found in diverse Chinese bat families, with a population of horseshoe bats at a site near Kunming city having the highest (96%) genetic similarity to SARS-CoV-1 as well as the genetic precursors for SARS-CoV-1 to emerge through recombination (Drexler et al., 2014; Hu et al., 2021; Lau et al., 2005; W. Li, 2005). The likely infection scenario is that horseshoe bats infected civets as intermediate and amplifying hosts, which then triggered the zoonotic spillover (Guan et al., 2003; Song et al., 2005). The 2003/4 pandemic infected 8096 people worldwide and killed 774 (9.5%) (Drexler et al., 2014).

SARS-CoV-2 is the causative agent for COVID-19 and the seventh known coronavirus affecting humans. Although COVID-19 was first detected officially at a Chinese market where live and dead animals were traded, epidemiological data indicate that some early cases were not related to wildlife markets and thus that it may not necessarily be the site of emergence (Frutos et al., 2020). The Wuhan Seafood market might have acted as an amplification chamber for the human-to-human spread. SARS-CoV-1 and SARS-CoV-2 genetically match closest to CoVs found in horseshoe bats making it likely that SARS-CoV-2 or its progenitor evolved in horseshoe bats with other mammals as plausible conduit for the transmission to humans (Boni et al., 2020; Hu et al., 2021; Zhou et al., 2020).

to cause disease in humans, and to spread easily from human to human" (Porta, 2014). Almost all recent pandemics have viral origin (Geoghegan et al., 2016; Jones et al., 2008).

4.5.1 Species most likely to harbour known zoonotic viruses

Overall, known zoonotic viruses are most abundant in domesticated species, primates, and bats (Johnson et al., 2020). Bats host a higher proportion of zoonoses than any other mammalian order (Olival et al., 2017); more than 200 viruses have been detected in bats, many of them causing zoonotic disease (Allocati et al., 2016). However, primates are disproportionate carriers of human disease: they constitute only 0.5% of vertebrate species but have contributed about 20% of major human diseases (Wolfe et al., 2007). Olival et al. (2017) noted that "the proportion of zoonotic viruses per species is predicted by phylogenetic relatedness to humans, host taxonomy and human population within a species range - which may reflect human-wildlife contact".

The relative risk of disease emergence is highest for bats, followed by primates and then ungulates and rodents (Cleaveland et al., 2007). For example, coronaviruses including SARS-CoV-1 and SARS-CoV-2 likely originated in bats (Box 8). Because bats host many coronaviruses, which represent 31% of all viruses found in bats (Chen et al., 2014), and because they are remarkably resistant to viruses (Storm et al., 2018), the risk of emergence of a novel bat-CoV disease is high (Afelt et al., 2018). In a recent study in DRC and the Republic of Congo, *Eidolon helvum* (which is frequently hunted and sold in markets; see Box 3) was found to have the highest rate of coronavirus RNA positives (suggesting it poses a high zoonotic risk) amongst sampled bat species (24 genera, 49 species) (Kumakamba et al., 2021).

A typical example of a bat-transmitted zoonotic disease is Marburg virus disease. The reservoir host is *Rousettus aegyptiacus* (the Egyptian Rousette Fruit bat, a widely hunted CMS species; Box 3), which are hunted in West Africa for wild meat (Mickleburgh et al. 2009), with antibodies and viral DNA also found in other insectivorous and fruit bats (Amman et al., 2012; Swanepoel et al., 2007). Marburg virus (MARV) is transmitted to humans through contact with body fluids and dead bodies of infected animals. It causes severe, often fatal, haemorrhagic fever in humans and primates and is a prime example demonstrating that measures to control a disease by persecuting the host species can fail (Amman et al., 2014). After MARV infected gold miners in Southwest Uganda at the Kitaka mine, the miners exterminated the bat colony. However, the bat colony re-established itself albeit at a lower total size, and the re-established colony had a subsequently higher level of active infection than before the eradication.

Box 9: Zoonotic diseases present in Latin American CMS species

In America, Insectivorous bats such as Lasiurus ega, Lasiurus blossevilii and Lasiurus borealis are hosts for rabies (Albas et al., 2011; Whitaker & Douglas, 2006). Lasiurus cinereus is a natural host for Leishmania (Castro et al., 2020). Bartonella spp., Neorickettsia risticii, and Rickettsia sp. have been evidenced in Tadarida brasiliensis (Cicuttin et al., 2017).

Ungulates from the Southern hemisphere, moving across borders between Peru, Bolivia, Argentina and Chile also carry a certain number of diseases that are shared with humans. For example, Echinococcus granulosus, responsible for Cystic echinococcosis, has been evidenced in huemul from Chile (Hernández et al., 2019). Mycobacterium Avium paratuberculosis, an important pathogen of cattle and small ruminants, responsible for causing economic losses worldwide was also found in huemul (Llanos-Soto & González-Acuña, 2019). Vicuñas are hosts for Leptospira icterohaemorrhagiae and Leptospira pomona (Rosadio et al., 2012), as well as Toxoplasma gondii (Dávalos & Heckla, 2006). Vicuñas are also known hosts for gastrointestinal parasites, such as Eimera spp., and nematodes such as Trichuris spp, Marshallagia spp., Lamanema chavezi and Fasciola hepatica (Samamé et al., 2016). Geographic overlap between sheep, cattle and wild ungulate populations likely facilitates parasite spillover into wild animals, with shepherd or stray dogs and wild foxes potentially acting as bridging hosts between livestock and the endangered huemul and the vicuña.

Carnivores such as Panthera onca are known reservoirs for Leishmaniasis (Zarza et al., 2015), Toxoplasma gondii (Silva et al., 2016), Leptospira spp. and Brucella abortus (Onuma et al., 2015).

Efforts to understand the risks and prevalence of infectious diseases in CMS species have increased over the past decade but remain limited to a low number of individuals sampled or are based on animals kept in captivity. This is particularly true for the Polar Bear (Ursus maritimus), for which the prevalence of zoonoses has only been studied in captive animals not representative of the infectious risks facing wild populations (Fagre & Duncan, 2015).

Whilst several species (including gorillas and chimpanzees) can harbour ebolaviruses the natural reservoirs of this genus are likely to be bats (Malvy et al., 2019; Spengler et al., 2016). Antibodies to Ebola virus have been detected in eight species of frugivorous bats, including CMS species the Straw-Coloured Fruit bat (*Eidolon helvum*) and the Egyptian rousette fruit bat (*Rousettus aegyptiacus*). Recent analysis of Ebola virus antibodies in fruit bats from DRC collected during the Ebola outbreaks in the Equateur and North Kivu provinces showed that over 10% of bats sampled contained antibodies (Lacroix et al., 2021). The highest number of antibodies were found in Eidolon helvum (which is heavily hunted and often sold in market; Box 3), for which researchers estimate that up to 34% of individual bats could have been infected with Ebola, and which is the most hunted bat species for wild meat in Africa.

In addition to the direct bat-to-human pathway of some viruses such as in the case of MARV, there are indirect pathways involving intermediate hosts, which makes the detection of the virus origin more difficult. An example is the Nipah virus, which spilled over in 1998 from fruit bats to pigs, and then from pigs to farm workers in Malaysia, causing 265 cases of encephalitis and 105 deaths (Chua, 2000). Since then, it has spread in Southeast Asia, especially to Bangladesh where spillover events now occur regularly (Gurley et al., 2017). In Bangladesh, the Nipah virus is indirectly transmitted from infected Pteropus fruit bats to humans when humans drink palm sap that has been contaminated by the fruit bats via pots used to collect the sap (Epstein et al. 2020).

Among the 105 CMS species reviewed here, data from Johnson et al. (2020) suggests that 54 species were known to host at least one of 60 pathogens that have been, or have the potential to be, transmitted to humans and cause disease. The average number of zoonotic viruses per species is smaller in the bat species covered by this review than in Proboscidea, Primates, Perissodactyla and Carnivora (Table 6; Appendix 4). However, bat species constitute half of the top 10 species with the highest number of reported zoonotic viruses for the 105 surveyed species (Table 7).

4.5.2 Linkages between wild meat hunting and zoonotic disease risks

Transmission of zoonotic pathogens from animals to humans occurs through direct human–animal contact (such as Brucellosis, rabies, influenza, and Hantaviruses), arthropod vectors (vector-born diseases such as Lyme disease, West Nile virus (WNV), plague), environmentally mediated zoonoses (such as Anthrax, Echinococcosis, Leptospirosis, that can persist on the ground), or through ingestion of contaminated food or water (enteric zoonoses such as Salmonellosis, Campylobacter, and Giardia infections). Wild animals used for food are major reservoirs for many foodborne pathogens or direct contact zoonotic diseases (Hilderink & de Winter, 2021).

There is strong evidence that zoonotic disease emergence is linked to human activities which bring wildlife, domestic animals and humans into increasingly intense contact. This includes destruction and degradation of natural areas (Allen et al., 2017), intensive livestock rearing (Han et al., 2016), and hunting, trade and consumption of wildlife (Swift et al., 2007). A meta-analysis of publications on the effect of anthropogenic land use change on infectious disease dynamics revealed that 57% of studies documented increased pathogen transmission, 10% decreased pathogen transmission, 30% demonstrated complex pathogen responses and 2% showed no detectable changes (Gottdenker et al., 2014).

The opportunities for zoonotic spill-over have increased in parallel with the increase of the intensity and extent of wild meat hunting, consumption and trade over the last decades (Karesh & Noble, 2009). Encroachment into remaining intact forests from road building, and forestry and mining concessions have increased zoonotic risks by bringing humans in contact with hitherto undisturbed host and pathogen populations, and by increasing the levels of wild meat hunting and trade due to the immigration of concession workers and their families who have cash incomes and few other dietary options (Auzel & Wilkie, 2000; Poulsen et al., 2009).

On one hand, there are individual hazards of zoonotic diseases that are mostly restricted to hunters and users of wild meat but without a direct health risk for the broader society. For example, the spill-over risk from helminths or bacteria is generally local, possibly affecting hunters and consumers (Kurpiers et al., 2016). One of the oldest known zoonotic diseases is anthrax, caused by the spore-forming bacterium Bacillus anthracis, which infects ruminants worldwide (de Vos & Bryden, 1996; Dragon et al., 1996; Lindeque & Turnbull, 1994). Muoria et al. (2007) recorded an outbreak of anthrax in Grevy's Zebra (Equus grevyi) in the Wamba area of southern Samburu, Kenya, during which more than 50 animals succumbed to the disease. Other species, including humans and primates, can be infected through direct contact, inhaling spores or by consuming meat from infected animals (Leendertz et al., 2004; Sirisanthana & Brown, 2002). Use of contaminated carcasses and animal skins is the principal zoonotic risk (Beatty et al., 2003; Hang'ombe et al., 2012), but the disease is not transmitted from human to human.

On the other hand, there are public health hazards of zoonotic diseases that carry extremely low chances of occurring yet exceptionally high global consequences when they do occur. Wild meat hunting and consumption are known to be the direct and causative behaviours for the spill-over of Monkeypox virus, SARS-CoV-1, Sudan virus and Ebola virus, into humans with subsequent human-to-human transmission (Loh et al., 2015). Based on a ranking of the number of zoonotic disease events since 1940, these four viruses placed wild meat in ninth place out of eleven primary drivers of zoonotic disease events, alongside breakdown of public health services (Loh et al., 2015). Three of the four events involved non-human primates (including chimpanzees), highlighting their importance as reservoirs for zoonotic diseases. All five human Ebola disease outbreaks during 2001–2003 in the forest zone between Gabon and Republic of Congo began after humans handled the carcasses of gorillas, chimpanzees, and duikers (Rouquet et al., 2005). Risks of zoonotic transfer between humans and wildlife can go both ways, and great ape species are highly susceptible to Ebola virus. The 2003 outbreak of Ebola virus disease in the Republic of Congo killed 114 people and up to 800 western lowland gorillas (*Gorilla gorilla gorilla*). (Rizkalla et al., 2007) used an epidemiological model to investigate the combined effects of Ebola and hunting on persistence of gorillas and predicted that under current harvest practices and the estimated annual outbreak rate, western lowland gorilla populations could undergo a 97% decline within 100 years.

Another important zoonotic disease derived from nonhuman primates is HIV which causes AIDS. AIDS was first recognized as a disease in 1981 (Barré-Sinoussi et al., 1983), although HIV originated sometime near the beginning of the twentieth century as indicated by molecular genetic data (Worobey et al., 2008). To account for HIV´s genetic diversity at least 12 zoonotic transmission events must have occurred, four to account for the diversity of the HIV-1 lineage derived from chimpanzees (Plantier et al., 2009) and eight to account for the diversity of the HIV-2 lineage derived from Sooty mangabey (*Cercocebus atys*) (van Heuverswyn & Peeters, 2007), indicating that spill-over events constitute an ongoing, dynamic process and that new zoonotic transfers are real possibilities. Although the exact circumstances of each spill-over event remain unknown, hunting and butchering of primate wild meat is the most parsimonious explanation (Hahn, 2000; van Heuverswyn & Peeters, 2007). By the year 2020, it is estimated that between 55.9 and 100 million people have become infected with HIV and that between 24.8 and 42.2 million people have died from AIDS-related illnesses since the start of the pandemic (UNAIDS, 2020).

4.5.3 The trade in wild meat and risks of zoonotic spillovers

The practices and conditions of urban wildlife trade present a continuing high risk of novel virus spillover. In commercial markets selling both live and freshly butchered animals for human consumption, the combination of high wildlife volumes, taxonomic diversity, crammed and stressful conditions for the captive wildlife, taxa with high risk for zoonoses, poor biosafety and close contact between wildlife, domestic animals and humans contribute to a high potential for pathogen transmission (Magouras et al., 2020). Often, live wild animals and domestic animals are housed alongside each other, with domestic animals also implicated in the transmission of zoonotic disease such as in the case of the H7N9 Influenza outbreak (Li et al., 2014; Yu et al., 2014). Turn-over of live and dead animals is enormous. For example, after the outbreak of SARS in November 2002 more than 800,000 animals were confiscated from the markets in China's southern province of Guangdong, where SARS originated, up to April 2003 (BBC, 2003).

The potential effect of trading activities along the market chain is demonstrated by a study on the prevalence of SARS-CoV in civets, the likely intermediate host responsible for the initial zoonotic SARS-CoV spill-over. Whilst civets on farms were largely free from SARS-CoV infection, the prevalence in one animal market in Guangzhou, China, was ~80% (Tu et al., 2004). Another study demonstrated that the transmission risk increases along wildlife supply chains for human consumption in Viet Nam (Huong et al., 2020): for field rats, the odds of coronavirus RNA detection significantly increased along the supply chain from animals sold by traders by a factor of 2.2 for animals sold in large markets and by a factor of 10.0 for animals sold and served in restaurants. Exposure and spillover are more likely when animals are transported and packed tightly in crowded conditions, are housed in crowded conditions (as in wildlife farms) and are transported and marketed close to other species of wildlife and domesticated animals (Huong et al., 2020).

Taxa sold as wild meat in restaurants, roadside stalls and markets in Malaysia potentially contain 51 zoonotic pathogens (16 viruses, 19 bacteria and 16 parasites), highlighting the extent of the problem (Cantlay et al., 2017). All samples from illegally imported African wild meat confiscated over an 18-day period in 2008 (18 separate consignments) at Paris Charles de Gaulle airport had viable counts of bacteria above levels considered safe for human consumption, (despite 80% of the bushmeat being smoked) including the pathogens Staphylococcus aureus and Listeria monocytogenes, which are associated with food-borne illnesses (Chaber & Cunningham, 2015). Trade of West African rodents to the United States triggered a local outbreak of monkeypox in prairie dogs and eventually the zoonotic transmission to humans (Reed et al., 2004). In a survey of blood samples taken from 573 monkeys sold as wild meat in a Cameroonian market 18.4% contained Simian immunodeficiency virus (SIV) antibodies in 13 primate species (Peeters et al., 2002).

The ongoing COVID-19 pandemic has led to calls for bans on wildlife trade from conservation NGOs on public health grounds, including bans on commercial trade in wildlife for human consumption and the closure of freshly butchered meat/live animal markets. China has committed to a crackdown on the illegal wildlife trade and has banned the consumption of terrestrial wild animals for food (McNamara et al., 2020). However, these responses must consider the impact of market closures on the livelihoods of many citizens in the global south, as well as the efficacy of such bans on reducing wild meat trade and consumption. As described in the introduction to this report, for some rural communities the wild meat trade provides a key source of income, and trade bans could have livelihood impacts on these communities. Previous market bans in response to the Ebola outbreak in West Africa seemed to have little impact on the trade in wild meat, which was simply pushed underground (Bonwitt et al., 2018; Duonamou et al., 2020; Friant et al., 2015). Doubts of the efficacy of market bans exist for other species and countries. For example, Booth et al. (2020) report the continuation of illegal trade in manta rays in Indonesia, following prohibition of their hunting and trade in 2014. Challender et al. (2015) review the continuing (and often highly profitable) illegal trade in many CITES Appendix I listed species around the world, and highlight that increased profitability from inflated black market prices can incentivise or even exacerbate illegal hunting and attract the engagement of organised criminality.

Several authors suggest that more nuanced solutions, rather than broad bans, could be necessary. MacNamara et al. suggest that rather than banning wild meat trade, solutions should be found in the formation of proactive management policies for wild meat hunting and trade which seek to reduce reliance on wildlife hunting and trade, while also supporting sustainable economic development at the national level, providing alternative economic opportunities. Wikramanayake et al. (2021) suggest that prohibitions of high disease-risk wildlife sales could be preferable to broad bans, combined with monitoring of wildlife trade chains to identify high-risk points on the chain and manage these appropriately. Nadimpalli & Pickering (2020) note that improved wet market infrastructure is urgently needed, particularly in low-resource settings. They advocate for the installation of handwashing facilities and toilets, adequate drainage, separating live animals from meat and produce, and implementing protocols for cleaning food and slaughtering animals, to reduce pathogen transmission and exposure, and note the success of these approaches in Hong Kong markets following the 2004 influenza A H5N1 epidemic. Petrikova et al. (2020) suggest that a focus on 'wet markets' disregards the impact of intensive domestic livestock rearing on land use change and zoonotic disease emergence, and advocate for a global reduction in all meat products, with a switch to small-scale animal husbandry, to reduce the risk of further pandemics.

Table 6: Average number of potential zoonotic viruses per CMS terrestrial mammalian species, by order. Calculated from data provided in Johnson et al. (2020).

Order	Average Number of Reported Zoonotic Viruses per Species	Number of Species
Proboscidea	3.7	3
Primates	2.6	5
Perissodactyla	2	5
Carnivora	1.6	8
Chiroptera	1.1	57
Artiodactyla	0.8	27

Table 7: Top 10 species with the highest number of reported potential zoonotic viruses. Calculated from data provided in Johnson et al. (2020).

Order	Scientific Name	Common Name	Number of Reported Zoonotic Viruses
Chiroptera	*Miniopterus schreibersii*	Schreibers' bent-winged bat	8
Chiroptera	*Rhinolophus ferrumequinum*	Greater horseshoe bat	8
Primates	*Pan troglodytes*	Chimpanzee	7
Perissodactyla	*Equus africanus*	African wild ass	7
Chiroptera	*Nyctalus noctule*	Noctule bat	6
Carnivora	*Panthera leo*	Lion	5
Chiroptera	*Rousettus aegyptiacus*	Egyptian fruit bat	5
Proboscidea	*Loxodonta Africana*	African elephant	4
Artiodactyla	*Cervus elaphus barbarus*	Barbary deer	4
Chiroptera	*Eptesicus serotinus*	Serotine bat	4

Table 8: Top 10 reported zoonotic viruses for the 105 CMS terrestrial mammal species. For the 105 species studied here, Appendix 4 provides information on the number and type of zoonotic viruses associated with each species. Calculated from data provided in Johnson et al. (2020).

Zoonotic Virus	Number of Species
European bat lyssavirus type 1	15
Foot and Mouth Disease	15
Rabies	9
European bat lyssavirus type 2	8
Rift Valley fever[22]	7
Cowpox[23]	6
Issyk-Kul	5
Bhanja	4
Encephalomyocarditis	4
Japanese encephalitis	4

[22] Rift Valley Fever poses little hazard to most humans. Less than 8% of people infected with this virus from livestock manifest acute morbidity.

[23] Cowpox typically causes cutaneous pustules that resolve relatively quickly.

5 Discussion

This report has analysed the use and impacts of wild meat hunting on CMS species, and the laws and regulations governing this use. Here we review our methodology, summarise our general findings and provide recommendations for further research.

5.1 Limitations of our study

This report presents results that are limited in scope and results should only be interpreted considering the limitations of our methodology.

- Our species review was a rapid review, conducted within a limited timeframe (February – May 2021). We therefore used Google Scholar with pre-defined search terms to identify up to 15 publications per species from the first 20 pages of results. For most species, fewer than 15 publications were found, suggesting that our upper publication limit was not limiting the amount of information that could be found using this method. However, for the other species, we only provide a snapshot of the available literature. More time to contact key researchers for each species would unearth more publications, especially unpublished reports, that may contain further information on hunting, and greatly improve the detail and breadth of the information presented in this rapid review.
- The rapid nature of our review also limited us to a simple analysis of the presence/absence of the species reviewed in available trade databases. We provide suggestions for more in-depth analysis of the international trade in migratory species in the following discussion.
- Our analysis of zoonotic diseases associated with CMS species is restricted to viruses. Bacteria and other pathogens such as internal and external parasites are not considered here, apart from in the broader literature review. However, effects of diseases caused by these pathogens are, in contrast to many viruses, normally limited to people that directly hunt or handle wild meat, as opposed to subsequent onward transmission through human communities.

5.2 Impacts of hunting on CMS species: significant impacts are documented, but current, systematic assessment is lacking

Our analysis of the IUCN Red List Assessment data, combined with our systematic literature review, found ample evidence that - excluding bat species - nearly all the species that we reviewed are hunted, and nearly all these species are threatened by hunting. Impacts of hunting for wild meat are especially evident for ungulate and primate species. While there was enough available evidence for us to draw these conclusions, this was because many population declines were extreme where hunting was known by experts to be a key driver of declines.

The review found a significant lack of systematically collected or collated data on hunting offtakes and species populations, especially outside of protected area landscapes. Generally, hunting data has been collected at small scales both geographically and temporally: individual market surveys, surveys of hunting offtakes for several villages, perception surveys over several communities etc. While these surveys provide useful snapshots of species offtakes and use, they provide very context-specific insights, and taken individually cannot provide an overview of hunting pressure for a species, especially for species with large ranges. Exceptions to this rule are the elephant species, where the MIKE programme has set up a systematic monitoring programme over a wide range of sites across Africa and Asia, to monitor the illegal killing of elephants (Box 1), and the Snow Leopard Crime Database. For marine species, the International Whaling Commission has set up a systematic monitoring programme across the worlds' oceans. However, this system does not exist for any other species that we know of.

The WILDMEAT database (www.wildmeat.org) has been set up in response to the general problem of a lack of information on wild meat use. The database holds data that has been collected on hunting offtakes, market sales, and consumption in a standardised format, and allows data from across different sites and studies to be combined and compared, to provide a holistic understanding of the volumes, characteristics, and correlates of wild meat use across space and time. However, while scheduled to become open access in late 2021, the database is currently limited to Central Africa and South America and can only hold data from studies that have used a systematic survey approach and where survey effort is quantified. Nevertheless, modelling numerous single-site datasets on wild meat offtakes could help to understand more fully the levels of hunting pressure that some species are under.

To assess hunting impacts on a species, species population numbers and trends must also be known. The IUCN Red List of Threatened Species provides expert assessment, using the best available information, for most CMS species. We note that the IUCN Red List of Threatened Species can be several years out of date for some species, as they tend to be assessed every ten years. For example, most of the ungulates were assessed in 2015-2016, and some of the great apes (such as Grauer's and Cross River Gorillas) in 2016. The Red List assessment can only be as solid as the population and threat data underpinning it. Assessing population abundance and trends can be very difficult for migratory species, those with large home ranges or cryptic species, as effective monitoring systems in one area can be offset by a lack of information in others. This situation should begin to improve as monitoring techniques become more sophisticated and automated. The Living Planet index (https://livingplanetindex.org/) collates and provides access to species population data from across the globe. Camera-trapping has become more cost-effective and accessible and can now be used to estimate actual abundance and distribution of species. Projects such as Wildlife Insights (https://www.wildlifeinsights.org/) are working to collate and standardise camera-trapping data across the globe, to enable it to be analysed effectively. Such advances should help IUCN, CMS and other institutions to build a better picture of species population numbers and trends for migratory species.

Linking hunting offtakes for wild meat use to trends in population abundance requires that other drivers of population decline aside from wild meat use (for example, other hunting uses such as trophies and skins, and other drivers of population declines such as land-use change) are accounted for. Realistically most species have multiple uses and are exposed to several different threats, and it will not always be possible to untangle the impacts of each use and threat. These authors would caution in this case to not 'let the best become the enemy of the good'.

Our interrogation of the IUCN Red List and our literature review suggests that, apart from a few fruit bat species, bats are not often used as wild meat. However, wild meat hunting surveys can fail to record bat species to species level, often recording offtakes as 'bats' or to the genus level (i.e., 'fruit bat' (Pteropodidae)) (pers. obs. Coad, van Vliet and Ingram). In addition, these authors (Coad, van Vliet and Ingram) have observed bats being killed by young people in villages as a pastime/practice for future hunting, and our review found evidence of bats being killed as percieved pests (Barquez et al., 2015; Frantz & Laniewicz, 2000; Gazaryan et al., 2020; Korine, 2016; Rabou, 2019). These types of killings are not often recorded in hunting offtake studies. The lack of information on bat hunting could either be because they are infrequently hunted, or that their hunting is being greatly under-reported. Half of CMS terrestrial mammal species are bats, and bats are key reservoirs of zoonotic diseases, therefore this issue warrants further investigation.

Where CMS species are consumed or traded as wild meat, our interrogation of the IUCN Red List data suggests that wild meat consumption is generally local or national with very little international trade. This agrees with the general consensus that wild meat is mainly traded nationally, although there has been little recent research into international trade volumes (Ingram et al. 2021). While tracking national use and trade is the most urgent priority, international wildlife trade databases should be interrogated further to try and quantify the amounts of wild meat that are being traded legal and illegally internationally, as well as identifying the type of wildlife products that wild meat accompanies (i.e. is elephant meat being trafficked alongside ivory?). While the CITES trade database provides a crucial tool for the regulation of international wildlife trade, many countries are very behind on submission of trade information to the database, and only a few include shipments that were seized or confiscated; most CITES Parties only report legal trade. As such, trade is significantly under-reported, even for those countries that are up to date on their submissions. We would therefore suggest a wider analysis of available illegal trade databases, while heeding the advice of Challender et al. (2021) on how to avoid their misuse. This was out of the scope of this rapid assessment but would be a useful and feasible follow-up analysis.

In summary, an overall lack of comparable and collatable data on wildlife populations and hunting offtakes makes the tracking of hunting offtakes over time, and the scientific analysis of impacts of offtakes on species populations almost impossible. This, in turn, significantly impedes efforts for sustainable and adaptive management of hunted populations, and is especially an issue for migratory species, whose ranges may span areas with varying levels of monitoring effort. We would advocate for the systematic and collaborative collection, collation and analysis of hunting and species population data at a national level, preferably collected and collated using internationally agreed standards, as a priority for international and national efforts to sustainably manage migratory species and wildlife in general.

5.3 Large-scale drivers of hunting: poverty, conflict, and land use change

Our investigation of large-scale drivers of hunting highlighted the impact of political upheaval. Many publications emphasized the impact of civil conflict and wars, due to increased reliance on wild meat for food and income for local communities, use of wildlife by armed groups, proliferation of firearms and breakdown of law enforcement. Migratory species are more at risk from civil conflicts, due to their movement across political boundaries, increasing the chance that they will move through conflict zones. Our review also highlighted the combined impact of hunting with other threats, such as land use change or disease. Examples included land use change from agriculture and mining, where the road networks and immigration created by land use concessions increased access to species, and demand for, and the ability to pay for, wildlife products, and the case of saiga antelopes, where populations already weakened by hunting were driven to local extinction by disease outbreaks. These results highlight that managing for local-scale drivers of wild meat hunting (for example, a communities need for food and income) may fail if the wider context (for example civil conflict, which increases access to high-calibre weapons and facilitates illegal hunting by organised militia) is not considered.

5.4 Hunting governance: the need for review, revision and effective enforcement of hunting legislation

In many tropical countries, urgent reform of national hunting legislation is needed for sustainable management to occur. While reviews such as Sartoretto et al. (2017), van Vliet et al. (2019) and (Coad et al., 2019) provide case-studies of hunting legislation for a few (mainly tropical) countries, a large-scale, systematic analysis of national hunting legislation has not yet been conducted, and we would highlight this as a research priority. This would allow for an understanding of the range of legislative and management approaches taken globally and highlight key issues and gaps in hunting legislation that need to be resolved to support sustainable management of wildlife. This analysis would also support efforts to manage hunting at a regional level, identifying legislative differences and similarities within a wider landscape. This is especially pertinent for the management of migratory species (Box 7). Projects such as Legal Atlas (https://www.legal-atlas.com/), the FAO FAOLex database (http://www.fao.org/faolex) and the EU SWM Legal Hub have created repositories for national policies and legislation related to natural resource management, making legislative documents more accessible to researchers and policy makers. In addition, tools and methodologies provided by the EU SWM Legal Hub now provide a standardised way of analysing these documents.

Although not the focus of this report, we described two examples of sustainable use initiatives for two migratory species in Box 6 (vicuña and polar bear). Sustainable use initiatives may, in some instances, provide avenues for the conservation of migratory species listed in CMS Appendix 2, while acknowledging the cultural identity and livelihood needs of wildlife users. However, there are pre-requisite conditions that must be in place for community-based management to succeed. In this report we identify a few of key pre-requisites, including the devolution of land and management rights to local communities, and support for these communities in excluding external commercial hunters from their lands. Voluntary guidance for the governance of a sustainable wild meat sector has been provided by the CBD as an Annex to Decision XIV/7, and as a more in-depth published report (Coad et al. 2019), and we direct readers to these two guidance documents for further discussion of the community-based management of wild meat resources.

At an international level, Coad et al. (2019) suggest that there is a clear demand enshrined in the intergovernmental conventions for sustainable use of wildlife. However, they also highlight that Convention secretariats have not yet adopted technical standards for measuring sustainability in wildlife harvests, methods for moving toward improved sustainability, or standard indicators for measuring wild meat hunting and use over time. While export quotas are set for international trade in CITES species (either by Parties to CITES or by the CITES CoP), offtakes for domestic use (including for consumption) may be overlooked when sustainable offtakes for international trade are calculated. A lack of data on hunting offtakes for domestic use, as highlighted by this report, could well lead to quotas for international use being set too high. The lack of international standards or guidance leaves these decisions to be made at a national level, which can lead to inaction or to varying methods and indicators between nations, and we would again highlight this as a priority for the Conventions.

5.5 Wild meat hunting and zoonotic disease transmission

The COVID-19 pandemic reminds us poignantly about the possible consequences of spill-over events of diseases from wildlife, including CMS species. Our review shows that the relative risk of disease emergence is highest for bats and primates, and several severe zoonotic disease outbreaks have been linked to these species. Wild meat hunting, consumption and trade brings humans into contact with high-risk species and are known to be the direct and causative behaviours for the spill-over of Monkeypox virus, SARS-CoV-1, Sudan virus and Ebola virus. Conditions in wild meat markets and along the wild meat trade chain can heighten the risk of disease spillover unless properly regulated.

Although there is now a considerable body of research - spearheaded by PREDICT (a project of USAID's Emerging Pandemic Threats (EPT) program) - that has identified potential human pathogens in wild animal hosts, there is still little understanding of how frequently spillover happens from wildlife hosts to humans. Understanding more about the spillover risks associated with wild meat use and trade, and the factors that might increase or decrease these risks, must be an immediate priority for wild meat research. This should include investment in serological studies that assess the prevalence of antibodies in different actors involved in the wildmeat and domestic meat trade to disease agents in host species traded as food, to identify key point in the commodity chain where risks occur. This knowledge should then be applied to design national and international standards for the legal wildlife trade to reduce the risks of zoonotic disease spillover. Support to market traders to ensure that they adopt good hygiene practices, targeted regulation of taxa with a high disease risk, plus strict enforcement of protected species regulations, is required both from a public health and a conservation standpoint.

5.6 Conclusions

Migratory species are being heavily impacted by hunting for wild meat and for a range of other consumptive

Bushmeat (monkeys) at the Moutuka Nunene market in Lukolela. Democratic Republic of Congo. © Ollivier Girard/ CIFOR

uses including for skins, trophies, medicine and due to human-wildlife conflict. Our capacity to monitor and sustainably manage these species is woefully lacking. This review highlights the need for systematic national and international efforts for monitoring hunting offtakes and populations of species (including a better understanding of national and international trade chains and volumes), the review and revision of national hunting legislation and its effective enforcement, the creation of international standards for measuring and monitoring sustainability, and the design of informed policies to reduce the risks of zoonotic disease transmission from wild meat hunting, consumption and trade. The CMS can play a key role, in collaboration with other key Conventions such as the CBD and CITES, in creating international standards and tools and providing technical support to national governments.

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7. Appendices

Appendix 1: List of searches conducted for each species and associated search terms

This is provided in the attached Access database (CMS_ Literature _review), in the table called 'Appendix 1_Searches'.

Appendix 2 : List of references for each species, with associated data on hunting uses, offtakes, impacts and drivers

This is provided in the attached Access database (CMS_ Literature_review), in the table called 'Appendix 2_References'.

The appendices are available from the CMS Secretariat and the authors upon request.

Appendix 3: Summary of finding from literature review, for each species

This is provided in the attached Access database (CMS_ Literature_review), in the table called 'Appendix 3_Summary', and below as a Word document table.

Appendix 4: Zoonotic diseases associated with each CMS species

This is provided in the attached Access database (CMS_ Literature_review), in the table called 'Appendix 4_Zoonoses'.

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