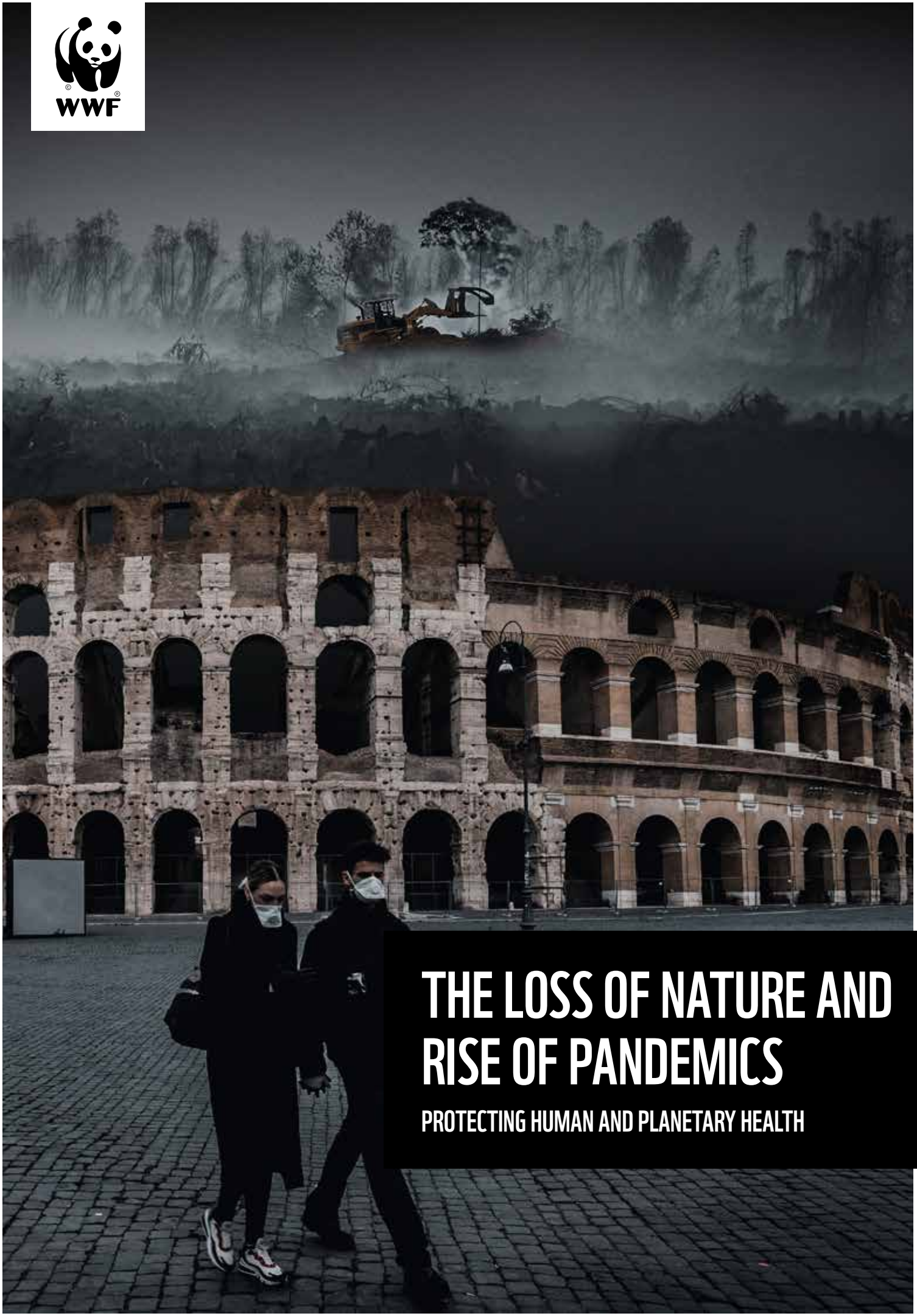

THE LOSS OF NATURE AND RISE OF PANDEMICS

PROTECTING HUMAN AND PLANETARY HEALTH

THE LOSS OF NATURE AND THE RISE OF PANDEMICS

Protecting human and planetary health

TEXTS

English version is written by Barney Jeffries with support from Forest and Wildlife Practices

Initial Assessment by Isabella Pratesi

SCIENTIFIC REVISION

Marco Galaverni, Gianfranco Bologna, Roberto Danovaro

TRANSLATION

Giorgio Bagordo

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WWF INTERNATIONAL

Avenue du Mont-Blanc
1196 Gland, Switzerland
www.panda.org

INTRODUCTION

At the time of writing, the world is in the grips of a global pandemic the like of which has never been seen before. The COVID-19 that has swept through countries and continents has caused untold human suffering, social upheaval and economic damage. But while the spread of the current crisis is unprecedented, the new coronavirus follows a number of diseases that have emerged in recent decades, such as Ebola, AIDS, SARS, avian influenza and swine flu. All originated in animals – and there is increasing evidence that humanity's overexploitation of nature is one of the factors behind the spread of new diseases.

Human activities have significantly altered three-quarters of the land and two-thirds of the ocean, changing the planet to such an extent as to determine the birth of a new era: the "Anthropocene". Changes in land use that bring wildlife, livestock and humans into closer contact with each other facilitate the spread of diseases, including new strains of bacteria and viruses.[1] Meanwhile, illegal and uncontrolled trade of live wild animals creates dangerous opportunities for contact between humans and the diseases these creatures carry. It is no coincidence that many recent outbreaks have originated in markets that sell a mix of wild and domestic mammals, birds and reptiles, creating the conditions for the development of old and new zoonoses: infectious diseases that can be transmitted from animals to humans.

This report illustrates the links between humanity's impacts on ecosystems and biodiversity and the spread of certain diseases. While many of these links are not yet fully understood, it is clear that human and planetary health are closely connected. Today's crisis creates an urgent need for an in-depth reflection on the relationship between human beings and nature, the risks associated with current economic development pathways, and how we can better protect ourselves in the future.

1 Kilpatrick, A. M. and S. E. Randolph. 2012. Drivers, dynamics, and control of emerging vector-borne zoonotic diseases. *The Lance*t 380:1946–1955; Lambin *et al.* 2010. Pathogenic landscapes: Interactions between land, people, disease vectors, and their animal hosts. *International Journal of Health Geographics* 9:54; Morse *et al.* 2012. Prediction and prevention of the next pandemic zoonosis. *The Lancet* 380:1956–1965.

KEY MESSAGES

- Viruses, bacteria and other microorganisms have played a vital role in life on Earth for 3.8 billion years. The vast majority are absolutely harmless, and are often essential for ecosystems and human health – just think of the human microbiome or the innumerable symbioses between microbes and other organisms.
- A few microorganisms, such as pathogenic bacteria and viruses or parasitic protozoa, can have significant negative effects on human health.
- Pathogens can transform quickly, which allows them to pass from wild animals to humans. These emerging diseases endanger human lives and have major socio-economic impacts.
- The chances of pathogens like viruses passing from wild and domestic animals to humans may be increased by the destruction and modification of natural ecosystems, the illegal or uncontrolled trade of wild species and the unhygienic conditions under which wild and domestic species are mixed and marketed.
- Human behaviour and demographic factors significantly increase these risks, and the speed with which humans travel between continents can cause the runaway spread of pandemics.
- Conserving and maintaining nature and the benefits it provides is essential for preserving our health and well-being.

PUBLIC ENEMY NUMBER ONE: THE CORONAVIRUS SARS-COV-2

Coronaviruses are a large family of viruses widespread in many animal species, including humans. While many have no negative effects, they can cause illnesses ranging from the common cold to more serious diseases such as the Middle East respiratory syndrome (MERS, which first appeared in Saudi Arabia in 2012) and the severe acute respiratory syndrome (SARS, which emerged in Guangdong province in southern China in 2002).

The virus responsible for the current pandemic is a new strain that has never before affected humans. The World Health Organization (WHO) has given the disease the official name CoVID-19, short for COronaVIrus Disease-2019, while the International Committee on Taxonomy of Viruses (ICTV) has assigned the official name SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) to the virus that causes the disease. This name was chosen because the virus is genetically related to the coronavirus responsible for the SARS outbreak. While related, the two viruses differ in two fundamental characteristics: SARS-CoV-2 has a lower mortality rate but is more contagious than SARS.

The new coronavirus can cause mild symptoms such as a cold, sore throat, cough and fever, or more severe symptoms such as pneumonia, severe acute respiratory syndrome and kidney failure.[2] While most of those infected will recover, many require hospital treatment, threatening to overwhelm health services. And for a minority, the complications can be fatal. Many thousands of lives have already been lost.

AT THE ORIGIN OF SARS-COV-2

The SARS-CoV-2 outbreak appears to have originated in the large animal market in Wuhan, in the Chinese province of Hubei, in December 2019. But where do these new viruses come from?

The outbreak among humans of viruses previously circulating only in the animal world is a phenomenon known as spillover.[3] This is thought to be at the origin of the new coronavirus. Transmission of viruses between animals and humans has been observed in the recent past. In 2012, a virus possibly originating in bats adapted to dromedaries and subsequently to people, causing the MERS epidemic in the Arabian Peninsula. SARS appeared in a Chinese market that sold Asian palm civets (*Paradoxurus hermaphroditus*), which appear to have contracted a similar virus from bats.

Every time a virus infects a host, it can mix its genetic heritage with that of other viruses present in the host (such as influenza viruses) or rapidly mutate. Then it reproduces at the expense of the cell that it infects and abandons the host, but with a different genetic makeup, sometimes allowing it to infect new species. By analysing the DNA or RNA of a virus, it is possible to trace its passage through different species.

2 Wang *et al*. 2020. A review of the 2019 Novel Coronavirus (COVID-19) based on current evidence. *International Journal of Antimicrobial Agents:*105948.

3 Thompson, R. C. A. 2013. Parasite zoonoses and wildlife: One health, spillover and human activity. *International Journal for Parasitology* 43:1079–1088.

We are still uncertain which animal species may have acted as intermediate hosts in the case of SARS-CoV-2, as the city market of Wuhan sells and slaughters on site live wild and domestic birds and mammals of many species. Recent studies[4] highlight the similarities between SARS-CoV-2 and coronaviruses found in some species of bats belonging to the genus *Rhinolophus*, which could have constituted the natural reservoir for the virus. These bats are abundant and widely present in southern China and throughout Asia, the Middle East, Africa and Europe. Bats carry many viruses with which they have co-evolved during their long evolutionary history, and which they spread and contract readily through their ability to fly long distances and their large aggregations (e.g. up to one million individuals in one site).

Research by the Campus Bio-Medico University of Rome suggests the current pandemic may have originated from bats sold live and slaughtered in Chinese markets.[5] Additional research found a high correspondence between the human SARS-CoV-2 genome and the coronavirus genome found in a bat in the Chinese province of Yunnan, though differences in the genetic sequence suggest the bat virus could have passed through an intermediate host before reaching human beings.[6]

Similarities have also been found between SARS-CoV-2 and coronaviruses carried by Malayan pangolins *(Manis javanica)*.[7] Pangolins are highly sought for their scales, which are used in traditional Asian medicine, as well as their meat, which is considered a delicacy in some Asian and African communities. As a result, they have become the most trafficked animal in the world, with these high levels of trade threatening their survival. International trade in pangolins has been illegal since 2016,[8] but the trade has by no means ceased. However, measures such as those recently adopted by China to restrict the consumption of wild animal meat could, in part, limit demand.

While we do not yet have conclusive evidence about the source and path of the SARS-CoV-2 infection, it is highly likely that the origin of this new virus is in part linked to trade of live wild animals and their body parts. This often illegal or uncontrolled practice is a vehicle for spreading old and new zoonoses, increasing the risk of pandemics with enormous health, social and economic impacts.[9]

4 Lu *et al.* 2020. Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. *Lancet*, 395:565-74. doi: 10.1016/ S0140-6736(20)30251-8.

5 Benvenuto *et al.* 2020. The 2019-new coronavirus epidemic: evidence for virus evolution. *BioRxiv*. doi: 10.1101/2020.01.24.915157

6 Lu *et al.* 2020.

7 Zhang, T., Wu, Q. & Zhang, Z. 2020. *bioRxiv* preprint. doi: 10.1101/2020.02.19.950253

8 https://cites.org/sites/default/files/eng/com/sc/69/E-SC69-57-A.pdf

9 Kreuder Johnson, C. *et al.* 2015. Spillover and pandemic properties of zoonotic viruses with high host plasticity. *Sci Rep* 5, 14830. doi: 10.1038/srep14830

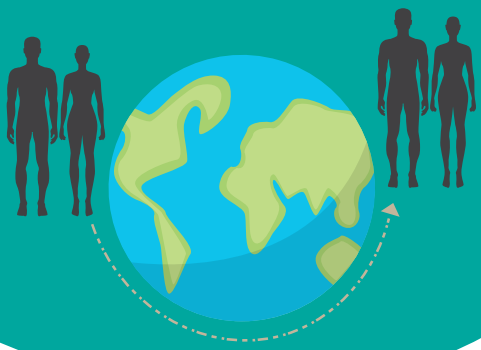
VIRUSES

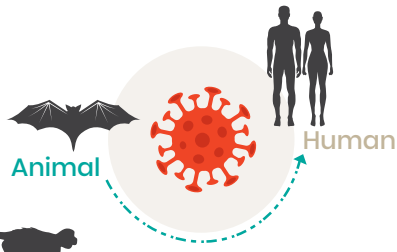
Viruses are incredibly simple organisms: essentially genetic material coated with a protein capsule. Their origin is unclear. Since they possess genetic material, reproduce and evolve through natural selection, they are considered by some biologists as real lifeforms. However, viruses are not able to reproduce autonomously: they always require a host cell, which can be an animal, plant, fungi, bacteria or archaea. Because they possess some, but not all, of the characteristics of other living beings, viruses have been described as "organisms on the edge of life". However, at an ecological level, viruses perform an essential task, regulating the populations of host species and ensuring their balance within ecosystems.

Depending on the type of genetic material they contain, viruses can be distinguished as DNA or RNA viruses, composed respectively of double- or single-strand nucleic acids. SARS-CoV-2 is an RNA virus, one of at least 158 known to infect humans; other particularly dangerous RNA viruses include HIV, SARS, Hendra, Nipah and MERS. Mainly shared among mammals and sometimes birds, RNA viruses rapidly mutate, meaning they can evolve, adapt to new hosts and develop resistance to drugs. This is especially the case when a cell is infected with different viruses which exchange genetic material, giving rise to a new virus (**antigenic shift**). The mixing of species typical of markets in Southeast Asia can favour such situations, increasing the probability of the appearance of new viruses capable of infecting new species, including humans.

Like all organisms, viruses try to maximize their survival and ability to reproduce. A virus in equilibrium with the species through which it has evolved does not cause excessive fatalities amongst that species, as the death of the host would most often mean the death of the virus itself. When there is a substantial change in the virus and it becomes able to infect a new species, this balance is lost. In the new host species, the initial rates of fatality are likely to be much higher until an equilibrium between the pathogen and the host species is eventually reached.

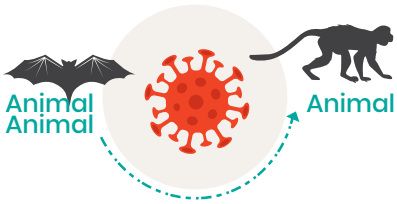
The pathway of epidemics





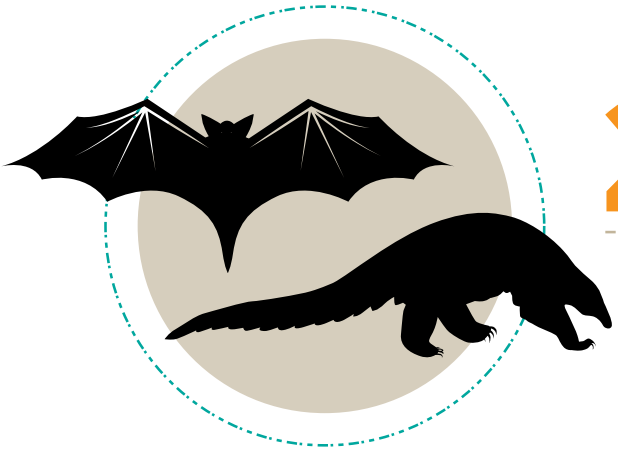
4. Risk of zoonosis

transmission from animal to animal,
from animal to human and from human to human



3. Animal markets

crowding and closeness between species



2. Species collecting and trafficking

1. Deforestation

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FROM ANIMALS TO HUMANS: ZOONOSES AND THEIR IMPACT

A zoonosis is any disease or infection transmitted to humans from other animals. Zoonotic diseases include a diverse group of infections, which can be caused by viruses, bacteria, fungi, other organisms or abnormal protein agents (prions). Zoonoses are numerous – the WHO records over 200 – and their study constitutes one of the areas of greatest interest in human and veterinary medicine. Rabies, leptospirosis, anthrax, SARS, MERS, yellow fever, dengue, HIV, Ebola, Chikungunya and coronaviruses are all zoonotic, as is the most widespread flu. So is malaria, carried by mosquitoes, which is responsible for more than 400,000 deaths and direct costs of more than US$12 billion every year.[10] So too was the bubonic plague, caused by the *Yersina pestis* bacterium transmitted to our species by fleas on rats, which in the Middle Ages killed up to a third of the European population.

As with viruses, the moment when a pathogen passes from one host species to another is called spillover. The transmission can take place by direct contact (as in the case of rabies), through other organisms known as vectors that carry the disease agent (e.g. mosquitoes, ticks), or through environmental carriers and food items. Some, like Ebola and the present coronavirus, subsequently adapt to our species, allowing for human-to-human transmission. These are the most dangerous for humans: the current crisis shows how quickly epidemics can spread in an increasingly globalized and connected world to become pandemics.

Of all the emerging diseases, zoonoses of wildlife origin represent one of the most significant threats to the health of the world population.[11] Three-quarters of human diseases known to date come from other animals, and 60% of emerging diseases have been transmitted by wild animals. Zoonoses each year cause around one billion cases of disease and millions of deaths,[12] with incalculable human consequences.

These diseases also have a heavy socio-economic impact, contributing significantly to enduring poverty in some regions. The World Bank estimates that the economic burden of just six zoonotic diseases amounted to US$80 billion over 12 years.[13] The 2003 SARS outbreak affected around 9,000 people and cost the global economy in the range of US$30-50 billion. Less well-known zoonoses also carry heavy costs: echinococcus, which is transmitted to humans by domestic dogs and has a number of ungulates as intermediate hosts, costs US$4 billion every year in analyses and drugs. Viral, bacterial or fungal outbreaks of animal origin transmitted to humans through food, such as those caused by salmonella and campylobacter, also affect millions of people every year.[14]

10 www.cdc.gov/malaria/malaria_worldwide/impact.html

11 Jones *et al.* 2008. Global trends in emerging infectious diseases. *Nature*, 451, doi:10.1038/nature06536

12 Morse *et al.* 2012. Prediction and prevention of the next pandemic zoonosis. *Lancet*, 380, 1956-65.

13 Gebreyes *et al.* 2014. The global one health paradigm: challenges and opportunities for tackling infectious diseases at the human, animal, and environment interface in low-resource settings. *PLoS neglected tropical diseases* 8:e3257–e3257.

14 www.ecdc.europa.eu/sites/default/files/documents/zoonoses-EU-one-health-2018-report.pdf

EMERGING DISEASES: WAITING FOR THE BIG ONE?

Fifty years ago, with the production and large-scale use of antibiotics and vaccines, humans appeared to have won the battle against infections. Since then, however, as well as growing antibiotic resistance among bacterial pathogens, there has been an increase in the outbreak of old and new zoonoses, mostly viral and often transmitted by wild animals.[15]

According to the WHO, **emerging diseases** are those that appear for the first time in a certain population, or that were already present but see a rapid increase in number or geographical spread. An emerging disease may involve:

- A known infectious agent appearing in a new geographical area
- A known infectious agent (or close relative) appearing in a new species
- An unknown infectious agent classified for the first time.

Emerging zoonoses are appearing at an unprecedented rate and are at the centre of intense research, with the awareness that sooner or later an epidemic of catastrophic proportions could develop among humans. Globalization, with the ever-growing movement of people and goods, compounds the growing human impact on ecosystems. This enables the widespread diffusion of emerging diseases and old ones that were believed to be under control.

15 Kreuder Johnson *et al.* 2015. Spillover and pandemic properties of zoonotic viruses with high host plasticity. *Sci Rep* 5, 14830. doi: 10.1038/srep14830

WILDLIFE TRAFFICKING, BUSHMEAT AND PANDEMICS

The unregulated trade in wild animals and direct contact with animal parts exposes humans to contact with viruses and other pathogens hosted by those species.

Contact with wild species such as bats, Asian palm civets, monkeys, pangolins and others can lead to the onset and contribute to the spread of serious zoonoses.[16] It is no coincidence that recurrent outbreaks of Ebola have been linked to the hunting, butchering, and processing of meat from infected wild animals.

Throughout history, human beings have hunted wild animals for meat. Today, **bushmeat** consumption is growing dramatically in many parts of the world. It can be an important source of nutrition for low-income and food-insecure households in forests and rural areas, particularly in Africa.[17] A wide variety of animal species are hunted for bushmeat, from reptiles to pangolins, from antelopes to hippopotamuses, as well as great apes such as chimpanzees and gorillas.

As well as being hunted for subsistence consumption, bushmeat may be sold in nearby villages, transported to cities and even trafficked to distant countries via illegal trade routes. In rural areas, it is the lower income households that consume more bushmeat. But in urban areas, the opposite applies: wild meat is preferred for its flavour and the price is higher than domestic meat. Some African and Asian diaspora communities also consume bushmeat, supporting a lucrative illegal international market.

As bushmeat consumption and trade grow, hunting, transportation, handling and cooking practices that do not follow food safety standards pose risks to human health, including through the transmission of pathogens.[18]

Like the hunting and consumption of bushmeat, other widespread trade in wildlife and animal parts poses serious risks to human health. The often illegal cross-border trade is not only a primary cause of biodiversity loss, but can also be an important mechanism for spreading zoonoses.

Wild animals of all kinds are trafficked along commercial routes that connect continents and distant countries, potentially amplifying the spread of pathogens.

In some cases, wild species are bred for trade. This too poses a danger due to the absence of adequate hygiene and the many unregulated farms.

Wild animals, or those that are captured and bred in captivity for consumption of meat or other parts, have enormous potential to transmit viruses, particularly when packed close together. As they scratch, defecate, urinate, cough and sneeze, they can contaminate each other and, more worryingly,

16 Kreuder Johnson *et al.* 2015. Spillover and pandemic properties of zoonotic viruses with high host plasticity. *Sci Rep* 5, 14830. doi: 10.1038/srep1483

17 Friant et al. 2020. Eating Bushmeat Improves Food Security in a Biodiversity and Infectious Disease "Hotspot." EcoHealth. doi: 10.1007/s10393-020-01473-0

18 Van Vliet *et al.* 2017. Bushmeat and human health: Assessing the Evidence in tropical and sub-tropical forests. *Ethnobiology and Conservation* 6(3). doi: 10.15451/ec2017-04-6.3-1-45

contaminate humans. Moreover, the close proximity of different species in animal markets increases the chances for the genetic recombination between different viruses and spillover into new species.

China's recent ban on eating wild animals and crackdown on illegal and unregulated wildlife trade is timely. But much more should be done to effectively tackle this problem at the global scale.

WWF has long campaigned against the illegal wildlife trade. Worth an estimated US$7-23 billion per year, it is the world's fourth most profitable clandestine market after trafficking in counterfeit goods, drugs and people.[19] The risk of pandemics, as highlighted by the current coronavirus crisis, underlines the urgent need for decisive global action to safeguard people's lives and health.

19 www.traffic.org/about-us/illegal-wildlife-trade

ECOSYSTEM DAMAGE AND HUMAN HEALTH RISKS

Natural ecosystems have a crucial role in supporting and nourishing life, including ourselves. Altering these ecosystems can aid the development and spread of infectious diseases.[20]

The loss of habitats, the modification of natural environments, and more generally the decline in biodiversity are all factors in the spread of **emerging infectious diseases**.[21] This can happen through various mechanisms:

- Increased breeding sites for disease vectors, such as irrigation channels and dams where mosquitoes proliferate
- Increased spread of host species
- Keeping wild species captive in close contact with each other, and with domestic animals
- Transfer of pathogens between different species
- Loss of predatory species
- Human-induced genetic changes in disease vectors or pathogens (such as the resistance of mosquitoes to pesticides or the use of drugs in intensive livestock farming leading to the appearance of bacteria resistant to antibiotics)
- Environmental contamination by infectious disease agents.

Our understanding of the interactions between ecosystem change, disease regulation and human well-being is still limited. We know very little about the diversity of microorganisms present on our planet, and the mechanisms that regulate the relationship between them and other species, including our own.

We need a better understanding of how our ecosystems function, and in particular their role in defending us from the spread of diseases. In the meantime, protecting and restoring natural ecosystems is crucial for avoiding unknown risks to our health; the risk of zoonotic diseases should be a key consideration in land-use planning.

20 Kilpatrick, A. M. and S. E. Randolph. 2012. Drivers, dynamics, and control of emerging vector-borne zoonotic diseases. *The Lance*t 380:1946–1955; Lambin *et al.* 2010. Pathogenic landscapes: Interactions between land, people, disease vectors, and their animal hosts. *International Journal of Health Geographics* 9:54; Morse *et al.* 2012. Prediction and prevention of the next pandemic zoonosis. *The Lancet* 380:1956–1965.

21 Di Marco *et al*, 2020. Sustainable development must account for pandemic risk. *PNAS*, 117 (8), 3888-3892. doi:10.1073/pnas.2001655117.

ECOSYSTEM CHANGE AND THE SPREAD OF DISEASE

Human activities are causing cataclysmic changes to our planet. The growing human population and rapid increases in consumption have led to profound changes in land cover, rivers and oceans, the climate system, biogeochemical cycles and the way ecosystems function – with major implications for our own health and well-being.

According to the UN Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES),[22] three-quarters of land and two-thirds of the marine environment have been modified in a significant way, and around 1 million animal and plant species are at risk of extinction. WWF's **Living Planet Report 2018**[23] charts a 60% average decline in abundance of vertebrate populations across the globe in just over 40 years. Greenhouse-gas emissions have already caused average global temperatures to rise by 1°C compared to pre-industrial times, and the impacts of the climate crisis are becoming increasingly severe.

These global changes spell an uncertain future, not only for the biosphere but for humanity itself – including our health.

Land-use change, including deforestation and the modification of natural habitats, are held responsible for nearly half of emerging zoonoses.[24]

Tropical forests in particular are home to millions of species, many of which are largely unknown to science. Among these are countless viruses, bacteria, fungi and parasites. Most are benevolent and cannot live outside their host, but some are different. RNA viruses in particular can quickly mutate and adapt to new conditions and new hosts. Ebola, Marburg, Lassa, monkeypox and the precursor of HIV are a minuscule sample of what could be a myriad of other undiscovered viruses.

The destruction and degradation of forests exposes humans to new forms of contact with microbes and the wild species that host them.

For example, increasing incursions into the forests of West Africa has brought the human population into closer contact with bats that carry the **Ebola** virus. Again in Africa, human communities entering into what were once intact forests has increased direct and indirect contact with disease reservoirs, leading to an increase in diseases such as **yellow fever** (transmitted through mosquitoes from infected monkeys) and **leishmaniasis.** Even **HIV** adapted to humans from the variant found in apes in the forests of Central Africa, before spreading through human-human transmission. The HIV/AIDS pandemic has caused more than 35 million deaths to date.

Logging in tropical forests creates environments conducive to mosquito-borne illnesses, including malaria and dengue. In Malaysian Borneo, for example, deforestation has been linked to increased cases of a new type of malaria.

22 IPBES. 2019. Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany. https://ipbes.net/global-assessment.

23 WWF. 2018. *Living Planet Report 2018: Aiming Higher*. WWF, Gland, Switzerland

24 Loh *et al.* 2015. Targeting Transmission Pathways for Emerging Zoonotic Disease Surveillance and Control. *Vector borne and zoonotic diseases* 15(7):432-43. doi: 10.1089/vbz.2013.1563

Table 1: Emerging diseases and potential impact mechanisms of human activities related to ecological changes (source: Millennium Ecosystem Assessment, Chapter 14[25])

DISEASE	GEOGRAPHICAL DISTRIBUTION	CASES PER YEAR	EMERGENCE MECHANISM	ANTHROPOGENIC DRIVERS
Malaria	tropical (America, Asia, and Africa)	350 million	niche invasion; vector expansion	deforestation; water projects
Schistosomiasis	**America; Africa; Asia**	**120 million**	**intermediate host expansion**	**dam building; irrigation**
Dengue fever	tropical	80 million	vector expansion	urbanization; poor housing conditions
Rabies	**tropical**	**35,000 (deaths)**	**biodiversity loss, altered host selection**	**deforestation and mining**
Lyme disease	North America and Europe	23,763 (U.S. 2002)	depletion of predators; biodiversity loss; reservoir expansion	habitat fragmentation
West Nile virus and other encephalitides	**Americas; Eurasia**	**5,483 (US average 2002-2004)**	**niche invasion**	**international travel; climate variability**
Ebola	Africa	-	forest encroachment; bushmeat hunting	forest encroachment

CASE STUDIES: LEARNING FROM PAST ERRORS

AGRICULTURE AND MALARIA

Some changes in land use directly affect disease exposure. In Belize, nitrogen and phosphorus from agricultural runoff in deforested areas hundreds of kilometres upstream changed the vegetation pattern of lowland wetlands. This favoured the most efficient vector for malaria, *Anopheles vestipennis*, compared to the less efficient carrier, *Anopheles albimanus*, increasing exposure to malaria for coastal human populations

TICKS, WILDLIFE AND HABITAT DESTRUCTION

Of all arthropods, ticks are responsible for the transmission of the most diseases, and the number continues to increase as humans and domesticated animals occupy more

25 www.millenniumassessment.org/documents/document.283.aspx.pdf

wildlife habitats. More than 40% of tick-borne pathogens have been discovered in the past two decades.[26]

Lyme disease caused by the bacterium *Borrelia burgdorferi* is transmitted by ticks to humans and other animals. According to research, the risk of humans contracting this disease is significantly higher in areas with low vertebrate diversity, such forests smaller than two hectares and intensely fragmented habitats.[27]

In Sweden, a reduction in roe deer (*Capreolus capreolus*) numbers has led to an increase in cases of **tick-borne encephalitis (TBE).** Roe deer is an important host for all stages of development of the carrier tick. The progressive scarcity of hosts has pushed the ticks to colonize voles, which are more numerous than roe deer, facilitating the transmission of the pathogen to humans.[28]

MALARIA AND PLANT DIVERSITY

Deforestation, fragmentation and destruction of habitats inevitably reduce the diversity of plant species in an area. This eventually affects the presence, abundance and distribution of mosquitoes, increasing the risk of **malaria** transmission.[29] In the Peruvian Amazon, for example, deforested sites, compared to still intact forests, have a higher density of *Anopheles darlingi*, the most efficient local mosquitoes for transmitting malaria.[30]

SCHISTOSOMIASIS AND THE DISAPPEARANCE OF PREDATORS

Schistosomiasis is a disease caused by blood flukes (trematode worms) of the genus *Schistosoma* that has spread with the disappearance of predators. The parasite enters the human body through skin contact with larvae that reproduce in aquatic snails. In Malawi, unsustainable fishing and the progressive disappearance of fish that feed on snails has led to the extensive spread of the parasitic worms.[31] Every year 200 million people globally fall ill with schistosomiasis, with over 10,000 deaths.[32]

HANTAVIRUSES AND BIODIVERSITY

Hantaviruses are a family of viruses spread mainly by rodents, which can cause haemorrhagic pulmonary and renal syndromes. Transmission between rodents occurs with bites and scratches, while humans can become infected through contact with the urine and faeces of the rodents. On the American continent hantaviruses cause

26 Eisen *et al.* 2017. Tick-Borne zoonoses in the United States: Persistent and emerging threats to human health. *ILAR J.*: 1-17.

27 Brownstein *et al.* 2005. Forest fragmentation predicts local scale heterogeneity of Lyme disease risk. *Oecologia* 146, 469-475.

28 McMahon, B.J., Morand, S. and Gray, J.S. 2018. Ecosystem change and zoonoses in the Anthropocene. *Zoonoses and public health*, 65, 755-765

29 Yasuoka, J. & Levins, R. 2007. Impact of deforestation and agricultural development on Anopheline ecology and malaria epidemiology. *The American Society of Tropical Medicine and Hygiene*, 76, 450-460

30 Vittor *et al.* 2006. The effect of deforestation on the human-biting rate of *Anopheles darlingi*, the primary vector of falciparum malaria in the Peruvian amazon. *Am. J. Trop. Med. Hyg.* 74: 3-11.

31 Stauffer *et al.* 2006. Schistosomiasis in Lake Malawi: Relationship of Fish and Intermediate Host Density to Prevalence of Human Infection. *EcoHealth* 3: 22-27.

32 Sayed *et al.* 2008. Identification of oxadiazoles as new drug leads for the control of schistosomiasis. *Nature Medicine* 14: 407-412.

major lung diseases with a mortality rate of over one in three.[33] The loss of biodiversity contributes to the onset of these diseases: researchers have found that a high diversity among rodent species limits the population of carrier species and, consequently, the number of human infections.[34]

DISAPPEARANCE OF VULTURES AND THE INCREASE OF RABIES

Last century, vulture populations in India collapsed due to the use of Diclofenac on livestock. This powerful anti-inflammatory drug remains in the carcasses that the birds feed on. The disappearance of vultures was followed by an upsurge in cases of rabies in the human population. This is because the carcasses that were no longer being disposed of by the vultures had allowed a rapid increase in the population of wild dogs, which are the main vector of rabies for humans.

NIPAH VIRUS

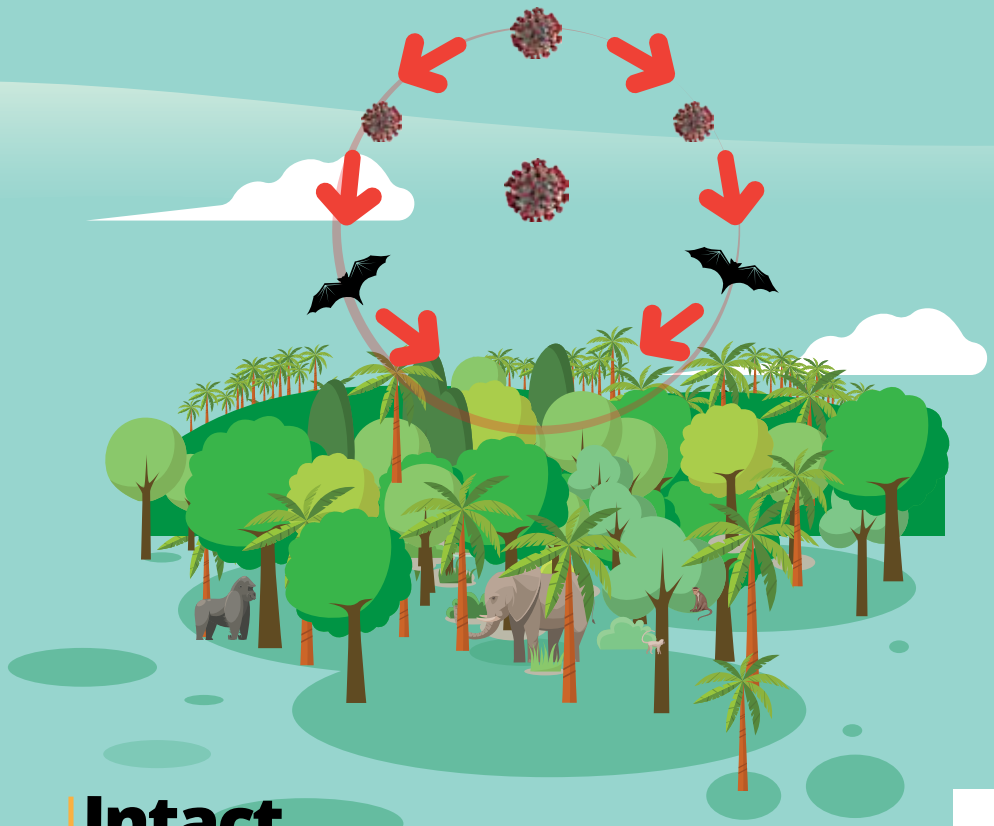
In 1999, the Nipah virus spread through Malaysia, creating havoc and causing serious damage to the local economy. The virus is transmitted to humans through contact with pigs or bats, causing acute respiratory infections or encephalitis, with a mortality rate greater than 40%. Once isolated in laboratories, this virus turned out to be completely new to science. Subsequent research has shown that the same virus had lived undetected for years, if not centuries, in frugivorous bats without causing any harm. The factors that triggered its transmission are related to habitat destruction, climatic events and the expansion of industrialized agriculture.[35]

33 Centers for Disease Control & Prevention. 2004. Case Information: Hantavirus Pulmonary Syndrome Case Count and Descriptive Statistics Atlanta, GA: Centers for Disease Control & Prevention.

34 Suzan *et al.* 2009. Experimental evidence for reduced rodent diversity causing increased Hantavirus prevalence. *PLoS One* 4(5): e5461. doi: 10.1371/journal.pone.0005461.

35 Brown. 2004. Emerging zoonoses and pathogens of public health significance - an overview. *Scientific and Technical Review of the Office International des Epizooties* 23: 435-442.

Forests: our antivirus



Intact forest

VIRUSES ARE IN BALANCE WITH THE ENVIRONMENT AND THE DIFFERENT SPECIES

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Degraded forest

VIRUSES MEET NEW SPECIES AND SPREAD GENERATING EPIDEMICS

WHAT TO DO

To control or prevent zoonoses, people have attempted to reduce populations of host or vector species. Drastic measures have been employed, including the unbridled use of insecticides or killing infected livestock. These types of intervention have several limitations, including:

- Resistance acquired by insects and other vectors (such as ticks) to insecticides and other chemical substances
- Unexpected changes in the ecology of the host populations
- Impacts on non-target species
- Negative, and often unexpected, consequences on ecosystems – as in the use of DDT against malaria
- Socio-economic impacts – as in the mass killing of poultry to curb avian influenza.

Over the last decade, the "**One Health**" approach has been promoted at a global level. This strategic concept recognizes how human health is closely linked to other animal and environmental health. It has been formally recognized by many UN bodies, the World Organization for Animal Health (OIE), the European Commission, research institutes, NGOs and others. By looking holistically at the health of people, other animals, plants, living and working environments and ecosystems, One Health promotes a multidisciplinary and collaborative approach to addressing the potential or active risks arising from the interface of human, animal and environmental health.

To make the One Health approach truly effective, stronger, systematic interaction is needed between the relevant professional groups, in particular between doctors and veterinarians, epidemiologists, ecologists and wildlife experts, but also sociologists, economists and legal practitioners. *

Only by recognizing that our health and well-being are closely linked to that of the natural world can we protect our species from the most harmful effects of pandemics.

OUR ANSWER: PROTECT AND RESTORE NATURE

The fallout from the COVID-19 pandemic will dominate the global agenda for the foreseeable future. As a global community, it is crucial that we take steps to reduce the risk of future pandemics. Some of the most important actions we can take are to crack down on illegal wildlife trade and close unregulated wildlife markets; and to preserve intact ecosystems and restore the health of those that have been degraded.

As we tackle the alarming impacts of the coronavirus crisis, we also need to keep in mind the ongoing nature and climate crises that threaten our future. It is now more imperative than ever for governments to sign on to a ***New Deal for Nature and People***, a globally binding agreement to:

- **Halve our footprint on nature**
- **Stop the loss of natural habitats**
- **Stop the extinction of living species.**

Along with maintaining our natural systems, action is needed to restore those that have been destroyed or degraded, in a way that benefits people and restores the fundamental functions that biomes such as forests provide. Aware of this challenge, the UN has dedicated the 2020s as the **Decade on Ecosystem Restoration**. Conserving and restoring our ecosystems and the services they provide – including disease regulation – should be seen as a fundamental part of maintaining human and planetary health.

As we survey the devastation wreaked by the coronavirus, we must take this time to reflect, and to harness the power of nature to prevent future health crises.

A healthy planet is the foundation of our own health and well-being.

WWF

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WWF, 28 rue Mauverney, 1196 Gland, Switzerland. Tel. +41 22 364 9111 CH-550.0.128.920-7

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