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WHITE PAPER ON A GEF COVID-19 RESPONSE STRATEGY

The Complexities and Imperatives of Building Back Better[i]

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EXECUTIVE SUMMARY

1. The COVID-19 pandemic is a signal of the fragility of the relationship between people and the natural world. Habitats—tropical reefs, forests, temperate grasslands, and wetlands—are disappearing, taking with them the ecological services that make the earth habitable for humans. The microbial world, relatively understudied but of enormous of ecological importance, is equally affected by the harsh human hand.

2. The GEF recognizes that it must act regarding the COVID-19 pandemic, a crisis that integrates the natural and the social systems at a truly global scale. The work of the GEF is central to restoring a healthy environment, which is the foundation of social and economic health. As the coronavirus pandemic is the result of the clash between humans and nature, the GEF will play a fundamental role in a lasting response to this and future pandemics.

3. The GEF is in a unique position to engage the pandemic and its consequences across a broad range of fronts: much of what the GEF is supporting in the current GEF-7 funding cycle is addressing factors underlying the increasing number of zoonotic diseases, such as the global wildlife trade and natural ecosystem degradation and destruction. Through programs like the Good Growth Platform, the Sustainable Cities Impact Program, the Food, Land Use, and Restoration Impact Program, and the Global Wildlife Trade Program, the GEF is working to help build an economy and a society will thrive despite the inevitable shocks that will come through climate change and future pandemics.

4. To support its response to COVID-19 the GEF created the COVID-19 Response Task Force, comprised of a group of experts from like-minded institutions with complementary skills and experience to help the GEF with the current crisis and with helping to prevent new ones. One of the responsibilities of this Task Force is to provide expert assessment and support the development of this White Paper, the purpose of which is to help identify the future risks linked to emerging infectious diseases and other issues touching human welfare linked to environmental degradation such as deforestation and habitat fragmentation.

5. The pandemic, and the new understandings that have emerged from it are creating opportunities for the GEF to engage in new grant-making or strengthen existing investments. Many of these investments are in traditional granting areas but a few may be novel to the institution.

6. This paper, however, is not intended to generate binding directives to the GEF or to cover only those potential investments that fit within the current GEF mandate or existing programs or projects. Rather, this information paper was drafted with the aim of looking more broadly and include issues that might rise in priority and be considered in the GEF-8 programming strategy.

7. This report explores opportunities for GEF investment at a program scale in the following areas:

- Biodiversity, invasive species and ecological reordering
- Land use change, land degradation, and disease
- Infrastructure and development
- Urban dwellers, Local and Indigenous peoples
- Legal and illegal wildlife use and trade
- Domestic animal production and agriculture
- Climate change and its impacts
- Cities
- Disease prediction and management
- Pandemic psychology

8. Each of the topics concludes with a list of possible investments that the GEF and/or its partners might choose to consider. Some of these are clearly within the current GEF mandate, while others would represent new avenues of investment should GEF choose to pursue them. The idea behind including the latter is to promote consideration of new areas if deemed valuable and necessary to further the GEF's mission. Many of these possible investments are already being pursued, in part or in whole, by GEF partners and other organizations, and possible GEF involvement would be predicated on developing informed partnerships.

9. The GEF also recognizes the need to consider a broadening in its thinking about how to approach its core mission of providing global environmental benefits. As such, human health outcomes have not been considered part of the GEF's operating sphere directly. But the universal disruption caused by the pandemic has revealed how human health and measures to maintain it are intimately associated with global environmental benefits. Addressing the larger issues will require broader coalitions.

10. The final section of this report examines opportunities for GEF investment and partnership at a global scale. These opportunities include addressing global inequities; shaping societal responses and the future of science; learning from past; learning to live in a virally-entangled world; promoting human health, One Health, and ensuring One Conservation; fostering effective nature-based solutions; and financing recovery and strengthening the role of the private sector.

11. All of these areas would contribute to a more sophisticated and realistic view about how pandemics take place and what can be done to try to ameliorate the next one. The COVID-19 pandemic opens a window and demands broad scale public, governmental, and business attention. As such it presents an opportunity to address vital issues facing humankind and the rest of life on earth.

1. GEF AND A COVID-19 RESPONSE STRATEGY

1. In late 2019, the world became aware of a previously unknown human pathogen, a virus that was soon named SARS-COV-2. The disease caused by the virus, called COVID-19, spread to nearly every country on Earth in less than a year, with catastrophic consequences: by mid-November 2020 at least 53 million people worldwide had contracted the virus, over 1.2 million people had died from COVID-19, and the economies in many countries were in serious straits. The world was not prepared for the pandemic, yet it was not a surprise. Global health practitioners, national governments, the World Health Organization, scholars, and pundits all had been saying for years that a global pandemic of influenza or a related disease was imminent.[1]

2. The COVID-19 pandemic began as a health crisis but quickly became the worst human and economic crisis of our lifetimes. Virtually all human occupations have been affected —from indigenous fisheries in Canada to tourism in Africa to farming in Brazil to meat processing plants in the United States. Global economic costs will run into the trillions of dollars. Over one and a half billion students have been out of school and tens of millions of people are expected to be pushed back into extreme poverty and hunger. Progress towards all of the Sustainable Development Goals, already faltering, has been slowed, stopped, or reversed.[2]

3. The unrelenting degradation of nature and the weakening of the services ecosystems have provided to humans lie at the root of COVID-19 and other pandemics. The only lasting solution to such zoonotic diseases is to address the ongoing environmental crisis by promoting transformational change to human systems in all their manifestations: cities, energy, food, and production/consumption.

4. The pandemic is a signal of the fragility of the relationship between people and the natural world. The human population, though representing only 0.01% of all living things by weight, has already caused the loss of 83%, by biomass, of all wild mammals and half of the biomass of all plants, along with severely reducing the genetic diversity that underpins all life. Habitats—tropical reefs, forests, temperate grasslands, and wetlands—are disappearing, taking with them the ecological services that make the earth habitable for humans. The microbial world, relatively understudied but of enormous of ecological importance, is equally affected by the harsh human hand.[3]

5. According to the leaders of WWF International, the UN Convention on Biological Diversity, and the World Health Organization’s department of environment, climate change and health, “coronavirus is a warning to us to mend our broken relationship with nature.” The conservation community and resource economists agree that any pandemic responses must place nature more directly in the center of human development, and not only for nature’s sake: $44 trillion of economic value generation—more than half of the world’s total GDP—is moderately or highly dependent on nature and its services.[4]

6. The Global Environment Facility (GEF) was established on the eve of the 1992 Rio Earth Summit to help tackle our planet’s most pressing environmental problems. The work of the GEF

is central to restoring a healthy environment, which is the foundation of social and economic health. As the coronavirus pandemic is the result of the clash between humans and nature, the GEF must play a fundamental role in a lasting response to this and any future pandemic.

7. The GEF unites 183 countries in partnership with international institutions, civil society organizations, and the private sector to address global environmental issues while supporting national sustainable development initiatives. The GEF is an independently operating financial organization and is the designated financial mechanism for five international environmental conventions: Convention on Biological Diversity; United Nations Framework Convention on Climate Change; Stockholm Convention on Persistent Organic Pollutants; UN Convention to Combat Desertification; and Minamata Convention on Mercury. It also serves the Montreal Protocol on Substances That Deplete the Ozone Layer. In the years since its establishment, the GEF has funded over 4,500 projects in 170 countries, and many thousands more through the GEF Small Grants Program, providing $20.5 billion in grants that leveraged $112 billion in co-financing.

8. In the face of overwhelming evidence that many of its previous investments were put at risk by the pandemic, the GEF recognized that it must take action regarding the COVID-19 pandemic. Such action flows logically from GEF's engagement with partners on programs like the Good Growth Platform, the Sustainable Cities Impact Program, the Food, Land Use, and Restoration Impact Program, and the Global Wildlife Trade Program, among others. In fact, many of the previous and on-going GEF investments are addressing factors underlying the increasing number of zoonotic diseases, such as the global wildlife trade and natural ecosystem degradation and destruction.

9. The pandemic reinforces the logic behind GEF's transformational programs and underlines the need for a lasting transformation to a sustainable, inclusive, resilient, low-carbon, low-polluting, nature-positive, and circular economy. Such an economy and a society will build resilience to thrive despite the inevitable shocks that will come through climate change and future pandemics.

10. The emergence of epidemics and pandemics, be they new or reemerging, can be attributed to a set of interlocking stressors: changing environmental factors (e.g. land use change or urbanization); changing socio-economic factors (e.g. poor public health services or increased travel); and changing viral profiles (e.g. changes in drug resistance or emergence of new viruses). COVID-19 is not a natural disaster in the sense of earthquakes or hurricanes. Rather it is a crisis that integrates the natural and the social systems at a truly global scale. This places the GEF is a unique position to engage the pandemic and its consequences across a broad range of fronts, including its own response to the pandemic and develop ways to decrease risks of future pandemics.[5]

11. In May 2020, the GEF proposed a set of immediate, medium-term, and longer-term action to anticipate and prevent further pandemics. Immediate actions included a greater focus on the wildlife trade and consumption challenges, expert analyses on the future risks linked to emerging infectious diseases along with their root causes and identification of risks to GEF

projects and programs that might compromise past gains and future outcomes. The principal medium-term action is to develop an internal draft blueprint on how to deploy ongoing and upcoming projects under its current four-year investment cycle (GEF-7) that can help lay the foundation for a sustainable post-COVID-19 recovery. It can also help orient the upcoming GEF-8 cycle of investments, which begins in 2022. In the longer term the GEF will learn from the current pandemic, develop new strategies to guide GEF-8 based on its analysis of the current situation and the needs and priorities of its partners.[6]

12. To support GEF's response to COVID-19, as part of its immediate actions, it created a Task Force comprised of a group of experts from like-minded institutions with complementary skills and experience to help the GEF with the current crisis and with helping to prevent new ones. One of the responsibilities of this Task Force is to provide expert assessment and support to the development of this White Paper.[7]

13. The Task Force met every two weeks starting in late May 2020 and will continue through December 2020. Each meeting had a theme and included presentations by GEF experts, Task Force members, and outside experts. Themes included the wildlife trade, sustainable cities, indigenous and local peoples, the private sector, and system change. As a result of these discussions and additional consultations, the GEF made dynamic changes is some of its programming to address urgent issues emerging as a result of the pandemic.

14. This White Paper is designed is to help identify the future risks linked to emerging infectious diseases and other issues touching human welfare linked to environmental degradation such as deforestation and habitat fragmentation. The charge was not to limit examination to topics currently within the GEF's purview, but to look more broadly and include issues that might rise in priority and be chosen to be included in GEF-8. This paper was jointly produced with input from members of the GEF COVID-19 Response Task Force and is not intended to generate binding directives to the GEF. Rather, this information paper was drafted with the aim of serving as one element among others that can guide GEF directions in the short, medium and long term when dealing with the impact and ramifications of the current pandemic.

15. The next three sections of this White Paper are: an overview of microbes and their ecological role, along with more specific detail about viruses in general and the virus that causes COVID-19 in particular; an in-depth discussion of where the GEF sees opportunities for programmatic investments that may help address the current crises and prevent future similar crises; and finally a discussion of global-level GEF investments and partnerships. Each of the topics concludes with a list of possible investments that the GEF and/or its partners might choose to consider. Some of these are clearly within the current GEF mandate, while others would represent new avenues of investment should GEF choose to pursue them. The idea behind including the latter is to promote consideration of new areas if deemed valuable and necessary to further the GEF's mission. Many of these possible investments are already being pursued, in part or in whole, by GEF partners and other organizations and possible GEF involvement would be predicated on developing informed partnerships.

Task Force Key Messages

16. The Task Force identified a few key messages that: 1) help understand the context within which the White Paper was written; and 2) identify critical opportunities for GEF immediate involvement in COVID-19 response and recovery.

1. Much of what the GEF has been doing to pursue its mandate to provide global environmental benefits is of clear importance in addressing response and recovery to this pandemic, though it has not been heretofore viewed as such.
2. Through dynamic programming of GEF-7 funds the GEF has already responded to suggestions generated through the Task Force. These efforts have included funding for wildlife-based economies in Africa and could also include: support for national environmentally sustainable COVID-19 efforts; increasing support for Global Wildlife Program efforts to test elements focused on reducing spillover risks and increasing understanding of viral abundance and spillover dynamics; and finally, testing approaches to reduce global threats and increase global benefits as part of national COVID-19 response plans and actions.
3. The COVID-19 pandemic has made clear that new approaches are necessary to address recovery and the building of resilience against future pandemics. Existing disciplinary and institutional boundaries must be bridged through new partnerships and strengthening and extending existing partnerships. A great deal of work is already being done that can be foundational for future GEF investments.
4. As laid out in the White Paper there is a great deal of innovation available to address the challenges presented by pandemics but lack adequate support for scaling up. A supportive policy and financial environments must be put in place for the necessary new work to proceed.
5. Human health, already included in the GEF's Chemicals and Waste Program, could become more central to activities of the GEF as an enabling condition for providing global environmental benefits.
6. The GEF's program on the illegal wildlife trade is central to responding to the current and future pandemics. It could be expanded and strengthened to include greater attention to threats from zoonotic disease spillover and through attention on the demand side.
7. There is ample opportunity and justification for the GEF to strengthen and expand its investments in the ecological dimensions of pandemic prevention. This might include attention to One Health work as an integral part of delivering on the UN's Sustainable Development Goals and to the prevention of pandemics as an ecosystem service to be valued and managed for.
8. Cross-sectoral and trans-national cooperation are both essential to allow countries and organizations to develop and implement programs to reduce the risk of future

pandemics. There is a key role for the GEF to help in the design and implementation of such cooperative efforts and to develop ways to catalyze cross-impact programs.

9. With its focus on global environmental benefits the GEF is well placed to help countries and others think about a systems approach both to post-COVID recovery as well as decreasing the risk of future pandemics.

Caveats

17. The White Paper is being written at a time of high uncertainty concerning almost all details of the virus, the nature of infection and the course of the disease, types and efficacy of human responses, and how people, societies, governments, and the environment will respond both to the disease and efforts to manage it. New science and analysis are being published daily and this document is not a comprehensive account of the myriad relevant literature. References were collected for possible inclusion until September 2020 with some references included through early November, and the most relevant literature was included, though with full awareness that future analyses might provide differing conclusions. There are now, and undoubtedly will continue to be, contested elements and there is a danger of early interpretation. Different institutions have taken different positions on complicated issues and the White Paper makes an effort to present a balance of points-of-view. Much about COVID-19 is not understood, and like the pandemics that preceded it the scholarship and understanding will continue to develop. It seems clear that COVID-19 is here to stay and second that its long-term impact will depend on a mix of human biology and psychology, social and health care responses, and environmental and climate factors—and of course the evolution of the virus itself.

2. Background

18. The current pandemic has the potential to impact the work of the GEF in important ways. In order to understand the parameters that will guide the GEF's response, this section provides background on how the novel coronavirus and viruses in general fit into the diverse world of microorganisms, how they cause disease, and how those diseases impact humans and how GEF and its partners may choose to respond.

The microbial world

19. Microbes are forms of life too small to be seen by the human eye and include bacteria, protozoa, fungi, algae, amoebas, and viruses. Microbes have lived on earth for three billion years. Humans evolved in, and currently inhabit, a microbial world.

20. Microbes are found throughout the earth, in the air, soil, water; each gram of soil contains thousands of millions of microbial cells. Microbes are found in the Antarctic ice and deep below the bottom of the ocean, and they are constantly on the move. Winds sweep microbes from Africa to the Americas in enormous clouds of dust, the mist of breaking waves carry microbes from ocean to land in, and they emerge from the thawing Arctic permafrost.[8]

21. Microbes play vital ecological roles everywhere they occur. They support the existence of all higher forms of life. They are essential to the ocean's carbon cycle and the nitrogen cycle in grassland soils. They comprise part of the coral polyps that form reefs in tropical oceans.[9]

22. Bacteria, fungi, protozoa and viruses are also found in and on the bodies of larger animals and plants. These microbes comprise an organisms' microbiome. The human microbiome, for example, has hundreds of different species which taken collectively equal the number of cells found in the human body. Emerging results are showing that there are strong interactions between microbes and the cells of their animal and plant hosts, and a healthy microbiome is a key part of overall organism health. There is also new evidence that the microbiome can exert strong effects on the genotype itself by influencing the immune system and modifying the expression of genes. Disruptions in the microbiome can result in outbreaks of infection or disease. Human-built structures also have microbiomes, including many viruses, that can influence the health and wellbeing of their human inhabitants.[10]

23. The microbial world is affected by the same factors as the much better-studied world of animals and plants, including environmental chemicals, pollution, habitat loss, and climate change. Climate change will not only affect the ecological and biogeochemical processes driven by microorganisms but the microbes themselves and the biological communities of which they are key parts. This will affect agriculture, animal husbandry, and all other human activities. It will also affect the prevalence and outbreak of diseases.[11]

24. Viruses are a major component of the microbial world and are the most abundant and most diverse microbial forms, and one author boldly states that "most of the biodiversity on the planet is actually found in viruses." Collectively viruses make up what has been called the "virome." Scientists are just beginning to appreciate their diversity; only some 7000 viruses have been named and an unknown number, perhaps millions, remain to be described.[12]

25. The overwhelming majority of viruses are not involved in diseases of animals, plants, or humans. Yet it is the disease-causing nature of a few viruses that have captured the attention of scientists and the public, and for good reason: viruses cause HIV/AIDS, Ebola, polio, rabies, certain forms of cancer, and other diseases of humans. They are also responsible for viral diseases of plants and can be a significant source of loss in agricultural systems. Of the viruses known to exist, fewer than 2,000 have been described as infecting animals, and it is estimated that around 1.7 million exist in mammals and water birds alone, the majority of which are as-yet undescribed. [13]

26. Today's strong associations between viruses and disease has its origin in the first discovery of the microbial world through early microscopes and the work of Antonie van Leeuwenhoek in the 16th century and the subsequent proof by Louis Pasteur and Robert Koch of the role of "germs" in causing infectious diseases.

27. In 1898, the Dutch microbiologist Martinus Beijerinck argued that tiny "filterable agents" caused tobacco mosaic disease, and he named them viruses, reviving an older term for

an infectious agent derived from the Latin for poison, venom, or slimy fluid. The reputation of viruses was sealed by their name.[14]

28. Viruses are not cells but particles, called virions, consisting of a protein coat, or capsid, which surrounds the genetic material. Capsids come in different shapes and sizes, and it is this shape that is most commonly used to classify viruses. Rabies virus is bullet-shaped, poxviruses are brick-shaped, and corona viruses are so named because of the crown-like spikes on their surface. In general viruses are around 100 to 500 times smaller than bacteria. Some viruses contain genetic material made up of DNA, but in many more viruses the genetic material is RNA. Another group of newly recognized viruses combines both DNA and RNA.[15]

29. The taxonomy of viruses is changing as researchers learn more about them. Virus taxonomy is governed by the International Committee on Taxonomy of Viruses which uses a 15-rank classification hierarchy similar to the familiar Linnaean taxonomy. For example, Severe acute respiratory syndrome-related coronavirus (SARS-CoV) is a species in the family Coronaviridae, which is in the order Nidovirales.[16]

30. Unlike true cells, viruses have genetic material only to reproduce themselves and must rely on other living cells for the genetic machinery to perform all other functions. As a result, they are inert until they have infected a cell—they are obligate parasites. In mammalian cells, copying of DNA has a built-in correction mechanism that minimizes mutations. Viruses, on the other hand, reproduce in a day or two and have no proof-reading mechanism, so they continually generate mutations. RNA viruses have mutation rates up to a million times higher than their hosts. This means they evolve extremely fast with new variants constantly generated and then subjected to natural selection. The result may be non-viable viruses but may also be viruses with mutations that allow them to hide from host immune attack, increase their ability to invade and spread, survive anti-viral drugs, or to reproduce at a faster rate.[17]

31. Viruses occur in virtually unimaginable numbers. By one estimate the global total of viruses is 4.8×10^{31}, on par with the numbers of stars in the universe. One estimate is that the weight of viruses is three times that of all humans combined. They are transported in the atmosphere from which they are deposited throughout the world in significant numbers; as many as 800 million viruses may be deposited onto every square meter of the planet every day. Viruses are also abundant in the ocean, numbering ten billion per liter of seawater.[18]

32. Viruses have been central players in the evolution of life on earth, including human evolution. At least 45 percent of the human genome consists of retroviruses—RNA viruses that, after infecting a cell, use an enzyme to convert its RNA into DNA and integrate it into the DNA of the host cell (HIV is a retrovirus). Some of these viral DNA sequences become fully incorporated into the host genome and take on key functions, including, in humans helping to sustain pregnancies. As Frank Ryan wrote in his book Virolution, viruses are “the only organisms small enough and primal enough to inhabit the genomic landscape.[19]

33. Viruses are significant ecological actors in their own rights and have been implicated as key actors in settings ranging from marine and soil food webs to planetary scale carbon,

nitrogen, and phosphorus cycles. A recent review concluded that parasites (including viruses) can strongly affect: 1) biogeochemical cycles of water, carbon, nutrients, and trace elements; 2) fluxes of biomass and energy, and 3) temporal ecosystem dynamics including disturbance, succession, and stability. Viruses are particularly well studied in oceans, where they are a major factor in ocean ecology, killing 20-40 percent of marine bacteria every day. They exert influence by controlling bacterial abundance and the knock-on effects of that abundance at community and ecosystem levels. Viral infections can change the behavior of the host organism, for example delaying migration in swans or changing food preference in aphids. At a population level, viral infections may influence behavior, mortality, and reproductive rates with knock-on ecological effects. And they may play vital roles in influencing the success of invasive species. [20]

34. Not all individual hosts – animal or plant – are equally likely to transmit viruses. There are dozens of other reasons that different portions of a given population are infected preferentially, for example, young people and animals often are the only individuals ever infected by some viruses because the immunity they develop lasts throughout their lifetime. For others, older people or animals are more susceptible for various physiological reasons. Recent work has also shown that individuals that are stressed are more likely to shed viruses and be more susceptible to contracting diseases. There also appear to be seasonal cycles in viral shedding, at least in some animals.[21]

35. Viruses are so successful because they are so adaptable. They reproduce rapidly, constantly create new genetic configurations, have many progeny and are often able to colonize new hosts easily. They can spread between hosts in a myriad of ways and can survive outside of their hosts for varying periods of time. It took the human species 8 million years of evolution to change their genome 1 percent. These genetically error-prone animal viruses can evolve by more than 1 percent in a matter of days.[22]

36. Viruses are vital parts of microbiomes and play a number of roles. Viruses infect host cells and become incorporated as viral elements in the genome of the host, which can change host gene expression, express proteins, or generate infectious viruses. They also infect other microbes in the microbiome, thus influencing the functioning of the overall microbiome. Viruses are emerging as complex ecological and evolutionary actors both within and outside of organisms.[23]

Diseases: zoonotic and otherwise

37. Viral diseases affect all forms of life. In humans, viruses can impact many different bodily systems, from respiratory (common cold) and gastrointestinal (norovirus) to the liver (hepatitis), skin (oral herpes), blood (Ebola), and the nervous system (rabies). The majority (70%) of emerging diseases (e.g. Ebola, Zika, Nipah encephalitis), and almost all known pandemics (e.g. influenza, HIV/AIDS, COVID-19), are zoonoses (i.e. are caused by microbes of animal origin). These microbes spill over due to contact among wildlife, livestock, and people.[24]

38. The majority of zoonotic viruses described as of 2015 are RNA viruses. Wild animals were suggested as the source of 91% of zoonotic viruses, significantly more often than from

domestic animals. Emerging pathogens seem to infect more than one species with 63% of zoonotic viruses infecting humans also reported in animal hosts from at least two different taxonomic orders and 45% reported in four or more orders. Viral diseases are transmitted to humans primarily from other humans, but also by arthropods as is the case with yellow fever, dengue, Zika and West Nile fever. They also reach humans through other vertebrates, most commonly bats, primates, rodents, and waterfowl.[25]

39. Emerging viral diseases are particularly serious and include chikungunya, Ebola, Hendra, influenzas of various types, MERS, SARS, and Zika. In some cases, these diseases are re-emerging, having dropped significantly in the past only to flare up again as a result of changes in the underlying epidemiology. Most emerging infectious diseases appear to be caused by pathogens already present in the environment which encounter new conditions that allow them to significantly increase infectiveness. In other cases, mutation in the virus allows for a new variant that can cause a new disease or a modification of an existing disease. Altered virus transmission can be caused by land use changes, breakdown of public health measures, and environmental changes that drive increased contact between animals and people. It seems clear that the rate of emergence and reemergence of viral diseases is increasing, and an expert international panel has proclaimed this as the "pandemic era."[26]

40. Diseases are an integral part of ecology, one of nature's services, though not valued by humans as much as carbon sequestration and clean water. Microbial pathogens serve as important ecosystem regulators, mediating primary productivity and global carbon in systems as diverse as grasslands, forests, and marine phytoplankton. Though the negative impacts of pathogens are always top of mind, pathogens also provide provisioning, regulating, and cultural services.[27]

41. Despite these beneficial services pathogens are most often considered in relation to their negative impacts on humans and the species they have domesticated, particularly crops and livestock. Crop losses to pathogens are estimated at 14-21 percent for five major food crops and may be higher in areas with marked food insecurity. Livestock diseases globally cost on the order of billions of dollars.[28]

42. In humans there are four main types of diseases: hereditary, physiological, deficiency, and infectious. The first three are all non-communicable, whereas infectious diseases, by definition, are communicable. Infectious diseases are those that are passed from organism to organism as a result of transmission of a biological agent—called a pathogen or parasite. Infectious diseases are caused by a variety of pathogenic microbes including bacteria, fungi, and viruses.

43. Diseases of all types are a major burden for humans, particularly those without sufficient access to health care. Diseases of greatest global concern include tuberculosis, influenza, malaria, measles, and diarrheal disease. On the African continent a series of neglected tropical diseases affect the poorest 500 million people, creating a tremendous burden of disease.[29]

44. An epidemic is an unexpected, widespread rise in incidence of disease at a given time. Epidemics occur when a disease-causing agent and susceptible hosts are present in adequate numbers, and the agent can be effectively conveyed from a source to the susceptible hosts. Epidemics may result from an increase in the amount or virulence of the virus, introduction of the virus into a new setting, enhanced transmission, or change in susceptibility of the host.[30]

45. Epidemics appear to be increasing in number and impact. Over the past 50 years the number of epidemics worldwide has risen significantly with an average of two to three emerging each year. Globalization has facilitated the spread of infectious diseases, though patterns vary depending on transmission mode and the taxonomy of the infectious agent. [31]

46. Zoonoses are infectious diseases that are transmitted from animals to humans. A spillover is a single event during which a pathogen from one species moves into another species. Zoonoses can be traced to bacteria, fungi, single- or multi-cellular animals, or viruses and can spread from animals to humans through direct contact, or indirect contact, and they can be vector-borne (e.g. bitten by a tick), food borne, or waterborne.

47. There are over 200 zoonotic diseases, including West Nile virus, plague, rabies, Lyme disease, zoonotic influenza, newly discovered rubella, and emerging coronaviruses. The majority of emerging infectious diseases make their way to humans through wild and domestic animals – 60 percent in a 2008 study. Of these emerging infectious diseases, 72 percent originated in wildlife. Estimates vary but somewhere between one and five new infectious diseases have emerged each year, with the majority of these of animal origin. Wild animal species carry many pathogens that could infect humans, with higher diversity in more diverse ecological settings. Primates, bats, and rodents (and domestic animals) have more potentially zoonotic viruses than other species. Relatively little is known about viral diversity in wild animals, for example one estimate is that there are 1.67 million viruses awaiting discovery, and that between 631,000 and 827,000 of these may be able to infect people.[32]

48. Zoonotic diseases appear to emerge most commonly when humans create situations in which the probability of transmission of disease-causing microbes increases. These situations are ones in which there is elevated contact between humans and some wild species due to three major factors.

49. The first factor is increased conversion of natural land cover to human-dominated land uses with resulting loss of habitat, increased direct and indirect contact between humans and their livestock and a widening range of wildlife species and their viromes, while habitat disturbance perturbs host-disease equilibria and in some cases increases disease agent shedding. For example, areas with substantial human use (e.g. agricultural and urban ecosystems) have a greater percentage of species that carry human-shared pathogens and parasites than do areas of less human impact.

50. The second factor is agricultural intensification, often combined with production of domesticated animals in more intensive settings, which creates ideal conditions for disease organisms to thrive, evolve, and make the jump to human hosts. The third factor is wildlife

exploitation—the production, sale and consumption of a subset of wildlife with an active trade moving animals to urban centers with a mixing of species of wild animals and their microbes with each other and domestic animals and of course increasing the exposure to humans. Areas of high biodiversity are particularly likely to be the setting where such situations lead to zoonoses. Underlying all of these factors are unsustainable practices partially driven by globalized production and trade coupled with rising rates of international trade and travel. And, affecting all of these, the impacts of climate change.[33]

51. In order for a microbe that causes a disease in animals to become a human disease, it must overcome three obstacles. First, it must cross the species boundary from an animal like a bat or chicken. Second, it must become established and able to reproduce within a human host. Third, it must be able to be transmitted from this first individual human to other humans. Success in all three defines a spillover and can lead to an epidemic or pandemic (an epidemic that has spread over multiple countries or continents). But it may also lead nowhere—a spillover with no long-term impacts to humans. These events are difficult to document and therefore the true number of spillover events is currently impossible to calculate.[34]

52. There is no doubt, however, that human activity has created an ideal environment for spillover to occur. As Morens et al. (2020) write: "We have created a global, human- dominated ecosystem that serves as a playground for the emergence and host-switching of animal viruses, especially genetically error-prone RNA viruses, whose high mutation rates have, for millions of years, provided opportunities to switch to new hosts in new ecosystems."[35]

53. Zoonotic emerging infectious diseases come in a variety of different types, with differing mechanisms of transfer from animal to human. Some are vector-borne, such as West Nile virus, transmitted by mosquitos, or vector-borne and now restricted to people, such as malaria., which may have originated in wild species. Other types are direct transmission from the animal host with no secondary transmission such as rabies while, yet others are due to pathogens with reservoirs in both wild and domestic species such as avian influenza. Finally, there are those that originate in a wild species, spread to humans and then are transmitted among individual humans without the need for further introduction from animal hosts—as is the case with SARS-CoV and SARS-CoV-2.[36]

54. Emerging zoonotic diseases can have major social and economic impacts. They bring suffering and death to many, particularly the disadvantaged, social and economic loss, and dislocation and stress for millions that may extend long after the current pandemic itself is over. The Global Preparedness Monitoring Board—an independent organization established by WHO and the World Bank—estimated in 2019 that the costs of many recent major outbreaks such as SARS, MERS and Ebola were in the tens of billions of dollars. According to a 2020 IPBES report, when the impact of COVID-19 and the high costs of influenza outbreaks are considered, zoonotic emerging diseases may cause as much as $1 trillion of economic damages each year. The non-economic costs are equally significant.[37]

55. Not all zoonotic diseases reach the status of a pandemic. Pandemics can be discrete events or persistent, as is the case with diseases like malaria or HIV/AIDS. In fact, a significant

zoonotic disease burden is from zoonotic diseases of long-standing impact on humans including Rift Valley fever, Chagas disease, and rabies. In order for an epidemic to turn into a pandemic there must be a concentration of hosts which are not immune to the disease and contact between groups of hosts. Until humans lived in stable settlements there were probably no pandemics. But it was transportation networks, be it Silk Route caravans carrying the plague among their cargos, sailing ships bringing smallpox to North America, steam ships carrying more plague, or airplanes transporting SARS-CoV-1. Modern transportation systems have dramatically increased the globe's connectivity and the SARS-CoV-2 virus moved from its putative origins in China to the rest of the world at the speed of transoceanic airplanes.

56. Pandemics disrupt all aspects of human life, from cities to transportation, from travel to agriculture. They lead to fear, prejudice, violence, despair, and poverty. They are also expensive. The annualized cost to the global economy of pandemics averaged over many years is estimated at $1 trillion year. Despite such high costs, and despite the fact that the global health community has predicted pandemics for decades, governments and multilateral institutions have paid little attention to preparing for pandemics. Christian McMillan, a historian of pandemics, concludes that the lessons taught by previous pandemics are never learned by human societies and "these lessons are not new; the history of epidemics and pandemics has been teaching them for centuries … Pandemics are not going away. There is no doubt more to come."[38]

Coronaviruses and COVID-19

57. The RNA virus family Coronaviridae, subfamily Coronavirinae, is of particular interest because it includes several human and other animal viruses that cause epidemics. The CoV family (Coronaviridae) infects more than 200 different hosts including dolphins, woodpeckers, fish, and humans and the same virus can affect more than one host species. Coronaviruses were not named coronaviruses until 1968. The pathogen responsible for the COVID-19 (from "coronavirus disease 2019") pandemic is the virus SARS-CoV-2. This virus is the seventh coronavirus known to infect humans, three of which, including this one, MERS-CoV, and SARS-CoV, cause severe disease, whereas the other four are associated with mild symptoms. Coronaviruses are responsible for the SARS epidemic in 2002-2004, the MERS-CoV outbreak in 2012-13, and the current SARS-CoV-2 pandemic. Prior to the outbreak of SARS in 2002 in China, coronaviruses circulating in humans mostly caused only mild infections.[39]

58. Despite speculation to the contrary, evidence on the origin of SARS-CoV-2 points strongly to an origin in a wild bat with subsequent evolution in either an intermediate host or directly in humans and not to a laboratory manipulation. Much remains to be learned about the details of the spillover of this virus and several previous reports have been shown to be incorrect. What is clear is that almost all human coronaviruses have animal origins or otherwise circulate in animals, including bats, palm civets, camels, and domestic cats, and dogs. Despite this range of animals that can be infected by coronaviruses, it appears that bats are the major evolutionary reservoir and ecological drivers of CoV diversity. Bats themselves appear not to show serious symptoms of the coronaviruses that cause disease in humans.[40]

59. SARS-CoV-2 is relatively large for a virus at 125 nanometers in diameter. It has some 30,000 genetic bases in its genome, the largest genome of all RNA viruses. Evidence points to an origin in horseshoe bats, in which over 500 strains of viruses genetically closely related to SARS-CoV-2 circulate.[41]

60. In humans, coronaviruses are transmitted via droplets generated by a cough, sneeze, or simply by talking, and close contact. High temperature and high humidity appear to reduce the transmission rates. Because they do not have an envelope, the viability of coronaviruses is strongly influenced by temperature and organic or microbial pollution, and they do not persist long in sewage. SARS-CoV-2 is particularly impactful to humans because it attacks cells at multiple points, with lungs and throat particularly susceptible.[42]

61. The COVID-19 pandemic is still in progress at the time of writing. By mid-October 2020 over 40 million cases of COVID-19 have been reported and over 1.1 million deaths, affecting nearly every country. Responses to the pandemic have varied markedly between countries. A survey of 14 countries with advanced economies published in August showed a median of about three-quarters of citizens say their country has done a good job of handling the coronavirus. However, about half feel that divisions within their country have grown. Fifty-eight percent say their lives have changed a great deal or fair amount due to the disease, with women particularly feeling the effects of the virus.[43]

62. The emergence of a pandemic, whatever its causal agent, was predicted in a series of papers and reports. Between 2005 and 2019, there were published reports of a wide diversity of SARS-related CoVs in bats in China that had the capacity to infect human cells in the lab, cause SARS-like disease in mouse models, and that had already infected people in rural south China. In 2018 the WHO published a list of "priority pathogens" that represent a pandemic threat and included SARS and other related coronaviruses. In a presentation in London in 2018, Bill Gates predicted a pandemic within the next decade. In 2012, the science writer David Quammen published a book entitled Spillover: Animal infections and the next human pandemic". The US government ran a scenario planning exercise around a global pandemic in October 2019. All of these warnings and many more were not widely heard, and the COVID-19 pandemic came as a shock to almost all people in almost all parts of the world.[44]

63. Humanity had no shortage of warnings but much of the world was still caught off-guard and unprepared. The COVID-19 pandemic has affected nearly all people on earth, from the premature death of tribal elders in remote Amazonian indigenous settlements to urban youth in Europe who have lost their livelihoods. Social distancing, novel public health rules, and travel restrictions have upended lives, creating fear, distrust, hunger, and flight. Schools have closed down, economies have been severely affected, and supply chains are stretched or interrupted.[45]

COVID-19 and the GEF

64. The coronavirus is forcing us to confront what we have long understood but too often ignored: the degradation of nature is driving the spread of wildlife-borne diseases into human populations. The pandemic is just the most recent and most dramatic example of how human pressure on nature and natural systems can have wide-ranging and lasting consequences.

65. A recent report from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) concluded that pandemics are becoming more frequent and that addressing the current crisis will require using scientific evidence to re-assess the relationship between people and nature, and to reduce global environmental changes that are caused by unsustainable consumption, and which drive biodiversity loss, climate change, and pandemic emergence. Among its findings, the report highlights that while global strategies to prevent pandemics by, for example, reducing the wildlife trade and land-use change, may be costly, in the long run the benefits far outweigh the damages that stem from pandemics.[46]

66. The linkages between the environment, sustainable development, the myriad threats caused by the pandemic and the multi-faceted response that will be necessary make the GEF a critical player in a COVID-19 response. The IPBES study concluded that the same environmental changes that threaten biodiversity are also driving increased spillover, amplification and spread of viral diseases. These diseases threaten both wild species as well as humans and their domesticated animals and plants. And the risk of pandemics is increasing rapidly with more than five new diseases emerging in people every year. The role of habitat loss and degradation, the wildlife trade chain, and consumption patterns are all woven into the fabric of society's troubles with animal-origin diseases. The environment must take a central place in humanity's response to the pandemic and to preventing future pandemics.

67. Global climate change has, with good reason, commanded much of the world's attention in recent years, as it is a challenge that will require unprecedented efforts, sacrifices, and choices, and therefore cooperation and collaboration. Coronavirus reminds us that we are intimately interconnected with and dependent upon nature in many other ways as well. IPBES concludes that the economic damages from emerging diseases are similar in magnitude to those from climate change. Addressing the interlinked issues of biodiversity loss, climate change and emerging diseases are part and parcel of ensuring a sustainable future for life on earth.

68. Preserving those connections will also require a global effort, or coronavirus will be far from the last pandemic we will face. At the same time, however, a greater focus on the profound connections between people and nature will be essential to building a sustainable and equitable economic system.

69. The GEF is confronting this problem mainly on two fronts. First, hunting, transporting, and consuming wildlife brings people wild species and domestic species together, often in crowded or poorly-regulated markets that form mixing bowls ideal for spillover events. The GEF is leading the largest effort to date to finance initiatives to tackle wildlife trafficking, through

the Global Wildlife Program, but more is needed in order to reach all developing countries that need assistance and to handle the unsustainable consumption of wildlife.

70. Second, widespread deforestation brings even more people into close contact with plants and animals that harbor pathogens that can leap into humans with devastating effect. Rapid development and competing land uses have cut wide swaths through the world's forests, undermining vital environment services, such as the maintenance of biodiversity, climate stability, integrity of land, and delivery of fresh water. Moreover, degraded ecosystems also lead to situations where natural, low-level background pathogens in native species increase in prevalence and shedding rate from stressed wildlife. The degradation of forests and their associated environmental services also threaten the livelihood of an estimated 1.6 billion forest-dependent people, with consequences for migration and security.

71. Over the past 25 years, advances in forest protection, management, and restoration helped slow the rate of forest loss. Building on these techniques and developing a concerted and comprehensive approach to the conservation and use of these vital ecosystems is at the heart of the GEF's Sustainable Forest Management Impact Program. The Impact Program works to protect the few places in the world where intact forest biomes still exist: the Amazon, the Congo Basin, and important dryland landscapes around the world represent the last geographies where innovative approaches to long-term development can be tested.

72. The GEF is also working to transform the global food system, which is currently responsible for over 60 percent of all tropical deforestation and most of the loss in biodiversity. The Food Systems, Land Use and Restoration Impact Program builds on the momentum and growing commitment by governments and private sector toward a transformational shift in food systems. The program seeks to advance a system-wide approach that brings together strategies and stakeholders through both horizontal (interventions with actors within landscapes, policy reform, governance strengthening, etc.) and vertical (food value and supply chain commitments and financing) dimensions.

73. Progress on combatting coronavirus and other emerging diseases will depend on building a strong alliance between donor institutions like the GEF, development agencies, scientific institutions, civil society organizations, the private sector and, in particular, governments. The GEF works directly with over 150 countries worldwide and is well placed to convene such an alliance that could develop an action plan to prevent or reduce future crises such as the one we are facing today. Much of the GEF's work is central to responding to the current pandemic and decreasing risks of future outbreaks. But there are opportunities to explore new areas and develop new, or strengthen existing, partnerships for future work.

3. OPPORTUNITIES FOR GEF INVESTMENT AT A PROGRAM SCALE: SOCIO-ECOLOGICAL DIMENSIONS OF ZOONOTIC DISEASES

74. The COVID-19 pandemic has affected all phases of life for many of the people and institutions on earth. This includes the environmental community in general and the GEF in particular. The pandemic, and the new understandings that have emerged from it are creating opportunities for the GEF to engage in new grant-making or strengthen existing investments. Many of these investments are in traditional granting areas but a few are novel to the institution.

(a) Biodiversity and ecological reordering

Situation:

75. The natural world and its biodiversity—genes, species, and ecosystems—is in a perilous state. An estimated 1 million species face extinction due to loss of habitat, hunting, live capture, loss of food and nesting resources, and competition from invasive species. Population sizes of mammals, birds, amphibians, reptiles and fish have decreased almost 70% between 1970 and 2016. Many of these species and the threats they face are by now familiar, but similar processes are having profound impacts on an often-overlooked component of biodiversity: microorganisms.[47]

76. Microorganisms are not only part of biodiversity in and of themselves, they also contribute to ecosystem structure and function. These ecosystems range from marine to boreal and also include the microbial communities associated with all larger animals and plants—their microbiomes. Parasites, including microbes, are major ecological actors, though they are often left out of ecological studies, and are also major causes of diseases. As with larger-scale communities, disruption of these microbiome communities, a process called dysbiosis, can result in ecological change leading to disease of the host organism, including humans.[48]

77. Across scales of biological organization, one major source of disruption is the rapid spread of invasive species in marine and terrestrial settings, a manifestation of the increasing globalization that characterizes the modern world. Species of plants and animals, as well as microbes, are being moved, primarily though not always purposefully due to human agency. This number is estimated to increase over 30% by 2050.[49]

78. Most invasive species do not become problems in their new homes, but those that do are major threats to native biodiversity as pests, weeds, parasites, and competitors. Symbiotic microbes can influence patterns of invasion in a variety of taxa. Both abiotic and biotic factors can also affect disease and other parasitic organisms, in some cases increasing and in other decreasing their impacts on host organisms. Emerging infectious diseases are, in fact, invasive species.[50]

79. The spread of invasive species leads to the loss of unique diversity in biological communities. They can have complex and often significant long-term direct and indirect

impacts. This is one part of the broader homogenization of these communities as a result of the human alteration of natural systems that extends from ocean-floor mining and rainforest clearing to massive use of antibiotics. Biological communities, large and small, now often have many more introduced species which are disproportionally interacting with other introduced species.[51]

80. This homogenization of ecological interactions is accelerating, having increased sevenfold over the past 75 years. Microbes can and do become invasive, including bacteria, fungi and viruses. Zoonotic diseases are examples of species moving niches—introduced species of a sort, either the disease organism itself or its vector. From the perspective of a virus, the number, density, and ecological location of domestic animals, wildlife markets that mix species that do not normally co-occur, and humans moving into newly converted ecological zones can all be thought of as new habitats. Spillover events are then a type of homogenization of disease-causing microbes, and emerging pathogens are noted for their ability to infect a range of animals.[52]

81. Homogenization means less diversity but in some habitats an increase in populations of certain animals. Agricultural areas, regrown and restored areas, and cities all maintain robust populations of animals (and plants), though often far different from those of the original habitat. It is in these modified natural communities, often relatively species-poor, that species of animals thrive with a greater capacity to become infected and transmit infection, seemingly correlated with specific life history characteristics such as weaker host defenses. Species that share more pathogens with humans are more commonly found in areas with substantial human use, such as agricultural or urban settings.[53]

82. Some researchers and environmental organizations make broad claims that loss of biodiversity is a cause of human disease and general lack of health. But this is a partial reading of human history. In some cases, and in some places, simplifying ecosystems has improved human health; e.g., by draining wetlands that are habitats for malarial mosquitos or by providing food security through increased agricultural conversion. Moving from areas of higher diversity to urban settings can also lead to improved human health in some circumstances. There has been a significant increase in interest in the relationship between biodiversity and health, but the relationship appears to be complex and frequently context-specific.[54]

83. The relationship between disease and biological diversity is an area of active study, competing conclusions, and a notable lack of agreement on global claims. In some cases, humans decrease diversity through habitat conversion or direct harvest, while in other cases they increase and homogenize local diversity by introducing species.[55]

84. Some hypotheses predict that diversity decreases infectious disease burden, whereas others predict the opposite. Still other work supports additional explanations, including that there is no relationship between disease burden and diversity, or that the relationship is context dependent — affected by pathogen life history, scale, presence of domestic species, type of biological community, and ecosystem type. Further complicating easy answers is the

contention that human diseases are exceptions to general rules about other types of disease and biodiversity.[56]

85. Vector-borne, generalist zoonotic pathogens appear to be the types of disease-causing organisms that are more sensitive to changes in biodiversity. In addition, it is also clear that disease emergence is higher in areas with higher mammal richness with increased contact between humans and native fauna, often tropical forest areas.[57]

86. A recent broad summary of available evidence concludes that biodiversity management as a tool for disease management can have two primary benefits. First, it might prevent zoonotic and wildlife diseases from becoming problems where they currently are not. Second, it might allow management of existing diseases where no or few conventional interventions are available. Translating results from this dynamic field will be necessary in order to determine when and where conservation of biodiversity will result in improving human health. Such work must incorporate ongoing and anticipated effects of climate change on biodiversity.[58]

87. The COVID-19 pandemic is having broad economic and social impacts, with inevitable impacts on biodiversity. Some of these will be positive, at least in the short term, but other will have both short- and long-term negative consequences. The shape of the pandemic and the global, national, and local responses will go a long way in determining what mix of positive and negative consequences will be experienced by biodiversity. Many areas of high biodiversity conservation value are showing strongly negative social, economic, and political impacts of the pandemic, with many predictable negative effects on biodiversity propagated largely through economic pathways.[59]

88. Of particular concern is the impact of a global collapse in nature-based tourism. The tourism sector is a major source of employment, revenue and foreign exchange revenue and projections in May suggested declines of 58% to 78% putting at risk 100 to 120 million direct tourism jobs. In Africa over a third of all direct tourism in 2018 was attributable to wildlife. Brazil's loss of protected area visitors is predicted to result in a total loss of US$575 million in total GDP in Brazil. Loss of this tourism has resulted in mixed impacts with reported increases in wildlife crime but also some declines where lockdowns have reduced transportation. Decreased travel may have minor positive impacts through lessened movement of invasive species and diseases.[60]

89. The pandemic has resulted in a mixed set of conditions for endangered species. In some cases—such as giant ibis in Southeast Asia, rhinos and elephants in Africa, and endangered fish in India—they are further endangered by increases in illegal killing. In a number of parts of the world bats have been targeted for killing out of fear of the coronavirus. The return of many migrant workers or refugees from cities to rural settings is expected to increase pressure on wild resources. Similarly, loss of income or livelihoods from labor or agriculture may cause rural families themselves to increase their illegal harvest of wild species. This will apply to fisheries and well as to terrestrial species. In other cases, though largely unproven, there may be direct infection of wildlife from humans. This concern has been expressed in particular for great apes in Africa and Asia and bats from North America.[61]

90. Many meetings of global bodies and scientific societies were postponed or cancelled due to the pandemic including IUCN's World Conservation Congress and several Convention of the Parties of the MEAs.

Opportunities to effect change[62]

(a) Link the study and control of invasive species to that of zoonotic diseases.

(b) Decrease movement of potentially invasive species through policy means that control ballast management, phytosanitary rules concerning domestic animals and the capture, holding, breeding, transport/shipping, and retail use of live wild animals, both domestically and across borders.

(c) Protected and conserved areas, including Indigenous and community areas and privately protected areas, are not funded or managed so as to meet their goals. Funding is needed to increase management effectiveness including professionalization and support of rangers.

(d) Work with high-risk stakeholders including protected area staff, veterinarians and researchers to limit the extent to which they spread disease themselves.

(e) Limit spread of vectors, for example, dogs into protected areas.

(f) Biosecurity and vaccination for domestic animals and farmed wild animals including decreasing possible overlap between domestic and wild species.

(g) Develop multidimensional and multidisciplinary models directed at stopping the illegal wildlife trade. Assess the existing and potential barriers to putting these into effect.

(h) Determine distribution, movement and status of potential disease-causing organisms.

(i) Develop better models and predictions for under what ecological and social circumstances biodiversity management can be a tool for human disease management. Address ways to overcome impediments to putting such information into practice.

(j) Develop better models for supporting nature conservation that are less reliant on long-distance tourism; models that may be more important as climate change impacts leisure travel.

(k) Develop new, or harmonize existing, regulations so that collectively they address One Health and biodiversity conservation.

(l) Proactively sample humans and animals for potentially emerging diseases within agricultural, pastoral, and urbanizing ecosystems.

(m) Incorporate disease-related health costs in land use and conservation planning.

(n) Build the emerging field that integrates conservation and microbial ecology.

(o) Seek agreement and protocols on limiting the risk of handling, transporting or consuming taxa with high risk for transmitting zoonotic disease.

(p) Build capacity for systematic surveillance for wildlife disease monitoring based on protected area networks (as is practiced in China for waterbirds / avian influenza)

(q) Build capacity of wildlife services and protected area networks for wildlife health monitoring and management, related to infectious disease control, rescue centers for animals in wildlife trade confiscations, support for threatened species breeding centers, veterinary support for control of feral dogs and other domestic animals.

(b) Land use change, land degradation, and disease

<u>Situation</u>

91. Land use change is a significant driver of the transmission and emergence of infectious diseases. Over 30% of emerging infectious diseases are linked to land use change, including the conversion of land for agriculture and livestock production.[63]

92. Since 1970 land-use change, primarily agriculture expansion, is the threat that has had the largest negative impact on terrestrial and freshwater ecosystems, followed by overexploitation of animals, plants, and other organisms, mainly via harvesting, logging, hunting, and fishing. In marine ecosystems, direct exploitation of organisms (mainly fishing) has had the largest relative impact, followed by changes in land and sea use. Agricultural expansion is the most widespread form of land-use change, with over one-third of the terrestrial land surface being used to raise crops or animals. This expansion, alongside a doubling of urban area since 1992 and an unprecedented expansion of infrastructure linked to growing population and consumption, has come mostly at the expense of forests (largely old-growth tropical forests), wetlands, and grasslands. A series of combined threats are prevalent in freshwater ecosystems, including land-use change and water extraction, exploitation, pollution, climate change, and invasive species. Human activities have had large and widespread impacts on the world's oceans. These include overexploitation of fish, shellfish, and other organisms, land- and sea-based pollution, including from river networks, and changes to land and sea use, including coastal development for infrastructure and aquaculture.[64]

93. The conversion of the biosphere to human purposes has been gradual but accelerating. In 1700, nearly half of the terrestrial biosphere lacked human settlements or significantly transformed land use, and most of the rest (45 percent) was semi-natural, with limited use for agriculture or settlement. By 2000, the opposite was true: less than 20 percent was semi-natural and only a quarter undisturbed. The critical transition from mostly undisturbed to mostly anthropogenic ecosystems came early in the 20th century.[65]

94. Damage to land results not only from complete conversion—rainforest to cattle pasture, for example—but also from the more insidious and harder to document process of degradation. Hunting can empty a forest of large animals that play key ecological roles. Pollution can poison

rivers. Smoke can kill insect faunas. An apparently intact ecosystem can, in fact, be a simulacrum of its original ecological condition.

95. Though not usually considered, ecological change can also occur in microbial communities due to human habitat change such as soil sealing, agriculture, and invasive species. Within microbiomes, antibiotics can significantly change species diversity and richness in microbial ecosystem. It is not surprising that such dramatic changes in landcover and land (and ocean) use have brought concomitant changes in the evolution and distribution of microbes, including those responsible for diseases of wild species, domesticated species, and humans. Land cover and land use change is the driver of much of this change and affects microbes of many types, including plant viruses. [66]

96. Forest loss has been shown to have complex and varied influences on animal populations and biodiversity, driving both increases and decreases of up to 48 percent with time lags that can extend up to 50 years. The specific mechanisms include increases in contacts between humans and wildlife along newly-created ecotones, creation of new communities by mixing formerly ecologically separated species, changes to pathogen abundance and distribution, changes of microclimate, creation of new habitats, and global trade in wildlife species. [67]

97. There is an active debate over the broad correlations between changes in land cover and disease, based on early conclusions that deforestation (mostly in the Amazon) was the cause of increased malaria. This pattern has not been found to hold in other regions like Africa. Work in other countries shows similar variability. In Costa Rica, areas with higher proportions of human-altered landscapes were at higher risk of vector borne diseases. More recent work at broader scales and in different regions of the world suggests that both the nature of the disease, and the type and history of land clearance (small scale in Africa and large scale in the Amazon) may explain marked regional differences.[68]

98. A number of spillover events leading to epidemic human disease outbreaks have been linked to ecosystem degradation and concomitant human activities, particularly along the edges of newly converted habitat. These include the Hendra virus in Australia, linked to declining eucalyptus forests; Nipah virus in Malaysia, linked to deforestation; and Lyme disease in the eastern United States, linked to habitat fragmentation. Human workers in newly opened areas can serve as vectors for novel and existing diseases. At a broader scale, land-use change, and agricultural industry change were concluded to be the two most important drivers of disease emergence events.[69]

99. However, it is important to note that not all zoonotic disease outbreaks are related to loss of natural habitat. In some cases, habitats that increase with human activities, like agricultural fields, increases in domestic animals, regrowing fields, reforestation, human structures, and urban environments, can increase numbers of species, including microbes, that transmit disease to humans. In other cases, there is no clear correlation between land use changes and zoonotic disease. The relationship between zoonotic disease and loss of habitat is thus highly context-dependent and influenced by a multitude of factors.[70]

100. The COVID-19 pandemic has brought about a wide array of impacts to natural landscapes. Since its start data suggest a sharp increase in deforestation in Africa and Asia and more deforestation during the pandemic noted for Brazil, Colombia, Cambodia, Indonesia, Nepal and Madagascar. Reasons for this pattern are numerous but include relaxing of government management, change in government policy, decreased law enforcement, and increased movement out of cities to pursue rural livelihoods and to secure cash for payment of health care. Artisanal gold mining in Amazon has increased during the pandemic and fires in the Amazon and Pantanal are severe. Finally, plastic pollution both terrestrially and in the oceans has increased markedly.[71]

101. Management of protected areas have been affected by the pandemic in all parts of the world. This has included economic impacts from loss of tourism, direct site-level impacts, management and enforcement impacts, resource management impacts and social and community impacts.[72]

<u>Opportunities to effect change</u> [73]

(a) Identify areas where there are higher potentials for emerging disease and focus disease monitoring in these areas as well as developing and funding plans for responding to reports of spillover.

(b) Invest in systems that allow for effective remote monitoring of key potential-spillover to use in relatively intact ecosystems to alleviate some of the need for on-the-ground monitoring and increase accountability of many other interventions.

(c) Work with existing long-term monitoring sites to add a One Health component to their work.

(d) Provide an alternative to degrading natural resources such as forests as a social safety net as a result of economic hardship due to pandemics such as COVID-19.

(e) Make prevention of zoonotic disease spillover a component of all projects designed to restore ecosystems or provide landscape/seascape connectivity.

(f) Structure any government stimulus to avoid increasing loss of more natural habitats.

(g) Work to ensure that all development activities (e.g. road-building, dam construction and mining) include the objective of decreasing the chances of disease spillover.

(h) Maintain legal and regulatory protection for ecosystems through the pandemic as well as in the re-building phase.

(i) Provide immediate emergency funds to protected and conserved areas to cushion the shock from the pandemic.

(j) Develop and implement plans to overcome the damaging effects of the pandemic on existing and planned biodiversity conservation initiatives.

(k) Prepare strategies to put protected areas on a more secure and effective trajectory.

(l) Provide support for establishment and effective management of Indigenous and community protected areas and privately protected areas to help build the global protected area portfolio.

(m) Build into protected area management plans a component directed at preventing viral spillover and ensure adequate support to realize existing plans as well as new health components.

(n) Include maintenance of human health as an ecosystem service.

(c) Infrastructure and development

Situation

102. Lack of adequate infrastructure is a major contributor to poverty and limits to economic development. Roads, water, electricity, and telecommunications raise productivity, and social infrastructure like schools and hospitals help grow human capital. For example, 0ne billion people live more than two kilometers from an all-weather road. The World Economic Forum estimates that $3.7 trillion is needed annually for infrastructure development, particularly in sub-Saharan Africa and Southeast Asia. Another estimate is that developed and developing countries around the world are facing a $15 trillion gap in infrastructure globally.[74]

103. Infrastructure is proliferating throughout the globe. From 2010 to 2050 the total length of paved roads is projected to increase by 25 million kilometers, with 90 percent in developing countries. There are approximately 40,000 large dams and some 3,700 more are being planned. WWF has estimated that $95 trillion will be invested in infrastructure by 2030.[75]

104. Poorly planned infrastructure development is having and will continue to have marked negative impacts on biodiversity. With roads comes increased human access for hunting, logging, mining, and agriculture. Roads and all the environmental damages they bring already present a severe threat: 70 percent of the world's forests are less than one kilometer from a forest edge. Dams fragment watersheds leading to both upstream and downstream effects on biodiversity. And construction uses materials with high carbon costs. In addition, infrastructure development is also linked to the spread and transmission of vector-borne diseases (e.g. malaria).[76]

105. The COVID-19 pandemic has impacted infrastructure development and the world economy. As in so many other sectors, the pandemic has forced attention to longstanding challenges to how the world addresses the long-term issue of infrastructure development. It has created sharp drops in employment and economic development. Local, sub-national, and national governments are all facing significant revenue shortfalls, with knock-on impacts on short- and long-term construction of all kinds. On the other hand, the need to provide jobs to the unemployed affected by the pandemic makes construction projects more attractive to governments. There is some speculation that a rise in emphasis on national production for

national markets may incentivize yet more roads and dams within countries working to build back in different ways.[77]

106. Infrastructure development is tied to climate change. As The Economist observed, the situation has created "a unique chance to enact government policies that steer the economy away from carbon at a lower financial, social, and political cost than might otherwise have been the case." But the pandemic has also created the opportunity for a variety of different responses in the development of infrastructure that are not climate- or environment-friendly. Governments from Brazil to the United States to India have relaxed environmental restrictions in the name of pandemic relief. Hard-won gains in managing infrastructure growth are being eroded.[78]

Opportunities to effect change[79]

(a) Encourage governments to focus all spending on low-carbon solutions and green infrastructure.

(b) Promote the practice of biodiversity net gain for development policies, going beyond no net loss of biodiversity in development practices.

(c) Avoid building new infrastructure in intact habitats.

(d) Develop strategic land use planning with a broad and critical role for conservation areas, broader conservation goals and the importance of One Health.

(e) Implement transparent project financing and accounting.

(f) Focus on high quality projects with assured financing.

(g) Work to ensure adherence to existing environmental regulations and to resist weakening of these regulations.

(d) Urban dwellers and Local and Indigenous peoples

Situation

107. The pandemic has affected the health and wellbeing of many, if not most, people across the globe. For urban dwellers, health risks are linked to overcrowding, limited access to water, sanitation, air pollution, and health services, reliance on crowded public transit, and circumstances associated with working in the informal sector. These risk factors, all exacerbated by the COVID-19 pandemic, are particularly strong for women and girls, children, migrants, refugees, internally displaced people, and the homeless.[80]

108. People living in more remote, rural settings rely more on natural services than those near built infrastructure. This dependence only increases with diminished health and well-being. Without the proper circumstances and options, such heavy reliance on ecosystem services can lead to ecosystem degradation, further limiting access to the goods and services necessary for livelihoods.[81]

109. Health is a necessary condition for life. The concept of health used to be conceived of as the absence of disease, but in 1978 the World Health Organization redefined the concept of health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." This change in the understanding of health illustrates the shift from focusing on disease-causing factors to considering factors supporting human health and well-being.[82]

110. The COVID-19 pandemic has further exacerbated the challenges facing poor and disadvantaged people in both urban and rural settings. It has precipitated a cascade of health, economic, livelihood, and food crises with short, medium- and long-term implications. Given the uncertain duration and severity of the pandemic in rural settings, it is difficult to say exactly how it will impact lives and livelihoods, except that they will undoubtedly get worse. Even conservative projections by the World Bank suggest that COVID-19 will push 71 million into extreme poverty. The downside scenario pushes this number to 100 million.[83]

111. Approximately 70 percent of the rural poor and 10 percent of the urban poor are dependent on livestock. Four countries have 44 percent of the world's poor livestock keepers: India, Nigeria, Ethiopia, and Bangladesh. There is a strong association between poverty, livestock keeping, and zoonoses. Border closures have meant that transhumance herders are facing even more difficulties.[84]

112. Such closures have a broader impact as well. Agricultural wage workers and seasonal workers crossing borders have been thrust further into poverty due to decreases in agricultural markets and border closings. One estimate is that agricultural production in Africa could contract between 2.6 and 7 percent if trade blockages persist.[85]

113. Of the 734 million extremely poor people prior to the COVID-19 crisis, 80 percent lived in rural areas. The collapse of many sectors of the economy has forced people out of cities and back into rural settings in search of livelihoods. Provision of health care is even more difficult in rural settings with dispersed human settlement, and these people are more likely to have chronic health difficulties that make them even more susceptible to the virus. Social services, including employment-related social protection, are often not extended to participants in rural economies. All of these factors combine to make health even more of a crisis for women than for men.[86]

114. The impacts of the pandemic will significantly set back sustainable development goals regarding poverty and food security. Food insecurity is a significant problem in many rural settings, and the pandemic, combined with the locust outbreak in parts of the Horn of Africa, has slowed the provision of food aid. This contraction has been exacerbated by national policies that have prohibited food exports. In addition to the direct health impacts of the disease there are major setbacks in addressing other pressing health issues such as AIDS, malaria, and tuberculosis.[87]

115. Only a tiny percentage of the world's poor, some of whom are indigenous peoples, live in areas with relatively intact ecosystems and close interactions with wild and domestic animals

and the diseases they carry. These rural settings increase the incidence of zoonotic diseases. For example, in the United States, hospitalization of Native Americans for zoonotic and vector borne diseases is 20 to 40 times higher than the general population, probably due to living in rural areas and engaging in agricultural work that exposes them to disease vectors. In other cases, indigenous peoples have lived with domestic and wild animals from which recent pandemics have arisen but not affected the humans. Humans living in intimate relationships with domestic and wild animals present an important place to investigate the role of emerging zoonotic diseases and a compelling need to provide healthcare.[88]

116. Indigenous peoples, particularly those in more rural or remote settings, are and will continue to be particularly hard hit by the pandemic, which is exacerbating underlying structural inequalities and discrimination. An October 2020 accounting of indigenous cases of COVID-19 in the Amazon basin listed 1.2 million cases with 32,000 deaths. This continues a pre-existing set of inequalities and vulnerabilities of indigenous peoples. These peoples experience a high degree of socio-economic marginalization and are disproportionately affected by public health emergencies, making them even more vulnerable as a result of COVID-19. They have suffered disproportionately from previous pandemics—for example Mãori died at a rate seven times that of the European population during the 1918 Spanish Influenza pandemic; First Nations in Canada were eight times more likely to die.[89]

117. The situation is little improved today but indigenous peoples still experience widespread discrimination in healthcare settings. Many healthcare and social service systems do not extend to indigenous peoples and few have access to medical and financial support in times of crisis. Lock-downs and stress exacerbate already high rates of sexual assault, and violence. Indigenous peoples often work in the informal economy and are disproportionately affected by poverty, the closure of markets and restrictions on transportation. There are already alarming signs of accelerating income loss, income insecurity and compounded impacts on women.[90]

118. Lack of enforcement of existing rules and new rules permitting greater natural resource exploitation and destruction has also had major impacts on indigenous peoples, particularly in the Amazon Basin. There are also increasing human rights violations and threats from fire, mining, land grabbing and aggression against indigenous environmental defenders. Social isolation has affected income and food systems, exacerbating existing inequalities.[91]

<u>Opportunities to effect change</u>[92]

(a) Recognize and address the possible urban bias in planning and response to the pandemic.

(b) Help provide urgent help to the most vulnerable – indigenous peoples, castes and other marginalized populations, the elderly, women and children – and the poorest of the poor.

(c) Work with public health agencies to develop precision public health approaches (providing the right intervention to the right population at the right time) for communities with the greatest risk of experiencing viral spillover.

(d) Catalyze ODA funding to support rural communities around protected and conserved area with particular attention to indigenous communities. This support could include medical assistance, health education, food security and livelihood support.

(e) Strengthen local governance and land rights.

(f) Ensure public services are uninterrupted including provision of clean water, housing, and safe shelter.

(g) Integrate both health outcomes into rural conservation programs as well as conservation outcomes into health programs.

(h) Ensure the active and meaningful participation of indigenous peoples in considering all appropriate recommendations, particularly those involving: 1) development and use of vaccines; 2) any new restrictions on wildlife use; and 3) strengthening hygiene and food safety practices.

(i) Work respectfully with indigenous peoples to evaluate and put into place measures to decrease possibilities of viral spillover.

(j) Include indigenous health care providers as part of any approach and include local knowledge on zoonotic diseases and traditional medicines to help prevent spillovers.

(k) Work with indigenous and other peoples living in remote settings to explore development of early warning systems for disease spillover, provide good healthcare and investigate the relationship between zoonoses and human health.

(l) Secure land tenure and governance of Indigenous people over their natural resources including Indigenous protected areas

(e) Legal and illegal wildlife use and trade

<u>Situation</u>

119. People have been trading wildlife and wildlife products for millennia: live macaw chicks in the desert southwest of North America; cowrie shells in the Sahel of Africa; furs and walrus ivory in Europe. Trade—any sale or exchange of wild animal and plant resources—has been instrumental to providing goods and services at all scales from household and settlement to national and global. Though often overshadowed by the illegal trade, the legal trade in wildlife involves thousands of species, provides income for millions of producers, raw materials for many businesses. and a broad range of goods for many consumers in all corners of the globe, including many luxury goods. In the European Union alone the estimated value of the legal wildlife trade is €100 billion.[93]

120. The term "wildlife trade" covers more than the illegal trade in elephant ivory or pangolin scales; it incorporates all wild fauna, flora, and fungi. In fact, most of the most-traded species do not fall into the common usage of the term "wildlife," including fisheries. Trade is most

often conceived of as all activities relating to the human harvesting, transportation, commercial exchange, and end use of wildlife at all levels. Between 2000 – 2014, the USA alone legally traded over 3.2 billion live organisms, corresponding to 8,641 species of birds, amphibians and reptiles and mammals. Similarly, between 2012 and 2016, 11.5 million individual live animals representing 1,316 species were legally exported from 189 different countries. China was the largest exporter of live mammals, Nicaragua was the largest exporter of live amphibians, South Africa was the largest exporter of live birds, and Peru was the largest exporter of live reptiles. In general terms the tropics were the source of the greatest number of vertebrates in trade, closely matching the overall diversity of species as well as the greatest number of emerging pathogens. Global wildlife trade is predicted to increase and may incorporate over 4,000 species not previously in trade.[94]

121. Illegal trade is considered to be all unlawful activities associated with commercial exploitation and trade of wildlife, living or dead, in entirety or in parts. A 2020 summary of illegal trade documented over 6,000 species traded illegally. No single species is responsible for more than 5 percent of the trade (though some like elephants and rhino command a significant portion of the trade by value), and virtually all countries in the world are involved. Though much attention has been drawn to open street markets, the greatest volume of commodities is usually marketed to buyers specializing in a single category of species.[95]

122. The COVID-19 pandemic has brought renewed attention to the role that the wildlife trade–legal and illegal—plays in the emergence of zoonotic diseases. By its very nature, the trade, whether for pets, food, medicine, spiritual practices, or other uses, moves individuals of a species out of their native range or out of their native ecosystem and places them in novel settings. Markets selling live animals—so called “wet markets” are found throughout the world, though they are most common in Asia and cities with large Asian populations. These markets mix wild and domestic animals from different places which would otherwise never come into contact: African pangolins with Chinese chickens, Nicaraguan frogs with French pigs, or African parrots with American guinea pigs. In such markets very little attention is paid to animal welfare and the trapping, transport, housing and slaughter are not practiced with much or any consideration of the welfare of the animals. Sanitary practices are less likely in such markets than in larger, more commercial livestock operations. Such markets have been proven or speculated as being the source of a number of zoonotic diseases, including the SARS outbreak of 2003.[96]

123. It is not just these species that are being placed in unnatural settings; so too are their microbes, some of which have the capacity to bring disease to humans and their domestic animals. The trade in wildlife has been shown to transmit over 60 wildlife diseases as of 2011. The number is now undoubtedly greater. Associated with this trade, one study reported 82 zoonotic diseases/pathogens causing 3,131 disease cases in 54 countries between 2008 and 2016. One case study of the microbial diversity of bushmeat from the Serengeti ecosystem found an abundance of species on the dried samples, including several of potential zoonotic pathogens.[97]

124. It is not just wildlife or domestic stock that can move diseases, humans can as well. Markets selling live and dead animals and animal parts, both wild and domestic, can be critical places where humans from many regions mix together and infection can take place. And already infected, humans moving by bicycle, bus, or airplane can carry and spread the viruses much more efficiently and effectively than any wildlife trade.[98]

125. Wildlife farms have also become significant sources of live animals sold in markets. In 2016. 'non-traditional animal' farming in China employed 14 million people. Nearly 20,000 such farms are reported across China; across southern Viet Nam over 4000 active farming operations raise rodents, primates, civets, wild boar, snakes, deer, crocodiles, and softshell turtles. Raised in often crowded conditions with little attention to sanitary procedures or animal welfare, they are also considered to be potentially important contributors to risks of viral spillover. Along the transport chain to market, wild animals and the viruses they carry mix with different species and the viruses can jump between them. Wild species can also be infected with new viruses along the transport chain, as has been shown for pangolins. The animals are also placed under greater stress the longer they are kept captive, which has been shown to cause increased shedding of viruses.[99]

126. A great variety of different species are found in larger wet markets, ranging from insects and amphibians to birds and mammals. Many threatened and endangered species are found for sale, as well as species capable of hosting zoonotic pathogens. There has been concern about the continued sales of such species along with what are termed "high risk" species—those more likely to be involved in transmitting viruses to humans. [100]

127. Calls have been made for bans on wet markets and greater enforcement of the wildlife trade, both legal and illegal. Many of these represent long-standing policy interventions that have found fresh impetus due to the COVID-19 pandemic. There is some evidence for consumer support for efforts to close illegal and unregulated markets. There may, however, be negative consequences of closing wildlife markets on food security and income for certain populations.[101]

128. There are also significant concerns about the adverse impact that moves to restrict wildlife trade will have on indigenous and local community rights. These communities have long-standing economic, cultural, and spiritual interests in wildlife use and trade, and any intervention in this trade needs to consider the rights-based perspective. There is not complete agreement amongst all organizations on the issue of closing markets. Wet markets are part of informal society and banning will only relocate and/or disperse these activities. Improving alternative sources of protein and income will allow people to move to safer practices, and improvement of hygiene will improve wet markets. Live animals (e.g. seafood) are offered in many places safely.[102]

129. Not all wildlife trade is global; much remains local or national and it can provide vital sources of nutrition as well as cash, particularly for poor households. This role of wild meat as food security can be particularly true during times of disruption and social stress. Despite this importance, the butchering of wild meat (bushmeat) can on occasion have serious health

consequences, as it has led to cross-species transmission of numerous infectious diseases, including monkeypox virus, Ebola, and Simian foamy virus. Bats, rodents, and primates pose the greatest risk to humans. Wild meat trade from rural areas into urban markets is growing in many areas and consumption by urban dwellers appears to be most often as a luxury food. This trade can be beneficial to rural families as a source of cash but can also increase harvest rates of vulnerable species, endangering income as well as nutritional security.[103]

130. The COVID-19 pandemic will impact the legal and illegal wildlife trade, though, as with most things related to the virus, the results are still not known with clarity. In the first half of 2020 there were reports of significant disruptions in routes used to smuggle illegal wildlife due to closing of borders and decreases in both travel and shipments. This will likely result in a movement away from passenger air as a major mode of wildlife trafficking. There may also be consumer avoidance of certain wild animals, such as bats, at least in the short term, due to a concern about disease transmission. On the other hand, there are reports of calls for treatment of COVID-19 using bile from bears, perhaps leading to greater emphasis on wildlife farms.[104]

131. It seems likely that illegal harvest of wildlife is taking place in some areas due to restrictions in patrolling and management work. There is also evidence of increased subsistence hunting caused by the collapse of urban employment that is sending workers back to rural settings. Many of these workers are young men who are hunters or potential hunters, who, without access to agriculture, may start hunting both for subsistence and sale. In some settings, such as West and Central Africa, the increased hunting may lead to more contact between people and wildlife and greater chance of another disease spillover.[105]

<u>Opportunities to effect change</u> [106]

(a) Strengthen biosecurity measures for both animals and plants through IPPC, Codex Alimentarius and OIE.

(b) Strengthen regulations and enforcement of the sale of endangered species and pursue additional measures for “high risk” species in trade.

(c) Disseminate guidance provided by the World Health Organization and other reputable scientific and public health bodies to the public in culturally sensitive ways, with significant efforts made to refute conspiracy theories and other messages that are not based on scientific evidence. Actions should focus on minimizing the spread and loss of life, as well as all social and economic impacts.

(d) Improve research both on the illegal and legal trade in bushmeat, high-density wildlife production farms and on the microbes that are transmitted through such trade.

(e) Improve research on viruses found in species in the trade in live animals.

(f) Improve sanitary practices and humane treatment associated with farmed wildlife and domestic animal raising and transport with particular attention to pigs and poultry.

(g) Promote disease prevention and good practices for improved animal health and production to limit the use of antibiotics in domestic animal raising.

(h) Focus policy actions on developed countries, as they are the ones driving most of the legal live animal trade.

(i) Work with partners to develop livelihoods initiatives, particularly those adjacent to protected and conserved areas, for example, providing alternative livelihoods for those people impacted by the closing of wildlife markets and facilities that are deemed to pose a risk to human health.

(j) Seek to replace unsustainable consumptive trade in wildlife with wildlife economies based on non-consumptive uses.

(k) Foster regional and international cooperation for wildlife law enforcement and beyond. The United Nations, INTERPOL and WCO convening power can be leveraged to bring together biosafety scientists, regulators, criminal justice officials, and key decision makers to put global health high on the national and global agendas.

(l) Establish and invest in a multilateral, surveillance, research and early warning initiatives for preventing emergence and spread of zoonotic diseases.

(m) Develop social marketing and behavior change approaches to reduce the disease risks related to wet markets and the wildlife trade more generally.

(f) Domestic animal production and agriculture

Situation

132. Lands used for agriculture constitute the earth's largest biome, occupying a third of the ice-free land. From the perspective of viruses, the fields of single crops stretching for kilometers in many parts of the world represent fertile ground for infection. Not only industrial agriculture, but smallholder agriculture fields are also impacted by diseases, including viral diseases. The crops are subject to infection, so are the workers: a study in Asia showed that people who live or work in agricultural land are almost twice as likely to be infected with a pathogen as those who live or work elsewhere. Agriculture often is practiced at the expense of natural ecosystems and the resulting mixing of the cultivated and the wild has been shown to increase transmission of zoonoses.[107]

133. The vast numbers of domestic animals also make prime habitat for viruses—the biomass of domestic animals globally is more than an order of magnitude greater than that of wild mammals and wild birds combined. Meat production increases risk of epidemics either directly through contact between wild animals and livestock or indirectly through the practices like habitat loss, climate change and antibiotic use. And there is a strong correlation between the increasing number of cattle and increasing number of infectious outbreaks.[108]

134. The transmission pathways of many zoonotic diseases involve domestic animals. The broad host range of many viruses is demonstrated by the fact that 26 percent of human pathogens also infect domestic and wild animals. Livestock can serve as intermediate or amplifier hosts from which pathogens can evolve and spill over into humans. In fact, a 2020 study looking at viruses across all groups of mammals concluded that domestic animals play central roles in many mammalian host-virus interaction networks. There is strong evidence that modern farming practices and intensified agricultural systems are linked to disease emergence and amplification. Expansion of agriculture and cultivated pasture leads to ecosystem changes and increases in the interaction between livestock and wildlife and its pathogens.[109]

135. Intensification of livestock production, particularly poultry and swine, create ecological conditions that favor the emergence of novel zoonotic viruses. Most of the meat consumed globally is raised in concentrated animal feeding operations which have been characterized as "unique environment[s] to create novel flu viruses." Animals have been bred for production, not disease resistance, and their production facilities become ideal settings for viruses to convert from low to highly pathogenic or undergo a reassortment between low and highly pathogenic viruses already in circulation.[110]

136. Chickens host more viral families (49) than other domestic animals, with cattle second with 33 and pigs with 32 families. In chickens, 37 of 39 independent conversions of viruses from nonpathogenic to pathogenic since 1959 took place in commercial poultry production systems, the majority in high-income countries. In less intensive chicken production systems 127 reassortments took place between 1983 and 2015. These two settings – intensive and less-intensive - create different ecological niches with different viral, environmental, and host associated factors.[111]

137. Pigs, with a physiology similar to humans, are also sources of emerging diseases and can contract influenza viruses from birds and transmit them on to other mammals. This makes them potent and dangerous mixing vessels for influenza. China has the largest pig population in the world, with 500 million animals, followed by the European Union and the United States. In 2020 a strain of influenza with the potential to jump to humans was detected in China that was made up of a mixture of three lineages, one similar to the strains found in European and Asian birds, the H1N1 strain that caused the 2009 pandemic, and a North American H1N1 with genes from avian, human, and pig influenza viruses.[112]

138. Markets selling live domestic animals can be significant places for pathogen dissemination and sites for horizontal transfer of viral and bacterial pathogens. Live animals are moved from many settings, some at distance, bringing with them local forms of pathogens. Bioaerosols can spread viral particles to humans and other animals – including wild species.[113]

139. Domestic animals can also transmit diseases to wild species. Elephants in India have been shown to contract anthrax from livestock, bison contract brucellosis from cattle, rinderpest passes from cattle to many wild ungulates in Africa, black-footed ferrets get rabies from domestic dogs, and sea otters contract toxoplasmosis from domestic cats.[114]

140. The COVID pandemic has rightfully drawn massive global attention. However, over 800 million people, 10 percent of the world's population, face food insecurity, and hunger-related fatalities which is approximately ten times the number of COVID fatalities. Despite agricultural surpluses in many parts of the world, the pandemic has greatly exacerbated food insecurity by limiting food aid, restrictions on agricultural markets, and decreases in wages to purchase food. Restrictions have impacted the livestock sector by reducing access to animal feeds and veterinary care, and access to markets and processing plants. Reduced consumer power has also had negative impacts. The pandemic is also expected to create challenges for the welfare of domestic animals, including a negative impact on the control of existing diseases.[115]

141. Across all of its numerous fronts the pandemic has affected the food sector. The informal food sector appears to be hardest hit. Food production has been declared an essential service, yet producers continue to suffer, and food supplies are uneven. Limitations on international trade have placed even greater strains on food availability.[116]

142. It is the brittleness of the whole global food system that has been revealed by the pandemic This system is both a contributing cause through habitat lass and an amplifier of its impacts through diseases associated with unhealthy eating as well as food related inequities and vulnerabilities.[117]

143. Despite the fact that diseases of both wild and domestic animals can become human diseases, the study and treatment of the three remain strongly siloed. SARS-CoV-2 has been shown to infect cats, dogs, mink, tigers, and lions, and other animals may prove to be susceptible. There is evidence that mink in a Dutch mink farm contracted COVID-19 from humans and then passed the disease on to other humans. Cross-species transmission, if proven to take place, might be a dangerous addition to the pandemic and result in consumer's avoiding meat-consumption, further depressing the market for domestic animals.[118]

Opportunities to effect change[119]

(a) Keep supply of food flowing with a focus on nutritional crops, particularly to the most vulnerable.

(b) Create a global food supply traceability system that will help ensure not only food safety and reliability but also increased sustainability of production, storage and transport.

(c) Strengthen vaccination programs for control of animal diseases to reduce therapeutic use of antimicrobials.

(d) Build veterinary service capacities to prevent, detect and respond in a timely manner to emerging disease threats, using a multi-sectoral One Health approach, linking human, animal and environmental health.

(e) Create incentives for uptake of sustainable livestock production practices by linking with market access.

(f) Build surveillance systems in the animal health sector for early warning/horizon scanning against potential, known and emerging threats

(g) Promote good animal husbandry practices at household and community levels, especially in the small-mid scale livestock production sector to reduce risks of disease emergence and spillover.

(h) Improve coordination between entities focused on human, domestic and wildlife health.

(i) Restrict prophylactic antibiotic use in domestic stock for growth promotion to prevent further development of antibiotic resistant microbes.

(j) Improve biosecurity by restricting contact between domestic and wild animals, particularly in settings where the two can mix. Prioritize known high-risk species and create public education programs.

(k) Prevent further conversion of natural ecosystems for agricultural purposes as part of a program to decrease chances of disease spillover

(g) Climate change and its impacts

<u>Situation</u>

144. The effects of climate change are felt in all aspects of life on Earth, and greater changes are anticipated. Species are moving, ecosystems are reordering, and time-lags in biological and social responses mean the future remains clouded.

145. Climate change contributes to increasing droughts, fires, floods, hurricanes, typhoons, and cyclones. These in turn increase risk factors of population displacement, injury, storm damage, malnutrition, water-borne disease, illnesses and impairment of crisis management interventions.

146. Rapid, broad-scale ecological changes can be triggered by climate, including drought-caused forest loss, large fires, and pest and pathogen outbreaks. Climate-driven species changes from local to global scales is affecting ecosystem services and human well-being. Climate change is affecting biodiversity from genes to ecosystems in freshwater, marine, and terrestrial biomes.[120]

147. A pandemic such as COVID-19 impacts all of these risks and the responses to them by impairing infection-control measures, increasing demands on health care systems, decreasing availability and quality of ecosystem services, decreasing capacity of health-care systems to respond and increase individual infection and mortality. As one author wrote: “Climate change is a pandemic enabler, a pandemic accelerant and a multi-pathway crisis engine.”[121]

148. Climate is one of the most important factors influencing the distribution and abundance of microbes. As microorganisms are instrumental in carbon and nutrient cycling, animal and plant health, agriculture, and the global food web, as the climate changes so too will the role of

these myriad species. They are not just passive responders to climate change but active players in some aspects of the change itself including microbial decomposition, ocean carbon cycles, and carbon release from melting permafrost.[122]

149. Climate change affects which microbes and vectors and therefore which diseases can thrive both in the ocean and on land. There is a strong link between increasing sea surface temperatures and coral disease. Climate change also affects the genetic basis of immune responses by hosts. As the climate changes, for example getting warmer and wetter, vector populations such as mosquitoes are changing their geographic distribution. Climate warming can increase pathogen development and survival rates, disease transmission and host susceptibility. The shifting distributions of microbes and hosts as a result of climate change will also reorder host-parasite relations. Similarly, wildlife hosts will move to track optimal environmental conditions, potentially exposing naïve populations to new pathogens. This is particularly important for highly mobile species such as flying foxes, carriers of different types of Henipaviruses (Nipah, Hendra virus).[123]

150. These climate-driven changes in health will affect humans as well as both wild and domestic species. In fact, host-switching in parasites appears to happen rapidly in changing environments. Some widespread declines of wild species, including extinction, may have been driven by increasing temperatures and infectious disease. Climate change also affects the diseases of livestock, which can in turn effect both biodiversity and human livelihoods. And it influences the pests and pathogens of the worlds' forests.[124]

151. Climate change has massive and multifaceted impacts on human health, particularly among children and marginalized peoples. It can act directly through death, disability, lack of attention to chronic conditions; or indirectly through collapse of health care and economies, loss of employment, and lack of food and shelter. Climate change can act on human health through increasing the frequency of extreme weather events, dust storms, heat stress, air quality, water quality and quantity, food supply and safety, and social factors. Climate change is the cause for a poleward expansion of crop pests, threatening crops and human health. It is predicted to increase the rate of antibiotic resistance of some human pathogens, with vector-borne, foodborne, airborne, waterborne, and other environmental pathogens predicted to be particularly responsive to changes in the climate. New spillover events of zoonotic diseases are predicted to increase substantially due to climate change.[125]

152. The COVID-19 pandemic has led to a sudden reduction of both greenhouse gas emissions and air pollutants, but modeling suggests that these will have a negligible lasting effect on global climate. Of greater impact on the climate will be significant increases in deforestation during the pandemic, with a reported increase of more than 50 percent, particularly in Africa and Asia.[126]

153. The cost of the pandemic may negatively affect climate mitigation efforts including subsidies for renewable energy. Ironically the costs of fighting climate-induced wildfire, tropical storms and other weather events have exhausted state and national coffers. On the other

hand, there are reports of broad support amongst citizens across G20 countries to make sure that economic recovery prioritizes climate change investment. [127]

154. The pandemic has had wide-spread impacts on individual human behaviors, social practices, beliefs, the role of government in economy, and the relations between states and international institutions. Many of these could have impacts on climate change— for example, remote working practices has led to concomitant decreases in aviation and car transportation—but it is too soon to judge the long-term consequences. The nature of the pandemic has led to calls for greater global cooperation, though it has also led some nations to withdraw from global institutions.[128]

Opportunities to effect change [129]

(a) Integrate health costs and benefits into climate change models.

(b) Develop green stimulus projects, which often have advantages over traditional fiscal stimulus.

(c) Design green construction and infrastructure projects that can deliver high multipliers (e.g. insulation retrofits).

(d) Design nature-based solutions as ways to achieve both climate adaptation as well as climate mitigation and tackle biodiversity issues.

(e) Foster natural capital investment for ecosystem resilience and regeneration.

(f) Ensure that climate change is included in all models of future zoonotic outbreaks.

(g) Ensure a quick healthy energy transition.

(h) Promote healthy, sustainable food systems.

(i) Stop government subsidies to non-renewable energy sectors and other areas with unsustainable practices.

(j) Apply lessons learned from climate change communication to pandemic responses to increase compliance in both sectors.

(k) Improve surveillance in health systems to monitor and detect impacts of climate change and other health situations, such as COVID19.

(l) Strengthen partnerships with ministries/departments of health to integrate climate change into health planning and investments.

(m) Climate proofing health and public facilities, providing clean uninterrupted energy access, and improving water, sanitation and hygiene infrastructure.

(h) Cities

Situation

155. Fifty-five percent of the world's population lives in urban areas, with the proportion expected to rise to 68 percent by 2050. More than half of the larger urban populations live in areas with between 4,000 and 10,000 people per square kilometer. There are also many urban areas with lower densities and vast areas of informal dwellings with little governance, planning, or services. Cities are responsible for 80 percent of global GDP, represent 75 percent of resource and energy use, and generate over half of global waste. Urban growth led to 190,000 km2 of habitat loss between 1992 and 2000.[130]

156. Cities are the hubs of global networks of supply, transport, and travel. Air routes connect large cities to all parts of the globe that can move people and their pathogens anywhere in the world in less than 24 hours. The decisions made by people who live in cities regarding the food they eat also structure the production and marketing of commodities locally, regionally, and globally.

157. Populations in urban areas are heavily impacted by the COVID-19 pandemic, with the urban poor particularly affected. In mid-2020 an estimated 90 percent of all reported COVID-19 cases have been from urban areas. The pandemic has changed a great deal about urban life: housing and food are increasingly scarce, many businesses are closing, and public transportation systems, often essential to functioning cities, are endangered by dramatic drops in ridership. Globally, the informal sector in urban areas represents 90 percent of total employment in low income countries and 67 percent in middle income countries. In Africa and Latin America, informal workers lost nearly 80 percent of their income in the first month of the crisis, with women being particularly hard hit. In fact, the pandemic has only further exacerbated the wider social and economic crisis with an estimated 100 million people living in cities likely to fall into poverty as a result.[131]

158. City governments were already under severe financial and political strain before the pandemic, and the World Bank estimates that local governments may on average lose 15 to 25 percent of their revenues in 2021. There has been an enormous increase in solid waste pollution. For example, in China's Hubei Province the COVID-19 response created a six-fold increase in medical waste and cities such as Manila, Hanoi and Kuala Lumpur produced 154 to 280 tons more medical waste per day than before the pandemic.[132]

159. The pandemic has not affected all cities similarly, even those of similar sizes. The ability of cities to respond appears to be determined by existing service delivery and infrastructure systems and their investment in risk reduction and preparedness to cope with disasters—measures of the effectiveness of their governance. In addition, there are strong national and even regional differences in cities' responses driven by different populations, history of exposure to disease, culture, and particularly public health strategies.[133]

160. This differential response in cities is still unfolding. Yet a few conclusions can be drawn. Strong leadership and governance at all levels need to be in place to provide a rapid and effective response. Timely, reliable, accurate, science-based information is vital to help inform citizens and governments. In its absence, rumors and misinformation have made pandemic responses slower and less effective. Adequate capacity to handle the pandemic's surge in patients is necessary, while at the same time care must be taken to minimize deaths from other acute or chronic causes. The impacts of the pandemic are not felt equally, and those with little get less. For example, in the slums of Mumbai, 67 percent of households rely on community toilets, clean water is scarce, and social distancing is impossible.[134]

161. The Global Mayors COVID-19 Recovery Task Force has developed a strategy based on a set of nine principles, including: 1) the recovery should not be a return to "business as usual"; 2) the recovery must improve the resilience of cities and communities; and 3) climate action can help accelerate economic recovery and enhance social equity.[135]

162. The authors of a recent study of cities' responses to COVID-19 conclude that the single most important action for cities to take is to strengthen and extend networks within and between cities. This includes links between civil society, religious organizations, business, and government. Links developed during previous epidemics were mobilized to address COVID-19 and lessons were shared with other cities. For example, Helsinki, Finland was well positioned to address the pandemic with part of its response being to reach to its local and international network for city-to-city collaboration to develop and share responses and results.[136]

<u>Opportunities to effect change</u>[137]

(a) Help cities develop functional resilience by sharing and coordinating disaster risk plans and actions.

(b) Most coastal cities will be affected by sea level rise in the next decades causing urbanization to expand into areas with more natural habitat creating increasing interaction between dense human populations and wild animals. Planning and management of future spillover should become part of urban planning to respond to climate change.

(c) Promote the concept of "learning cities," which lays out an approach for urban residents to build the social infrastructure to learn from crises and apply previous lessons.

(d) Build learning networks among cities.

(e) In the spirit of green recovery, cities should consider that responses to previous pandemics led to some positive urban transformation such as sewage systems, public parks and housing regulations.

(f) Engage city planners to build "future-ready" cities by focusing on sectors with potential for high ecological transformation and job creation, such as decentralized urban energy, local food systems, and retrofitting sustainable buildings). 70 % of urban infrastructure is yet to be built.

(g) Pursue options to use non-carbon-based sources for powering cities and their infrastructures.

(h) Increase public and private financial flows towards city level action.

(i) Improve and implement disease surveillance of potential vectors in urban and peri-urban environments.

(j) Greater planning and investment need to be made into blue infrastructure – sustainable water and water treatment.

(k) Improve education of local communities on One Health issues.

(l) Strengthen the focus on urban food systems, improving the coherence in urban planning, ensuring that national urban policies provide the right framework for local government action.

(i) Disease prediction and management

Situation

163. Knowledge of diseases has increased greatly since the human discovery of viruses. However, the ability to predict and manage viral diseases remains a nascent field. Understanding of the steps to achieve these goals is developing rapidly across many fields of science and medicine, and there have been a number of efforts to lay these out. Approaches such as One Health and Planetary Health are efforts to weave together disciplinary approaches to create a more unified approach to predicting and managing diseases. Experience from recent pandemics other than COVID-19 have also contributed to increased understanding on what is needed.[138]

164. However, some researchers are concerned that the world has changed in important ways since Ebola, MERS, and other recent epidemics making their lessons less applicable. These changes, including a reconfiguration of governance in many parts of the world, increased connectivity, increasing biodiversity loss, and greater effects of climate change may mean that lessons from the past need to be evaluated before being applied to global health in the Anthropocene.[139]

165. There are numerous problems—psychological, social, and ecological—associated with epidemic disease prediction and management, from political to biological, impacting the ability to develop actionable and useful forecasts. The processes that connect viral biology and evolution, dynamics of infectious agents, and recipient exposure and susceptibility occur over multiple scales of biological organization. Equally, the processes that connect the ability of pathogens to achieve human to human transmission—“viral chatter”—to the diverse movements of humans is a scalar phenomenon. Current approaches to predict spillover include viral evolution, macroecology, landscape change, pathogen discovery, and surveillance of

human populations. As a result, predictions of pathogen spillover that aim to predict the region and time period within which interventions to prevent spillover have the greatest changes of success.[140]

166. Other methods are designed to predict the ways that a pandemic will affect human societies. Using scenario planning integrating weather, individual, and government responses, these approaches are helping steer current decisions surrounding COVID-19. A revised global reporting system of outbreaks and use of artificial intelligence to analyze internet and mobile phone use are amongst the developments that are being applied in the current pandemic.[141]

167. Despite all of these efforts, to date no specific pandemic has been predicted before infecting human beings. Achieving this highly desirable outcome would require a number of steps.[142]

168. First would be identifying underlying viral diversity and predicting which ones are most likely to emerge. Estimates for viral diversity in mammals range from over 1 million species to a more recently calculated 40,000, of which approximately 10,000 have zoonotic potential. Another estimate calculated that some 1.67 million viruses are yet to be discovered and between 631,000 and 827,000 of these have zoonotic potential. There are programs active in discovering and cataloging viruses, in particular the Global Virome Project. Coronaviruses cause diseases in wild animals, domestic animals, and humans and are the group of viruses most indicated for on-going research and monitoring. Detection would take place by using genetic sequences and/or biological assays of viral traits to identify those with the greatest risk of evolving into pandemic threats.[143]

169. The second step would be to determine which species are likely to carry predicted high-risk pathogens. There is controversy in the literature about which groups of mammals are most likely to carry such viruses, but the most recent work suggests that it is bats and rodents because they have the greatest number of species and therefore the greatest number of viruses, particularly coronaviruses. Non-human primates are another group of concern because of their close relationship to humans and the established history of spillover. Overall, it appears that host phylogenetic similarity and geographical range overlap are strong predictors of viral sharing across all mammals.[144]

170. The tropics and subtropics, with their many species, are particularly rich areas for spillover events. Species that have increased in abundance by adapting to human-dominated landscapes also represent high transmission risks. Novel techniques are becoming available for identifying viruses in host wild species, for example through the use of environmental DNA collected from leech bloodmeals and from waterholes. Wild waterbirds and domestic animal species can also play key roles in spillover events.[145]

171. Third, as is true for species, not all individuals within a given species are likely to be the source of viral spillover. As a result, it is important to predict which individuals or populations are most likely to transmit high-risk pathogens. Genetic differences, hormonal differences, reproductive status and nutritional differences all contribute to an individual’s ability to host,

survive, and transmit viral infections. Stress can also play an important role in disease susceptibility with evidence of individual differences is response to stress and infectivity. Population-level differences may also drive different host animal responses to disease and transmissibility including abiotic and biotic conditions that impact host immune defenses as well as anthropogenic changes that can affect immunity such as urbanization or pollution. Similar responses have been shown in plants with high population genetic diversity associated with lower rates of infectious diseases.[146]

172. Individuals of wild species with closer contact with humans appear to have larger percentages of coronaviruses than those living more remotely. Live individuals being transported to market exhibit different viral loads at different stages of the supply chain with Cambodian field rats sold alive and served in restaurants being 10-fold more likely to have detectable corona virus RNA than those in the wild. Closer contact with humans also seems to foster cross-species mixing of viruses with rodents raised on wildlife farms found with both avian and bat coronaviruses.[147]

173. Fourth, it is important to be able to predict which land/seascapes, and which human behaviors within those land/seascapes are most likely to result in spillover. Human behavior ranges from that of individuals to communities, governments, and businesses. Not all places and not all behaviors are equivalent in terms of the risk of spillover. Ecosystems harbor different species compositions with varying concentrations of viruses potentially harmful to humans. The key to the pathogenicity of these behaviors and ecosystems is an increase in interfaces between contact, invasion, and onward transmission and enhanced permeability across species and ecosystem boundaries.[148]

174. At one end of the landscapes of transmission are places with intimate interaction between humans and animals, both wild and domestic. These include nature-based tourism, hunting, private animal collections, traveling entertainment venues such as circuses, rodeos, petting zoos and animal fighting. As with wet markets, many of these settings bring together species from different parts of the world and place them in close proximity to one another and to humans, both handlers and visitors. For example, at least 1,051 cases of monkey bites of travelers were reported between 1995 and 2016. The ways that humans interact with animals in all of these settings influence likelihood of disease transmission.[149]

175. Human behaviors often bring susceptible and infected animals into contact, frequently involving wild and domestic animals. For example, the avian influenza, H5N1, is largely a disease of birds, though humans can contract it. In this case it seems that it was migratory birds, particularly waterfowl mixing with free-ranging poultry (in rice paddies) that brought the virus out of the wild and through poultry, into humans. Live animal markets also mix species from all parts of the globe.[150]

176. Landscapes with two different levels of human alteration seem to be sites at which viral transmission probabilities are greatly increased. The first are areas with little previous human alteration that are sites of direct contact between humans and wild animals. This contact may be between hunters and their prey where butchering and consumption of wild meat has been

shown to have been responsible for diseases like Ebola. But it can also potentially take place through greater contact with wild primate species when humans are foraging, gathering non-timber forest products, or tending garden plots.[151]

177. Land-use change can increase the risk of emerging zoonoses by increasing the number of reservoir hosts, increasing the incidence of infection in reservoir hosts or creating changes in the pattern and rate of frequency of contact between reservoir hosts. Particular attention has been paid to deforestation in tropical settings due to the higher numbers of potential zoonotic viruses in forest faunas.[152]

178. At the other end of the spectrum are areas where human alteration is extensive, such as large agricultural fields or urban and peri-urban areas. In the former it appears that ecosystem simplification increases not only populations of rodents that can transmit diseases to humans but also the emergence of plant viruses. Landscapes with domesticated animals are also places where spillover can take place, as not only are they frequently in dense numbers, often in association with wild species, but also harbor more zoonotic viruses than wild species. In areas of substantial human use such as agricultural and urban systems, mammal species that harbor more pathogens overall are more likely to occur. Underlying drivers of increased human pathogen richness include not only environmental conditions but also socioeconomic drivers including human population density and antibiotic drug use.[153]

179. The probability of transmission in a given landscape varies over time. Some climatic conditions make transmission more likely than others. Land use practices, types of governance, and conflict can increase or decrease this possibility. Agriculture and associated land use changes and other drivers are associated with over half of all zoonotic infectious diseases that emerged in humans—a percentage that is predicted to only increase.[154]

180. At a broader geographic scale, in some regions, spillovers are more common, largely because of different species composition and species abundances. For example, Southeast Asia is a hotspot for filovirus-positive bat species. After taking into account differences in reporting effort, risks of emerging infectious disease are greater in forested tropical regions experiencing land-use changes and where mammal species richness is high and where human population is growing fast. This is true for tropical areas in all regions of the world.[155]

181. Finally, it is important to identify the likely patterns of spread that will happen once a pathogen emerges. This is particularly important as climate change (terrestrial and oceanic), habit degradation and conversion, and human population movement and increase are already known to be drivers of the spread of emerging infectious disease and will most likely result in new diseases as well as known diseases in new places. And diseases that occur not only as single outbreaks but repeatedly, as with the 23 outbreaks of Ebola and the successive waves of the 1918 Spanish influenza. In addition, they can remain circulating and evolving in host species, such as avian influenza in wild bird populations, with periodic movements into domestic poultry and the continued threat of movement into humans.[156]

182. A review of zoonotic disease transmission (of all types, not just viral) showed that at a broad scale 42 percent were transmitted through oral transmission, 42 percent were vector-borne, 36 percent by airborne transmission, 29 percent by direct contact and 24 percent via contact with a contaminated environment. The top three primary drivers were land-use change, agricultural industry change, and international travel and commerce. Human behavior, from funerary practices and attitudes towards social distancing and hospitalization all impact and shape the spread of infectious diseases.[157]

183. Long-scale movement of diseases can take place as well. For example, toxoplasmosis, an Amazonian parasite, has become a health concern for the Arctic Inuit, apparently through northward migration of wild felids. Migratory animals, particularly waterbirds are also long-distance movers of disease, for example West Nile virus.[158]

184. As people move, so do the infectious diseases they carry, a pattern as old as the Silk Route and as new as globe-spanning air travel. Global air travel and seaborne trade routes are also routes traveled by diseases and their vectors. As the authors of an article on airline transportation networks and epidemics conclude "the air-transportation-network properties are responsible for the global pattern of emerging diseases." In general, diseases are geographically constrained, following similar geographical patterns of wildlife. However, increasing global human connectivity is leading to homogenization of diseases where pathogens that were restricted to one region are now found in other regions (e.g. Zika virus, SARS-2-CoV) can be found elsewhere.[159]

185. The imperative to track emerging viruses as they spread has been addressed by many organizations and by academics and health care practitioners using a variety of tools. These include new epidemiological models, genetic tracking of viruses employing phylogenetics, cell phone and social media use, and satellite mapping. There are also opportunities to learn lessons from management efforts of other infectious diseases, of humans and other species such as Ebola, rinderpest, and Peste des Petits Ruminants. The COVID-19 pandemic has only increased work in all of these areas.[160]

186. The comprehensive IPBES analysis of biodiversity and pandemics concluded that there is an emerging pathway to predicting and preventing pandemics that includes predicting geographical origins of future pandemics, identifies key reservoir hosts and pathogens most likely to emerge and demonstrates how environmental and socioeconomic changes correlate with disease emergence.[161]

<u>Opportunities to effect change</u> [162]

(a) Develop predictive multi-dimensional, multi-disciplinary models to predict spillover.

(b) Develop and deploy better estimates of the unknown viral diversity and number of potential pathogens

(c) Develop modeling and remote sensing tools to increase prediction of circumstances for potential outbreaks. Combine with field survey techniques and in-country diagnostic capabilities to monitor wild and domestic species for spillover.

(d) Strengthen public health surveillance worldwide.

(e) Strengthen data reporting from field level and develop early warning systems to detect and respond promptly to outbreaks.

(f) Develop data sharing agreements and methods to harmonize national and regional results for surveillance field data.

(g) Improve genetic tools to track movement and evolution of viruses within hosts, including the linking of epidemiology and genetic data to track drivers of pathogen evolution.

(h) Learn from other forecasting systems such as those for severe storms and fire.

(i) Develop tests for environmental RNA to test for new and existing viruses.

(j) Develop and test ecological interventions to manage underlying transmission processes based on ecological understanding.

(k) Develop and test use of phone and internet usages and the use of open source data to detect and treat emerging infectious diseases.

(l) Establish longitudinal surveillance networks in populations that maintain regular contact with a diversity of domestic and wild animals while simultaneously sampling both types of species of zoonotic pathogens.

(m) Explore the advantages and disadvantages of using vaccines to prevent zoonotic diseases in animals including exploring the use of self-disseminating vaccines to suppress zoonoses.

(n) Evaluate possibilities of applying synthetic biology tools to developing means of decreasing viral spillover.

(o) Develop cost effective methods for viral detection in the field.

(p) Train local researchers on sequencing methods and serological assays.

(j) Pandemic psychology

Situation

187. Before there was an understanding of microbes and their relationship with disease, pandemics were terrifying events ascribed to divine wrath, contamination by outsiders, or other events outside the control of the afflicted group. As a result, human responses to previous pandemics—plague in the 14th century, cholera in the 19th century, or HIV/AIDS in the late 20th century—have been characterized by fear, distrust, and anxiety. Discrimination was common against those with the disease or thought to be sick, 0r even those from countries

thought to be the source of the disease. Quarantines, named after the forty days that the Venice required ships to be isolated during the plague before passengers could go ashore, were instituted under the logic that the common good was more important than the health of individuals. Isolating sick individuals, a common biological trait found in many animals, is practiced in humans at multiple levels from individuals, to communities, and entire towns. As commonly as such practices were instituted, they were routinely broken.[163]

188. Epidemics and pandemics have always been a complex mix of biology and human behavior with complicated feedback loops between the two, sometimes exacerbating the severity of the disease and sometimes playing a critical role in stopping spread. The psychological responses of humans play an essential role in both the spreading and containment of the disease and have a lasting impact long after the disease has died down. SARS-CoV-2 may be a new virus causing a new pandemic, but the ways humans are responding are familiar from previous epidemics and pandemics, and there is much that can be learned from these earlier outbreaks.[164]

189. Pandemics are multiscale crises affecting cells, individuals, and the entire human population either directly or indirectly. As crises they occur in inherently unstable periods when short-term responses can create greater long-term problems. The ways that humans behave in these periods of crisis can play important roles in determining both short-term and long-term impacts. There are significant individual differences in not only susceptibility and spreading of the virus but also in response to uncertainty, stress, and illness.[165]

190. The COVID-19 pandemic and the ways that humans have responded recapitulate these patterns and continue to influence the course of the disease. The COVID-19 pandemic arrived in a world already riven by social and political discord. It has increased existing disagreements and pushed the disadvantaged into further poverty, ill health, and death.

191. At the level of the individual, the stress associated with pandemics can result in negative responses by the behavioral immune system as well as health anxiety leading to adaptive and maladaptive coping mechanisms. Social stigma associated with the diseases amplifies the dangers of the pandemic and the psychological impacts.[166]

192. At the level of the country, governments have sometimes been willing and able to identify an incipient epidemic and begin health care interventions at an early stage, as is the case with COVID-19. But in other pandemics, this has been delayed for years and in still other cases there was no unified national governmental response, which either changed course frequently or defaulted to sub-national levels to implement responses. For the current pandemic, national leaders have provided broadly varied leadership during the first six months of response.[167]

193. The much-anticipated SARS-CoV-2 vaccine has not yet been approved as of fall 2020, yet its release is already the subject of misinformation and conspiracy. Antivaccine activists are active on social media and their campaign has met receptive ground. Polls show that people throughout the world are not committed to receiving a vaccine, many of them disadvantaged

groups already at greater risk from COVID-19. This “vaccine hesitancy” is so widespread and potentially harmful that in 2019 the World Health Organization listed it as one of the major global threats. Overcoming this reluctance to being vaccinated will be one of the major obstacles public health professionals need to overcome. Doing so must be based on the recognition that vaccination has often been a proxy for wider fears about social control.[168]

194. At least some of the vaccines being developed to address the current pandemic incorporate novel genetic technologies, including an engineered gene and a genetically modified common cold virus. These run the risk of being lumped with GMOs and “synthetic” foods and therefore being rejected by the public. There is a potential for the anti-vaccination movement to join with the anti-GMO movement and influence both the course of the pandemic as well as the potential of crops modified using synthetic biology technologies.[169]

195. The media of all types is playing key roles in structuring human responses to COVID-19. To varied extent, regional and local media has often downplayed the severity of the pandemic, amplifying misinformation (including conspiracy theories) and discouraging audiences from taking steps to protect themselves recommended by health care providers. The public’s respect for experts of all sorts, from public health to medicine to statistics to businesses has been thrown into doubt, with potential for long-term consequences in the face of the next pandemics.[170]

196. Diseases have always been in part socially constructed, certainly by the afflicted individual but also by society and the medical establishment as well. The rise of social media and the platform it offers for contestation of expert opinion has shaped the ways people experience and respond to COVID-19. Social networks shape the kinds of information that is shared—be it medically-sound cures or conspiracy theories. Social networks are also enabling the rise of a sense of individual entitlement to become an expert has severely hampered the ability of public health professionals to effect interventions. For example, the act of wearing a mask has itself become a political statement—irrespective of its public health benefits. There has also been a proliferation of false claims about the efficacy of various treatments for the disease.[171]

197. Efforts to implement effective interventions addressed at human behavior, psychology, and response to the pandemic can learn from the extensive literature on the psychology of climate change communication. Fear, guilt, and helplessness contribute to barriers to responding to climate change. Cognitive, affective, motivational, interpersonal and organizational responses are all involved in affecting how individuals and organizations are responding to climate change. Story telling is a key part of responding; an expert in climate change communication concludes that “experts and non-experts alike, convert climate change into stories that embody their own values, assumptions, and prejudices.”[172]

198. Steven Taylor, a clinical psychologist and author of “The Psychology of Pandemics,” said that “… pandemics are essentially psychological phenomena. Pandemics were not simply about some virus infecting people. Pandemics were caused and contained by the way that people

behaved." Knowing this and acting on it has the potential to considerably lessen the impact of the next pandemic.[173]

<u>Opportunities to effect change</u> [174]

(a) Garner lessons regarding communicating costs and benefits of environmental action from the interventions to address the current pandemic.

(b) Investigate the extent of social construction of the problem.

(c) Devise ways to reverse the demise of technical expertise.

(d) Invest in risk communication, a subfield of public health, which offers lessons for communicating the importance of environmentally-centered behaviors and policies.

(e) Promote storytelling as a communication strategy for this and future pandemics.

(f) Determine if the pandemic creates opportunities to promote and instill environmentally-favorable behavior change.

(g) Use behavioral psychology to change behaviors that increase likelihood of viral spillover.

4. OPPORTUNITIES FOR GEF INVESTMENT AND PARTNERSHIP AT A GLOBAL SCALE: SHAPING A RESILIENT FUTURE IN A COMPLEX WORLD

199. Over the last 50 years, the earth and its inhabitants have been reshaped by climate change and biodiversity loss. Globally, species are being redistributed with resulting changes in ecosystem functioning, human well-being and the dynamics of climate change itself. Human action, from agricultural expansion into natural ecosystems to wildlife trade to global travel networks, are all breaching natural barriers and homogenizing nature. This process is happening to microbial diversity as well, from soils and corals to the atmosphere and the microbiomes of plants and animals.[175]

200. The rapid spread of the novel coronavirus puts those challenges in stark relief. As WHO Director General Dr. Tedros Adhanom Ghebreyesus wrote: "The pandemic is a reminder of the intimate and delicate relationship between people and planet. Any efforts to make our world safer are doomed to fail unless they address the critical interface between people and pathogens, and the existential threat of climate change, that is making our Earth less habitable."[176]

201. Changes in climate and patterns of biodiversity are affecting the number, type, and location of human diseases. As humans and other species of animals shift their ranges, or are transported by human agency, they create novel opportunities for sharing of viruses, some of which will spillover to humans. With the changes to climate and biodiversity come changes in society, technology, and politics. These sweeping changes have combined to create the

opportunity for the SARS-CoV-2 virus to move from its original home, most likely in bats in southern China, into humans in every country in the world.[177]

202. Thinking of COVID-19 as a pandemic is both true and insufficient. Pandemics and other disasters do not cause effects but rather, "the effects are what we call disasters." COVID-19 cannot be fixed, it is not a symptom but a snapshot of the multi-faceted, multi-scaled, integrated, socio-techno-ecological system of human life on earth. The journey of the virus has been long, beginning with the ageless churn and chatter of viruses in the microbial world, probing and sampling a world of potential hosts, extending, as is currently hypothesized, through people catching bats in a cave and shipping them to be sold alive in a market, to the first SARS-CoV-2 viral spike protein that successfully bound to its receptor in a human, perhaps shoppers in that market, to the joyous travels of tens of thousands of humans for Chinese New Year, to the deaths of over a million people and the work of countless institutions and resulting in a global cost of $8 to $15 trillion globally.[178]

203. The COVID-19 pandemic is a complex system, a manifestation of this large, complicated system that links evolution, human history, land-use change, global transportation networks, national politics, and social norms. As a complex system the pandemic generates "wicked problems:" systemic in nature, similar to but not a precise duplicate of previous events, without a single root cause, and understood and approached in many ways—none of which is complete or sustainable by itself. Individual parts of the COVID-19 problem can be addressed, such as the urgent development of a vaccine, but the entire complex system of which the virus is just a single manifestation must be examined and addressed as a whole.[179]

204. The COVID pandemic across this full range of biological, ecological, social, institutional, political, and value scales is a complex system. Complex systems have a set of defining characteristics including limited predictability, fundamental uncertainty, constant change and innovation, self-organization with no central control, non-linear dynamics and emergent behavior. [180] The COVID pandemic has not been treated like such a complex system. Instead it is being viewed as an invasion to which humans need to declare 'war' and win.

205. From the earliest understanding of the existence of microorganisms they have been associated with disease and fighting disease meant fighting microbes. The focus was on the individual kind of disease-causing microbe and not on the tangled microbial web in which humans live. The disease could be isolated, arrested, excised, and destroyed and human life could return to normal. Humans needed to wage a war against microbial invasion and modern medicine and its pursuit of vaccines—the magic bullets—was the way to pursue this battle.[181]

206. This simplified view of any pandemic is almost completely blind to the relationship between disease and environment. This relationship was understood early in the history of Western medicine when, writing over 2000 years ago Hippocrates observed that human diseases were related to environmental conditions, be they climate, water, or soil. Instead, environmentally-related diseases have become medicalized; that is, they are seen as a problem only the medical or public health professions can solve.[182]

207. It is essential to reframe the COVID-19 pandemic as a complex system and bring to bear a multi-disciplinary approach, alive to complexity, uncertainty, and the essential environmental sciences and actions. There is an important set of efforts flying under the banner of "build back better" a phrase with origins in the UN's disaster risk reduction work. In the case of the pandemic, this phrase, used by the UN, OECD, World Bank and the GEF, has a variety of different interpretations, perhaps best summarized as not returning to business as usual and taking into account climate change and biodiversity loss.

208. The underlying model is one of linear change: the pandemic caused a deviation and humankind must return, hopefully "better." But the lessons of complexity science including fundamental uncertainty, non-linear dynamics, and limited predictability are not consistent with such a model of pandemic response. And they include ways to move forward against these odds.[183]

209. The one certainty is that there will be another pandemic. Pandemics are not black swans, but what author and policy analyst Michele Wucker terms "gray rhinos—highly probable, high impact, yet neglected threats. Black swans are improbable and unforeseeable while gray rhinos occur after a series of warnings and visible evidence.[184]

210. The GEF recognizes the need to consider broadening its thinking about how to help provide global environmental benefits. Per se, human health was not considered part of their operating sphere. But the universal disruption caused by the pandemic has revealed how human health and measures to maintain it are intimately associated with global environmental benefits. The GEF can play a key role in addressing the parts of the system discussed in Section 3 but addressing the larger issues will require broad coalitions, new partners and new terms for existing partners. Some of the priority issues are addressed in this section and all would contribute to a more sophisticated and realistic view about how pandemics take place and what can be done to try to ameliorate the next one. The COVID-19 pandemic opens a window and demands broadscale public, governmental, and business attention. As such it presents an opportunity to address vital issues facing humankind and the rest of life on earth.[185]

(a) Inequities and the need for resilient governance

211. The world has long been a place of inequality between humans. The pandemic has only exacerbated these differences. In its earliest stages, COVID-19 was described as "the great equalizer." But it has become clear that the pandemic has not treated all humans equally. There are marked differences in the ways that the SARS-CoV-2 virus has impacted people from genetic makeup to ethnicity to global region.[186]

212. Emerging work is showing that there seem to be a number of genetic differences between humans including a major genetic risk factor, likely inherited from Neanderthals, carried by some 50 percent of people in South Asia, compared to some 16 percent in Europe today. Differences are also seen between sexes, with men appearing to be significantly more susceptible to COVID-19 than women. Younger people appear to either not get the virus or have milder symptoms. In the US COVID-19 has disproportionately affected African American

and Latino peoples. It has also disproportionally affected American Indian and Alaska native peoples.[187]

213. All nations have been affected by the pandemic irrespective of prosperity and geography. Early results suggest that in countries that are more prosperous there has been a greater impact of the pandemic with the fatality rate higher in wealthier nations. Countries that are more economically unequal and lack capacity in some dimensions of social capital experienced more COVID-19 deaths. Countries with limited health care and high rates of infection have high death rates. Countries with high co-morbidity factors also have higher death rates. Whereas, in the first wave of disease, countries that acted more rapidly to impose lockdowns suffered a lower death rate despite differences in socio-economic variable. This result has started to change as the northern fall season begins. Significant anomalies remain unexplained at this stage in the disease and the analyses, including the fewer than expected cases and reported deaths in Africa.[188]

214. Strategies to mitigate against the pandemic have had mixed success and the results are only known from analyses early in the course of the disease. Complicated patterns between age, transmissibility, and population movement remain to be discovered but it would be a surprise if they did not recapitulate the patterns seen in other pandemics. A just recovery for all will require careful attention to the long-standing inequities in access to and efficacy of health care, livelihoods, nutrition, employment and income. Such inequities have been shown to increase the non-sustainability of ecosystems, species and water.[189]

215. The pandemic has revealed the threadbare nature of the governance systems designed to control such events. It brings to the fore "how catastrophe feeds on dysfunction in national and international governance." One development practitioner observed that "Covid has changed both the focus and the urgency of the governance discourse more in the last six months than anything else has done over the last decade."[190]

216. The COVID-19 pandemic presents a series of governance challenges, not all of which are appropriate for consideration by the GEF. There are, however, some key issues that the GEF and its partners should consider.[191]

- The pandemic reveals the need to examine broad-based governance across sectors including health, the environment, indigenous peoples and city administrations, *inter alia*. Intersectoral dialogue and decisions will need to be made to address questions of inequality, the need to increase equality, who needs to do what and how such actions will impact global environmental goods.
- As the pandemic winds down, different actors will "capture" different narratives of what happened and why. These will be used to promote particular goals and values. The GEF and its partners could work to minimize this narrative-capture, particularly as it will be used to direct critical resources.
- As complex systems with nonlinear dynamics, surprise, and limited predictability, pandemic present challenges for existing governance types, built on notions of

predictability and linear causality. It will be important to promote discussions with a wide range of stakeholders about governance models for complex systems that reflect the need to create a "co-management" of the biosphere between humans and biodiversity.

- There is a human pattern of creating increasing levels of top-down, command-and-control management of biological systems. This results in attempts to manage ecosystems through institutions that ratchet up their efforts to exert control as the systems demonstrate unpredicted or unpredictable results, only further enhancing the brittleness of biological and institutional systems. The GEF and partners could create systems to work to avoid this response to the current pandemic, and promote an inclusive, bottom up approach that engages civil society and provides the mechanisms for their inputs into governance of natural resources, through co-management, round tables, and other fora.
- GEF should promote global cooperation and learning that transcends the current national-dominated responses to the COVID19 pandemic.

(b) Societal responses and futures of science

217. One of the most significant developments in understanding human behavior has come through the field of behavioral economics and the work of Daniel Kahneman and Amos Tversky. Part of this growing body of work has explored how behavior influences the ways people respond to pandemics. It has helped to elucidate how important it is to understand why public health experts have classified hubris, isolationism, and distrust as major threats to global public health. It is also helping to elucidate public responses to climate change and mitigation activities.[192]

218. Decisions made about human health are not always straightforward but embedded in uncertainty, interconnectedness, unpredictability and context-dependency. They are further influenced by erosion of trust in public administration and partisan-motivated reasoning. Given these factors, it is not surprising that public health interventions justified by "evidence" are not always received in as straightforward a manner as proposed. Part of this is due to the fact that there are competing definitions about what constitutes "evidence." Additionally, evidence does not tell people what to do and networks and institutions filter evidence. As a result, there are differing decisions as to what policy proscriptions should look like and it can be strategically useful to present decisions as 'evidence-based' concealing the political basis for recommendations.[193]

219. In recent years, any pretense of agreement on 'evidence' or even science has been obviated by what has been termed a pandemic of misinformation. The language of viral spread applies to the speed and breadth of movement of incorrect science, false cures and conspiracy theories. The situation affects societal responses to public health interventions, pandemic prevention, climate change and environmental policies. As one author wrote: "emotional contagion, digitally enabled, could erode trust in vaccines so much as to render them moot."

The situation has become so bad that the Director-General of WHO declared that WHO was having to start a battle against the "infodemic."[194]

220. Countering such an infodemic requires attention less to short-term scientific accuracy than on a recognition that facts are moving targets, the pandemic information is partisan, and that many of the possible choices ahead for public health and other government officials will be rooted in values and relationships whose importance will be largely independent of science.[195]

221. Trust has always been an important dimension in public health in the face of pandemics. During an Ebola outbreak, low trust in government was associated with being less likely to take precautions against the virus in homes or to abide by government-mandated mechanisms to contain spread. In a survey in the US during this pandemic, trust in science was a major factor explaining whether people practiced social distancing. Work in Europe has shown a similar phenomenon.[196]

222. The pandemic has pushed science to center stage where it remains buffeted by the winds of politics and polarization. The spotlight is on the ways politics is used to bend, embrace, or deny science—sometimes all at the same time. The role of values in determining the fate of science has never been clearer. The fundamental functioning of science with hypothesis, testing, and refinement has become warped into public positions about the failure of expertise and dueling interpretations of data and has resulted in a significant downgrading of science. But awareness of the biases in science are also being revealed – public bias, selection bias and confirmation bias—all making the public even more willing to discount the word of "experts" without examining the basis of their expertise.[197]

223. In the face of the swirling societal concerns and values associated with disease, climate and conservation what could the GEF and its partners consider doing in this arena?[198]

- There is active interest in applying to the COVID pandemic what has been learned from behavioral economics as applied to climate change, a problem much greater than any pandemic will be. Engaging strategically with the field of climate change communication with the purpose of informing a post-COVID-19 strategy might be something the GEF and its partners would consider doing.
- Changing behaviors is a complicated undertaking even if peoples' motivations, beliefs and actions are understood. Specific suggestions about steps to take are starting to be published. Consideration of this body of work is vital if the GEF and its partners are to take on any work that has a public-facing component. The GEF could consider introducing some elements of 'behavior-centered design' for certain projects that include interventions that can lead to learnings about how human behavior responds and adjusts.
- It is clear that there needs to be a global effort to strengthen science around the world and work has begun by organizations like the International Institute for Applied Systems Analysis and the International Science Council. Suggested actions include creating more open science (available more broadly), promoting research on

risk and systems resilience particularly increasing the role of social sciences, increasing scientific cooperation at regional and global scales to avoid the growing problem of nationalization of science, grow public awareness of science as well as increasing trust in science, and finally enhance cooperation between public science and private sector science.

- Promote investments around citizen science focused on development and distribution of low-cost tools, for example, or that focus on enlisting average citizens as data collectors and analysts.
- The sciences that need to inform a post-COVID-19 strategy must be extended beyond virology, public health and conservation to include social and behavioral sciences. They should be woven together is a “post-normal” science understanding of the pandemic and recovery.
- Science diplomacy has played key roles in previous periods of history. Science focused on fundamental questions and global processes, such as those involved in the COVID-19 pandemic “could help in maintaining connections and building understanding, even in the face of growing political and security tensions.” Existing GEF partners as well as academies of science and the International Council for Science could be instrumental in such an effort. Of particular importance is facilitation of South-South scientific exchanges.
- Build collaborations with the risk communication community who work on the exchange of real-time information, advice, and opinions between experts and people facing threats to their health, economic or social well-being. The risk communication community could extend their work into the intersection between conservation and One Health.

(c) Learning from the past to shape the future

224. Pandemics have been a part of human history since the creation of concentrated settlements, the domestication of animals and long-distance movements for trade or transhumance. Lessons have been sought from these numerous pandemics including the Black Death episode of the plague and tuberculosis to the recent waves of Ebola and Nipah as well as pandemics of domestic animals. Archaeological evidence combined with work on the 1918 pandemic influenza has emphasized that pandemics can shape demographic and health trends long after the disease has passed.[199]

225. The pandemic of 1918 received a flurry of attention on its one-hundred-year anniversary. Historians and public health officials have documented lessons including that cities with greater air pollution (from coal use) had higher mortality, that the pandemic spread in waves, an absence of transparency (wartime censorship was still in place) contributed to the spread and severity of the disease, and children born during and immediately after the pandemic showed lower educational attainment by adulthood, had increased rates of physical disability and lower lifetime income. Lessons learned from the African experience sound eerily

familiar today: social distancing has an impact, trust is indispensable, public health professionals need to be protected, and action must be taken to ensure food security.[200]

226. In other words, a disaster is an amalgam of the results of an event or series of events, whose impact is disruptive, destructive and/or negative in nature, and whose magnitude is sufficient to be labelled 'disastrous'. If disasters are amalgams of 'effects', as Dombrowsky, a German scholar of disasters, suggests, then it is possible that not all of the 'effects' are negative. One positive effect is learning.

227. Lessons have also been sought through developing and running scenarios. Pandemic simulation exercises predicted what have become failures in the COVID pandemic response including leaky travel bans, medical-equipment shortages, massive disorganization, misinformation and a rush for vaccines. Perhaps the biggest limitation of the numerous scenarios that have been run is that they have failed to convince policy makers to prioritize improvements to the public health system.[201]

228. The current pandemic, though not the specific details, was predicted, frequently and by different sectors of society from epidemiologists, to wildlife health experts to the World Health Organization. Planning exercises around a "virus x" were run by President Trump's administration in the US government from January to August 2019, and by the World Economic Forum and the Gates Foundation in 2017. In March 2020, The Lancet published an article entitled "Disease X: accelerating the development of medical countermeasures for the next pandemic"—that had already arrived.[202]

229. Anxious to start learning from COVID-19 there is already a flush of papers reporting on early lessons. These include that transparency is vital, decisive leadership is critical; unified responses are required, existing global insurance institutions and policies are inadequate, and accountability is critical to build trust.[203]

230. But publishing on lessons is not the same as acting on them, in fact one author called such lessons "fantasy documents" generated to prove that some authoritative actor has "done something." Learning does seem difficult, as countries like the UK have failed to change their pandemic response even based on what has been learned in the last eight months. The authors of an article entitled "lessons we don't learn" states "our experience suggests that purported lessons learned are not really learned; many problems and mistakes are repeated in subsequent events." It may be that the most fundamental lessons are also those most difficult to learn.[204]

231. Despite the long history of pandemics humans are better at forgetting than remembering. As the historian of pandemics, McMillen has written: "For very often history is forgotten or rediscovered only when we confront contemporary epidemics and pandemics, and thus patterns from the past are repeated thoughtlessly." Or as Michael Baker wrote in 2015 regarding the latest Ebola outbreak: "the biggest surprise about pandemics is that we are still surprised they happen."[205]

232. In the face of the repeated difficulty societies have had in learning how to think about preventing and minimizing the impact of pandemics what might the GEF and its partners consider doing?[206]

- Extreme events and disasters may open a window of opportunity for change, including changes that result in improved environmental conditions Using the hoped-for opportunities created by COVID-19 is a vital part of the GEF's post-COVID action strategy aimed at "building back better". This could be informed by consulting with experts in the field of disaster prevention and response and lessons learned from previous pandemics with particular attention to finding ways to overcome the unfortunate fact that most such lessons are not used effectively.
- The GEF and partners could create and support a systematic study of the origins and lessons from pandemics that is policy-relevant and involves people from indigenous groups and national policy makers to historians and the global policy bodies including WHO and CBD. This "integrated science of the past and future" could serve as an important foundation for all post COVID-19 investments and partnerships.
- Work with scenario developers and implementers who worked on "Virus X," the H1N1 avian influenza work, and similar exercises to learn what worked and didn't work in societies' responses to COVID-19 pandemic. From this develop and widely publicize recommendations for the next pandemic.

(d) Learning to live in a virally-entangled world

233. Humans live lives entangled with viruses. Viruses were evolutionary actors in the human past, and they are current inhabitants of human genomes and microbiomes. Viruses are ecological actors on sea and land, and, of course, agents of human suffering and death. For over a century, humans have thought of viruses only in this last category: they are an enemy which must be defeated when they invade the human world. They are only detected when already inside the walls of human lives and starting to wreak havoc. And the readiness and response to viral diseases have been highly inadequate: across 18 indicators of preparedness to prevent, detect, and respond to outbreaks of a novel infectious disease, only 57% of 182 countries had the functional capacity to perform crucial activities at national and subnational levels. This poor preparation is not unique to COVID-19, but it typifies human's response to epidemics and pandemics in general— ineffective, inefficient, and costly.[207]

234. This situation contrasts with the science being done on prediction of infectious diseases, published in 427 different journals in the last 23 years. The literature as well as decades of experience suggest that there are a set of societal interventions for reducing risks of further epidemic disease transmission from animals to humans. These can serve both as places to conduct interventions but also places to set up monitoring and surveillance and include: 1) supply side or the production or sourcing of animals; 2) transport and sale; and 3) consumption.[208]

235. The early-detection approach to reducing the risks of zoonotic disease focuses on discovery of potential human pathogens before they spillover. Tools for such discovery include modeling viral sharing and land use and climate change impacts on viral transmission based on host range shifts. Other means of early detection rely on surveillance of pathogens circulating in human populations or sentinel animals. There have been significant investments in this approach including the PREDICT project funded by USAID, which is designed to strengthen capacities in developing countries to prevent, detect, and control infectious diseases in animals and people by focusing on early identification of and response to dangerous pathogens. A second major effort called the Global Virome Project, established in 2018, seeks $1.2 billion to conduct a genomic survey of the estimated 1.67 million unknown viruses in order to predict which might infect humans and therefore be prepared to prevent future pandemics.[209]

236. One of the advantages of working on potential pathogens while they are still in animal hosts is that researchers can apply genetic characterization to help prepare vaccines. There are significant concerns regarding this approach, including that there are too many viruses to consider and too few that actually spillover into epidemics to make this an efficient approach. Another concern is that viruses evolve so rapidly that yesterday's survey might miss today's threat. And finally, the cost of this method is high and the money might be better spent on monitoring human populations where spillover is most likely to occur, though others argue that upstream investment is in fact more cost effective.[210]

237. Sentinel humans or sentinel animals can serve as a place to focus sampling. On the human side these would include individuals in close contact with wild animals and livestock, like herders, hunters, and veterinarians. On the animal side this could be close companions of humans like dogs and chickens, animals in zoos (tigers and lions in New York's Bronx Zoo were diagnosed with COVID-19) and wild species like freshwater bivalves, primates, and bats.[211]

238. Using humans as sentinels for disease monitoring must incorporate values, norms, and behaviors when assessing susceptibility and exposure and examine when, how, and why they interact with wild and domestic animals. Behavioral economics can help explain, for example, why small-scale poultry farmers in Vietnam respond to disease outbreaks by selling their flocks rapidly to mitigate losses, thereby increasing disease transmission.[212]

239. The final societal intervention, and the one most often targeted by traditional medical approaches, takes place in the general human population. Here the main approach is through general screening of a broad range of individuals. This is the approach most widely deployed during the current pandemic.[213]

240. All of these targets can take advantage of the rise and decreasing cost of new technologies and collaborative approaches that have opened new ways to help detect epidemics. These include citizen scientists, genomic technologies—including high-throughput sequencing—complex systems models, data analysis and visualization, and collaborations with indigenous peoples.[214]

241. With all of these approaches there are weaknesses in training, coordination and harmonized reporting, data assembly and storage and visualization and reporting. Systems like the FAO's Global Early Warning System (GLEWS) and the joint GLEWS+ of the FAO, World Organization for Animal Health, and the WHO.[215]

242. There are a number of approaches that have been launched to prevent another pandemic, that include the Trinity Challenge, a coalition to use data and advanced analytics to develop action and insights contributing to a world better protected from health emergencies; The US National Institutes of Health's Center for Research in Emerging Infectious Diseases; the World Health Organization's "The Access to COVID-19 Tools (ACT) Accelerator, the Coalition for Epidemic Preparedness Innovations, and a dedicated bio-preparedness organization. A less conventional idea is the Bio-weather Map Initiative designed as a global, grassroots, distributed environmental sensing effort to determine the geographical and temporal patterns in microbial life – including disease-causing microbes.[216]

243. In order to learn to thrive in a viral world, the GEF and its partners might consider the following opportunities:[217]

- Support work on an "anthropology of viruses" that seeks to understand and reframe the relationship between humans and viruses.
- Support work examining the variation within a species across individuals, immune state, life history phases (e.g. migration) and the ways that trapping, handling, and processing animals affect the potential for spillover.
- Work with partners to strengthen existing regulations and frameworks including the International Health Regulations and the Sendai Framework for Disaster Risk Reduction.
- Create integrated monitoring systems that allow for early detection of pathogens, focused on areas where land use change creates risk and with capacity for precision health deployment.
- Develop partnerships with indigenous and local peoples to develop multi-cultural approaches to understanding and addressing viruses and other microbes.
- Improve area-based management such as protected areas that prevent land use change and animal collecting and hunting and thereby lessen chances of viral spillover.
- Scope and consider investments in forecasting and novel management technologies based on emerging work done to predict fires, locust swarms, weather forecasting, solar flares, winds, etc.
- Deploy complex system science to collect and analyze data from a broad range of sources using tools like System Dynamics Models, developed collaboratively with a wide range of stakeholders.

- Develop ways to integrate real-time genomic testing into a systems approach in three parts: discovery—the design, collection and analysis of omics data; representation—modeling, integration and visualization of complex data; and interpretation and hypothesis-based inquiry designed for translational outcomes.
- Invest in approaches to managing land use change that incorporates socio-institutional factors into models that incorporate spatial decisions joining conservation and zoonotic disease policies.
- Explore potential to use genomic tools to engineer viral resistance in wild host species and to deliver vaccines to alter viral dynamics in wild host species populations.

(e) Human health, One Health, and One Conservation

244. The COVID-19 pandemic has generated diverse and complicated messages. Among the most pervasive is the call for an approach that spans the silos that were created and separate human health, domestic animal health, and wild animal health. The traditions, training, literature, and reward structures of each of these have driven different approaches to an obviously connected, integrated single health. The very existence of zoonoses shows the importance of such an integrated way of confronting the current and potential future pandemics.

245. Numerous examples show the need for a practice that incorporates multiple applications of health, including tuberculosis shared by humans and Asian elephants, respiratory diseases shared between humans and mountain gorillas, the viral disease Petit Peste Ruminant shared between domestic goats and saiga antelope, and toxoplasmosis shared between humans, domestic cats, and sea otters. In fact, coronaviruses are called “One Health viruses” for their propensity to infect a broad range of animals as well as humans. Attending to health of humans, domestic animals and wild animals can result not only in health to these species but can also result in healthier ecosystems.[218]

246. The concept of One Health is an emergent one that took concrete form at a 2004 meeting where the 12 “Manhattan Principles” defined cross-sectoral and integrated approaches to health. The Berlin Principles expanded on these in 2019 to include more attention to climate change and the world’s poor, as well as to plants.[219]

247. Some researchers are promoting a related concept, Planetary Health. It is broader than “One Health” in referring to the health of human civilization and the state of all-natural systems on which it depends. Planetary Health focuses on improving understanding of the public health impacts of anthropogenic environmental change and the ameliorating impacts of conservation action, as where well-protected wetlands decreased disease transmission between migratory waterbirds and poultry. The boundaries between One Health and Planetary Health are not always clear or consistent as different initiatives pick and choose from amongst human health, domestic animal health, wild animal health, ecosystem health, climate change impacts, and other dimensions.[220]

248. A One Health approach has been promulgated by many professionals and institutions, including a collaboration between FAO, WHO, OIE (World Organization for Animal Health), and the World Bank that provides specific guidance on strategy and implementation. USAID announced in May 2020 that it would establish a new program, STOP Spillover, to develop interventions to reduce the risk of transmission of pathogens from animals to people.[221]

249. No matter the approach, health in all its forms is a moving target that shifts with the rapid changes to the earth, through climate change, biodiversity loss, agricultural growth, human migration, and urbanization. Though often considered as applicable only to places with a low human footprint, the One Health approach is equally applicable to cities. With 2.5 billion people expected to move to cities by 2050 recent work has shown that urban areas house species that are important sources of zoonotic pathogen transmission.[222]

250. Concerns have been raised that homogenizing health into one thing—across all humans, all societies, and all species (of vertebrate animals)—violates the conception of human health as more than physical wellbeing, as well as the many husbandry practices of domestic animals. and the many differences between wild species.[223]

251. Incorporating a One Health approach, the GEF and its partners could consider investments in the following areas:[224]

- Encouraging partners to consider how adopting One Health approaches could consider integrating conservation practice.
- Extend One Health approaches to the microbial world in general and microbiomes in particular.
- Working with multiple stakeholders to create policy frameworks to implement "Health Impact Assessments" that tie the impacts of development projects to human health as well demonstrating the health benefits of conservation projects.
- Encourage adoption of One Health approaches in urban and periurban settings.
- Encourage better understanding of the environmental drivers of zoonotic disease emergence.
- Support research designed to develop a better understanding of the links between agricultural expansion, agriculture, and disease emergence.
- Build capacity among health stakeholders to incorporate environmental dimensions of health.
- Consult with indigenous people and reconfigure One Health to incorporate different knowledge and management systems.
- Promote a political ecology approach to One Health that builds on different systems and societies and can address contentious topics in zoonotic control like traditional harvesting of wild species and closing of wildlife trade.

- Support work on climate change impacts on One Health through application of genomic tools, bioinformatics, and systems thinking.
- Support processes to develop data collection, analysis, modeling, and visualization of pathogens that combines genomic diagnostics and epidemiology in a One Health frame.

(f) Natural problems and implementing natural solutions

252. Humans are ecosystem creatures, relying on them for clean water, clean air—in fact, air itself—food, recreation, shelter, and spiritual solace. This reliance has not been accorded economic value in national accounting systems. However, recent work has begun to place values on such ecosystem services: the World Economic Forum estimated that $44 trillion of global GDP (about half) is highly or moderately dependent on nature.[225]

253. The Millennium Ecosystem, initiated in 2001, elevated to global attention the foundational economic and cultural importance of the services provided by ecosystems, and the dangers of degrading them. Actions to protect, sustainably use, manage, and restore ecosystems to provide for human well-being and biodiversity conservation became known as "nature-based solution" or "natural solutions." This original definition has been broadened to include solutions inspired and supported by nature that provide environmental, social, and economic benefits and build resilience. The term is also used more narrowly to signify ecosystem services from protected areas such as regulating rivers, protecting crop wild relatives, storing carbon, and providing livelihoods to vulnerable human populations.[226]

254. Whether used broadly or narrowly, researchers, practitioners, and policy makers have applied the concept of nature-based solutions to issues such as climate change, water security, food security, and disaster risk management. There has been a remarkable rise in work on and interest in ecosystem services that has been applied to all of these topics throughout the world, spurred by the Millennium Ecosystem Assessment. For example, an article titled "Natural climate solutions" concludes that there is a "robust basis for immediate global action to improve ecosystem stewardship as a major solution to climate change." Climate mitigation is an active topic in this application of natural solutions.[227]

255. Businesses are also recognizing the role of natural solutions. The insurance and re-insurance industry has identified a range of ecosystem services as critical to their business: habitat intactness, pollination, air quality and local climate, water security, water quality, soil fertility, erosion control, coastal protection, food provision, and timber provision. The Dutch National Bank calculated that a loss of ecosystem services would lead to substantial disruption of business processes and financial losses and calculated that 36 percent of the €1.4 trillion in investment held by Dutch financial institutions is highly or very highly dependent on one or more ecosystem services. Nature-based solutions can offer a triple dividend of benefits: short- and long-term economic gains, avoided losses, and social and environmental benefits.[228]

256. Though less discussed, the concept of natural solutions can be applied to cities and food systems where many of the same health-biodiversity-climate problems exist, though framed in different ways. Urban parks provide ecosystem services, as do greenways, gardens, and urban trees. With the increasing urbanization of human populations this dimension of natural solutions grows in importance.[229]

257. The current pandemic has brought about a broad appreciation of the impact that destruction and degradation of natural ecosystems has on emerging infectious disease. Even The Lancet, the bastion of human medical research, stated: “to protect against zoonoses, we require new precautions such as ending deforestation and protecting conservation areas and endangered species.”[230]

258. The frameworks of natural solutions and ecosystem services provide a useful and potentially powerful way to look at some of the drivers of pandemics, as it is becoming increasingly clear that ecological transformations can dramatically affect human health in obvious as well as subtle ways. Climate change and loss and degradation of natural habitats can lead to a greater number of important emerging infectious diseases and reduced biodiversity can increase zoonotic disease emergence and worsen endemic diseases. In turn, ecological interventions—or natural solutions—can limit or prevent viral spillover by reducing or preventing the flow of pathogens across one or more barriers thereby preventing them from infecting a spillover host. These include preventing wildlife-livestock contact, encouraging ecosystem management, and prevention of ecosystem degradation or conversion.[231]

259. UN Agencies, the European Union, and others are developing programs that address these sorts of natural solutions, many with a focus on post-COVID stimulus packages and the design of what the World Economic Forum calls “nature-positive” stimulus packages. One, a “Marshall Plan for Nature” in Africa would target green infrastructure with job programs to do things like replant mangroves and watersheds, upgrade and rewild conservation areas, and restore shorelines. The UNDP has proposed a “Nature offer” that supports a One Health approach, engages in public awareness concerning ecosystem degradation, and invests in nature and inclusive nature-based solutions through green stimulus packages. The EU is proposing a far-reaching 2030 biodiversity strategy that will transform at least 30 percent of Europe’s lands and seas into effectively managed protected areas at least partially to ensure a healthy society through healthy ecosystems. And the Rockefeller Foundation has committed $1 billion USD to a green recovery from the pandemic. [232]

260. One recent analysis shows that significantly reducing transmission of new diseases from tropical forests would cost between $22.2 and $30.7 billion per year. This is compared to the approximately 500 times greater estimated COVID-19 pandemic cost of between $8.1 and $15.8 trillion globally.[233]

261. Many of these approaches include a component for restoration of ecosystems, not traditionally a mainstream conservation activity. New approaches to strategic investment in restoration show promise to avoid extinction debt, sequester carbon, and decrease chances of spillover.[234]

262. Yet the future of such efforts is far from clear. WRI reports in an analysis of coronavirus pandemic stimulus packages that few can be described as "green" and some may contribute to further environmental and climate problems, with 13 of 16 countries examined potentially damaging economic flows outweighing those supporting nature. And the EU's Green Deal has been criticized for simply moving offshore its environmental damage.[235]

263. The concept of natural solutions is also complicated in that it elides the role of humans as actors thoroughly emmeshed in nature as well as humans who decide what are nature's solutions and what, like pandemics, are nature's problems or disservices. It is also largely uniformed by regime shifts and other dynamic dimensions of ecosystems as well as the complex interactions across ecosystems and planetary boundaries. There are few, if any natural solutions that do not involve human action, past or present, in the natural system being turned to for relief. Nor are the proposed and implemented solutions uniformly beneficial to all nature—there are, and will be, some species and ecosystems that benefit and others that will not. There are also power imbalances between different human groups, with some likely to suffer when natural solutions are implemented for the good of others.[236]

264. The GEF and partners should consider:[237]

- Creating the research and policy necessary to add to the list of natural solutions/ecosystem services disease regulation and decreased spillover.
- Pandemic relief funding should prioritize support for those businesses that do not harm biodiversity, support climate-positive solutions and put restrictions on those that accept investment.
- Businesses receiving COVID-19 bailout funds should implement biodiversity risk-mitigation plans, requiring disclosures of impact, or building ecosystem considerations into decision-making, particularly for industries with demonstrated impacts on and risks to biodiversity.
- Governments should consider large-scale jobs creation, as part of a job creation drive in response to the COVID-19 pandemic, in ecological restoration, carbon-neutral development and green infrastructure aiming to achieve multiple objectives, with a focus on addressing more vulnerable populations.

(g) Financing recovery and the role of the private sector

265. Even prior to the outbreak of the COVID-19 pandemic the world was failing in its attempts to live sustainably and conserve the natural world. None of the Aichi Biodiversity Targets will be fully met, in turn threatening achievement of the Sustainable Development Goals (SDGs) and undermining efforts to meet climate change goals. The pandemic has made matters much worse, greatly reducing the hopes that globalization and economic growth would provide the investments need to meet global targets and the SDGs.[238]

266. The pandemic has put pressure on funding on all fronts from public health and national parks budgets to export agriculture, food aid, and poverty alleviation. Estimates are that it will cost up to $82 trillion over the next five years to recover from the costs of the pandemic. Climate change will make matters worse—in 2019 the US alone experienced 14 separate billion-dollar disasters related to climate change, and 2020 will only increase that number. By one calculation, two-thirds of the 169 SDG targets are either under threat as a result of the pandemic or not well-placed to mitigate its impacts. Ten percent of the targets could actually worsen the impacts of future pandemics, for example by extending roads into wilderness areas.[239]

267. None of this is good news for generating long-lasting environmental benefits. Governments generally did not respond well to the threat of the pandemic nor to its management, even though the threat and its consequences were well known. Commentators are quick to point out that this is not a good sign when it comes to addressing the impending crises of climate change and biodiversity loss. Furthermore, there are widespread reports of businesses and governments taking advantage of the pandemic to increase environmentally damaging actions or decrease funding for sustainability activities of their businesses. Additionally, the volume of potentially harmful spending committed as part of the economic recovery outweighs the volume of spending beneficial to biodiversity.[240]

268. There are clearly opportunities to reorient existing expenditures to address the SDGs and environmental goals. As of October 2020, governments had committed to over $12 trillion in economic recovery packages. As of August 2020, at least 30 OECD and Key Partner countries have included measures directed at supporting the transition to greener economies in their recovery programs. More than 220 state and regional governments issued a statement urging that the core of economic recovery funding must include the tools of the Paris Agreement and the SDGs. These include military budgets which continue to increase; last year 81 countries increased the percentage of their GDP that goes into military budgets. Yet large military budgets were ineffective against the pandemic. Relatively small portions of budgets for pandemic recovery could be directed to a green transformation of the energy sector.[241]

269. One of the commonly used phrases is that society needs to “get back to normal,” yet “normal” was not delivering desired outcomes for health, equity, climate, and biodiversity. There is excitement, and public support, about being able to help structure pandemic relief and rebuild budgets, placing health, climate and environmental sustainability at the center of these efforts and working to decrease or eliminate subsidies to environmentally damaging businesses. For example, the 2019 total fossil fuel subsidies totaled $478 billion worldwide. Reconstruction efforts could, at the minimum, do no harm to the environment, and at their best address long-standing systemic drivers of climate, biodiversity and health disparities and losses.[242]

270. The private sector must play a key role in responding to the pandemic and its aftermath. 155 multinational companies collectively worth $2.3 trillion issued a statement reaffirming their science-based commitments to achieving a zero-carbon economy. Nature is essential for

business: the World Economic Forum estimated that $44 trillion of global GDP (about half) is highly or moderately dependent on nature. Yet to play their role private sector businesses need governments to put in place the right regulatory environment, smart incentives, and market structures to catalyze financial flows from the private sector.[243]

271. The pandemic has made it clear that health—of humans, animals, and the environment—are critical for functioning of societies and the ability to deliver on sustainable development goals. Sustainable global environmental goods are not achievable or receivable unless the enabling condition of One Health is in place.

272. The private sector is key to generating and delivering global environmental goods—which will only be possible in a healthy world. The insurance and reinsurance industry has strongly stated that biodiversity and ecosystem services are an essential part of its business, and the Organization for Economic Cooperation and Development has stated that the importance of addressing issues like climate, pollution, and biodiversity loss have become even more important as countries rebuild their economies and seek to enhance resilience against the next pandemics.[244]

273. There are provocative ideas currently being considered for private sector players to use financial instruments to seek biodiversity and climate returns during and after this pandemic. These include the opportunity of emerging sovereign debt to alleviate pressure on sovereigns while protecting nature and increasing future resilience by linking the cost of the sovereign debt to protection of a country's natural capital.[245]

274. The GEF and its partners could consider investments in the following areas.[246]

- Work with partners to decrease or eliminate subsidies harmful to one health, biodiversity and climate and promote beneficial subsidies.
- Work with stakeholders to propose expansion of new taxation policies for environmental and climate harms.
- Help ensure that COVID recovery funds support biodiversity, climate and one health outcomes.
- Help incentivize employment programs that provide benefits to biodiversity and one health.
- Support private investment in clean infrastructure, green infrastructure, and natural capital.
- Support efforts that decrease and eventually stop the loss and degradation of existing intact ecosystems, and where appropriate, undertake restoration to lower the probability of zoonotic disease spillover.
- Create and incentivize agricultural development and infrastructure investments with rigorous measures to minimize the loss, degradation, and fragmentation of intact ecosystems.

- National and subnational governments should strengthen their regulatory and financial enabling conditions to significantly accelerate private sector actions and finance for biodiversity conservation.
- Explore development of innovative financial mechanisms to buffer economic impacts of future impacts (e.g. insurance for protected areas to cover loss of ecotourism revenue).
- Private sector actors should have in place environmentally supportive policies on sustainable supply chains, harmful subsidy reform, natural infrastructure, biodiversity offsets, nature-based solutions and carbon markets, green investment, and investment risk management.
- There is a significant open place for collaborative, strategic, learning-oriented private philanthropy in the efforts to achieve One Health in the context of delivering global environmental benefits.

CONCLUSION

275. SARS-CoV-2 is a virus, 60-14o nanometers in diameter. At this size 400 to 1000 of them would equal the thickness of a human hair. Yet as synthetic biologist Drew Endy has pointed out, this virus was responsible for sending an entire French carrier battle group to port and forced the closure of a US naval base outside Tokyo. It has killed over a million people and severely impacted the global economy. Hence the virus has been called an “enemy” against which humanity must declare “war.”[247]

276. This martial framing of viruses is not helpful. We are only now learning the intricate histories and massive entanglements humans have with viruses—evolutionarily, physiologically, and ecologically. Humans needs a new frame for thinking of microbes in general and viruses in particular. Yet humanity also needs powerful tools to heal both itself and the natural world of which viruses are such an important part. To prevail, humans must embrace the uncertainty characteristic of wicked problems and spur on creativity and innovation. We must apply systems thinking that addresses inter-connected environmental, social, economic, and governance challenges across sectors and across time and build resilience.[248]

277. Carter Roberts, President and CEO of WWF-US, and Carlos Manuel Rodriguez, CEO of the GEF wrote: “we ignore nature’s warning signs at our peril. The pandemic has made that clear. Governments crafting plans for their post-coronavirus recovery have a once-in-a-lifetime opportunity to address the root causes of zoonotic disease spillover and turn the tide on climate change and biodiversity loss.” Pope Francis said on Earth Day, 2020, that humanity needed “to overcome our selfishness and rediscover a sacred respect for the earth, we need a way of seeing—an ecological conversion.”[249]

278. Governments are promising to act. Political leaders representing 78 countries from all regions and the EU participating in the UN Summit on Biodiversity in September 2020 committed to reversing biodiversity loss by 2030 through undertaking a number of actions. In

their "Leaders' Pledge" they state that: "Nature fundamentally underpins human health, wellbeing and prosperity. We need to appropriately value nature and the services it provides as we make decisions and recognize that the business case for biodiversity is compelling. Against the backdrop of COVID19, which has crippled the world's economies and pressured governments everywhere to begin the process of rebuilding and renewing, decisions made now will have ramifications for all of us and for generations to come."[250]

279. The world, already a complex system has been made even more complex by the COVID-19 pandemic. We have seen the complex system characteristics of limited predictability, self-organization, emergent behavior, constant change and innovation, and most of all, fundamental uncertainty. It is against this setting that all proposed policies and interventions need to be understood, experimented with, monitored, and modified. Rapid, short-cycle experimentation is critical in this pandemic world. There are calls for transformational change, yet such calls are based on a view of the situation as other than complex.

280. All disasters, including pandemics, occur at the intersection of natural and human systems, where interactions are characterized by complexity and conflict. These complex intersections mix history, ecology, values, and power in a cauldron cast from uncertainty, fear, and hope. The enormously consequential steps being proposed to deal with the pandemic and its aftermath are saturated with power dynamics and fears of who will bear the costs and who will reap the benefits. Yet alongside fears of "one world-ism" and the tyranny of the powerful are opportunities to build the enabling circumstances to deliver vital global environmental goods.[251]

281. Crises have long been seen as opportunities to seek and put into place substantial change. One of the important lessons is that there is no durable conservation nor global environmental goods without health for all—humans, domestic animals, wild animals, and the environment. The GEF has a critical role to ensure that this lesson is learned. The challenge is to deliver global benefits while strengthening diversity; biological as well as cultural and institutional.

282. Trust, often in short supply, is particularly scarce during crises like the pandemic. Yet trust is exactly what is needed in such fraught times, trust that health can be achieved while the natural world is conserved. Examining the role of ethics in the pandemic philosopher Jordan Pascoe and emergency manager Mitch Stripling argue that what is needed are pandemic ethics that acknowledge emergent dependencies in multidimensional networks of care. We need networks of care that span from viruses to coral reefs and from traditional peoples of the Congo Basin to the citizens of Scandinavia; networks of care that will save humanity and the natural world.[252]

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