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Science & Society

COVID-19 Highlights the Need for More Effective Wildlife Trade Legislation

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Zoonosis-based epidemics are inevitable unless we revisit our relationship with the natural world, protect habitats, and regulate wildlife trade, including live animals and nonsustenance products. To prevent future zoonoses, governments must establish effective legislation addressing wildlife trade, protection of habitats, and reduction of the wildlife–livestock–human interface.

Risk of Zoonotic Disease

Over the past three decades, most new human pathogens with substantial impacts on human health or economies have originated in wildlife [1,2]. Coronavirus disease 2019 (COVID-19) is among the latest of these zoonotic diseases and is now a pandemic that has resulted in more than a million fatalities globally as of 1 October 2020 (https://www.who.int/emergencies/diseases/novel-coronavirus-2019). Direct contact between people and animal species due to the wildlife trade and increased human–livestock–wildlife interactions through rapid fragmentation of wildlife habitat are two major factors that contribute to the spread of zoonotic diseases [3,4]. Although localized quarantines and lockdowns around the world appear to be having some minor positive effects on the environment, these short-term successes should not be glorified in view of the profound negative environmental, social, and economic impacts of the COVID-19 pandemic (https://www.iea.org/reports/global-energy-review-2020). We call for urgent action to regulate the trade of wildlife, expand protection for native ecosystems, and reduce consumer demand for wildlife parts and products to lower the risk and severity of future zoonotic diseases (Figure 1).

Restrictions to Wildlife Trade Implemented in Response to COVID-19

Recognizing that COVID-19 may have emerged from the wildlife trade [5], several governments have enacted new or more effective regulations to control its trade. In the People's Republic of China, the National People's Congress adopted legislation banning the consumption of any field-harvested or captive-bred wildlife, thereby closing the market for the domestic wildlife trade [6]. In the Socialist Republic of Vietnam, the Ministry of Agriculture and Rural Development ordered a reinforcement of wildlife trade regulations (instruction No. 29/CT-TTg) and lawmakers in the Republic of Korea capitalized on the general public agreement that COVID-19 is linked to animal trade by banning imports of several invasive alien species (notice 2020-61 in Biodiversity Conservation and Use Act 21-2). These recent actions ultimately support wildlife conservation by reducing pressure on wildlife populations. They

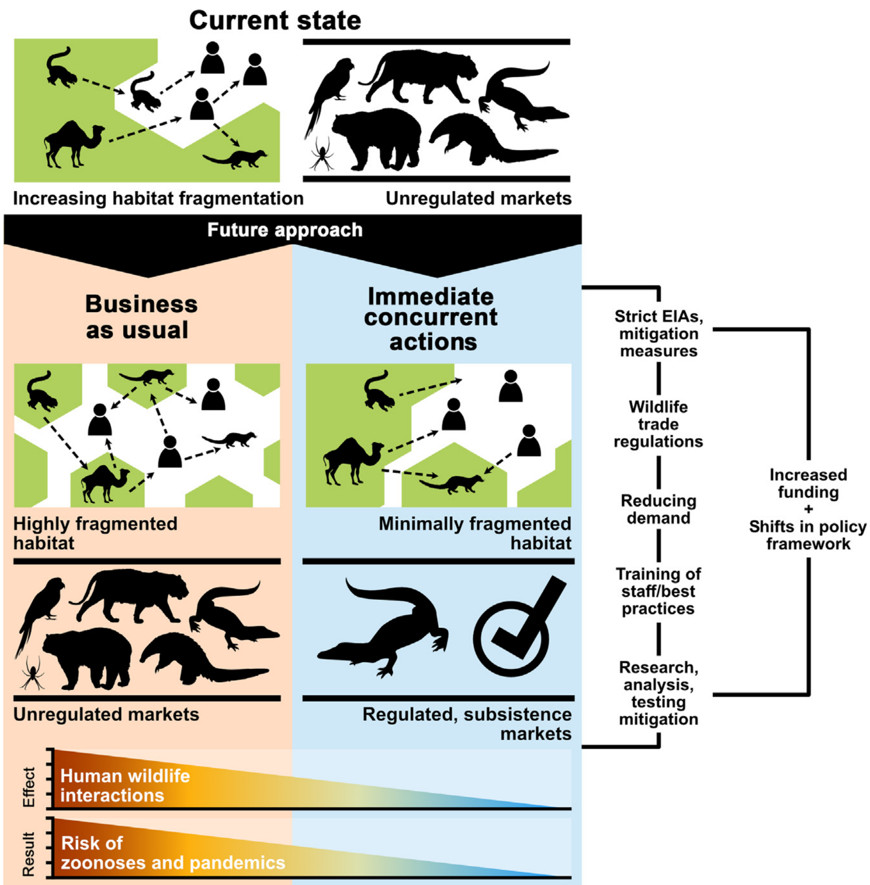

Figure 1. Relationship between Zoonoses, Wildlife Trade, and Environmental Protection. Currently, wildlife trade, degradation of natural habitats, and the interaction and interface between humans and wildlife leads to zoonoses such as coronavirus disease 2019. A shift away from the current practices through enhanced and proactive regulation of trade and reduction in environmental degradation would decrease the risk of zoonoses and benefit environmental conservation. Abbreviations: EIA, Environmental impact assessment.

also provide examples that other countries can consider when evaluating how best to protect against future zoonotic episodes.

Opportunities for Strengthening Trade Regulations

We call for the regulation of, and encourage the consideration of bans on, the wildlife trade, specifically live animals and nonsustenance wildlife products. A crucial initial step towards reducing the wildlife trade and the harvesting of animals from the wild is the widespread development and enactment of regulations that control human use of wildlife [7]. Governments must clearly articulate, implement, and enforce these regulations so that they do indeed deter the demand for wildlife and wildlife products. To be effective, regulations must also be sufficiently comprehensive and address potential loopholes. For example, in June 2020, the People's Republic of China banned the trade of pangolins (eight species from the family Manidae) under the Wildlife Protection Law (http://www.npc.gov.cn/zgrdw/npc/xinwen/2018-11/05/content_2065670.htm). However, there is no legal procedure to prevent the production of patented medicines that contain pangolin scales, so the trade in pangolin scales potentially continues, albeit from stockpiled scales. Thus, additional legislation to monitor the inventory of stockpiled pangolin scales and to address the law enforcement challenges of regulating permitted stockpiles is needed. Moreover, governments may need to consider criminalizing the use of pangolin scales in medicines and their total ban from the trade. Otherwise, the demand for pangolins will continue to drive these species to extinction, despite national laws and legislations established to protect them, the inclusion of all Asian pangolin species in the Convention on International Trade in Endangered Species of Wild Fauna and Flora regulations, and the listing of all four species of Asian pangolins (*Manis javanica*, *Manis crassicaudata*, *Manis culionensis*, *Manis pentadactyla*) as endangered on the International Union for Conservation of Nature Red List (iucnredlist.org).

The wildlife–human interface is becoming increasingly intricate, resulting in ever greater contact between humans and wildlife. The wildlife trade in Asia is supported by live markets in most population centers that include sales of both native and exotic species. These animals are often housed in overcrowded and unsanitary conditions that place both sellers and buyers under high risk of pathogens and zoonotic diseases and create the perfect conditions for pathogens to jump the species barrier [8]. Wildlife markets threaten the survival of a wide range of species, contributing to the extinction crisis looming over most of Asia's wild fauna [9]. In addition, biodiversity-rich forests, wetlands, and aquatic resources throughout Asia are being cleared and converted to meet the growing demands of increasing human populations. The resulting fragmentation of natural habitats is bringing domestic animals into closer contact with wild animals that may be reservoirs of zoonotic pathogens that can be easily transmitted to rural people and then more broadly throughout the global human population [7] (Figure 1).

Thus, regulations and their proper implementation are also required to manage interactions between domestic animals and wild species, reducing the risk of transmission from animals to humans [3]. Conservation policies that should protect threatened species from extinction and humans from zoonotic diseases are slow to be implemented, despite urgent calls, [10] and ecosystem degradation further reduces their potential for disease regulation [3]. Therefore, the wildlife trade needs to be better regulated, the list of species protected from trade needs to be extended to taxonomic groups beyond mammals and terrestrial habitats, and forest and aquatic ecosystems need to be protected against fragmentation and degradation from agriculture, urbanization, and domestic animals. In the absence of such regulatory measures, the emergence and spread of novel zoonotic pathogens and future epidemics are not only likely but inevitable: the open trade of animals in wildlife markets creates ideal conditions for further spillover events and could result in zoonotic pathogens that are even more economically and socially damaging than COVID-19.

Supporting Measures and Caveats for Wildlife Trade Bans

The legal and regulatory basis of the wildlife trade must now be strengthened and complemented by the development, enaction, and implementation of necessary supporting measures. We recommend both proactive and reactive measures, including budgetary support, staff training, monitoring technologies, and leveraging social media to build public support for wildlife protection; in addition to ensuring an informed, independent, and transparent judiciary, supported by appropriate penalties. A general policy of ecosystem restoration is needed at a broad scale for most countries [3]. In Asia in particular, some of the specific issues that need to be addressed immediately to decrease the risk of novel zoonotic pathogens include the consumption of wildlife and the trade of species for farming and the pet trade, which facilitate the human–wildlife interface [11].

A total ban of the wildlife trade would impact millions of people, in Asia and globally, who depend on the wildlife trade for subsistence [12]. Therefore, the wildlife trade should not be placed under an immediate blanket ban [13]. The global pandemic has already had a disproportionately high negative impact on economically disadvantaged, migrant, and rural populations. Furthermore, an ill-considered blanket ban would mean that some of the world's most vulnerable human populations might not be able to provide for their families. This might possibly result in further unregulated harvesting of wild plants and animals that could change pressure on species and potentially result in a higher transmission rate of zoonotic pathogens [14]. Examples of such transmissions include HIV-AIDS and Ebola, in which the viruses jumped to humans from chimpanzees (*Pan troglodytes*) and (likely) blue duiker (*Philantomba monticola*), respectively, probably as a result of wild meat consumption [7]. Therefore, in parallel with enforcing appropriate wildlife trade bans and strengthening wildlife protection, governments should work with local communities to create and stabilize alternative means of subsistence, as well as compensatory mechanisms, at local and regional scales. Broader bans may also be necessary and appropriate once these alternatives are in place.

Wider Implications and the Way Forward

We urge governments to follow the positive examples of legal measures enacted by some governments in Asia and formulate, adopt, and enforce stricter regulations and, where appropriate, bans on the wildlife trade. Non-subsistence wildlife markets should be permanently closed and the potential of zoonotic transmission from marine and aquatic species should be recognized and addressed [15]. Enforcement of all wildlife laws and regulations must be reviewed and strengthened and the illegal and legal wildlife trade must be effectively monitored. However, such controls and regulations of wildlife trade must be implemented, keeping in mind the globally accepted principles of social equity and sustainability to which governments have committed. We encourage the governments in countries where wild meat may be a key part of the staple diet and primary source of protein to make efforts to ensure that species are hunted only when such trade can be sustainably monitored and controlled (including mandates to prove legal origin) to provide a safer future for humans and wild species. We also invite the governments of regions beyond Asia where wild meat is consumed for subsistence, wild animal populations are harvested, and live markets are present, to examine their existing legislation and consider revisions in accordance with these recommendations. All wildlife trade must be regulated to ensure that what is sold for consumption minimizes the risk of passing zoonotic diseases to humans.

Acknowledgments

We are grateful to Benjamin Michael Marshall for help with the figure.

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https://doi.org/10.1016/j.tree.2020.10.001

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Letter

Dormancy Class: Another Fire Seasonality Effect on Plants

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Fire plays a fundamental role in shaping the evolution of plant functional traits in various terrestrial ecosystems. In a recent review in *TREE* [1], Miller *et al.* summarized the negative effects of altered fire seasonality on local plant persistence, especially compensation for fire-killed individuals via postfire recruitment and survival. They provided a holistic framework of plant responses to fire seasonality mainly from the perspective of aboveground populations. Plant populations also consist of a belowground (seed bank) component, which is a source of propagules for maintaining the aboveground population. Heat resistance and capacity of seeds to germinate when buried at different soil depths play a vital role in plant responses to fire [2]. Moreover, seeds in soil seed banks exhibit various classes of dormancy and different germination behaviors in postfire environments. Here, we suggest that seed **dormancy class** (see Glossary) mediates an additional mechanism of plant responses to fire seasonality.

Soil Seed Banks Respond to Fire Seasonality via Multiple Processes

Soil seed banks respond to fire (seasonality) via input (postfire seed dispersal), maintenance (survival of soil-stored seeds and resistance to heat shock), and output (destruction by fire and postfire germination). Keith *et al.* added postfire dispersal as an additional mechanism of plant responses to fire seasonality [3], which Miller *et al.* accepted as a propagule availability process [4]. Persistence of soil seed banks, resistance to heat shock, and seed survival after fire damage and predation also provide propagule availability [1].

Miller *et al.* described two mechanisms associated with postfire germination, namely juvenile growth and maturity (Mechanism 4, M4) and post-fire seedling establishment (M7). M4 concerns the importance of early seedling emergence in competition and M7 the effect of emergence timing on length of growth period [1]. Herein, we evaluate the role of seed dormancy in regulating postfire germination in