



## Zoonotic Diseases and Our Troubled Relationship With Nature

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The coronavirus pandemic provides us with an opportunity to reassess and reboot our relationship with nature. Reducing the pressures on our planet's life-giving ecosystems will help solve converging environmental crises as well as benefit public health and well-being. Rather than piecemeal solutions to the rising probability and magnitude of zoonotic disease outbreaks, runaway climate disruption, and mass biodiversity loss, we suggest systemic change in the way humanity functions and interacts with nature.

The staggering loss of human life and disruptions to everyday life from the coronavirus (COVID-19) pandemic have caused immeasurable pain across the world as well as enormous financial losses. If and when the time comes that it is deemed safe to resume all our typical activities, the world will still be a markedly different place. To reduce the likelihood and impact of the next pandemic and other natural disasters, we need to address human, animal, and planetary health together. Immediate action is critical to solving these co-linked crises.

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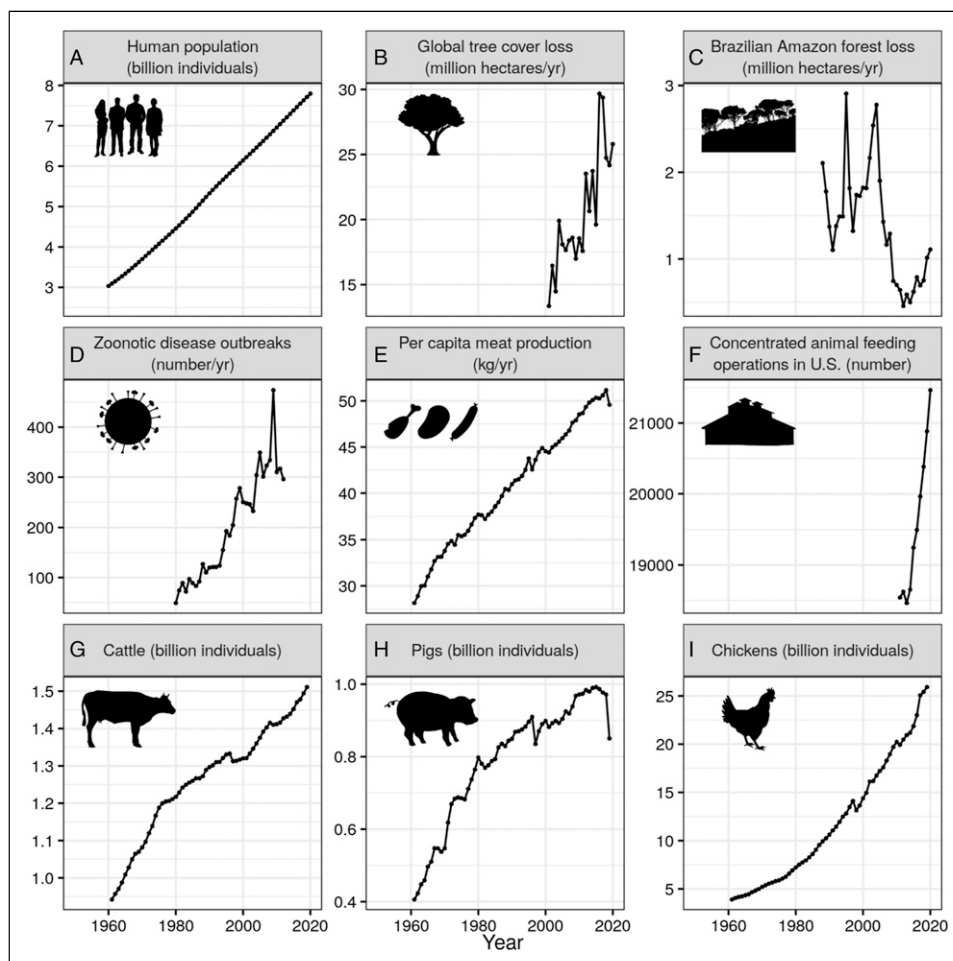
One hypothesis on how COVID-19 originally infected people in China is that the virus spilled over from infected bats and possibly other wild animals that were forced into close proximity with humans, making it a zoonotic disease. Humans – their increasing numbers, soaring extraction of natural resources and escalating consumption – are changing the planet in fundamental ways that threaten our overall health and well-being, especially that of future generations.<sup>1</sup> The ever-increasing pressure we exert on nature endangers not only the biosphere, but human civilization itself.<sup>2</sup>

Phenomenal economic growth, particularly in wealthy nations, has consumed massive amounts of natural resources, only to deposit much in landfills, with unprecedented global warming emissions as a byproduct. Explosive world population growth (3 billion people in 1960, nearing 8 billion now) has spread human populations to remote areas, thereby destroying wildlife habitats, and forcing wild animals to adapt or perish (Figure 1A). Some 1 million species of plants and animals are now facing extinction worldwide.<sup>3</sup> In North America alone, 3 billion birds have

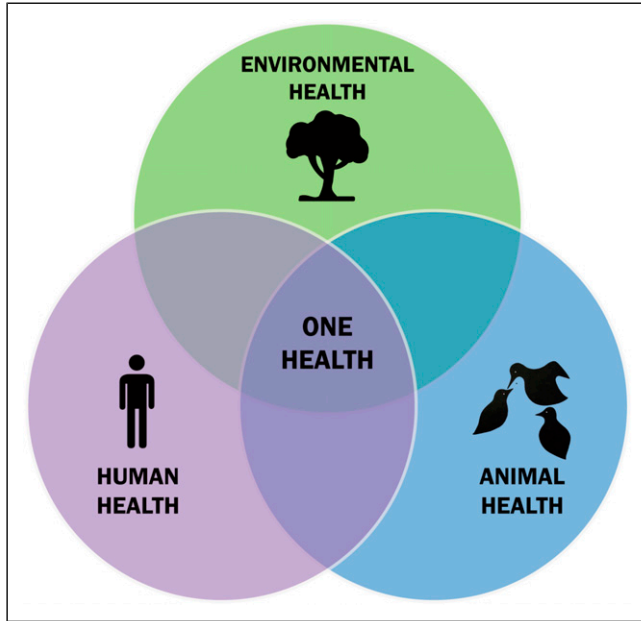
vanished in recent decades.<sup>4</sup> The world has likely now entered the sixth mass extinction.

Our global environmental footprint — a measure of our use of natural resources and the consequent impacts on ecosystems — has depleted 60% of the ecosystem benefits provided to us free of charge by nature.<sup>5</sup> These benefits are best maintained by natural features that purify drinking water, cleanse the air, pollinate crops, regulate the climate, provide new medicines, inoculate our microbiomes, and enrich our lives. Unfortunately, at the rate we are going, these losses will only accumulate as we force more wild animals out of natural habitats (Figure 1B and 1C), alter wildlife migrations, and melt the permafrost that could be harboring novel pathogens.

Our insatiable meat consumption is upping the ante on pathogen spillover (Figure 1D and 1E). Large and dense populations of poultry and livestock can facilitate the rapid spread of pathogenic agents to humans, and crowded farm animal-feeding operations can increase the probability of emerging infectious diseases (Figures 1F-1I). The H5N1 bird flu, which spilled from chickens to people in 1997,



**Figure 1. Trends in variables related to zoonotic disease risk.** Increasing human population size and expansion (A) has been a major driver of deforestation (B, C), contributing to an overall rise in the incidence of zoonotic disease outbreaks (D). This rise might be exacerbated by increasing concentrated animal feeding operations (F), meat consumption (E), especially of cattle (G), pigs (H), and chickens (I). Note that we omitted the final estimate of zoonotic disease outbreak (A) because it could be based on incomplete data. The recent major decrease in pig numbers (H) is likely due to African swine fever in Asia.<sup>12</sup> Global tree cover loss (B) does not account for forest gain. Data sources: A, E, G, H, I - FAOSTAT<sup>13</sup>; B - Hansen et al<sup>14</sup>; C - Butler et al<sup>15</sup>; D - Smith et al<sup>16</sup>; F - EPA<sup>17</sup>.



**Figure 2. Illustration of the One Health concept.** One Health lies at the intersection of human, animal, and environmental health, and reflects the important connections among these components. For example, reducing zoonotic disease risk requires careful consideration of all 3 types of health and how they can be optimized together. This image is a derivative of <https://commons.wikimedia.org/wiki/File:One-Health-Triad-en.png> (Thddbfk; CC BY-SA 4.0).

ravaged chicken stocks and killed approximately 60% of the humans known to have contracted the virus. Fortunately, this outbreak subsided before many more people died. The H1N1 swine flu was a massive pandemic, jumping from pigs to people in 2009. The Centers for Disease Control and Prevention estimated that from 2009 to 2018, the H1N1 swine flu caused at least 100.5 million illnesses, 936 000 hospitalizations, and 75 000 deaths in the United States alone.<sup>6</sup> Globally, an estimated 151 700 to 575 400 people died from H1N1 swine flu in just the first year of that pandemic.<sup>7</sup>

The loss of predators that keep host animals, like mice and deer, in check is connected to the spread of Lyme disease in North America.<sup>1,8</sup> Poaching, overhunting, and the global trade in wild animals contribute to disease spread (Figure 1D). Zoonotic diseases that were likely caused by wild meat hunting and butchering include Ebola, HIV-1 and HIV-2, among others.<sup>9</sup> The source of the deadly Ebola outbreak has been linked to both deforestation and to virus spillover from the hunting and consumption of primates or bats in Africa. The HIV epidemic was likely the result of African primates being killed, processed, and eaten by hunters. More than 30 million humans have died from HIV since the beginning of this epidemic.

### What can be Done to change Direction and Reduce Human Suffering and Death From Zoonoses?

Immediate changes include accelerating the development of new medicines and vaccines while caring for the most vulnerable. One-quarter of all medicines come from the tropics. Of special importance

are the phyto-chemical properties of rainforest plants, particularly those derived with the cooperation and respect of Indigenous Knowledge. Veterinarians working with ecologists and medical doctors need rapid response capabilities to locate and contain emerging infectious-disease hotspots quickly. An encouraging program is 'One Health' at the Centers for Disease Control and Prevention.<sup>10</sup> This multidisciplinary approach to zoonotic disease prevention explicitly links human and ecosystem health (Figure 2).

'Wet markets', where wild animals are housed in high densities in typically unhygienic conditions, must be closed, and the trade of wild species that have elevated risks of zoonotic disease transmission strictly curbed. Much of the demand is fueled by the U.S., which consumes some 20% of the global wild-species trade.<sup>11</sup>

As consumers, we have choices; eating lower on the food chain is one of them that will have sweeping benefits in many sectors of sustainability. In addition to being a healthier choice for many, major reductions in meat consumption would help slow the rate of deforestation, biodiversity loss, and climate change, while simultaneously improving human health and potentially reducing risks of diseases being transferred from animals to humans. No longer are plant-based protein products just for vegetarians, as now some of the biggest meat producers in the world have launched plant-based meat analogs (substitutes) for the mass market. Plant-based dairy and egg analogs are also becoming widely available. Research on laboratory or cultured meat (growing meat from muscle cells in the lab) also shows promise as being environmentally friendly.

We urgently need international sustainability efforts to reduce the pressures on the planet's life-giving ecosystems by at least bending the human population growth curve downward. There are policies that can lower fertility rates ethically and equitably while strengthening human rights: achieving full gender equity and making secondary education and job opportunities a global norm for girls and young women.

Greater collaboration among governments and local communities is needed to protect at least 30% of Earth's terrestrial and marine habitats by 2030, particularly in regions that still have vast areas of intact ecosystems, large carbon stores, and vulnerable species. The timing is critical to stem accelerating biodiversity losses. Along with other climate-conscious efforts such as weaning ourselves from our fossil-fuel addiction, this protection would help keep carbon safely stored in ecosystems like forests instead of emitting most of it to the atmosphere when forests are cleared.

As we recover from this pandemic, it would be foolish to go back to business as usual and lose sight of the climate and biodiversity crises about which the world's scientific community and religious leaders like Pope Francis and the Dalai Lama are warning us. If we ignore their calls, we will pave the way for new pandemics and other threats, such as the potential catastrophic effects of global heating. The COVID-19 pandemic has shown us that, if absolutely needed, we can make life-saving behavioral changes. It has taught us how to lower our consumption habits and our carbon footprint.

An integrated nature-based agenda is gaining momentum. Rather than piecemeal solutions to the climate crisis, biodiversity loss, and pandemics, we need transformative change in the way society fundamentally interacts with the natural world.<sup>12</sup> We must create a new carbon-free economy operating within the limits of the biosphere and atmosphere. We must restore and preserve ecosystems, and change the way we interact with animals. We can reduce fertility rates through voluntary family planning, while eating mostly plant-based

foods. We can remodel our economy to account for the actual impacts of development and resource extraction on the wellbeing of humans and the preservation of the environment. We can do all of this while addressing social justice issues and honoring the diversity of people, especially Indigenous populations, around the world. Making good on these essential goals is necessary to ensure climate stability and provide life support for future generations on Earth.

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