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Global wildlife trade and trafficking contribute to the world's nonhuman primate conservation crisis

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A growing global human population, habitat conversion, and the indiscriminate exploitation of natural resources have created unsustainable demands on nature, resulting in widespread biodiversity loss. Primates, which represent the third most speciose Order of mammals, are facing an extinction crisis. Currently, 69% of primate species are listed by the IUCN as threatened (Vulnerable, Endangered, or Critically Endangered) and 94% have declining populations. Here, we examine two primary threats to primate population persistence, namely the commercialized hunting and capturing of wild primates and their body parts for food, traditional medicine, pets, and use in biomedical research. Both the legal wildlife trade and illegal wildlife trafficking represent multibillion-dollar industries that contribute to primate population decline, a reduction in genetic diversity, and local extirpation. Trade and trafficking also can lead to the emergence of infectious diseases, increasing biosecurity risks to humans. Between 2015 and 2021, CITES reported 337,511 live primates representing at least 99 species were legally traded, with 6.5% sourced directly from the wild. The recent indictment of Cambodian officials for allegedly laundering wild-caught long-tailed macaques into the U.S. by labelling them as captive-bred, highlights the need for greater transparency and accountability. Comprehensive data on the illegal trafficking of primates are extremely difficult to obtain. However, between 2009 and 2017, primates accounted for 20% of all seizures of illegally traded mammals in the air transport sector. International wildlife trafficking is dominated by criminal networks, corruption, and driven by the demands of

wealthy consumers. In addition, the internet has expanded international opportunities to connect buyers and sellers of wild-caught primates and their body parts. Despite explicit bans on selling endangered primates, social media sites continue to do so. Moreover, data on the global food security index (GFSI) indicate that as the international demand for wild live primates, their meat, and other body parts has continued to increase, the majority of people in primate range nations have remained food insecure. Given that almost 70% of primate species are negatively impacted by hunting and trapping, we offer a set of recommendations to reduce the trade and trafficking of wild primates.

KEYWORDS

extinction, pet trade, conservation, zoonotic spillover, corruption

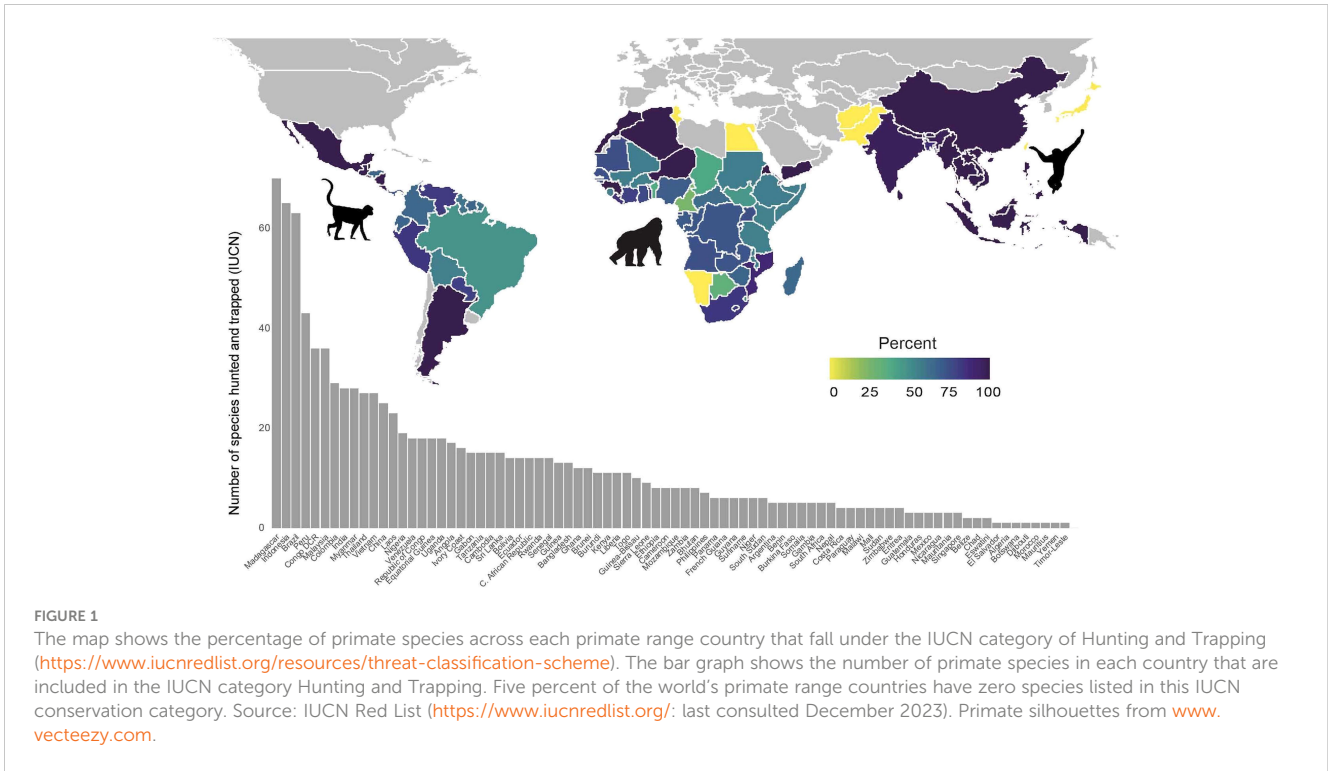
Introduction

A growing global human population, increasing economic activities, and the consequent indiscriminate exploitation of natural resources have resulted in widespread deforestation, loss of ecosystem services, habitat fragmentation and conversion, an increase in extreme weather events, and an increased risk of zoonotic disease transmission between humans, domesticated animals, and wildlife (Young et al., 2016; Nunez et al., 2019). Only 4% of the world's terrestrial mammalian biomass is now represented by wild individuals (Bar-On et al., 2018), and some one million animal and plant species are threatened with extinction (IPBES, 2022). This includes many of the world's nonhuman primates (strepsirrhines, tarsiers, monkeys, and apes; hereafter primates), our closest living biological relatives. Primates are the third most speciose mammalian radiation ($ca = 521$ extant species), after rodents (2,375 species) and bats (1,335 species) (IUCN RedList, 2023).

Primates naturally inhabit tropical and temperate forests, wetlands, savannas, and anthropogenic habitats across the American tropics (Mexico, Central and South America), Africa, Madagascar (hereafter, we use the term Africa to include both mainland Africa and the island of Madagascar), and Asia (Figure 1). Primates play critical roles in supporting community-wide ecological services including predator-prey relationships, seed dispersal and pollination, forest regeneration, and contribute to carbon sequestration by disproportionately dispersing seeds of tree species characterized by high wood density (Brodie, 2016; Peres et al., 2016). A recent study found that forests in areas of equatorial Africa, Amazonia, and Indonesia with the largest remaining stocks of irrecoverable carbon (total of 21 billion metric tons) overlap with large and diverse primate communities (6–12 species), and therefore mitigate climate change (Wolf and Ripple, 2022). Primates also play an important role as indicator or sentinel species warning of the deleterious effects of habitat conversion, hunting, and infectious disease transmission on ecosystem health (Engel et al., 2010;

Calvignac-Spencer et al., 2012; Kuthyar et al., 2021). Moreover, given that primates represent our closest biological relatives, they are essential models for the study of human evolution, behavior, biology, cognition, and health (Estrada et al., 2017). It has been argued that “if we continue to harm, pollute, and degrade our environment such that nonhuman primates cannot survive, then in the not too distant future, humans will not be able to survive in these environments” (Garber, 2019). Thus, prioritizing local, national, and international laws and practices that safeguard primate populations is a necessary pre-requisite for protecting the biodiversity and health of forested and impacted ecosystems that benefit wildlife and local and global human communities (Brodie et al., 2021; Wolf and Ripple, 2022; Garber et al., 2023; Vale et al., 2023).

Primates are facing an impending extinction crisis with 69% of species, for which data are available, listed as Threatened (IUCN categories Vulnerable, VU; Endangered, EN; Critically Endangered, CR) and 94% with declining populations (Table 1; Supplementary Tables S1–S3; IUCN RedList, 2023). Moreover, as illustrated in Figure 1, the countries with the greatest number of primate species, also have the greatest number of primate species affected by hunting and trapping (IUCN RedList, 2023). Here, we focus on a set of primary threats to primate population persistence, namely the commercialized hunting and trapping of wild individuals and their body parts for food, traditional medicine, as pets, and for use in biomedical research. In many parts of the world, Indigenous Peoples have sustainably hunted and captured primates for millennia (Estrada et al., 2022). In other regions, such as Madagascar and parts of Southeast Asia, this has resulted in the extinction or major reduction of some primate communities (Godfrey and Irwin, 2007; Fan, 2017; Meijaard et al., 2021). However, it is the more recent widespread commercialized use of primates, across all primate range regions and all primate families (Table 1), that represents a core driver of their rapid population decline. Unless we act now, the vast majority of primates will be extinct or effectively extinct by the end of this century (Estrada et al., 2017, 2022).



Both the legal wildlife trade (hereafter referred to as trade) and the illegal wildlife trade (hereafter referred to as trafficking) represent multibillion-dollar industries designed to capture and sell live wild and captive bred animals or their body parts (ROUTES, 2018; Scheffers et al., 2019; Hansen et al., 2022a; CITES, 2023). Trade and trafficking exacerbate conservation problems worldwide through the unsustainable harvesting of plant and animal species resulting in reductions in population size and genetic diversity, changes in population demography, local extirpation, and reduced ecosystem services. In many regions of the world, trade and trafficking also

threaten peoples' livelihoods, food security, and local economies (Estrada et al., 2022; Garber et al., 2023). Moreover, trade and trafficking facilitate corruption and money laundering, resulting in a weakening of the rule of law and the legal economy, a weakening of sustainable development and governance, and promote criminal networks and violence (FATF, 2021; Gore et al., 2023; Lupton, 2023). Often, it is difficult to distinguish between trade and trafficking, as both have the potential to result in disease transmission/spillover increasing biosecurity risks to human communities and contribute to the loss of sentinel wild animal

TABLE 1 Number of primate species in the three major primate range regions that are considered threatened and are included on the IUCN Red List category of Hunting and Trapping.

Region	Primate species richness	IUCN Red List Hunting and Trapping		IUCN Red List Threatened conservation categories ¹					Species ¹ with decreasing populations
		Species	%	CR %	EN %	VU %	% Threatened	GFSI ² 2022	
	Total								
American Tropics	178	97	54.5	10.0	14.2	21.9	45.8	63.1	132 (91.7%)
Africa	212	150	70.7	20.6	32.7	21.1	74.5	46.7	191 (94.0%)
Asia	131	116	89.9	21.7	41.0	25.6	88.4	61.7	123 (95.3%)
Total extant primate species: 521		363 (69.7%)							446 (93.7%)
Global %		69.6		17.3	28.6	22.5	68.4	54.9	

¹Calculations based on species for which data are available. Species for which data are listed as Unknown or Data Deficient were not included in the calculations. The total number of DD species for conservation status was 14 and the total number of Unknown cases for population trend was 45.

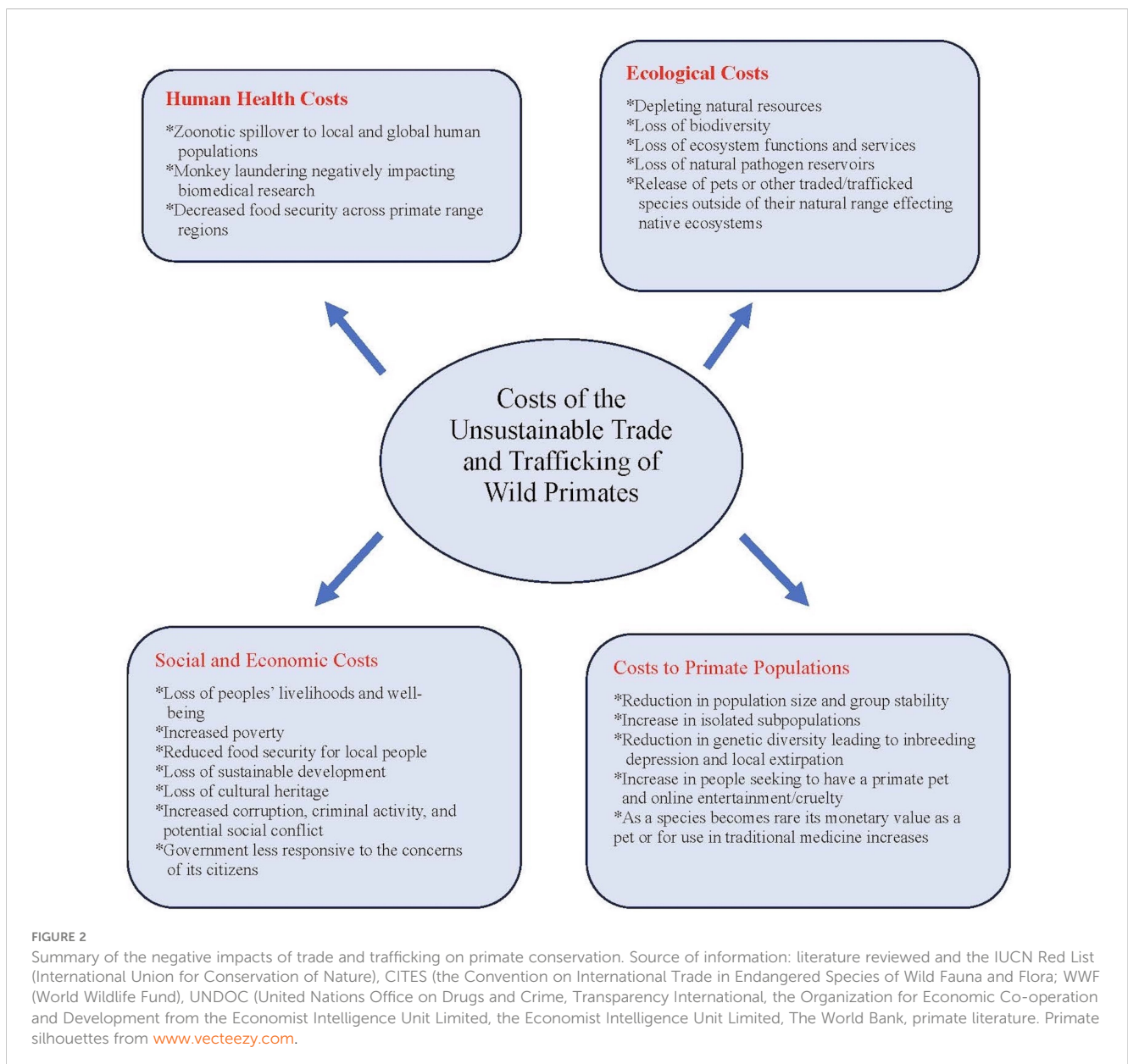
²GFSI is the Global Food Security Index.

Also shown is the percent of primate species in each IUCN Red List conservation category: EN Endangered, VU Vulnerable, CR Critically Endangered. Data on food security comes from the Global Food Security Index (Global Food Security Index (GFSI), 2022) of The Economist Intelligence Unit Limited. The number of primate species with populations decreasing in each primate region is presented in the last column (source: IUCN Red List, <https://www.iucnredlist.org/>; last consulted December 2023).

species that can provide early warning of emerging disease outbreaks (ROUTES, 2018; Tajudeen et al., 2022; World Health Organization (WHO), 2022; CITES, 2023; Gore et al., 2023).

The United Nations Office of Drugs and Crime (UNODC, 2022), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2023), and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2022) indicate that at a global scale, unsustainable trade and trafficking, which affects *ca* 26% of the world’s terrestrial mammals (*ca* = 5,180) (IUCN RedList, 2023), represents the second of five direct drivers (along with land-use changes, climate change, invasive species, and pollution) of biodiversity loss and animal extinctions. Below we provide a global review of the impact of trade and trafficking on wild primate population persistence by integrating information from international databases including the International Union for Conservation of Nature (IUCN), CITES, UNODC, Reducing Opportunities for Unlawful Transport of

Endangered Species (ROUTES), Transparency International, the World Bank, the Organization for Economic Co-operation and Development (OECD), the Wildlife Trade Monitoring Network (TRAFFIC), the Economist Intelligence Unit Limited and the World Bank Worldwide Governance Indicators, along with the peer-reviewed scientific literature. Our goals are to (1) describe the nature of both the legal primate trade and illegal primate trafficking, (2) critically evaluate the primary drivers of primate trading and trafficking, which include wild meat hunting, use in traditional medicine, online trade and trafficking as pets, and use in biomedical research, and (3) discuss the risks associated with primate trade and trafficking in fostering criminal networks and corruption, zoonotic spillover, and reduced food security for human communities (see Figure 2 for a summary of the costs of unsustainable trade and trafficking). We end with a series of recommendations designed to reduce the harmful effects of trade and trafficking on human well-being and primate survivorship.



Legal primate trade

We define as wild, any naturally occurring primate population that is free-ranging without human fencing to contain their movement. Across many countries of the world, wild primates are legally traded as pets, hunted for food, used in traditional medicine, and captured and bred for use in biomedical research (Prescott, 2023; Badihi et al., 2024). Aspects of this trade are fairly-well documented by CITES. However, year to year discrepancies in the number of individuals reported as exported compared to the number reported as imported are common. This is due to several factors, including that countries have several years to report their data and that the reported information can be based on the number of permits obtained and not the number of animals exported (Robinson and Sinovas, 2018). This presents challenges in accurately interpreting the CITES data set (Kolby and Reaser, 2024).

Between 2015 and 2021, the legal international cross-border primate trade involved 337,511 live individuals representing at least 99 species (CITES, 2024, consulted January 22, 2024). We focus on this most recent period because it is indicative of the direction and magnitude of current and future trade patterns. Approximately half of these primates were exported from countries within their native range, and half were exported from countries where these primates either have been introduced or housed in breeding colonies.

Based on the CITES trade database, the majority (76.4%) of legally exported primates were labelled as at least second-generation captive bred (meaning that the exported individual and both its parents were born in a captive setting), 17.1% were first generation captive born (meaning that one or both parents were sourced from the wild) and 6.5% (21,818 individuals) were sourced directly from the wild (CITES, 2024). These numbers exclude re-exports. Re-exports refer to the fact that live individuals or dead specimens were exported from their country of origin to a second country and then transferred to a third country, which can make it difficult to verify their origin (CITES Glossary, 2023). In 2018, for example, some 10,000 live macaques exported from Cambodia to an international buyer were labelled as re-export (Warne et al., 2023).

Long-tailed macaques are by far the most common primate species traded (85.3% of all exported primates), followed by rhesus macaques (*M. mulatta*, 3.6%), common marmosets (*Callithrix jacchus*, 1.7%), and squirrel monkeys (*Saimiri sciureus*, 1.5%) (Table 2). Nine of the top ten primate species most traded internationally are listed by the IUCN as Least Concern and one, the long-tailed macaque, has recently been uplisted to the status of Endangered (Hansen et al., 2022b). Given that 7 of these 10 species have declining populations (Table 2), the trading of wild individuals, even among species listed as Least Concern, can have a strong negative impact on local population persistence and survival.

Overall, Asian species account for 89% of the international primate trade, African species 5.4%, and species native to the American tropics 5.6%. The countries exporting the most live primates between 2015 and 2021 were China (31.3% of all live exports, n=105,585), Cambodia (18.0%, n=60,641), Mauritius (12.7%, n=42,810), Vietnam (11.9%, n=40,194), and Thailand

(9.2%, n=30,919). In the case of both China and Mauritius, almost all of the primates exported were non-native species. China is among the largest breeders of primates for the international biomedical and pharmaceutical industries (Hsu et al., 2003). In the case of Mauritius, long-tailed macaques were brought to the island by Portuguese sailors some 400 years ago as a food source and are considered an invasive species (Lawler et al., 1995). In contrast, major exporting countries like Cambodia, Vietnam, and Thailand have both naturally occurring and captive primate populations.

Data from the UN Com Trade database provide information on the customs declared monetary value of the exported primates. Between 2015–2021, the mean declared value for a live primate averaged US \$900 (range US \$400–US\$ 3,100). The amount received by exporting countries totaled US \$462 million for this seven-year period. However, given pandemic driven increased demands and reduced supply of live captive-bred long-tailed macaques, “an individual macaque can be sold for between \$20,000 and \$24,000 USD” (Warne et al., 2023).

TABLE 2 Number of individuals of the top 10 most traded live primate species during the period 2015–2021 from the CITES trade database (consulted January 22, 2024).

<i>Macaca fascicularis</i> Endangered Decreasing	287,897	USA (180,028)	China (94,398) Mauritius (42,810) Cambodia (60,641)
<i>Macaca mulatta</i> Least Concern Unknown	12,113	USA (7,980)	China (11,168)
<i>Callithrix jacchus</i> Least Concern Decreasing	5,803	China (1,592)	South Africa (5,263)
<i>Saimiri sciureus</i> Least Concern Decreasing	4,976	China (3,355)	Guyana (3,613)
<i>Chlorocebus sabaues</i> Least Concern Decreasing	3,580	USA (2,239)	Saint Kitts and Nevis (1,853)
<i>Chlorocebus pygerythrus</i> Least Concern Decreasing	3,390	Ukraine (1,662)	Sudan (2,196)
<i>Callithrix penicillata</i> Least Concern Decreasing	2,279	Bangladesh (686)	South Africa (2,255)
<i>Sapajus apella</i> Least Concern Decreasing	1,601	China (974)	Guyana (996)
<i>Saguinus midas</i> Least Concern Stable	1,253	Bangladesh (494)	South Africa (777)
<i>Galago moholi</i> Least Concern Stable	1,360	Thailand (1,151)	South Africa (815) DRC (295)

Species/No. Traded Primary Primary.

IUCN conservation status/Import Country Export Country.

Population trend.

Primate trafficking

In contrast to the legal primate trade, the extent of primate trafficking, both within range countries and internationally is undocumented and difficult to estimate (Nijman and Healy, 2016; Nijman et al., 2021, 2023). The recent indictment by the U.S. Department of Justice of officials from a Cambodian macaque breeding center (Vanny Bio Research Corporation Ltd.) and members of the Cambodian government for allegedly laundering wild-caught and endangered long-tailed macaques (*Macaca fascicularis*) into the U.S. by labelling them as captive-bred, suggests that trafficking within the context of legal trade may be more widespread than previously acknowledged (Gamalo et al., 2023). Similarly, in December 2023, 38 wild-caught monkeys trafficked from the Democratic Republic of Congo (DRC) were confiscated by Togolese authorities (Makal, 2024). The CITES permits that accompanied this shipment authorized the transfer of 8 not 38 monkeys. Two of the species shipped were listed by CITES as threatened and not indicated on the permit. The final destinations for this illegal shipment were China, Thailand, and Dubai, most likely for the exotic pet trade (Makal, 2024). The fact that the DRC exporters had obtained CITES permits, suggests that corruption along with international demand remain a major obstacle to protecting wild primate populations. Figure 3 provides images of threatened primate species subjected to trade and traffic.

Primate trafficking can generally be partitioned into three activities that vary in scale. Locally, the hunting and trapping of wild primates for meat, pets, or traditional medicine often occurs for personal use or small-scale commerce (Conroy, 2023; Norconk et al., 2023; Chavez et al., 2024). This type of illegal trade is best

described as opportunistic, loosely organized, and occurs principally across neighboring communities. At a national scale, wildlife trafficking is run by intermediaries or local criminal organizations that move the animals into larger regional consumer markets (Shanee, 2012; Shanee et al., 2017; Mendoza et al., 2022). Many of these networks are also involved in the cross border or international primate trafficking, which is highly organized and can include vast networks of national and international brokers, hunters, trappers, and smugglers moving large numbers of live individuals and/or body parts over long distances (Anagnostou and Doberstein, 2022). The financial benefits are realized principally by exporters and those at the end of the trafficking chain, rather than by those at the point of animal capture (Cardoso et al., 2021).

Comprehensive data on trafficking are extremely difficult to obtain. However, between 2009 and 2017, Utermohlen and Baine (2017) report that primates accounted for 20% of all seizures of illegally traded mammals in the air transport sector. In addition, the expansion of e-commerce (see below), has provided suppliers and smugglers access to worldwide markets (Nekaris et al., 2013; Shanee et al., 2017). This has facilitated wildlife laundering (mixing protected species with legal shipments of similar species) and the intentional mislabeling and trafficking of wild-caught primates as captive bred (UNODC, 2020; Grimm, 2022, 2023).

Evidence of disparities in observed cross-border trafficking with data reported to CITES, offers some indication of the extent of the illegal trade. For example, for the period between 2005 and 2014, Peru, Brazil, and Colombia reported to CITES the export of fewer than 400 wild-caught night monkeys (*Aotus* sp.). However, independently published assessments estimated that ~4000 wild



FIGURE 3

Examples of IUCN threatened primate species subject to trade and traffic. (A) chimpanzee (*Pan troglodytes*, Endangered) photo credit Magdalena Svensson, (B) pig tailed macaque (*Macaca nemestrina*, Endangered) photo credit Anna Nekaris and Vincent Nijman, (C) pygmy marmoset (*Cebuella pygmaea*, Vulnerable) photo credit Shanee/NPC, (D) Peruvian spider monkey (*Ateles chamek*, Endangered) photo credit Shanee/NPC, (E) yellow-tailed woolly monkey (*Lagothrix flavicauda*, Critically Endangered) photo credit Shanee/NPC, and (F) Sumatran slow loris (*Nycticebus hilleri*, Endangered) photo credit Anna Nekaris.

night monkeys (*Aotus nancymaae*, *A. vociferans*, and *A. nigriceps*) were traded to a single biomedical research facility in Colombia between 2007 and 2008 (Maldonado et al., 2009). In the case of China, news reports indicated that between 2000–2017, 487 Bengal slow lorises (*Nycticebus bengalensis*) and northern pygmy lorises (*Xanthonycticebus intermedius*, this species is not recognized by the IUCN and instead is listed as *Nycticebus pygmaeus*) and 165 rhesus macaques were confiscated by local police (Ni et al., 2018). Most of these rescued primates were found in residences as pets (57%), confiscated from people living adjacent to wild areas (19%), in the process of being transported (14%), or for sale in local markets (10%). Fully 68% were reported “unhealthy, injured or dead when rescued” (Ni et al., 2018). Given that there are currently only 800–1200 Bengal slow lorises and less than 100 northern pygmy lorises remaining in China (Li et al., 2018), the legal or illegal removal of these primates from the wild raises the risk of population extirpation. In 2020, more than 5,000 long-tailed macaques for use in biomedical research were seized at the Chinese border. These monkeys were illegally imported to China from habitat-countries such as Vietnam, Cambodia, and Myanmar (Zhu, 2022).

Similarly, Svensson et al. (2023) reported that during the period from 2002–2021, 569 primates were seized in Germany, 76 in the UK, and 33 in Spain. The majority of these seizures were of dead primates or primate parts (61%), mostly from Cameroon, Madagascar, and Indonesia. During the past 20 years, an estimated 589 metric tons of primate meat were imported into the EU from primate range countries, however, this number may be somewhat exaggerated due to errors in the harmonized system codes used to classify imported products (Svensson et al., 2023).

Primary drivers of primate trade and trafficking

Wild meat hunting

Subsistence hunting contributes to food security, and is a main source of protein, fat, and micronutrients for numerous Indigenous and rural populations worldwide (Golden et al., 2011; Nasi and Fa, 2015; Shaffer et al., 2018). In some regions, primate subsistence hunting has remained sustainable for hundreds or thousands of years (Estrada et al., 2022). In other regions, however, wild meat hunting has become unsustainable due to the effectiveness of firearms as a primary hunting technology, the commercialized consumption of wild meat, and extensive land conversion, forest fragmentation, and habitat loss, leading to primate population reduction (Peres and Nascimento, 2006; Peres and Palacios, 2007; Nasi et al., 2011; Bortolamiol et al., 2023). As primate populations decline, and the effort required to hunt rare species increases, so does the price of primate meat, driving poachers to hunt more frequently and to recalculate the risks and benefits of hunting inside protected areas (Bortolamiol et al., 2023). Primate taxa impacted by wild meat hunting are listed in Supplementary Tables S1–S3.

In the American tropics, the Amazonian nations of Brazil, Peru, Colombia, Venezuela, Bolivia, and Ecuador have the greatest number of primate species and the greatest number of species harvested for wild

meat (Figure 1; Supplementary Table S1). The taxa most commonly hunted are howler monkeys (*Alouatta* spp.), spider monkeys (*Ateles* spp.), and woolly monkeys (*Lagothrix* spp.) (Figure 3) (Peres and Dolman, 2000; Shane et al., 2017). In Peru’s largest Amazonian city, Iquitos, an estimated 28,000 primate carcasses are traded annually, with yearly increases paralleling the increase in urban population growth (Mayor et al., 2022). Moreover, a comparison of live wildlife sales and confiscations in 13 urban markets across Peru between 2007 and 2012 found that almost half of all mammals traded or seized were primates (Mendoza et al., 2022). In Brazil, Lemos et al. (2021) reported that in a single market in the city of Tefe that averages 5,000 visitors per day, wild meat from spider monkeys (*Ateles chamek*), howler monkeys (*Alouatta puruensis*), woolly monkeys (*Lagothrix cana*), and capuchin monkeys (*Sapajus marcocephalus*) was commonly sold. At heavily hunted sites in the Brazilian Amazon, Peres and Dolman (2000) reported that the biomass of spider monkeys ($20 \pm 6 \text{ kg km}^{-2}$) was seven to eight times lower than at sites where these primates were lightly hunted ($186 \pm 32 \text{ kg km}^{-2}$) or not hunted ($191 \pm 80 \text{ kg km}^{-2}$). And in Colombia, the wild meat hunting of spider monkey and woolly monkey populations inside national parks and reserves is considered a major factor in their population decline (Stevenson et al., 2010).

Across Africa, Madagascar stands out with its exceedingly high number of lemur species affected by hunting and trapping (70 of 107 species; Supplementary Table S2). And, despite the fact that several lemur species have been traditionally protected from hunting by taboos, these traditions are changing in response to increased food insecurity, shifts in the ethnic composition of local populations, and modifications in belief systems, putting already threatened species at even greater risk of extinction (Louis et al., 2020). Across other parts of Africa, large numbers of primate species are under hunting and trapping pressure in the Democratic Republic of Congo (DRC), Laos, Nigeria, Congo, Equatorial Guinea, Cameroon, and Uganda (Figure 1; Supplementary Table S2). Despite the difficulties in tracking the extent of commercial primate wild meat hunting, published information indicates that during the six-month period from August 2002 to January 2003, some 150,000 primate carcasses from 16 species were traded as wild meat in 89 urban and rural markets in Nigeria and Cameroon (Fa et al., 2015). In DRC, approximately 8,515 individuals were traded in one market over a 131-day period (~65 primates per day) (Van Vliet et al., 2016). As larger-bodied species are depleted, smaller-bodied species such as bushbabies (*Otolemur* spp., *Galago* spp. and *Galagoides* spp.) are targeted for consumption (Svensson et al., 2021). In addition, in areas heavily logged and mined for minerals and diamonds, the creation of small isolated or temporary settlements has resulted in unsustainable levels of wild meat hunting (Haurez et al., 2013). Across central Africa, the population density of apes in mined forests (45.3 to 126.3 nests/km^2) is two to four times below that reported in forested sites where mining is absent (185 to 299 nests/km^2) (Lanjouw, 2014). Similarly, wild meat hunting associated with the mining of coltan, tin, gold, and diamonds in the DRC is the main threat to Grauer’s gorilla (Mehlman, 2008), resulting in a 77% decline in its numbers, from 16,900 in 1995 to 3,800 in 2015 (Plumptre et al., 2015).

In the case of Indonesia, Asia’s primate-richest country, hunting and trapping are reported to affect all 65 of its native primate species. Similarly, the proportion of primate species that are hunted

and trapped in 16 of the 18 other Asian primate range countries varies from 95% to 100% (Figure 1; Supplementary Table S3). In southern Sumatra, Indonesia, and across much of Southeast Asia, the hunting and trapping of primates for wild meat has resulted in persistent killing of southern pig-tailed macaques (*Macaca nemestrina*) and long-tailed macaques (Hansen et al., 2021; Ruppert et al., 2022; Hansen et al., 2022b) to satisfy the demands of restaurants (Rashid et al., 2015). In Borneo, between 1,950 and 3,100 orangutans are reported to be killed annually for meat consumption (including 375–1550 females), significantly impacting the sustainability of numerous small, isolated populations as well as the entire species (Ancrenaz et al., 2016; Santika et al., 2017). On Dingat Island, Philippines, the hunting threat posed by miners resulted in a marked decrease in the population of Philippine tarsiers (*Carlito syrichta*) (Brown et al., 2014). Given that, compared to many other mammals, primates are characterized by a slow rate of natural population increase, their ability to recover from persistent hunting pressure is extremely limited (Jones, 2011; Pearson et al., 2014).

Primate use in traditional medicine

Primates feature prominently in the cultures, traditions, and belief systems of many Indigenous Peoples and non-Indigenous societies across the world (Cormier, 2003, 2006; Fuentes, 2012; Estrada et al., 2022). This status has afforded a small number of species (i.e. Hanuman langurs [*Semnopithecus schistaceus*] and rhesus macaques [*Macaca mulatta*] in Asia, ring-tailed lemurs [*Lemur catta*], Verreaux sifakas [*Propithecus verreauxi*] and Sclater's guenons [*Cercopithecus sclateri*] in Africa, and red-handed howler monkeys [*Alouatta belzebul*], red-faced spider monkeys [*Ateles paniscus*] and black-bearded sakis [*Chiropotes satanas*] in parts of Amazonia) protection from hunting because of taboos or their status as sacred beings or reincarnated ancestors (Cormier, 2003, 2006; Hill and Webber, 2010). However, for other primate species, their body parts (blood, organs, brains, meat, bile, fat, eyes, viscera) are used for traditional medicine and in ritual magic across their range (Alves et al., 2021).

Some 123 primate species are hunted for use in traditional medicine and ritual practices, with the majority of these species residing in Asia (40.1%) and Africa (35.8) (Supplementary Tables S1, S2, and S3). Presently, 61% (n=75) of primate species used in traditional medicine and for ritual, ceremonial, and magical purposes are listed by the IUCN as threatened (Supplementary Table S1, S2, and S3). Illnesses that primate body parts are reported to treat include impotency, respiratory problems, pain and inflammation, arthritis, mental illness, insomnia, poisoning, snake bite, fever, and to increase vitality and strength for men and pregnant women (Alves et al., 2013). In the American tropics, 29 primate species are reported to be used in traditional medicine or ritual magic (Supplementary Table S1). Thirteen (44.8%) of these species are threatened with extinction. This includes a taxonomically diverse set of both smaller-bodied (adult body mass ≤ 1 kg) and larger-bodied (adult body mass 6–9 kg) taxa (Supplementary Table S1).

In Africa, 43.2% of species used in traditional medicine are threatened. Data obtained from 95 traditional healers and animal medical traders in Benin indicate that 9 of 11 native primate species are used in traditional medicine (Sogbohossou et al., 2018). The most valued species are white-thighed colobus (*Colobus vellerosus*), vervets (*Chlorocebus pygerythrus*), and olive colobus (*Procolobus verus*). Most of these primates are hunted in national parks and protected forests (Sogbohossou et al., 2018), highlighting the difficulties associated with enforcing local hunting laws and safeguarding what, on paper, are protected populations (Sogbohossou et al., 2018). Svensson et al. (2015, 2021) report that across Africa, several species of galagos, pottos, and angwantibos are used in traditional medicine (Supplementary Table S2). In the case of the Nigerian-Cameroon chimpanzee (*Pan troglodytes ellioti*), with an estimated remaining wild population of ~6,000 individuals, use in traditional medicine is a contributing factor to their severe population decline (Oates et al., 2016).

In Asia, 86% of primate species used in traditional medicine are considered endangered (Supplementary Table S3). Among Asian countries, the demand for primates in traditional medicine in China remains particularly high. In their review of primates used in traditional medicine, Alves et al. (2010: 169) report that “gibbon bones are regarded as more valuable than any others in Chinese traditional medicine; Houzi cream is made from gibbon bones and is generally believed to cure arthritis and to accelerate recovery”. In parts of India, the hands, fingers, or skull of rhesus macaques are hung over the front door to guard against evil spirits (Alves et al., 2010). In Sri Lanka there are reports that the lungs and kidneys of toque macaques (*Macaca sinica*), when mixed with other components, are an effective aid in reducing swelling (Westwood, 2018). Moreover, these local residents believe that medicines derived from toque macaque organs have fewer side effects than those that occur when taking Western medicines. In this regard, many species of langurs are captured and killed to acquire bezoar stones (undigested calcareous concretions that form around fibrous material in the gut). These stones are used in traditional medicine as an antidote for poisoning, to cure fevers, to reduce bleeding, and to prevent depression and skin diseases. According to Barroso (2013), Hindus' use bezoar stones as elixirs “of life and vigour”. In many parts of southeast Asia, langur bezoar stones are so highly prized, they are valued as precious gems increasing the incentives for hunters to kill langurs (Barroso, 2013). Bezoar stones of Hose's langur (*Presbytis hosei*) in North Kalimantan sell for US\$20–30/gram (Nijman, 2005). Finally, In Cambodia, body parts of the endangered southern pygmy loris (*Nycticebus pygmaeus*) and the endangered Bengal slow loris are used to treat some 100 ailments (Starr et al., 2010).

Online trade and trafficking of primates

As of 2022, more than five billion people (ca 63% of the human population) across the globe have access to the Internet, providing unprecedented opportunities to connect buyers and sellers of wildlife and their body parts (Siriwat and Nijman, 2020;

Stringham et al., 2021; Hootsuite, 2022). Given the rapid expansion of the online trade and trafficking of primates as pets, researchers have relied on monitoring social media sites that serve as virtual pet shops as well as the accounts of individual sellers identified by primate photographs uploaded to their personal websites. A recent review of the online primate trade and trafficking found that both the Human Development Index (a composite measure of a country's standard of living and its ability to provide healthcare and education to its population) and the Internet Penetration Rate (percent of a country's population that use the internet) were positively related to how easy it was to purchase primates (Nijman et al., 2023). Despite explicit bans on selling globally threatened species, some social media sites continue to do so. For example in Mexico, a one-year study of nine Facebook groups identified 45 primates of 8 different species (four of these species were Endangered or Critically Endangered and six were not native to Mexico) for sale as pets (Salas-Picazo et al., 2023). In India, 250 posts requesting to sell or purchase slender lorises (*Loris* spp.) for use in traditional medicine or black magic were found over a one-year period on a popular website selling antiquities, minerals, plants, and animals believed to have magical properties (Morgan and Nijman, 2020). Similarly, Nijman et al. (2021) recorded 106 gibbons, 17 orangutans, and 4 chimpanzees for sale in Indonesia on five Facebook accounts and 19 Instagram accounts. Over a 17-month period, Siriwat et al. (2019) found primates for sale on seven Thai Facebook accounts, including 20 species from 9 families, totalling 380 individuals. Slow lorises (*Nycticebus* spp.) were the most commonly sold taxa, followed by macaques (*Macaca* spp.). These sites also advertised gibbons (*Hylobates* spp.), as well as monkeys native to the American tropics (marmosets, *Callithrix* spp. and squirrel monkeys, *Saimiri* spp.) for sale. Finally, primates are also sold on more traditional classified advertisement sites. For example, in Algeria and Morocco, nine barbary macaques were listed for sale on two different classified ad websites (Bergin et al., 2018; Atoussi et al., 2022).

Quantifying the number of primates portrayed as pets on social media and other web sites can be used as an index of the extent of the trade and trafficking of primates as pets. In this regard, over a one-month period, Nekaris et al. (2016) identified individuals of five species, including 122 slow lorises (*Nycticebus* spp., *Xanthonycticebus* spp.) portrayed as house pets on the video sharing platforms YouTube, Tudou, and Youku. Lorises are difficult to breed in captivity, and thus likely represent individuals captured in the wild. More than one-third of the videos were from Japan and Russia, where slow lorises are not native, and where no CITES records are available of their legal import, implying trafficking. Other primate species are more easily bred in captivity, and thus their appearance in online content is harder to classify as illegal or legal. For example, Nunes et al. (2023) found 1,138 videos on YouTube, and 39,000 posts on Instagram of capuchin monkeys (*Cebus* and *Sapajus*). In another study, Reuter and Schaefer (2017) examined hotel web sites in Madagascar, which often keep lemurs in cages to attract tourists. In a three-year period, they found 55 lemurs identified to 10 genera.

In the U.S., it is legal to own primates as a pet in 25 states (Norconk et al., 2023). A one year-study in the U.S. identified 551

pet primates legally reported as captive bred for sale, including marmosets, lemurs, capuchins, and squirrel monkeys (Seaboch and Cahoon, 2021). The extent of the legal primate pet trade in the U.S. has been partly attributed to the use of primates in movies, commercials, and via images and videos online. The more frequently primates are seen outside of their natural context, the less the public is likely to perceive that they are threatened with extinction in the wild (Ross et al., 2011). Taken together these studies reveal that regardless of whether a primate was legally or illegally purchased as a pet, the acceptance and normalization of primate imagery contributes to the demand fuelling the primate pet trade (Quarles et al., 2023). This has critical implications for primate welfare and conservation even when captions explain the context in which the image was taken (Freund et al., 2023).

Finally, a number of researchers and organizations have linked the primate pet trade to instances of online animal cruelty involving chimpanzees, capuchins, squirrel monkeys, lemurs, slow lorises, and macaques (Nekaris et al., 2016; Social Media Animal Cruelty Coalition [SMACC, 2021; Macaque Coalition [MACC, 2022; Carvalho et al., 2023). An even darker trend has emerged, largely focussed on long-tailed macaques, whereby online communities pay content providers (usually in the primate's range country) on demand for extremely violent content, including crushing, sexual abuse, and killing (SMACC, 2021; Carvalho et al., 2023). Platforms like YouTube create the entry point for providers, who then can direct interested parties to private encrypted accounts like Telegram Messenger, where this extreme violent torture can be viewed. Clearly, there must be legislation nationally and internationally to criminalize and prosecute these acts, which are not only inhumane, but also threaten wild populations as no captive breeding facilities exist for private use of long-tailed macaques (Badihi et al., 2024).

Primate use in biomedical research

For decades, wild primates have been captured and bred in captive colonies for use in pharmacological and biomedical research. Given the nature of the CITES dataset, however, it is difficult to precisely determine the full extent of this trade. This results from the fact that while the CITES trade database includes the category M (medical), live primates can also be imported for biomedical research under the categories S (scientific research) or T (commercial). These later two designations may be used interchangeably with M or when primates are imported by an intermediary company or unaccredited breeding facility and then later transferred to the biomedical industry. For example, the majority of macaques imported into the Netherlands during the period from 2004 through 2018 were imported under the T category, as the main importer was a trader who then sold the macaques for purposes of biomedical research (V. Nijman, unpubl. data). During the period from 2010 to 2022, approximately 19% of primates legally traded were listed under the category medical, 7% for scientific research, and 70% for commercial purposes (Badihi et al., 2024).

A consequence of the COVID-19 pandemic was that China suspended almost all wildlife exports, and this included their captive

long-tailed macaque breeding colonies, which contained an estimated 250,000 individuals (Gamalo et al., 2023; Kolby and Reaser, 2024). Between 2010 and 2018, China exported an average of 20,147 long-tailed macaques per year for biomedical research (total of 181,328 over this the 9-year period) (Hansen et al., 2022a). This accounted for 44% of the total worldwide export (CITES, 2023). In 2021, China was reported to have a captive breeding population of 300,000 primates, 80% of which were long-tailed macaques (Tian, 2021). Long-tailed macaques are listed by the IUCN as Endangered, and are reported to have experienced an 80% decrease in their population size over the past 35 years (Koch Liston et al., 2024). The pandemic-related reduction in the availability of captive-bred long-tailed macaques is alleged to have resulted in an increase in the importation of wild monkeys falsely labelled as captive bred and pathogen-free, a practice referred to as 'monkey laundering'. The use of wild-caught rather than pathogen-free primates jeopardizes wild populations and has the potential to invalidate or confound the results of biomedical research into vaccine and other therapeutic trials designed to prevent human diseases (Conroy, 2023; Grimm, 2023; Warne et al., 2023).

Breeding farms have played an essential role in producing primates used in biomedical research. It is crucial, however, to acknowledge that some primate breeding centers in range countries capture wild primates for general upkeep of their captive breeding populations (Hansen et al., 2021; Gamalo et al., 2023). At present, the EU and the US cannot breed a sufficient number of captive primates to satisfy the demands of their biomedical research communities (Grimm, 2023). This has resulted in the US importing some 32,000 long-tailed macaques yearly (Gamalo et al., 2023). A recent article by Grimm (2023) indicates that "the U.S. uses about 70,000 monkeys per year in studies of the brain, infectious disease, and aging; the EU about 5,000; and the U.K. about 2,000". This does not include primates used in other forms of research and in preclinical toxicology tests and proof of concept testing (Hansen et al., 2021; Gamalo et al., 2023; Grimm, 2023). Given the number of primates used in biomedical research and constraints on the captive supply, monkey laundering appears to be increasing (Gamalo et al., 2023). This requires expanded oversight by the biomedical industry to ensure that individuals labeled as captive bred are truly captive bred. Ending the use of wild-caught primates in biomedical and pharmaceutical research is imperative to protecting wild primate populations from extirpation and protecting human populations from disease transmission throughout the supply chain (IPS, 2023; IUCN et al., 2023; Badihi et al., 2024).

Risks of primate trade and trafficking to human communities

Criminal activity and corruption

Illegal supply chains and criminal trafficking networks operate both inside and outside of primate range regions (Wilson and Kurland, 2019; TRAFFIC, 2023). Many of these networks are also

involved with the illegal selling of weapons, drugs, antiquities, precious gems, and in promoting social conflict (Gore et al., 2023). This is an extremely complicated problem to solve due to differences in national laws, criminal penalties, as well as local and global attitudes about environmental security and biodiversity exploitation (INTERPOL-UN Environment, 2016). However, it is important to distinguish between those who engage in such activities to ensure food security for themselves and their families and those who traffic in primates purely for profit. Having this information can provide a roadmap to best incentivize sustainable alternatives, such as improved methods of food production and/or targeted subsidies or employment for former illegal hunters as rangers, conservation guards, and field guides (Gore et al., 2023).

Wildlife crime is generally perceived as a low-risk, high-profit enterprise by organized groups that target individual species because of their high monetary value. In the case of bonobos, chimpanzees and gorillas, criminal networks of illegal hunters, suppliers, dealers, wholesalers, and consumers form part of a multimillion-dollar industry to obtain live apes, their wild meat, and their body parts. The estimated average annual value of this trafficking is \$2.1 million to \$8.8 million USD (Clough and May, 2018). Recent UNODC World Wildlife Crime and TRAFFIC reports have noted that the perpetrators of international trafficking in live primates, use fraudulent export permits, and this would not be possible without the corrupt behavior of local officials who collaborate with national and international criminal syndicates (Broad et al., 2014; Clough and May, 2018; UNODC, 2020; TRAFFIC, 2023).

Corruption undermines democratic institutions, causes governmental and societal uncertainty, weakens public trust, motivates criminal activity, limits fair economic development, promotes inequality, weakens governments' ability to protect its citizens, contributes to poverty, social, and political unrest, and leads to policies and practices that promote deforestation, resource over-exploitation, and land grabbing (Maldonado and Lafon, 2017; Estrada et al., 2020). Corruption also facilitates the illegal exploitation of protected areas in the form of clandestine mining, logging, poaching and the trafficking of wildlife that may lead to local species extirpation (Murshed and Mredula, 2018; UNODC, 2020). In the regard, both the UNODC and the United Nations Environment Programme (UNEP) report that corruption is the most important factor enabling the trafficking of wildlife (UNODC, 2022).

Studies of primate trafficking indicate that arrests and prosecutions are rare. For example in Peru, of 176 wildlife trafficking cases presented to prosecutors, including many involving primates, only 3% resulted in a court appearance, and 44% of cases were never investigated (Shanee and Shanee, 2021). In 2020, Zimbabwean officials confiscated 25 juvenile primates of at least 4 species in the back of a truck entering from Zambia and bound for South Africa (Fobar, 2020). The four smugglers attempted to bribe the border officials, and were arrested. Nijman (2017) found that out of 440 arrests for orangutan trafficking in Indonesia between 1993 to 2016, only seven people were arrested and prosecuted (Nijman, 2017). Similarly, of 43 EU seizures of

primates or their body parts between 2013 and 2021, only 12 cases resulted in prison sentences.

International wildlife trafficking is largely facilitated by corruption in the air, sea, and land transport sectors. For example, at least 136 countries had at least one instance of wildlife trafficking in their airports between 2009 and 2017. In the case of mammals (whole or as body parts) confiscated at these airports, big cats were seized most (31%), followed by primates (20%) (ROUTES, 2018). The top 9 countries for mammal seizures at airports included 6 Asian nations (Asian countries accounted for 68% of airport seizures), two African countries, and the US (ROUTES, 2018). Moreover, the illicit funds obtained via illegal wildlife trafficking transit the world through the global financial system (Clough and May, 2018). Corporate sector involvement can occur within and outside country transit locations, when transportation workers knowingly launder plant and animal species and falsify official documentation (FinCEN, 2021). The financial trail left by these illegal activities is seldom investigated (Nijman et al., 2011). If we are to reduce wildlife trafficking, it must be considered a transnational criminal activity of the highest concern and hence counter measures, including the reporting of suspected financial transactions are needed (FATF, 2021; FinCEN, 2021; TRAFFIC, 2023). Other possible counter measures include working with airlines and logistics companies to use AI to identify international smuggling, connecting with tech giants to eradicate trafficking on social media, and improved data tracking by national governments and transnational organizations (SMACC, 2023; Weissgold, 2024). Partnering with the business community in the fight against wildlife crime may prove to be an effective way to reduce wildlife trafficking and enforce compliance with local and international laws (FATF, 2021; FinCEN, 2021).

Zoonotic spillover and biosecurity

Increased spatial overlap among humans, domesticated animals, and wild animals raises the risk of pathogen exchange (Cooper and Nunn, 2013; Nunn et al., 2016; Morand and Lajunie, 2021; Gamalo et al., 2023). This is exacerbated by widespread wildlife trade and trafficking, which exposes hunters, primate trappers, local market sellers, pet traders, researchers, and end consumers to novel viruses and pathogens. Wild primates are host reservoirs of bacteria, helminths, protozoa, retroviruses, and viruses such as the simian immunodeficiency virus, HIV/AIDS, simian-T-lymphotrophic virus, adult T-cell leukaemia (HTLV-1), and simian foamy virus (Barré-Sinoussi et al., 1983; Cooper and Nunn, 2013; Devaux et al., 2019). Examples of pathogen exchange between humans and African great apes include outbreaks of Ebola and the global HIV/AIDS pandemic (Calvignac-Spencer et al., 2012), cross-species transmission of diarrhea causing enteric pathogens between humans and lemurs inhabiting anthropogenic landscapes (Bublitz et al., 2015), *Cryptosporidium* parasite infections between humans and chimpanzees (*Pan troglodytes*) (Parsons et al., 2015), yellow fever (*Flavivirus* spp.) outbreaks affecting lion tamarins, marmosets, howler monkeys, titi monkeys, capuchins, and humans in Brazil and Argentina (Bicca-

Marques and de Freitas, 2010; de Azevedo Fernandes et al., 2017; Dietz et al., 2019; Berthet et al., 2021; Possamai et al., 2022), and the increased prevalence of malaria-carrying mosquitos (*Plasmodium knowlesi*) in urban areas inhabited by long-tailed macaques, southern pig-tailed macaques, and humans in Borneo (Yunos et al., 2022). In this later case, anthropogenic modifications to the natural environment have resulted in an expanding public health threat associated with an increase in malarial infections. Macaques serve as hosts for the malarial parasite, *Plasmodium knowles*. The movement of people into forested areas traditionally inhabited by the macaques "...expose them to wild macaques and mosquitoes that feed on these animals, resulting in potential zoonoses" (Yunos et al., 2022).

Similarly, primates that escape or are released from the pet trade or sanctuaries can carry pathogens with a potential of transmission to resident human and nonhuman primate populations (Karesh et al., 2005; Sherman et al., 2021; Zhang et al., 2022). Trafficked animals are rarely tested for the presence of pathogens, and significant mortality has been reported in animals during transport or shortly after arrival at their destination (Maher and Sollund, 2016). Despite the fact that primates host numerous viral diseases potentially infectious to humans, only limited effort has been made to end the sale of primates as pets (Devaux et al., 2019; Norconk et al., 2023; Mendoza et al., 2024). Pathogen exchange between humans and primates also can occur in laboratories, even after the post-quarantine period (Badihi et al., 2024). Policies that follow an integrated One Health approach (i.e. acknowledging that the health of humans, wild and domesticated animals, and the environment are interconnected; Zinsstag et al., 2005) are needed to prevent future pandemics and a zoonotic disease event that could result in the extinction of a large number of primate species (Adisasmito et al., 2022; Markotter et al., 2023).

Food security

The World Food Summit (1996) stated that "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". For more than one billion people in tropical nations, the natural environment is the leading source of food, energy, and clean water. Consequently, food security depends on well-functioning ecosystems (Food and Agriculture Organization of the United Nations (FAO), 2022; Jouzi et al., 2022; World Health Organization (WHO), 2022). Wild meat is a vital protein source and a key contributor to the food security of millions of people across primate range regions (Fa et al., 2003; Brashares et al., 2011; Cawthorn and Hoffman, 2015). Trafficking in wildlife leading to unsustainable hunting and trapping, along with expanding anthropogenic habitat conversion, deplete animal populations with far-reaching consequences for peoples' food security, livelihoods and for biodiversity conservation (Fa et al., 2003; Brashares et al., 2004).

The 2022 Global Food Security Index (GFSI) of The Economist Intelligence Unit Limited, is an internationally accepted standard used to assess the level of food security. The GFSI integrates the core

issues of affordability, availability, quality, sustainability, and safety to assess the drivers of food security in developing and developed countries. The index also considers a country's exposure to the impacts of climate change, its susceptibility to natural resource risks, and how the country is adapting to these risks. The GFSI ranges from zero (lowest food security) to 100 (highest food security) (<https://foodsecurityindex.eiu.com/Index>). Among primate range countries, African nations are reported to have the lowest 2022 GFSI (mean FSI = 46.7; range 40.5–61.7; $n = 27$) (Table 1) followed by Asian nations (mean FSI = 61.7; range 52.2–79.5; $n = 16$), and those of the American tropics (mean FSI = 63.1; range 42.6–77.4; $n = 14$). GFSI values indicate that as the international demand for wild live primates, their meat, and other body parts has continued to increase, the majority of people in primate range nations have remained food insecure (Table 1). In this regard, there exists a negative correlation between a country's food security index and the proportion of its primate species threatened by hunting and trapping.

Discussion

The commercialized trading and trafficking of live vertebrates and their body parts, annually represents an estimated 8–21 billion USD transnational industry that contributes to food insecurity, increased risks of zoonotic spillover, is unsustainable for primate survival, and remains a primary driver of wildlife and natural ecosystem decline worldwide (Scheffers et al., 2019; Gore et al., 2023). And, while much of the focus has remained on primate range countries, the role of wealthy countries as consumers and drivers of wildlife trade and trafficking has not received sufficient attention (van Uhm, 2016; Halbwax, 2020; Gamalo et al., 2023; van Uhm, 2023).

The academic literature on trafficking, enforcement, and corruption, has tended to focus predominantly on source countries, with limited information provided on the mitigating measures that need to be taken by those nations and regions where the demand for wildlife is high. Media reports also tend to focus on exporters instead of importers, thereby misrepresenting the drivers of trade and trafficking (Svensson et al., 2023). At the same time, voices calling for solutions based on sustainable livelihoods in range countries and a reduction in global demand are often marginalized (Massé et al., 2020; Hughes et al., 2023; van Uhm, 2023). Even in the face of more effective law enforcement, a greater commitment to community-based conservation, and expanding opportunities for sustainable economic alternatives to reduce local hunting pressure and increase food security across primate range countries, a significant reduction in the demand for live wild primates and their body parts by consumer nations is required (Supriatna and Ario, 2015; Shanee et al., 2018; Gamalo et al., 2023). Currently, all 17 primate families are heavily traded/trafficked (Scheffers et al., 2019, Supplementary Tables S1–S3) and 94% of primate species, for which data are available, have declining populations (IUCN RedList, 2023 checked December 25, 2023). Only two of 521 primate species, the Cat Ba langur (*Trachypithecus poliocephalus*, Critically Endangered) and the hamadryas baboon

(*Papio hamadryas*, Least Concern) are reported by the IUCN to have increasing populations (IUCN RedList, 2023). If we are to avoid a mass primate extinction event, immediate action must be taken to severely limit the unsustainable trading and trafficking of wild primates. This includes species that are currently listed as threatened (Vulnerable, Endangered, or Critically Endangered), as well as species not currently listed as threatened but that have declining and highly fragmented populations. This is due to the fact that as a species becomes rarer, both its perceived traffic and trade value and demand increase (Scheffers et al., 2019).

Recommendations

A first step in identifying sustainable solutions to reduce primate trade and trafficking, is working with concerned local, national, and international partners to develop culturally and economically appropriate policies that view primates as having a greater societal 'value' when thriving in their natural environment, than as pets, trophies, part of the commercialized wild meat industry, or exploited in videos and social media (Cardoso et al., 2021). In this regard, we encourage national and international primate societies, NGOs, global citizens, and governmental agencies worldwide to work collaboratively to create knowledge sharing and behavioral programs that are designed to educate and change the public perception of primates, end the portrayal of primates as suitable pets, discourage wild primate meat consumption by people who have access to other sources of protein, and work towards removing primate entertainment/cruelty videos from the internet and mass media (Norconk et al., 2020; Aldrich et al., 2023; Norconk et al., 2023). Movie and social media companies hold great power and responsibility in ending the use of primates as online entertainment (SMACC, 2023). We call on all social media, movie, and Internet companies (You Tube, Facebook, X, Instagram, Tik Tok, Telegram, Google, Amazon, and others) to implement and enforce strict regulations for the protection of primates and other wildlife exploited online. We ask governments to enact legislation that facilitates the prosecution of online service providers who violate laws protecting animals. A model for such legislation is the 2023 United Kingdom's Online Safety Act (Online Safety Act, 2023).

Additional counter measures required to reduce international wildlife trafficking include more severe criminal penalties, prioritized monitoring of suspected financial interactions by banks and the International Monetary fund (FATF, 2021; FinCEN, 2021), and support from airlines and logistics companies to identify and combat international smuggling. Partnering with the international business community in the fight against wildlife crime may prove to be a crucial tool in protecting wild primate populations (FATF, 2021; FinCEN, 2021). Knowledge sharing and transparency between law enforcement, the business community, scientists, NGOs, primate breeding and research centers, and primatological societies can aid in identifying regions and species of immediate and future concern, illegal networks, as well as country-specific actions that must be taken to prevent species

loss. This could include making it illegal for restaurants to serve primate meat, boycotting businesses that use captive primates for entertainment, and increasing investment in programs that promote food security and access to healthcare for the poor across primate range countries (Ratompouarison et al., 2023).

Given the role that primates have played historically in the development of vaccines, therapies, and in modeling chronic and infectious human diseases, along with recent advances in gene editing (Phillips et al., 2014; Havel et al., 2017), their use in biomedical research may continue, even in those instances in which equally valid alternatives are available (Burm et al., 2014). Therefore, whenever possible, we urge the biomedical community to actively promote the use of alternatives to primate models and to take the necessary and transparent measures needed to ensure that wild-caught primates are never included in their research (Carvalho et al., 2018; Conroy, 2023; IUCN et al., 2023). This includes requiring regular inspections and auditing of breeding facilities and suppliers and genotyping of all primates used in biomedical research to authenticate parentage and their captive-bred status (Conroy, 2023). Given that large numbers of primates have been removed from the wild to create breeding colonies to supply the biomedical and pharmacological industries, we argue that these industries have a responsibility to prioritize funding conservation initiatives that serve to protect and expand primate habitats through forest restoration, increase wild primate population size, and promote positive interactions between local human and nonhuman primate communities.

In conclusion, the unsustainable trade and trafficking of wild primates and their body parts for meat, traditional medicine, biomedical research, and pets are taxonomically widespread, occur across both primate and non-primate regions, and represent major drivers of primate population decline (Supplementary Tables S1–S3). Moreover, trade and trafficking negatively impact ecosystem health and function, and increase the risk of zoonotic spillover across every sector of the supply chain, making it arguably among the most costly and serious of transnational activities (Doody et al., 2021). Currently, primates are the most taxonomically diverse threatened Order of mammals, with 69% of species listed as Vulnerable, Endangered, or Critically Endangered (IUCN RedList, 2023). In combination with deforestation, industrial agriculture, cattle ranching, mining, fossil fuel exploration, the expansion of road and rail networks, urban development, an increasing human footprint, and climate change (Estrada et al., 2017, 2019, 2020, 2022), the trade and trafficking of wild primates results in their pain, suffering, social isolation, and death, and is moving us towards a mass primate extinction event by the end of the century. If we are to save primates, their habitats, and local human communities who depend on primates and their ecosystem services, the time to act is now!

Author contributions

PAG: Writing – review & editing, Writing – original draft, Data curation, Conceptualization. AE: Validation, Writing – review &

editing, Writing – original draft, Funding acquisition, Data curation, Conceptualization. SS: Writing – review & editing, Writing – original draft, Data curation, Conceptualization. MS: Writing – review & editing, Writing – original draft, Conceptualization. LV: Writing – review & editing, Writing – original draft, Data curation. VN: Writing – review & editing, Writing – original draft, Data curation. NS: Writing – review & editing, Writing – original draft, Data curation. SG: Writing – review & editing, Writing – original draft, Data curation. KN: Writing – review & editing, Writing – original draft, Data curation. AC: Writing – review & editing, Writing – original draft, Data curation. JCBM: Writing – review & editing, Writing – original draft, Data curation. MH: Writing – review & editing, Writing – original draft, Data curation.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fcosc.2024.1400613/full#supplementary-material>

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