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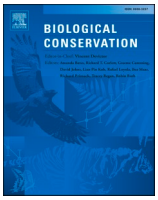

Scientists' warning to humanity on illegal or unsustainable wildlife trade

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ABSTRACT

Illegal or unsustainable wildlife trade is growing at a global level, threatening the traded species and coexisting biota, and promoting the spread of invasive species. From the loss of ecosystem services to diseases transmitted from wildlife to humans, or connections with major organized crime networks and disruption of local to global economies, its ramifications are pervading our daily lives and perniciously affecting our well-being. Here we build on the manifesto 'World Scientists' Warning to Humanity, issued by the Alliance of World Scientists. As a group of researchers deeply concerned about the consequences of illegal or unsustainable wildlife trade, we review and highlight how these can negatively impact species, ecosystems, and society. We appeal for urgent action to close key knowledge gaps and regulate wildlife trade more stringently.

1. Introduction

Wildlife trade permeates the tree of life (Fukushima et al., 2020). While the definition of wildlife is often limited to non-domesticated animals with perception dominated by terrestrial vertebrates, there is increasing awareness that wild uncultivated aquatic vertebrates, invertebrates, plants and fungi are also part of a broader concept of wildlife and deserve equal conservation focus (Wandersee and Schussler, 1999; Cardoso et al., 2011, 2020; Gonçalves et al., 2021). We therefore adopted the broader definition of wildlife here. The scale is immense and increasing (Harfoot et al., 2018), whereby trade in wild vertebrates is estimated to involve a quarter of terrestrial species (Scheffers et al., 2019), while the trade in invertebrates, plants, and fungi remains considerably overlooked and poorly documented (Fukushima et al., 2020). The drivers of wildlife trade are diverse, from pet ownership, collections, and exhibitions, to derived products, including food, medicine, decoration, fuel, or construction (Scheffers et al., 2019; Andersson et al., 2021).

Sustainability is a concern in wildlife trade. Positive examples and practices exist and should be promoted (Fukushima et al., 2021). From

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certification of traditional or sustainable practices (Kasterine and Lichtenstein, 2018; Gutiérrez et al., 2012), to captive breeding and artificial propagation contributing to fulfil market demand (Šetlíková and Berec, 2020), different approaches have been adopted aiming to improve sustainability of trade. In this warning and review we do not focus on such practices, but on the large remaining fraction of wildlife trade that is either illegal or unsustainable, even both. However, it is necessary to point out that some of the impacts discussed here, such as the spread of diseases and invasive species, can occur due to the lack of proper regulation or enforcement even in cases where the trade of wildlife is legal and sustainable.

Given its ubiquity, illegal or unsustainable wildlife trade (hereafter IUWT), represents one of the five major drivers of biodiversity loss and extinction at global scale (IPBES, 2019). While its effects remain unquantified for most taxa, IUWT, including wild harvesting and fishing, and forestry targeting uncultivated plants, is known to have caused major population declines in many species (Morton et al., 2021). Yet, the effects on targeted species are only the tip of the iceberg, repercussions reaching much beyond, and negatively affecting ecosystems and society in less predictable ways (Fig. 1).

Here we build on the manifesto World Scientists' Warning to Humanity, issued by the Union of Concerned Scientists (1992) and re-

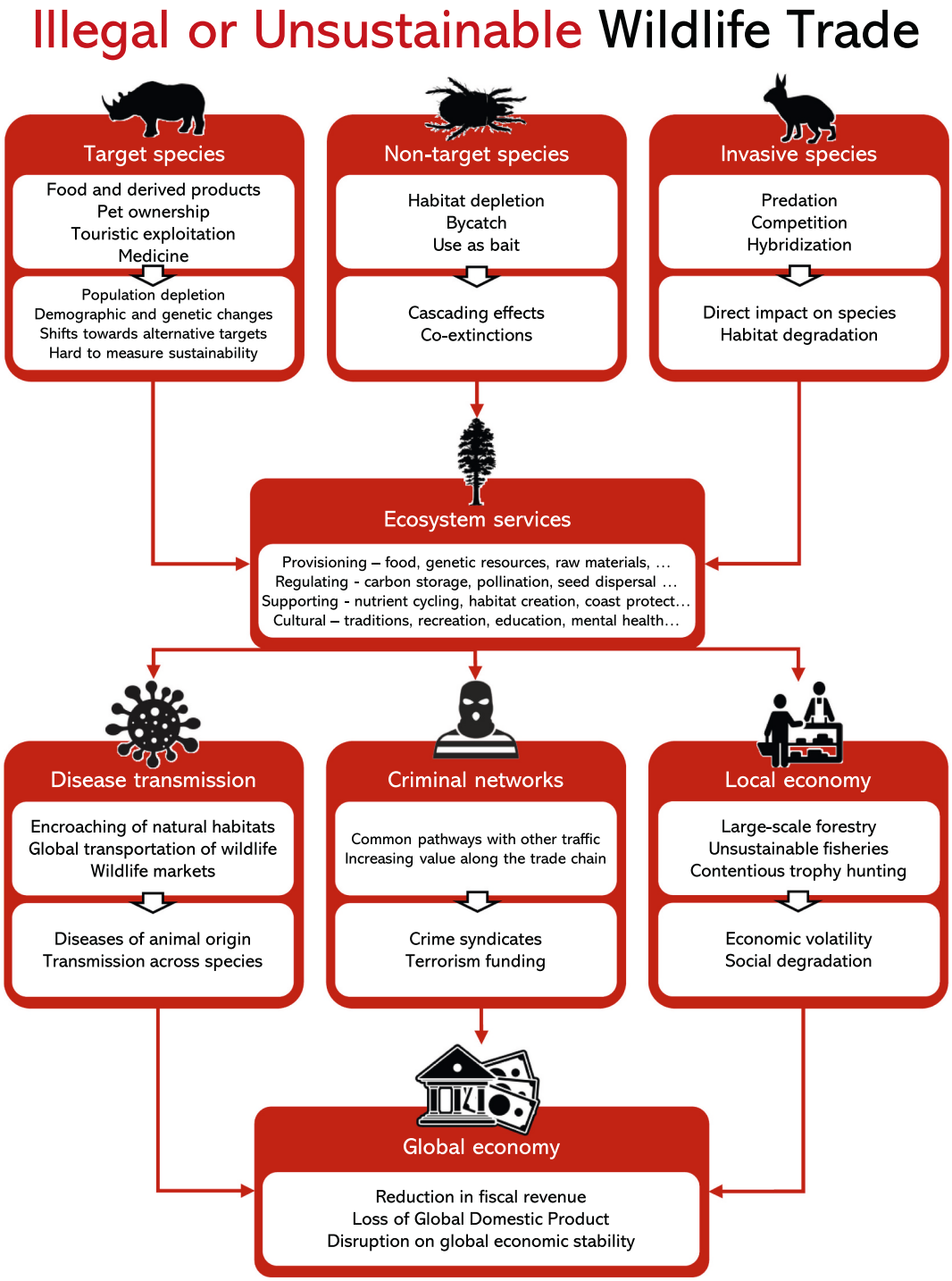

Fig. 1. Summary of the discussed causes and effects of illegal or unsustainable wildlife trade on species, ecosystems, and society.

issued 25 years later by the Alliance of World Scientists (Ripple et al., 2017). We are a group of biologists, activists, enforcers, and other stakeholders from across the world that together see the urgent need for cooperation between actors and disciplines to regulate wildlife trade and curb its negative consequences, for both ecosystems and humanity. We review what is known about the consequences of IUWT to species, ecosystems, and societies, and end with a call to action.

2. Impacts on the target species

The most direct effect of trade on species is population depletion. It is estimated that 61.6% of the traded bird, mammal and reptile species show a decline in abundance, with 16.4% already facing local extirpations (Morton et al., 2021). The pressure of the increasing market value for several fish has had visible effects on many wild populations, especially those that depend on spawning aggregations, leading to loss of formerly healthy populations. Groupers, for example, are heavily fished worldwide and many wild stocks are now depleted (Sadovy de Mitcheson et al., 2020). The intensification of both illegal and legal shark finning and fishing throughout the world's oceans are causing the demise of several shark species that were once abundant (Worm et al., 2013). The totoaba (*Totoaba macdonaldi*), is extensively fished in Mexico, and is now Critically Endangered due to the value of its swim bladder, considered a delicacy in China (Jaramillo-Legorreta et al., 2019). IUWT is also leading to declines in many invertebrate populations, although these were rarely quantified (Fukushima et al., 2020). Among plants, ~15,000 species used and often traded as medicinals are currently threatened with extinction (Schippmann et al., 2006), while many fungi are seen to have great potential for further exploitation (Hyde et al., 2019). Furthermore, the large numbers of individuals recorded in the trade usually do not reflect the mortality between harvest and destination, which can occur at high rates along the trade chain (Auliya et al., 2016).

Demographic and genetic changes are commonly reported (Crespo and Dunn, 2017). Over-exploitation can ultimately lead to a reduction in genetic diversity and to inbreeding depression of targeted populations. This impact can be even more dramatic when hunters and consumers target specific individuals with desirable characteristics, i.e., certain colour variations, sizes, sex, or life stage.

Worryingly, a common consequence of over-exploitation is that, after the decline of the most desired species, the harvest often shifts towards complementary, smaller-bodied or look-alike species to fulfil the market niche, a pattern detected for both aquatic and terrestrial animals (Anderson et al., 2008; Braga-Pereira et al., 2020), and likely also applies for plants and fungi.

Much of the global trade is in live animals as pets. Within a six-year timeframe over 1.36 billion individuals were imported into the US solely to supply the pet market (Smith et al., 2009). As most countries have no accounting besides for select species listed in CITES with 16.75 million trade records over 40 years (Harfoot et al., 2018), global unreported numbers could be several times higher.

Other economic activities, such as tourism, can also stimulate IUWT. Shells and conchs from molluscs or arthropods in pinned displays are widely sold as souvenirs or jewelry, while live animals can be used as tourist attractions for interaction in photographic and sales opportunities (Osterberg and Nekaris, 2015).

Among the derived products, wild-sourced timber is by far the most traded wildlife commodity globally (World Bank, 2019), used variously for building, fuel, furniture and instruments, and where even selective extraction can lead to wider habitat access and damage. Industrial wild fisheries are responsible for the decline of numerous aquatic animal species worldwide (Pauly et al., 1998), although recent management efforts seem to be reversing the trend (Hilborn et al., 2020). Wild meat also stands out as a widely consumed and traded product worldwide, with at least 8563 t traded annually in the Central Amazon (El Bizri et al., 2020).

The trade of medicine has received some attention from an ethnozoological perspective. At least 50,000 plant, 584 animal and 700 fungal species are reported to be used and often traded for medicine worldwide, including pangolin scales, rhino horn and all kinds of medicinal plants (Alves et al., 2013; Chen et al., 2016; Hyde et al., 2019). Responsible harvesting practices are often still lacking, plus failure to address concerns about efficacy of farmed alternatives.

Guaranteeing the sustainability of this global market is challenging at best. Data on wild populations are often limited and key life-history traits are hard to quantify if robust surveys are lacking (Martin, 2018; Annorbah et al., 2016). Traders rarely supply evidence of sustainability of the catch, putting the burden on any regulator, which often has no capacity for adequate assessment (Macdonald et al., 2021).

3. Impacts on non-target species

With each species traded, comes a cascade of incidental effects on other species within impacted ecosystems. Overharvesting of wildlife can lead to disrupted interspecific interactions and ecosystem structure, altering species composition, functioning and services such as seed dispersal, pollination, and carbon storage (Costanza et al., 2017; Gardner et al., 2019). In wild marine fisheries, bottom trawling and dredging affect benthic species composition, most non-targeted, and modify the sea floor in ways similar to intensive land agriculture (Puig et al., 2012; Watling and Norse, 1998).

Bycatch often corresponds to more than 80% of marine catches, which are either dumped or sold illegally (Diamond, 2004; Davies et al., 2009). Intensive fishing pressure negatively affects diverse species ranging from mammals to jellyfish and non-target fish species or sizes (Davies et al., 2009). For example, the population of the vaquita (*Phocoena sinus*) declined by 98.6% between 2011 and 2019, with an estimated population size of 18 adults in 2019, because of bycatch in gillnets intended for the totoaba (Jaramillo-Legorreta et al., 2019). The vaquita will probably become, very soon, the second species of cetacean to become extinct due to anthropogenic activities, illegal fisheries with bycatch in this case. In the terrestrial realm, off-target species are susceptible to various techniques used by hunters. For example, the use of snares to capture tigers has the unintended consequence of rising mortality of the Malayan tapir (Campbell et al., 2019). Finally, certain species are not directly targeted by trade but are deliberately harvested for bait (Tavares et al., 2020).

Many species also provide habitat for others and their loss results in habitat depletion. Timber is the most important commercialized wildlife product in terms of money generated and volume (World Bank, 2019). Deforestation leads to the loss of extensive habitat for many species (Putz et al., 2008). Logging activities can also cause damage to neighbouring plant species and disrupt stream (Lunn et al., 2017) and soil communities (Cardenas et al., 2018). Bromeliads and their aquatic micro ecosystems can host diverse and specialised assemblages of many animal life stages (Ladino et al., 2019) and thus their harvest for ornamental markets can threaten many dependent taxa (Negrelle et al., 2012). Specialisation of parasites, epizoic mutualists, or commensals like some coprophages are especially vulnerable to co-extinction (Dunn et al., 2009).

4. Spread of invasive species

Wildlife trade can also impact the area where traded species are introduced. Invasive species cost up to an estimated US$162.7 billion/year (Diagne et al., 2021). Wildlife trade-facilitated invasions include snakes introduced in Florida (Capinha et al., 2017), trout species around the globe (Crawford and Muir, 2008), and pine trees in many austral countries (e.g., Richardson et al., 1994). The release probability is biased towards specific species traits, such as large adult mass and low market value (Stringham and Lockwood, 2018). Moreover, live pet and ornamental plant traders tend to prefer more resilient species that can be

invasive (Humair et al., 2015; Gippet and Bertelsmeier, 2021). Some of the most significant impacts of wildlife trade of invasive species are on ecosystem services, which can suffer massive losses due to regime shifts and trophic cascades (see review in Pyšek et al., 2020).

On islands specifically, the deliberate or accidental introduction of predators in previously large-predator-free territories has caused havoc on the native systems, in extreme cases causing the extinction of native species (e.g., Bellard et al., 2016a).

Alien species can compete with native species for resources. Some ornamental plants displace native plants from natural habitats where introduced (e.g., Piqueray et al., 2008). Such changes can also have direct or indirect effects on the fauna, from insects to vertebrates (e.g., Aravind et al., 2010; Borges et al., 2020). The Lake Titicaca endemic fish *Orestias cuvieri* is reportedly extinct (Villwock, 1972). This process was apparently caused by the introduction in this alpine lake of the North American Great Lakes trout *Salvelinus namaycush* in 1937. This trout has itself been severely depleted in its original habitat by introduced sea lampreys (Schneider et al., 1996). Due to legal trade, many endemic inland fish throughout the world are considered already extinct or critically endangered.

Hybridisation has often been observed between closely related native and alien species. A series of cases exist from traded birds where either escapees, or deliberate releases (including as 'mercy' for religious merit, fortune, etc.) have resulted in either hybridization or out-competition to closely related natives (Eaton et al., 2015). For example, the introduction of the mallard to New Zealand has led to the local extinction of pure stock for a native congener (Tracey et al., 2008).

The species traded can carry unwanted hitchhikers when transported (Sinclair et al., 2020), such as pest arthropods, parasites, and pathogens. Notably many invasive insects have traceable sources to traded plants (plus their soils) or their derivatives (i.e., lumber, packing). In the United States, invasive forest pests cause massive damages for timber producers, property owners, and governments (Lovett et al., 2016). Elsewhere, an Iberian millipede has been introduced to islands around the world, probably with soil or plants on ships, with major consequences on the community structure of native habitats (Borges et al., 2020). Furthermore, the ornamental plant trade has been associated with accelerated spread of invasive weeds in Australia (Coleman et al., 2011).

5. Loss of ecosystem services

All life likely contributes in one way or another to ecosystem services as defined by the Millennium Ecosystem Assessment (2003): i.e., the benefits people obtain from ecosystems, subdivided into i) provisioning services, ii) supporting services, iii) regulating services, and iv) cultural services (see Costanza et al., 2017). From the largest trees that supply oxygen and act as carbon sinks, to the many tiny insects that pollinate, decompose organic matter, or predate others, one can find examples of species that are traded worldwide and whose declines affect ecosystem services on which humanity depends. Costanza et al. (2014) estimated a global net loss of US$20.2 trillion in annual ecosystem services, mainly due to logging and consequent habitat loss (World Bank, 2019).

Wildlife trade can be also considered an ecosystem service itself and we note here that the illegal and unsustainable trade may also threaten the provision of this service, in addition to the other ecosystem services mentioned in this study. We also acknowledge that the link between wildlife and ecosystem services loss is yet indirect, meaning that further studies are needed for many species and populations to prove and explain this cascading effect. Nevertheless, numerous examples exist and have been quantified. Provisioning services are the tangible products that people obtain from ecosystems. Deforestation and overfishing lead to the loss of raw materials and food sources, either realized or potential in the form of genetic resources (Link and Watson, 2019). Pharmacological resources can also be lost due to IUWT. For example, some spiders or scorpions with interesting venom properties for medicine or insecticidal development (Lüddecke et al., 2019) are being adversely affected by ongoing trade which may hasten their extinction (Zamani et al., 2021).

Regulating services allow ecosystems to maintain a delicate balance. The loss of many forests due to logging influences carbon storage, water filtration and climate regulation (Edwards et al., 2014). Pollination, biological control, and seed dispersal are affected by the decline in numerous animal species affected by IUWT. For example, African forest elephants (Campos-Arceiz and Blake, 2011) and the Asian hornbills (Kitamura, 2011) are important seed-dispersers, both with populations greatly impacted by hunting.

Supporting services create the necessary conditions for other species to survive. Many traded species participate in nutrient or soil cycling, serve as food, or create habitat for other species (Edwards et al., 2014). Harvesting of coral reef organisms can lead to decreasing coastal protection and of suitable conditions for seagrass beds and mangroves (Moberg and Folke, 1999).

Cultural services are non-material benefits to humans. Hunting, fishing and the general lack of well monitored Protected Areas impact ecotourism (Dellink and Ruijs, 2008). Deforestation of pristine areas reduces capacity for recreation, education, and mental health benefits (Bratman et al., 2019). Among local people in some African and South American countries, specific species are used in traditional cultural festivities and celebrations with some attachments of animals to their origins (Alves and Barboza, 2018). The use of animal totems continues to exist and the loss of such species could mean the loss of cultural identities and traditions.

6. Disease transmission

Two-thirds of emerging infectious disease outbreaks affecting humans, many leading to pandemics, have zoonotic origins (Jones et al., 2008; Smith et al., 2014). Of these, the majority originate in wildlife (Jones et al., 2008). HIV, H1N1, H5N1, MERS, Ebola, and many variants of SARS, possibly including those causing COVID-19, are only the best known zoonoses encompassing thousands of outbreaks, with enormous detriment to global health and the economy (Smith et al., 2014). Zoonoses cause around one billion cases of illnesses and millions of human deaths every year (Karesh et al., 2012). These staggering numbers are likely on the rise due to increasing urban population density and long-distance travel facilitating spread (Jones et al., 2008).

Encroachment in natural habitats together with pressure from hunting and IUWT increases contact between humans and wild animals and ultimately facilitates disease transmission. As much as one third of zoonoses are related to human encroachment, i.e., intrusion beyond acceptable levels, through facilitation of wildlife trade (Allen et al., 2017). There is also evidence that mammalian wildlife threatened by IUWT have an increased zoonotic disease spillover to humans (Johnson et al., 2020). Recently, Morand and Lajaunie (2021) presented support at the global level for important links between human-driven changes in forest cover and outbreaks of zoonotic and vector-borne diseases.

The global transportation of wildlife and their display in markets break geographical and ecological barriers between species that would not be in contact in nature. The risks of zoonotic spill-over are increased in markets without proper veterinary and hygiene measures (Cantlay et al., 2017), where large numbers of people conduct activities in close contact with stressed and often immunosuppressed live animals that are usually kept in dense and unhealthy conditions (Gao et al., 2016). In such situations, there may even be amplification of pathogen prevalence along the trade chain (Huong et al., 2020). Interspecies transmission is not limited to vertebrates, as for example zoonotic rat lungworm (angiostrongyliasis) parasites can be hosted by centipedes and transmitted to humans consuming them raw as medicine (Wang et al., 2018); others can be transmitted from Giant African snails consumed as food (Pavanelli et al., 2017).

In addition to humans, wildlife trade can facilitate the transmission

of diseases across other species and geographical areas. Alien and invasive species have often contributed to emerging infectious diseases both directly and indirectly (Ogden et al., 2019). Diseases or their invasive hosts can cross geographic barriers via human aided pathways or due to anthropogenic environmental change. The distribution of chytrid fungi, a disease threatening one quarter of all red listed amphibian species (Bellard et al., 2016b), and implicated in several extinctions, is attributed to the trade of live amphibians (Scheele et al., 2019). Beak and Feather Disease Virus, which causes a disease profoundly affecting an assortment of birds globally and negatively impacting some wild populations of threatened parrots is now widespread because of the global parrot trade (Fogell et al., 2018).

7. Criminal networks

Not only does IUWT have negative ecological consequences, but it is also detrimental to societies as it undermines the rule of law. Offenders engage in wildlife crime for different reasons, ranging from profit or commercial gain, to thrill or sport, necessity of acquiring food, antipathy towards civil authorities, and for traditional, social, or cultural reasons (Nurse, 2011; Moneron et al., 2020). Despite the real and potential impacts, some governments and international bodies continue to treat IUWT purely as a conservation problem, managed and financed separately from other anti-crime activities, and without considering its serious economic, health and security ramifications (Peters, 2017). Law enforcement bodies may not yet make a long-lasting impact by failing to fully target trafficking networks or disrupt the illicit financial flows, but in many countries instead focusing on the often-impoverished people who harvest wildlife (Peters, 2017).

In the past, wildlife crime was generally seen as a small-scale local activity in which comparably few targets would be smuggled by collectors or opportunists, usually for subsistence reasons. Nowadays, criminal networks with a wide range of motivations, organization, sophistication, and operating practices dominate the wildlife market in several areas (Wyatt et al., 2020). High profit margins, low risk compared to that for other illegal goods such as narcotics or weapons, relatively small penalties and minimal consequences are incentives to engage in wildlife crime (Ratchford et al., 2013; Harrison et al., 2015).

Well-entrenched organized crime syndicates have diversified into wildlife crime, including hardwood timber, ivory, rhino horn and pangolin scales (van Uhm and Nijman, 2020). Such crime syndicates with the capacity and connections to smuggle multi-ton shipments across continents are sometimes also key players in the trafficking of other contraband like narcotics, weapons, and humans. However, in the fight to save iconic wildlife species from extinction or their dwindling habitats, scant attention – either investigative or scholarly – has been paid to these powerful syndicates.

On a smaller scale, wildlife crime also intersects with another security challenge: the insurgents and sometimes terrorist groups, that are controlling areas outside of national government control (Kiser, 2013; Barron, 2015). These groups are reportedly poaching, usually at a relatively small scale, and appear to sell wildlife products they obtain to syndicates involved in export (Roberts, 2021).

Seizure records have shown that smuggling techniques are diverse. Corporations and businesses can blend illegal wildlife trade into their legal infrastructure to launder wildlife. Otherwise, legitimate animal suppliers and breeders, zoos, circuses, antique shops, and fashion companies can either deliberately or unknowingly conceal the illegal origin of wildlife, declare it as legal to get a fraudulent document or permit about its origin, laundering illegal trade (Wyatt, 2013; Wyatt et al., 2020). Further techniques involve false labelling of products, the use of prepared baggage or smuggling on person (Alacs and Georges, 2008), or paying bribes to enforcement personnel (Musing et al., 2019).

Investigations have also revealed that values differ along the trade chain (Kurland et al., 2017), but often most profit is earned near the end of the chain, either by exporters or final sellers. These trade chains sometimes include actors at the destination country providing the means for local agents to poach or harvest organisms, this way influencing local economies, such as the Vietnamese and Chinese syndicates that finance rhino poaching in South Africa and Mozambique (Rademeyer, 2012).

8. Effects on local economies

Local communities, including indigenous and rural communities may rely, at least in part, on wildlife trade for their subsistence, as both food source (Nasi and Fa, 2015) and income (Schulte-Herbruggen et al., 2013; Robinson et al., 2018). Thus, trade regulations that do not take this into consideration tend to increase vulnerability and poverty in those areas. In China alone, wildlife farming is valued at US$8 billion per year which often helps alleviate poverty and boost the local economy (Roe and Lee, 2021). Hunting is also a food source in developed countries, although rarely without alternatives. Despite these considerations, wildlife trade as an economic activity is often unreliable and volatile (Robinson et al., 2018) or increases dependence on illegal activity, resulting in income that local people would struggle to reach by legal means (Barron, 2015).

As highlighted by repeated zoonotic disease outbreaks originating in wildlife trade, this is a volatile business in both legal backup or market demand, hardly constituting a reliable source of income when local socioeconomic factors are not considered (Roe and Booker, 2019). The 2020 ban of all wildlife trade for human consumption in China following the COVID-19 outbreak creates challenges for thousands of wildlife traders that have to search for alternative livelihoods (Koh et al., 2021). Many responsive measures have been questionable at best, including compensation by the Chinese government helping transition from food-oriented trade to medicine and pets (Roe and Lee, 2021). The Ebola outbreak of 2013–2016 led to the ban of wild meat hunting across West Africa, depriving many local communities of meat, driving the trade underground, and exacerbating social unrest in the region (Bonwitt et al., 2018). In Africa, wild meat trafficking has increased due to COVID-19-related lockdowns, with tourism collapse leading to decreased food availability and damaged economies (MacNamara et al., 2020).

Industrial and traditional practices in fisheries and timber extraction can cause different levels of sustainability and income for local communities. Although improving, overfishing might have consequences to local economies, with management and monitoring being important even for traditional practices (Plagányi et al., 2013). Timber products are increasingly traded internationally, with developed nations having the largest footprint as drivers of trade (O'Brien and Bringezu, 2018; Zhang et al., 2020). Logging is often illegal, connected with man-made fires, corruption, or organized crime networks (Wyatt, 2014), with consequences on the local economy and community wellbeing. Not only do local communities often not benefit from logging but are also then deprived of ecosystem services such as water security, or different sources of income that the intact forest would provide.

Trophy hunting has long been a contentious issue worldwide. Often important for local economies and funding conservation groups (Di Minin et al., 2016; Saayman et al., 2018), it has seen major opposition from multiple parties due to ethical and law enforcement concerns (Ghasemi, 2021; Rademeyer, 2012). With increasing perception of trophy hunting as ethically condemnable, dependent economies must explore alternatives, including tourism wherever possible. Whale hunting, for example, underwent a major shift to whale watching in many regions where hunting was previously a tradition (Cisneros-Montemayor et al., 2010).

Finally, local economies might suffer through social aspects of IUWT. Children in Uganda, and possibly elsewhere, might leave school to engage in illegal activities such as lumber processing (Harrison et al., 2015) or wild meat poaching, with future consequences of a spiral of economic loss to the local populations due to decreasing education levels and restricted opportunities (Scherr, 2000).

9. Effects on the global economy

The annual revenue generated by the global legal trade in wildlife was estimated at between US$2.9 and 4.4 trillion from 1997 to 2016 (Andersson et al., 2021). Much more difficult to assess, the revenue estimates for the illegal wildlife trade vary widely from US$ 4–23 billion ('t Sas-Rolfes et al., 2019), up to US$48–216 billion if illegal logging and fishing are included (World Bank, 2019). Yet overall, governments lose up to US$12 billion annually in potential revenues from illegal wildlife trade (Schloenhardt, 2008; World Bank, 2019). If negative economic effects owing to reduction or loss of ecosystem services due to IUWT are accounted for, this leads to an annual decrease in value of between US $1–2 trillion, mostly due to loss of carbon sequestration services (World Bank, 2019). Additionally, lost revenue and lost natural resources have a negative impact on a country's ability to develop. The legal market itself is distorted by the illegal market, as skewed prices result from the true extent of demand not being represented by the legal industry.

In key hotspots around the planet, IUWT also reportedly funds terrorists, insurgents, and violent criminal organizations (Kiser, 2013) that destabilizes economies and reduces Gross Domestic Product across entire regions, routinely sparking an exodus in both people and capital. As an example, the Taliban are known to be involved in timber trafficking, their military power being partly financed by such operations (https://www.wsj.com/articles/SB10001424052702303960604575157683859247368). Environmental degradation caused by IUWT creates another dangerous feedback loop, increasing economic and political instability as it worsens. This way, IUWT has the potential to exacerbate asymmetries between the Global North and South economies.

Zoonotic diseases and ecosystem collapse have the potential to cause sporadic but major disruptions in economic stability. Due to the current COVID crisis that may have started in wildlife markets, unemployment has risen to levels unseen for years, with worse consequences in economies that rely on low job protection levels for employees (World Bank, 2020). As many as 150 million people are expected to be added to the extreme poverty numbers by the end of 2021 (World Bank, 2020). The global Gross Domestic Product shrunk by 4.3% compared with pre-pandemic levels (United Nations, 2021). Stock market values plummeted and most countries across the world went into recession in 2020.

10. Conclusion

The illegal or unsustainable wildlife trade is growing at a global level, pervading our daily lives, and affecting our well-being. It threatens targeted and non-targeted species, promotes the spread of invasive species, the loss of ecosystem services, the spread of diseases across geographic areas and taxa, and disrupts local to global economies especially when connected to major organized crime networks (Fig. 1).

We emphasize that many communities depend on wildlife trade and solutions must consider the type of use and social scale, distinguishing between essential and 'luxury' or non-essential uses of wildlife (Zhang and Yin, 2014). It is also crucial for global efforts to tackle IUWT with both policy and enforcement while also considering the needs of the many stakeholders depending on trade, ensuring a balance between these often-opposing views (Cooney et al., 2016). Initiatives and proposals to ensure the sustainability of trade, and that many people are not depleted of economic gains are numerous and have had success in the past. We refer the reader to the companion paper for extensive information on successful proposals (Fukushima et al., 2021).

The main root of nefarious aspects of IUWT is at local level, with the partial blindness of researchers, wildlife managers, private sector, economists, NGOs, civil society, and government policies, among others, creating and promoting continued inertia to wicked problems by trying to solve only the most "evident" parts without an integrated approach (Murphy, 2012). Over 30 years have passed since Ostrom (1990) published a body of literature offering a multidisciplinary understanding of sustainability science and the relevance of collective action. However, short-term economic views have led society to miss the complexity and multidisciplinary required to solve the problems around IUWT.

We appeal for urgent action to close key knowledge gaps, connect interested parties and regulate wildlife trade, legal and illegal, national and international. Solutions are available and implementable, as we point in our own sister paper on challenges and perspectives on IUWT (Fukushima et al., 2021). Urgent action by society is needed now to match our intentions.

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CRediT authorship contribution statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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