Pandemics rapidly reshape the evolutionary and ecological landscape and have cascading social, economic effects

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Detail: "An Irish Peasant Family Discovering the Blight of their Potato Store." Daniel MacDonald. 1847. Credit: National Folklore Collection, University College Dublin

Like human pandemics, plant pandemics are also associated with the coming of the Anthropocene and first started appearing with the rise of

an interconnected world. Some of the first recorded pathogen outbreaks were associated with wheat, as recorded by the Romans (2100-1950 B.P.). In fact, the Romans had a god/goddess of rust (Robigus/Robigine) because these new pathogens were so feared. Feasts, processions, and sacrifices in their name were conducted in order to prevent crop destruction and stop future waves of reinfection. Over the past 200 years the number and severity of plant diseases has increased exponentially. Once a pathogen spreads globally, eradication becomes difficult or even impossible. Pathogens do not respect international boundaries. Efforts to reduce the movement of pathogens across borders or by quarantines are easily frustrated by globalization, travel, and trade.

Governmental plans to deal with plant pandemics—mainly associated with agriculture—now largely revolve around prevention, response, and recovery. The effort to protect the food supply and human health is largely focused on limiting spread and impact. The chestnut blight was one of the first major pandemics in forests, but there are many more that impact wild ecosystems. Dutch elm disease, sudden oak death, Phytophthora cinnamomi, and Armillaria honey fungus are all pathogens in an age of pandemics with potential to alter ecology and cultures, if not entire civilizations. Human pathogens and the threat of new pandemics reveal a sobering reality. While considerable effort is now expended on learning how pathogens emerge and identifying potential pandemic pathogens, less has been done to recognize the general signatures of pathogens within and across populations. So this raises the question: what, in terms of ecological and cultural impact, will the next chestnut blight or COVID-19 bring? In particular, what lessons have we learned from trees that inform our ability to deal with the losses and envision a recovery from any pandemic pathogen?

The parallels between COVID-19 and the 1904 blight of chestnut trees are striking. COVID-19 (caused by the SARS-CoV-2 coronovirus) and chestnut blight (caused by the Ascomycota fungus Cryphonectrica

parasitica) both likely arose in Southeast Asia and were transported via international travel networks that enable pathogens to circumnavigate the globe. Over the course of about a month, both spread rapidly and simultaneously across Europe and North America, causing a broad spectrum of disease, from mild to severe and even death. In the U.S., both pathogens first devastated the New York region. Both infections first revealed their presence by several symptoms, but ultimately the more stressed and susceptible individuals died first as the pathogen more easily blocked and "suffocated" the vascular network. The collateral damage of both pandemics was remarkable. Spreading unimpeded, the chestnut blight decimated what had been one of the most dominant species of trees. Similarly, the novel coronavirus hit the local subsistance economies, mainly in the poor areas of the continent. Spikes in unemployment and dramatic changes in the traditional ways of life left culture irreversibly altered and shifted economic models.

For years, the American chestnut tree largely defined American deciduous forests, ranging from Maine to Georgia and west to the prairies. It survived all evolutionary adversaries for 40 million years, but then, within 40 years, it effectively disappeared. The American chestnut had no evolutionary history of interaction with this new exotic fungal pathogen. First discovered in 1904 in New York City, the chestnut blight was a global pandemic hitting forests around the world. In fact, it has been called the first great ecological disaster to strike the world's forests. It is estimated that in some places, such as the Appalachians, one in every four trees was an American chestnut. Within the span of a generation the North American forests had no chestnut trees. Chestnut blight spread rapidly and caused significant tree loss on different continents. The primary plant tissues targeted by C. parasitica are the vascular tissue and the cambium, a layer of actively dividing cells. The fungus girdles the stem, severing the flow of nutrients and water to the vital vegetative tissues. The absence of nutrient dispersal from leaves to roots causes the main stem to die, though, ironically, the root system

may survive. The American chestnut still exists, but poorly; its individuals are continuously knocked back by a resurgence of the pathogen when any one grows bigger than a sapling.

Pandemics offer a sober reminder that no matter how dominant the host or how grand and impressive the ecological or economic impact of a species, the exponential growth of a highly transmissible pathogen can be overwhelming. Pandemics rapidly reshape the evolutionary and ecological landscape and have cascading social, economic, and other system-level effects. They remind us that selective pressures are not a mere abstraction: they can happen quickly and are a grim reality of mortality and adaptation. A pandemic represents the impact of novel selective events that change the rules of interactions and allow some genotypes and phenotypes to be favored at the expense of others.

More information: Alberto Santini et al. Tracing the role of human civilization in the globalization of plant pathogens, *The ISME Journal* (2018). DOI: 10.1038/s41396-017-0013-9

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Agricultural recovery responses in post-pandemic situations arising from major animal and plant diseases. United States Agency for International Development. www.hsdl.org/?abstract&did=231734

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