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Introduction: public health, EcoHealth, planetary health, and you

> *For decades, many of us have turned a blind eye to what is happening to the planet. But now, given that Earth [as we know it] may well be dying, we may be ready to stand up to protect what we love. An extraordinary alchemy can take place when people follow their inner directives to stand up and face squarely the dire odds of biosphere survival. These actions involve extraordinary outer and inner courage, which can nurture a profound activism.*
>
> Dahr Jamail (2019)

1.1 Connections

This book is about connections, often unexpected links in a complex world. It brings together detailed information about seemingly disparate subjects. In the process, the growing air traffic of Miami International Airport is shown to be connected to the city's low-lying status in the ocean, to the use of sediment rock in the area's hydraulic and drinking water filtration systems, and to king and red tides. Elsewhere, the connections are examined between the climate of Earth and human evolution, the peopling of the world, and the historic development of modern society. Also of concern are the multiple ways national and international development under capitalism are entwined with deforestation, coral die-off, emergent infectious disease, and mounting food insecurity around the world. This list could go on, but the basic point is that a holistic perspective on diverse issues is needed in the investigation of the interaction of contemporary ecological dangers, human behavior, and health.

In visiting ecocrises around the globe, from U.S. nuclear waste buried below the melting glaciers of Iceland to the deteriorating asbestos cement used to construct homes in Australia, and many other catastrophes in many places in between, a considerable amount of detail is offered. Why such a thoroughgoing approach to cases and examples? Because, while there are redundancies reflective of the unfortunate fact that in countless ways adverse elements of environmental history repeat themselves, it is by knowing a multitude of events that the patterns and their determinants are brought into sight. In this way, we begin to see the forest through the trees. It is a critical moment for this task, as the logger's saw, intensifying wildfires, climate change-induced pest invasions, drought, global warming, and over-extraction conspire to denude the planet of oxygen-generating forests, depopulate the oceans, melt the cryosphere, and put human well-being at risk.

1.2 Is this a dangerous book?

In an essay entitled "The Danger of Environmentalism," Michael Berliner (2020), senior advisor to the Ayn Rand Archives, writes: "Earth Day approaches, and with it a

Ecosystem Crises Interactions: Human Health and the Changing Environment, First Edition. Merrill Singer.

grave danger faces mankind. The danger is not from acid rain, global warming, smog, or the logging of rain forests, as environmentalists would have us believe. The danger to mankind is from environmentalism." The perception, by some, of the danger inherent in being concerned about the industrial destruction of the environment is what has led covering the environment to be one of the most risky assignments in journalism. It is estimated that 40 reporters around the world died between 2005 and 2016 because of their environmental reporting. This is more than were killed covering the U.S. war in Afghanistan. Notes journalist Saul Elbein (quoted in Warren 2016): "In Cambodia and in remote forests elsewhere, a rising boom in the illegal sale of wood, land and minerals has turned the environmental beat into a new sort of conflict journalism. The dead have overwhelmingly been local reporters, covering illegal mining or logging. They are largely independent, poorly educated, untrained and despised by their nations' establishment media. Reporting on a violent, corrupt frontier, they are never sure when they'll cross a line and end up dead. Their lives in their hands, they head into the woods." Newsworthy environmental controversies often involve powerful business and economic interests, explosive political clashes, criminal gangs, anti-government rebels, or outright corruption. Often, they focus on struggles between elites and local people over indigenous rights to land and natural resources. In wealthy and developing countries alike, journalists covering environment issues find themselves the targets of attack by military, police, and paramilitary forces. In 2013, for example, independent journalist Miles Howe was assigned to cover protests by the Elsipotog First Nation in New Brunswick, Canada against hydraulic fracturing for natural gas. In his reporting, Howe sought to highlight unreported and underreported incidents. He recalls (quoted in Freedman 2018): "Many times I was the only accredited journalist witnessing rather violent arrests, third-trimester pregnant women being locked up, guys tackled to the ground." On one occasion, a member of the Royal Canadian Mounted Police pointed at him and shouted, "He's with them!" His equipment was taken and the police searched his home. In addition, they offered to pay him to spy on the protesters—an offer that he rejected. In 2014, the body of Taing Try, a journalist covering the illegal logging of the forests of Cambodia, was found by local farmers in Kratie Province. He was lying face down in the mud on a logging road, a bullet in the back of his head. Try's fate was not his alone. In 2008, Mikhail Beketov, a Russian journalist who wrote about the destruction of the Khimki Forest, part of the green belt surrounding Moscow, to make way for the Moscow–Saint Petersburg motorway, died of injuries suffered several years earlier after unknown attackers crushed his skull, broke his legs, and left him for dead in his own front yard. Similarly, in 2012, Chandrika Rai, an Indian reporter for the Hindi-language newspaper *Navbharat* and the English-language *The Hitavada*, who covered illegal coal mining, was bludgeoned to death along with his wife and their two teenage children in their home in Umaria, a small city in Madhya Pradesh state in central India. In 2017, Colombian radio journalist Efigenia Vásquez Astudillo was shot to death while covering the emergence of an indigenous movement to reclaim ancestral land that had been stolen and converted to large farms, resorts, and sugar plantations (Elbein 2016; Freedman 2018). The list goes on. Environmental reporters are often put at risk because they stand between the public and its need to know about environmental destruction and business interests or corrupt and criminal organizations intent on profit or personal gain. Degraders of the environment have a great deal invested in preventing the public from knowing the truth, or from knowing that is unencumbered by corporate spin (Conway 2018).

While environmental journals have been subjected to the most brutal forms of violence, environmental scientists—especially climate scientists—have been the targets of violent intimidation. The Climate Science Legal Defense Fund (2019), which has assisted numerous researchers who have been harassed and attacked through email, social media, and other online platforms or subjected to more explicit politically motivated personal threats, notes that:

> Vicious hate mail and death threats are common occurrences for climate scientists: One was the victim of an anthrax scare. Another had a dead animal dropped on their doorstep—while their child was at home. There are websites devoted to publishing scientists' contact information, a practice known as doxxing, so that the followers of these sites can flood scientists' inboxes with threatening messages. Other internet harassment tactics involve posting private details about researchers, such as the names of their family members or home addresses, for harassers to use against them.

These forms of intimidation have also been directed at other kinds of scholars who have written about climate change. A founding member and current board member of the Climate Science Legal Defense Fund, Naomi Oreskes, a science historian at Harvard University, became a target of the anti-climate science movement in 2004 when she published an article in *Science* documenting the broad scientific agreement on climate change. Based on an analysis of 928 scientific abstracts with the keywords "global climate change," she concluded that "there is a scientific consensus on the reality of anthropogenic climate change. Climate scientists have repeatedly tried to make this clear. It is time for the rest of us to listen" (Oreskes 2004, p. 1686). In response to her publication, Oreskes began receiving hate mail, and extremely hostile letters were sent to *Science*. Many of the letters to the journal were penned by economists and others affiliated with pro-free market think tanks, such as the Competitive Enterprise Institute. James Inhofe (R-Oklahoma), a recipient of significant campaign funding from the fuel industry and a science denier who has called global warming a "hoax," attacked Oreskes by name on the floor of the U.S. Senate. He cited Benny Peiser, a British social scientist, who claimed that his own review showed that fewer than 2 percent of climate studies endorsed the so-called "consensus view" that human activity is driving global warming, and some actually opposed it. Inhofe was unaware of or failed to acknowledge the fact that Peiser later admitted he could only find one "peer-reviewed" article that challenged the anthropogenic climate change consensus; this turned out to be published in a journal that is not peer-reviewed and is owned by a fuel industry organization, the American Association of Petroleum Geologists (Littlemore 2006). Moreover, not a single climate scientist subsequently disputed Oreskes' finding. Oreskes concluded: "We weren't being attacked because we'd done something wrong . . . We were being attacked because we'd done something right. Because we'd explained something significant, we'd laid facts on the table, those facts had implications, and some people were threatened by those implications" (quoted in Cho 2018).

Tyrone Hayes, a biologist at the University of California, Berkeley, notes that the history of such abuse predates the Internet: "Especially in the area of environmental science, it's mostly been women that have been the target, going all the way back to Rachael Carson" (quoted in Begos 2014). When her book *Silent Spring*—a groundbreaking science-based exposé of the environmental harms of pesticide use—was published in 1962, Carson was subjected to vicious personal assaults. The late novelist Michael Crichton—himself an outspoken climate change denier—even branded her "a mass murderess," directly responsible for the deaths of millions of African children from malaria because her efforts led to a ban on the pesticide DDT in the United States (a chemical to which mosquitoes in Africa already were evolving resistance) (Graham 2012).

Hayes came to personally experience the vitriol of the agricultural chemical industry when he began publishing his research showing that the widely used herbicide atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino)-S-triazine) is an endocrine disruptor that demasculinizes and feminizes male frogs. He even wrote a poem, "The Atrazine Rap" (Hayes 2008), about ecocrises interaction, which includes the lyrics:

> Atrazine ain't a good thing
> it causes male frogs to grow eggs
> contributes to extra legs
> and exposed males don't want to sing
> If that ain't enough
> when you combine the stuff
> with a few other pesticides
> it causes greater than additive effects
> unpredictable defects
> exposed larvae don't grow
> and they develop slow
> and they contract diseases that otherwise
> could be beaten

Appreciating neither his well-documented science nor his lyricism, Syngenta Crop Protection, the Basel, Switzerland-based manufacturer of atrazine and initial funder of Hayes' research, unleashed a barrage of attacks against him through press releases, letters to the editor, and a formal ethics complaint filed with the University of California, Berkeley (Aviv 2014). Internal memos, notes, and e-mails from Syngenta released during a subsequent class-action lawsuit revealed how it had conspired to discredit Hayes, including attempting to get scientific journals to retract his publications, investigating his funding, and examining his private life. The documents also showed that Syngenta's P.R. team had proposed that the company purchase "Tyrone Hayes" as a search term on the Internet, so that any time someone searched for Tyrone's research findings, the first thing they saw was an advertisement saying, "Tyrone Hayes Not Credible." Finally, Syngenta launched a multi-million-dollar no-holds-barred campaign to protect its considerable atrazine profits, hiring a detective agency to investigate scientists on a federal advisory panel, digging into the personal life of a judge, and commissioning a psychological profile of Hayes. In 2003, Hayes received a job offer from Duke University. Duke is close to Syngenta's headquarters in Greensboro, North Carolina and the company's research center in Research Triangle Park. When Syngenta officials got wind of the offer, they contacted university administrators and had it withdrawn (Howard 2013; Rohr 2018). Subsequently, Steven Milloy, a freelance science columnist and lobbyist with ties to the tobacco and fossil fuel industries and the head of a nonprofit organization, CSRWatch.com, to which Syngenta has given tens of thousands of dollars, wrote an article for Fox News titled "Freaky-Frog Fraud" in which he attacked a Hayes paper published in *Nature*, characterized Hayes as a "junk scientist," ridiculed his "shoddy write-up [and] shaky research," and dismissed his "lame" conclusions as "just another of Hayes' tricks" (Milloy 2015). Hayes weathered the storm and continued his research and publications. By 2001, atrazine was the most commonly detected pesticide contaminating U.S. drinking water, and its safety remains controversial. Ultimately, Syngenta was forced to pay $105 million to more than a thousand Midwestern water utilities in reimbursement for the cost of filtering atrazine out of public drinking water (Duhigg 2009).

The eminent novelist and journalist George Orwell (1953) explained that there were four reasons why he wrote: sheer egoism, aesthetic enthusiasm in words and their right arrangement, a historical impulse to find out true facts and store them up for the use of posterity, and political purpose: to push the world in a certain direction. This book was motivated by similar impulses. The degree to which it is deemed to be dangerous is the degree to which it succeeds in effectively communicating to readers the true and pressing dangers of anthropogenic environmental destruction and motivating them to action. Most desirably, it will be a book of the sort Mary Harris "Mother" Jones (1837–1930), a beloved activist and union organizer who was committed to pushing the world in a certain direction, had in mind when she advised, "Sit down and read. Educate yourself for the coming conflicts" (quoted in Fetherling 2010).

1.3 Three alternative approaches to health and the environment

There is a wealth of evidence connecting ecosystem change with human and nonhuman health impacts. The following discussion of this relationship is organized around the examination of three holistic and interdisciplinary approaches to health: EcoHealth, One Health, and planetary health. All of these, rooted philosophically in wildlife ecologist Aldo Leopold's (1949) concept of "land health"—the maintenance capacity of organisms and natural systems for internal self-renewal—reflect an ecological turn that occurred in public health beginning in the 1980s. Deeper roots extend to early thinkers such as Calvin Schwabe (who worked with pastoralists in East Africa and coined the concept of "one medicine," linking biomedicine and veterinary medicine) and Rudolf Virchow (who pointed to the role of the socioeconomic environment in the origins of infectious and other disease outbreaks), both of whom recognized the close relationship between the health of humans and work done in veterinary medicine (Zinsstag *et al.* 2010).

Expressing a holistic vision, these approaches seek to break down the historic compartmentalization that separated specialized understandings of the environment and specialized understandings in health. While their points of origin differ, "the relative synchrony of the success of [these] paradigms . . . did not come about purely by chance: they respond to a growing common perception of the complexity of the linkages between animal and human health and their proximate and distant socio-ecological environment" (Roger *et al.* 2016). All three were influenced by the Ottawa Charter of 1986, which highlighted the centrality of ecosystems and sustainable resources for human health. They share: 1) a focus on environmental factors in health; 2) a recognition of the increasing interconnectedness of ecosystems in a globalizing world; and 3) the underlying assumption that humans and other animals face many of the same environmental challenges (e.g., infectious disease, food and nutrition, contention with weather). Roger *et al.* (2016) note that:

> Despite their different origins, One Health and EcoHealth are convergent in their vision and goals to reposition animal and public health within their broader context. Both are motivated by the conviction that health concerns must be addressed at the human–animal interface within their broader natural and social environments (i.e., socio-ecosystem approach). Both try to integrate scientific disciplines combining multi- and cross-disciplinary approaches. Both aim to mitigate the risks threatening ecosystems and public health, including veterinary public health. Both deal with the complexity of diseases and health . . . Finally, both struggle to properly define the boundaries of their paradigms despite their apparent similarities regarding principles and objectives.

The Ottawa Charter was a product of the first International Conference on Health Promotion, which took place in Ottawa, Canada in November 1986. Its objective was to expedite the achievement of the U.N. goal of Health For All. A response to the growing expectations for a new public health movement around the world, signatories to the Charter recognized that a key requirement of health is having a supportive environment.

While the primary focus was on the built or human-created environment (e.g., cities and industrial workplaces), there was also a recognition of the need for a stable ecosystem and sustainable natural resources. Subsequent key events in the study of ecology and health included the Rio Declaration of 1992, which was a product of the U.N. Conference on Environment and Development, the launching of the journal *EcoHealth* in 2004, and the founding of the International Association for Ecology & Health (IAEH) in 2009. These developments have been described as representing a "transdisciplinary imperative for a sustainable future" (Wilcox *et al.* 2004).

Because of the similarities among them, some have urged a merging of these three alternative approaches to health promotion (Parkes 2012; Zinsstag *et al.* 2012; Roger *et al.* 2016). Despite their shared features, however, they are not synonymous. One critical factor that differentiates them is their handling of the human–animal–environment interface (see later). The effort to discuss and compare these approaches is complicated by the various definitions that exist for each of them. Following Lerner & Berg (2017), the focus here is on their respective core values.

1.3.1 EcoHealth

The multidisciplinary EcoHealth approach affirms that humans, animals, and their environment form complex socioecological systems and that destabilization can lead to disease. EcoHealth "examines the complex relationships among humans, animals, and the environment, and how these relationships affect the health of each of these domains" (Listza & Wolbring 2018). It provides a platform to bring together physicians, veterinarians, ecologists, economists, social scientists, health planners, and others to study, understand, and respond to the effects of ecosystem changes on human health. Moreover, it facilitates the integration of different epistemologies, including local, traditional, and indigenous knowledges (Rapport *et al.* 1998). EcoHealth seeks to build participatory frameworks that include more than conventional expert-led research toward a richer participatory process that includes relevant community actors in everything from initial problem definition to project design to the interpretation and sharing of findings (Mertens *et al.* 2005). Underlying all this is the insight that interventions for improving health are more effective if they respond to local realities. In Waltner-Toews' (2009, p. 519) assessment, the goal of EcoHealth is "sustainable human and animal health and well-being, [achieved] through healthier ecosystems."

The leading journal of the approach, *EcoHealth* (n.d.), defines it as being:

> committed to fostering the health of humans, animals, and ecosystems and to conducting research which recognizes the inextricable linkages between the health of all species and their environments. A basic tenet held is that health and well-being cannot be sustained in a resource depleted, polluted, and socially unstable planet.

Alternately, Waltner-Toews (2009, p. 520) states that EcoHealth:

> can be defined as systemic, participatory approaches to understanding and promoting health and wellbeing in the context of social and ecological interactions. They reflect not only an understanding of social systems and ecosystems, and how they interact, but also a convergence of applied, organizational ideas from business management, environmental planning, community operations research, participatory action research, critical systems theories and a variety of other fields

Within veterinary medicine, EcoHealth is viewed as an expansion of the scope of the field from a focus on the health of individual animals to a concern about animal populations and herd health. Promoted especially by the International Development Research Centre, Canada (IDRC), the approach appraises "the effective multi-sectoral collaboration and the engagement of multiple types of stakeholder" (IDRC 2008) through its six integrated principles—namely, system thinking, transdisciplinary research, participation, gender and social equity, knowledge to action, and sustainability—in order to provide a consideration of the human–animal disease interface. A medical perspective on EcoHealth is offered by the International Society of Doctors for the Environment (ISDE), a not-for-profit organization based in Switzerland with member groups in 38 countries. The Australian chapter, for example, Doctors for the Environment Australia (DEA), defines its mission as being to publicize "the relationship between the condition of the environment and human health, promote environmentally friendly behaviour amongst physicians, patients, and the public, and [cooperate] at all political levels in the reduction of harmful environmental influences on health" (DEA 2018). In the perspective of the DEA, doctors cannot narrowly focus on the health of individual patients in a world in which a descent into environmental chaos will seriously imperil their ability to use the findings of medical research and advances in patient care to relieve human suffering.

The IDRC supports research in developing countries by offering financial resources, advice, and training to address local problems. Since its foundation in 1970, it has provided funding for multiple projects. In 2002, for example, it funded a study in Molango, Mexico that traced the transport of locally mined manganese through various components of the ecosystem and examined its impact on human health. Researchers were able to track manganese from mine smokestacks, through wind and dust and along trucking corridors, into people's homes. They showed that exposure to contaminated air led to motor skill damage in adults, especially in women, and they identified nervous system risks in children. These findings prompted changes in local policies (IDRC 2008). Similarly, in Lebanon, IDRC-supported researchers implemented EcoHealth approaches to address water sanitation and waterborne diseases. In the town of Bebnine, they found that women played the greatest role in managing water at the household level. Consequently, they recruited more than 25 Bebnine women to shared their experiences working in the community. According to Iman Nuwayhid, who led the research, "In this way, researchers learned that some women preferred to use untreated well water rather than to pay for access to a new water network, even when they could afford to do so. They rejected the new network because they believed it was affiliated with certain political views or families, and refused to contribute to its shared costs" (IDRC 2010). Further, monthly water quality monitoring in 423 households revealed high levels of fecal contamination. These findings led the local municipality to install a water disinfection unit and to develop a health promotion communication strategy (IDRC 2010). In 2008, the IDRC co-convened the International Ecohealth Forum in Mérida, Mexico with participants from around the world in order to consolidate an international community of practitioners around the EcoHealth perspective. It has provided funding to the Communities of Practice in Ecosystem Approaches to Health in Canada, Latin America, the Caribbean, Africa, and the Middle East, as well as to a Field Building Leadership Initiative on EcoHealth in Asia. Its work of this sort has continued through to the present.

Another critical step in the development of the EcoHealth approach occurred at the "Healthy Ecosystems, Healthy People" conference in Washington, D.C. in 2002, which initiated a process that led both to the formation of the professional journal *EcoHealth* and to the eventual establishment of the IAEH. The IAEH seeks to support transdisciplinary initiatives that combine the strengths of various scholarly disciplines in order to achieve hybridized innovative approaches to problem-solving. In the organization's perspective, "Today's complex environmental public health challenges demand this level of strategic team-based approaches to the tightly coupled human-natural system interactions underlying many of our most pressing threats to our sustained health and environment" (IAEH 2019). The IAEH has sponsored a series of annual conferences at sites around the world. The theme of its 2018 conference, for example, hosted by the University of Valle, Cali, Colombia, was "Environmental and Health Equity: Connecting Local Alternatives in a Global World." This theme emphasized the need to connect local initiatives in a world with global drivers that threaten healthy ecosystems and populations in pursuit of both health and ecological justice.

The first issue of the journal *EcoHealth*, published by the International Society for Ecosystem Health (ISEH), appeared in March 2004. It provides similar-minded researchers across disciplines a venue in which to communicate and participate in sometimes lively debate. As Wilcox *et al.* (2012, p. 27) observe:

> [t]he rationale for ecohealth articulated in the first issue of the journal *EcoHealth* centered on the increasing need for applying ecological concepts to understand and nurture sustainable human health and, conversely, applying health concepts to understand ecosystems; collectively, this was referred to as "integrative studies in ecology, health, and sustainability." Issues identified as within the scope of the journal included: 1) global loss of biological diversity; 2) the drivers of human-induced changes in climate and the degradation and pollution of natural habitats; 3) health of human populations influenced by large-scale environmental changes, including the increasing gap between the rich and poor; and 4) interactions between environment, development, and health.

In sum, the core value of EcoHealth is addressing and improving human health through participation in collaborative efforts to protect biodiversity in the context of development, as expressed in the preceding review, and as derived from its grassroots practical focus on the relationship among health, ecosystems, and sustainable development.

1.3.2 One Health

Development of the One Health approach was motivated at official levels (e.g., the World Health Organization, WHO; the U.N. Food and Agriculture Organization, FAO; the World Organisation for Animal Health, OIE) by recognition that many of the same microbes infect both animals and humans. Diseases like COVID-19 that have passed from nonhuman animal to human populations are known as zoonotic diseases. Almost two-thirds of human pathogens have a zoonotic origin, and almost three-quarters of emerging and re-emerging infectious diseases of humans are zoonoses (Woolhouse & Gowtage-Sequeria 2005). These include both newer human threats, such as COVID-19, severe acute respiratory syndrome (SARS), West Nile virus, Nipah virus, and bovine spongiform encephalopathy (BSE), and ancient zoonotic maladies, such as rabies, anthrax, brucellosis, bovine tuberculosis, and zoonotic trypanosomiasis. The incidence of both types has risen significantly over time, contributing to a significant contemporary burden on global public health (Morens *et al.* 2004). Moreover, their occurrence is significantly correlated with identifiable socioeconomic, environmental, and ecological factors, especially social inequality, environmental and habitat degradation, and ecosystem disruption. In the case of the emergence of COVID-19 as a human disease, for example, there is growing evidence indicating the role of deforestation and land use for intensive farming in the pandemic (Arora & Misra 2020). Many of these multihost dangers require multisectoral responses, as efforts by just one sector

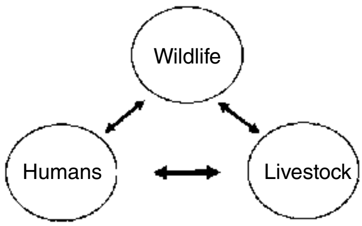

Fig. 1.1 Zoonotic disease triad.

(e.g., biomedicine or veterinary medicine) cannot prevent or eliminate the problem. In the case of rabies in humans, for example, targeting of the animal source of the virus (e.g., vaccinating dogs) is required to control incidence (Lloyd-Smith *et al.* 2009). At any point in time, particular zoonotic threats may be wide-ranging (e.g., the influenzas globally), regional (e.g., Middle East respiratory syndrome, MERS), or local (e.g., Kyasanur forest disease in parts of India). Different forms of monitoring at the human–animal interface are required depending on the conditions and route of transmission. Moreover, local and regional zoonotics may spread widely beyond their point of origin. While found primarily in Middle Eastern countries, for example, confirmed cases of MERS have been identified in Austria, China, France, Germany, Greece, Italy, Malaysia, the Netherlands, the Philippines, the Republic of Korea, Thailand, the United Kingdom, and the United States (CDC 2017). In the case of COVID-19, spread has included all nations. All disease vectors (e.g., mice, deer) and pathogenic diseases have their own features, and thus there is no single surveillance, prevention, or intervention strategy to tackle all zoonotic threats to health. One Health stresses expanding awareness of the conscious and less overt ways in which humans interact with animals in their daily lives (e.g., livestock for food, pets, hunting) (see Fig. 1.1). While animals represent part of the human physical environment, they also are deeply embedded in the human social environment. Increasing movements of people and an increased trade in animals and animal products are contributing to emerging zoonoses.

The Washington, D.C.-based One Health Commission defines One Health as "the collaborative effort of multiple health science professions, together with their related disciplines, and institutions—working locally, nationally, and globally—to attain optimal health for people, domestic animals, wildlife, plants, and our environment" (Roger *et al.* 2016). An outgrowth of collaboration between the American Veterinary Medical Association (AVMA) and the American Medical Association (AMA), and ultimately the American Public Health Association (APHA) as well, the One Health Commission seeks to break down disciplinary silos and establish closer professional interactions, collaborations, and educational and research opportunities across the health science professions. Alternatively, the One Health approach has been defined by the One Health Global Network—a worldwide computer-linked assemblage of organizations (e.g., One Health Alliance of South Asia, One Health Central and Eastern African Network, International Federation of Red Cross and Red Crescent Societies, Centers for Disease Control and Prevention One Health)—as an effort to "improve health and well-being through the prevention of risks and the mitigation of effects of crises that originate at the interface between humans, animals, and their various environments" (Whitmee *et al.* 2015). In both of these definitions, focus is placed on a "whole of society" orientation in which all of the health sciences work collaboratively across traditionally well-guarded disciplinary borders not only to improve the health of humans and animals but also to address biodiversity, ecology disruption, climate change, urbanization, and the changing impacts of expanding agricultural systems.

In Lerner & Berg's (2017) assessment, the core values of One Health involve safeguarding the health—and especially the individual health—of vertebrate species. There have been calls to expand the One Health concept. Keune *et al.* (2017) identify ecology, agriculture, and especially the social sciences as missing links for a coherent One Health approach. From their perspective, "[s]ocial and cultural drivers of health are often neglected and considered only in case of programme failure" (Kene *et al.* 2017, pp. 7–8).

1.3.3 Planetary health

> Global health is not merely a constellation of diseases, a collection of national health systems, or even a set of values. It is a way of looking at our world. It seeks to observe, document, monitor, interpret, and eliminate the harms that accrue from national and transnational forces inimical to health—political, commercial, military, financial, diplomatic, legal, intersectional, and cultural. Global health is about power and poverty, violence and exploitation, oppression and silence, and collusion and exclusion. (Horton 2014)

Planetary health, the newest of the three concepts under consideration, begins with the understanding that human health and the health of the planet are intimately connected. One might say, this is the "one health" of this approach. The origins of this line of medical thinking lie in the conclusion drawn by the Commission on Managing the Health Effects of Climate Change, organized by *The Lancet*, a British medical journal, and academics from many disciplines across University College London that climate change is the biggest threat to human health in the 21st century (UCL News 2009). The Commission, made up of faculty from the fields of health, anthropology, geography, engineering, economics, law, and philosophy, focused on six key areas: patterns of disease and mortality, food security, water and sanitation, shelter and human settlements, extreme events, and population migration. According to Anthony Costello, a world leader on issues affecting the health of children and the lead author of the Commission's report: "The big message of this report is that climate change is a health issue affecting billions of people, not just an environmental issue about polar bears and deforestation . . . The impacts will be felt not just in the U.K., but all around the world—and not just in some distant future but in our lifetimes and those of our children" (UCL News 2009). The Commission examined the global health implications of the Intergovernmental Panel on Climate Change (IPCC) projections and considered a myriad of pathways through which climate change exerts its effects on health.

Health clearly has entered a new epoch when environmental factors, under ever mounting adverse human influence, have outpaced other threats to human well-being. This recognition sparked the planetary health initiative, spearheaded by *The Lancet* and the Rockefeller Foundation, which is guided by acceptance of the fundamental need for collective achievement of a world "that nourishes and sustains the diversity of life with which we coexist and on which we depend" (Horton 2014). From the perspective of planetary health:

> By unsustainably exploiting nature's resources, human civilisation has flourished but now risks substantial health effects from the degradation of nature's life support systems in the future. Health effects from changes to the environment including climatic change, ocean acidification, land degradation, water scarcity, overexploitation of fisheries, and biodiversity loss pose serious challenges to the global health gains of the past several decades and are likely to become increasingly dominant during the second half of this century and beyond. These striking trends are driven by highly inequitable, inefficient, and unsustainable patterns of resource consumption and technological development, together with population growth. (Rockefeller Foundation 2020)

The emergence of planetary health has been described as constituting a fifth stage in the historic evolution of the modern population health paradigm (Singer 2014). This mode of thinking about health as more than an individual-level condition—which historically was the prevailing orientation of biomedicine—has its roots in local public health efforts, which began especially in Europe during the 19th century, transitioned to tropical medicine as a consequence of the European colonial encounter with the infectious diseases of tropical colonial environments, blossomed during the post-World War II period into international health with the expansion of multinational health initiatives like the World Health Organization (WHO), and emerged during the 1990s as global health, a reflection of the consolidation of a global neoliberal economy and global communication systems, combined with a recognition that risks to health transcend borders and require multilateral responses. The shift to a planetary health understanding as a further advance in population health thinking was motivated by the growing awareness that not only are human communities worldwide now multiply linked together by flows of commodities, ideas, people, and health-related influences from vectors to medicines, but that the health and well-being of human communities are increasing linked to the environment and to other species. As stated in the planetary health manifesto: "Our patterns of overconsumption are unsustainable and will ultimately cause the collapse of our civilisation. The harms we continue to inflict on our planetary systems are a threat to our very existence as a species" (Horton *et al.* 2014, p. 847). A planetary health perspective, in other words, reveals the fundamental ways in which human beings are not just agents of environmental change, but also vulnerable objects of that change.

Pivotal to the planetary health movement is a vocal commitment to equity in a world of unjust societies and unequal relations among societies. As articulated in the planetary health manifesto: "The discipline of public health is critical to this vision because of its values of social justice and fairness for all, and its focus on the collective actions of interdependent and empowered peoples and their communities" (Horton *et al.* 2014, p. 847). The evidence on anthropogenic climate change demonstrates the consequences of inequity. Translated into stark moral and palpably human terms, anthropogenic climate change can be assessed as a form of "social murder," a term introduced by Frederick Engels in 1845 to characterize the impact of the corporate-owning class on the health and survival of poor and working people. Chernomas & Hudson (2009) redeploy the term to label contemporary corporate policies designed to maximize the accumulation of private profit while socializing associated risks and costs.

To advance the perspective, *The Lancet* initiated a new journal called *The Lancet Planetary Health* in 2017. Exemplifying its content, in its second year it published a study of the adverse health effects of air pollution on diabetes in China (Yang *et al.* 2018). This study's cohort included over 15 000 people aged 18–74 years from three cities in Liaoning province, in the northeastern sector of the country. Diabetes was defined according to American Diabetes Association (ADA) recommendations. Exposure to air pollutants (sulfur dioxide, nitrogen dioxide, and ozone) was measured by monitoring stations. The researchers found that all of the pollutants studied were significantly associated with increased diabetes prevalence. They were also associated with higher concentrations of fasting glucose. Stratified analyses indicated greater effects on those individuals who were younger (<50 years) or overweight or obese. The researchers concluded that long-term exposure to air pollution is significantly associated with increased risk of diabetes, especially in some subgroups. Other articles in the journal have documented the health benefits of other kinds of environmental exposure. Crouse *et al.* (2017), for example, reported the findings of a study in

30 cities in Canada that showed that increased amounts of residential greenness (based on a vegetation index) were associated with reduced risks of dying from several common causes of death (e.g., cardiovascular disease, diabetes, ischemic heart disease) among Canadian urbanites. While affirming the effects of social inequalities and personal socioeconomic status on health, in terms of both exposures to greenness and mortality risks, the study found that greener cities were healthier cities.

The three somewhat different approaches to health and the environment described in this section are all products of the increasing risk of anthropogenic environmental and climatic changes on species health on the one hand, and the growing awareness of this fact and of living in the Anthropocene on the other. The objective in introducing these concepts, their histories, and their core values was not to choose the best or most useful among them but to illuminate the ways our comprehension of our role in the environment and of the fundamental role of the environment in health have been changing in the contemporary world. Collectively, the emergence of these approaches affirms the importance of accessing not simply the health–environment nexus but specifically within this initiative the role of the growing number of interacting ecocrises in health.

1.4 Global warming or climate change?

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The climate is changing and Earth is warming. In fact, however, neither term fully captures the entangled set of significant atmospheric and environmental changes that stem from the release of greenhouse gases (e.g., ocean acidification) or other changes such as the effects of black carbon pollution on solar reflection. Warming of the planet certainly is the force driving a complex array of transformations taking place around us, but the everyday understanding of warming does not adequately describe the erratic nature of what is occurring, nor does it quite encompass the sudden and ever more frequent occurrence of extreme weather events, including extreme cold spells. The world is not just increasing in temperature—weather is becoming less stable, less predictable, weirder, and more deadly in various ways (Climate Central 2012). And while it is accurate to say that the climate is changing, this has been the case for the whole history of Earth (Brooke 2014). What is critical is the clear pattern of that change (an uptrend in average annual temperature) over the last 150 years since the beginning of the Industrial Revolution, and especially the last 50, and our own role in pushing that change. Moreover, climate-related changes are not occurring in isolation from other dramatic planetary changes resulting from human activity. In short, it is not all about warming or climate. Both terms only cover part of the contemporary problem of environmental/climate turmoil (Baer & Singer 2018).

The first recognition of the relationship between carbon dioxide in the atmosphere and atmospheric temperature dates to the work of Swedish scientist Svante Arrhenius (winner of the Nobel Prize in Chemistry), who in 1896 linked what would come to be called the greenhouse effect to the use of fossil fuels. Of historical note, early on Arrhenius “strongly advocated remedies to stop the indiscriminate waste of fossil energy and chemical resources, oil, gas and coal" (Arrhenius *et al.* 2008). By the 1970s, the connections among fossil fuel burning, CO_2 emission, and climate were becoming clear to scientists, and the terms "global warming" and "climate change" were becoming increasingly frequent in the scientific literature. Both terms began to filter into the mass media during the 1990s, and then into everyday discourse. In the contemporary scientific literature, "climate change" is generally used unless the focus is on the pattern of increase in Earth's surface temperature. Those who deny or downplay the changes that are occurring on Earth tend to prefer "global warming," however, as it allows them to argue during extreme cold events that surely the planet cannot be warming, just step outside your front door—or, in the case of Senator James Inhofe of Oklahoma, author of *The Greatest Hoax* (2012), bring a snowball on to the floor of the U.S. Senate (Bump 2015). In Inhofe's view, it is a "scientific scandal . . . to make it sound like man is responsible for all these things [i.e., climate change]" (MSNBC 2015).

In this book, both terms are used, but it is with the understanding that there is a need for a broad picture of the patterns of change, the components of change, the causes of change, the consequences of change, and, most especially, the interactions at the heart of the vast changes occurring around and because of us.

1.5 Depth of the human footprint

As Lewis (2006, p. 195) states:

> Humans moved more rock, sediment and soil than all natural processes combined, by an order of magnitude . . . Between a third and half of all land was appropriated for human use . . . By the [21st] century's end three to six times as much water was held in reservoirs as in natural rivers . . . Two predictions stand out: changes in land-use will cause the sixth mass extinction in evolutionary history . . . while atmospheric CO_2 concentrations will reach their highest levels for 60 million years.

The human footprint on Earth is already very deep, and each year that passes without significant reversal of course will make our presence an ever-greater disrupter of Earth ecological, climatic, atmospheric, hydraulic, and other systems. As Vitousek *et al.* (1997, p. 494) observe, "[u]ntil recently, the term 'human-dominated ecosystems' would have elicited images of agricultural fields, pastures, or urban landscapes; now it applies with greater or lesser force to all of Earth." Quite literally no location on the planet is totally untouched by our species. One place you would not expect to find a human footprint is at the bottom of the ocean. While our knowledge about the complexities and lifeforms of the deep ocean (below 10 000 feet) remains limited, of one thing we are certain: human activities are increasingly affecting deep-sea habitats. This is the conclusion of an international study conducted by over 20 deep-sea scientific experts who participated in the Census of Marine Life project SYNDEEP (Towards a First Global Synthesis of Biodiversity, Biogeography, and Ecosystem Function in the Deep Sea). They grouped the impacts they detected into three types: waste and litter dumping, resource exploitation, and evidence of the effects of climate change (Ramirez-Llodra *et al.* 2011).

The routine dumping of many types of waste from ocean-going ships was legally banned by the London Convention of 1972. An even stricter convention went into force in 2006. Before these bans, a wide array of human litter regularly was dumped from ships, large and small, in ocean transit. New litter continues to accumulate as a result of illegal disposal, lost or discarded fishing gear, and being washed from the coast and through river discharges. It is estimated that 6.4 million tons of litter is deposited into the oceans each year, part of which sinks to the deep ocean bottom (Jeftic *et al*. 2009). In places like the Mediterranean and North East Atlantic, the most common litter types found on the deep ocean floor are soft plastic (e.g., bags), hard plastic (e.g., bottles, containers), and glass and metal (e.g., cans) (Galil *et al*. 1995; Galgani *et al*. 2000).

Expanding technological capabilities have facilitated the exploitation of biological, mineral, and petrochemical resources from the oceans. Trawl fishing can reduce the biodiversity and biomass of deep-water invertebrates, such as cold-water corals, with long-term effects persisting even after fishing has ended. Deep ocean mining is also of increasing concern. Three forms of mineral resources have been identified for commercial exploitation: manganese nodule mining on deep ocean plains, cobalt-rich crusts on seamounts, and polymetallic sulfide deposits at sites of hydrothermal vents. An additional threat is ultra-deep-water oil and gas drilling, the potential adverse consequences of which were exposed by the 2010 *Deepwater Horizon* catastrophe in the Gulf of Mexico (Michel *et al*. 2013).

Rising levels of anthropogenic (human-generated) greenhouse gases have made parts of the North Atlantic and hot spots in the Northern Atlantic, Indian, and Pacific Oceans so acidic that the chalky white form of calcium carbonate known as calcite that makes up the seafloor is dissolving. This dissolution is "altering the geological record of the deep sea" (Sulpis *et al*. 2018, p. 11 700). Moreover, in the European sector of the North East Atlantic, the extent of the effects of bottom trawling by fishing boats is significant—an order of magnitude greater than the total impact of all other activities (e.g., waste disposal, telecommunication cables) (Benn *et al*. 2010).

As these examples suggest, and as illustrated in Fig. 1.2, not only are human impacts varied and widespread, but they reveal "how, even on the grandest scale, most aspects of the structure and functioning of Earth's ecosystems cannot be understood without accounting for the strong, often dominant influence of humanity" (Vitousek *et al*. 1997, p. 494).

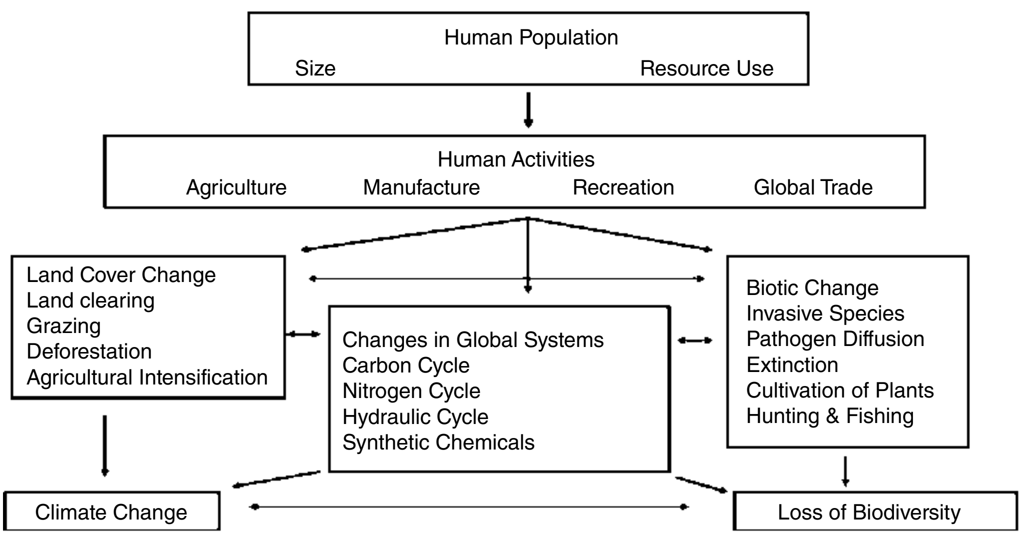

Fig. 1.2 Model of direct and indirect human effects on earth systems. *Source:* Modified from Vitousek, P., Mooney, H., Lubchenco, J., & Melillo, J. (1997). Human domination of the Earth's ecosystems. *Science* 277: 494–499.

1.6 Introducing ecocrises interactions and health

Environmentally speaking, what is a crisis? Further, how do we know we are in a crisis, and when is it time to sound the alarm? What kinds of environmental thresholds must be crossed to recognize we have passed from a noncrisis period into a time of such turbulence and threat that it is aptly called a crisis? Historically, in medicine, dating to the 15th century, "crisis" has referred to a "decisive point in the progress of a disease," the point at which change must come, for better or worse—toward a return to wellness or toward death (though a new up-and-down or slow-progression "steady state" of chronic illness also occurs). Beyond medicine, the word "crisis" has come to mean an unstable or crucial time or state of affairs in which the possibility of a highly undesirable outcome is possible. With regard to the environment, as Moore (2016) comments, "[t]he conditions of life on planet Earth are changing, rapidly and fundamentally. Awareness of this difficult situation has been building for some time. But the reality of a crisis—understood as a fundamental turning point in the life of a system, any system—is often difficult to understand, interpret, and act upon."

Part of this difficulty is a result of the complexity of environmental systems and the fact that the environment is constantly changing. Cycles of disruption and recovery are the usual state of environmental affairs (Paine *et al.* 1998). Another part occurs because we never know everything at once—new and perhaps initially controversial scientific findings are constantly coming to light. Additionally, humans are frequently unready to recognize both the full power of nature and our own capacity to adversely influence it. Finally, there is the intentional denial or even falsification of environmental crises because of the short-term benefits and profits of maintaining business-as-usual practices. As a result, "reasonable treatment of environmental concerns often falls prey to the political agendas of those who have a vested interest in an unsustainable, resource-extractive approach to economic development" (Hudson 2001).

While cycles of change are the "normal" state in nature, "rapidly compounded perturbations have more serious implications for long-term alterations of community state, occasionally or even often generating a different assemblage of species" (Paine *et al.* 1998, p. 536) because the "effect of compounded perturbations is multiplicative, not additive" (Paine *et al.* 1998, p. 537). In this book, I refer to compounded environmental disturbances as "ecocrises interactions." Ecocrises interaction—the synergistic interface of two or more environmental events or pollutants that multiply resultant harmful health effects beyond their additive impact—puts both humans and other species at catastrophic risk. This book is designed to increase understanding of the link between health and the environment in times of the ever-more-pervasive anthropogenic impacts on natural assemblages. Its specific concern is that the diverse ecological calamities we face are encountered not as standalone threats, which has been the conventional perspective to date, but as adversely interacting events and processes with magnified hazardous effects. The sixth Global Environment Outlook issued by the U.N. Environment Program (2019), a continent-by-continent 740-page assessment written by 250 scientists and experts from more than 70 countries, concludes that because of the perilous combination of climate change, pollution, and the growing human population, the damage already done to the planet is so severe that people's health will be increasingly threatened unless rapid action is taken. In the view of the report's authors, without drastically scaled-up implementation of environmental protections, cities and regions in Asia, the Middle East, and Africa may see millions of premature deaths by mid-21st century. This discussion raises essential questions about the extinction of populations, species, and ways of life.

Ecocrises interactions occur when the various pollutants and environmental disruptions generated especially today by fossil capitalism are not only co-present in the same environmental context but combine to uni- or multidirectionally magnify their impact on human health and society, and on the health and survival of other species as well. Critical to explicating ecocrises interaction is the development of an understanding of the pathways and mechanisms through which two or more ecocrises deleteriously intermingle in the air, on land, and in bodies of fresh or salt water. For example, respiratory health around the world has been growing worse in part because of the combined effects of heavier pollen loads caused by global warming and increased air pollution linked to prevailing fossil fuel use at a time when more intense wildfires are being triggered by climate change (Fig. 1.3). These kinds of complex sets of interactions between global warming and anthropogenic (human-caused) impairments to clean air can be seen in various planetary ecozones and involve a diverse set of environmental corridors of interaction. Most importantly, they increase human vulnerability to a range of debilitating and deadly diseases.

Similarly, there is a perilous interaction between meat production, nutrient pollution, and climate change. In the Gulf of Mexico off the coast of Louisiana, there is an 8000-square-mile area in which marine life is suffocating due to nutrient pollution. The nutrients, which feed a dead zone of algae bloom—a process known as eutrophication—flow down the Mississippi River in the form of excess nitrogen and phosphorus in fertilizers used on industrial corn farms. As meat production increases, the demand for corn rises, leading to mounting nutrient pollution. In 2017, the largest dead zone on record occurred in the Gulf region. More meat production also increases the release of methane, a powerful greenhouse gas (Weiss 2013).

Fig. 1.3 Smokestack pollution from a power plant. *Source:* bhumann34/Pixabay.

In this book, the familiar term "pollution" is used specifically to refer to "unwanted, often dangerous, material that is introduced into Earth's environments as the result of human activity, that threatens human health, and that harms ecosystems" (Landrigan *et al.* 2018). Diseases caused by pollution resulted in an estimated 9 million premature deaths in 2015, which is 6 percent of the total number of deaths that occurred worldwide. The significance of this rate of mortality is seen in the fact that it is three times higher than that of AIDS, tuberculosis, and malaria combined, and 15 times higher than that of all wars and other forms of physical violence. In some countries, primarily in South East Asia and the western Pacific, pollution-related disease is responsible for 25 percent of all deaths (Landrigan *et al.* 2018). Further, pollution is responsible for more deaths globally per year than a high-sodium diet, obesity, alcohol consumption, vehicular accidents, or child and maternal malnutrition.

Of special note are the populations globally most adversely impacted by pollution. Over 90 percent of pollution-related deaths are in low- and middle-income countries. In all nations, pollution-related disease is most prevalent among ethnic minorities, the poor, and the socially marginalized. In particular, children are at highest risk of diseases linked to pollution. In utero and in early infancy—periods of high vulnerability—exposures to even very low doses of pollutants can lead to disease, disability, and death, with impacts that occur throughout an individual's lifespan. What's more, "ambient air pollution, chemical pollution, and soil pollution—the forms of pollution produced by industry, mining, electricity generation, mechanised agriculture, and petroleum-powered vehicles—are all on the rise, with the most marked increases in rapidly developing and industrialising low-income and middle-income countries" (Landrigan *et al.* 2018). Cities, especially the most rapidly growing cities in developing nations, are severely affected by the production and health risks of pollution. This constitutes one of the great global existential challenges of the Anthropocene.

These facts notwithstanding, pollution remains an understudied and often ignored cause of human morbidity and mortality. Even though 70 percent of pollution-caused diseases fall into the category of noncommunicable diseases—those such as cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes not transmitted from human to human or animal to human—there is rare mention of interventions to address them in the WHO's Global Action Plan for the Prevention and Control of Non-Communicable Diseases 2013–2020, and pollution is often downplayed in both global health assessments (WHO 2013) and evaluations of the full social costs of fossil fuel production (NAS 2010).

To the degree that environmental pollution has been considered as a driving force in global health, it has been treated as an inevitability, an inescapable blemish of socioeconomic development. This element of conventional wisdom is referred to as the "environmental Kuznets hypothesis" (Van Alstine & Neumayer 2010), a label stemming from the graphic known as the Kuznets curve, developed by Nobel Memorial Prize-winning economist and statistician Simon Kuznets (1955). Specifically, the curve, in the form of an inverted U-shape, reflects Kuznets' hypothesis that, as a society develops from a primarily agrarian to an industrialized economy, market forces first increase and then later decrease its overall degree of economic inequality. This hypothesis has been applied to environmental economics, where it is postulated that pollution and environmental degradation will unavoidably increase during the early stages of industrial economic development, and that pollution will continue to rise until the threshold of per capita income is achieved, after which the level of pollution will decrease despite continued economic growth. If the environmental Kuznets hypothesis is accurate, rather than being a growing threat to the environment, economic growth should be seen as an anthropogenic means of eventual environmental improvement. As Stern (2004, p. 1419) points out, “[t]he possibility of achieving sustainability without a significant deviation from business as usual was an obviously enticing prospect for many—letting humankind ‘have our cake and eat it’.”

Despite its comfortable appeal, the environmental Kuznets hypothesis is not confirmed by environmental health research, and the data used to support it have been criticized as being econometrically weak (Perman & Stern 2003). Part of the problem is that a reduction in pollution levels in wealthy countries often results from the outsourcing of polluting production to cheaper-labor developing ones (Carmin & Agyeman 2011). Indeed, enhanced environmental regulation designed to limit pollution in wealthier countries may contribute to corporate outsourcing to developing countries as a cost-cutting/profit-enhancing strategy (Lucas *et al.* 1992; Cole & Elliott 2003). The Lancet Commission on Pollution and Health concluded that “pollution is not the unavoidable consequence of economic development, and that it is much more important to formulate sound laws, policies, and regulations to control pollution than to wait for an economy to reach a magical tipping point that will solve the problems of environmental degradation and pollution-related disease” (Landrigan *et al.* 2018, p. 467).

1.7 Thresholds in the environment

Like pollution, other forms of anthropogenic environment disruption are not inevitable, unavoidable, or too costly to avoid. The full costs of pollution and disruption are manifest in ecocrises interactions. Critical to the development of many ecocrises interactions is the crossing of the thresholds of planetary boundaries. Environmental conditions are defined as intrinsic features at local, regional, or global scales that constitute positions along one or more control variables, such as temperature and the albedo (solar reflection) feedback pathway involving floating sea ice. Icebergs in the ocean, being lighter in color than the surrounding water, reflect more solar radiation. Consequently, the significant rate at which sea ice is melting—a phenomenon driven by planetary warming—represents a negative feedback loop that feeds further warming. Once the volume of sea ice threshold is passed, environmental degradation will continue even without further human input, reducing the possibility for mitigation. Staying within such thresholds, as a result, is critical for human well-being and the well-being of the other lifeforms we depend upon and with which we share this planet.

On July 28, 2000, the U.N. Economic and Social Council established the Permanent Forum on Indigenous Issues to discuss and advise on issues facing indigenous peoples of the world related to social development, culture, environment, education, health, and human rights. Nine years later, on May 27, 2009, during the eighth meeting of the Permanent Forum in New York, one of the speakers was Nicolas Lucas Ticum, a priest and researcher from Guatemala of Maya ancestry. In seeking to reframe the human/environment relationship, Ticum stated: “All of humanity must work together to re-establish harmony and unity with the natural environment . . . The Earth does not belong to human beings. Human beings belong to the Earth” (Economic and Social Council 2009). The alternative is ever more devastating anthropogenic ecocrises.

1.8 Sustainability of human life on Earth

Ultimately, ecocrises threaten the sustainability of human life on Earth. Already, research suggests that Earth may be in the midst of its sixth mass extinction of species, in no small part because of the human reshaping of the environment. At this point in our history, the idea of pristine environments untouched by our presence is an illusion. We have left an indelible impression everywhere on the planet; there are no hidden natural sanctuaries that are unsullied by the effects of human society and activity. Archeological, paleoecological, and genetic research suggests that:

> As our planet experiences its sixth "mass extinction event" . . . the effect of anthropogenic landscape modification, habitat fragmentation, overexploitation, and species invasions could not be more apparent . . . These transformations are linked largely to the industrial economies, burgeoning populations, and dense transport networks of contemporary human societies. (Boivan *et al.* 2016)

In fact, Boivan *et al.* (2016) stress, the human-mediated alteration of Earth long predates the rise of industrial economies. Relative to our impact on other species, they identify four pivotal phases in the loss of pristinity: 1) the Late Pleistocene near-global dispersal of our ancestors; 2) the emergence and spread of agriculture and livestock domestication beginning in the Early Holocene; 3) the human colonization of the world's islands; and 4) the premodern expansion of urbanization and trade beginning 5000 years ago during the Bronze Age. While socioeconomic developments since the Bronze Age have dramatically accelerated the magnitude and range of the human impact, all of these prior moments in the making of a human-dominated Earth are significant.

A significant biological effect of the Late Pleistocene expansion of our species, for example, was felt by larger animals or megafauna, those weighing over 100 pounds. While there is debate concerning the extent of the human role in the extinction of about 90 megafauna genera in the period between 50 000 and 10 000 years ago (Koch & Barnosly 2006), new analytic approaches affirm at least some direct human role through hunting in the disappearance of animals like the giant ground sloth, woolly mammoth, saber-tooth cat, a giant 6-foot-long beaver, and the 3-ton Diprotodon, the largest marsupial that ever lived. This research suggests an inverse relationship between the severity of the extinction and the duration of hominin–megafauna contact.

If hunting only partly accounts for the megafauna extinctions, what else was involved? According to Koch & Barnosky (2006, p. 239):

> Taken as a whole, recent studies suggest that humans precipitated the extinction in many parts of the globe through combined direct (hunting) and perhaps indirect (competition [for food or habitat], habitat alteration and fragmentation) impacts, but that . . . environmental change influenced the timing, geography, and perhaps magnitude of extinction. Put another way, absent the various impacts of Homo sapiens . . . it is highly unlikely global ecosystems would have experienced a mass extinction of large, slow-breeding animals in the late Quaternary. But, absent concurrent rapid climatic change evident in many parts of the globe, some species may have persisted longer.

In other words, it is likely that it was the interaction of human hunting and climate change that eliminated or fragmented the environmental conditions necessary to maintain the megafauna, leading to their extinction.

Without question, the vast majority (99 percent) of species that have ever lived are now extinct (Novacek 2001). Human presence on the planet is not guaranteed; indeed, like all species, and despite our comparatively big brains and powerful technologies, we are dependent upon our fragile relationship with the environment. Failure to fully appreciate this simple truth and move with determination to more sustainable socioeconomic systems will place our near future at grave risk. This idea touches on a broader question about lifeforms elsewhere in our galaxy: namely, why, with all of our searching (e.g., NASA probes, monitoring of electromagnetic radiation, the work of the SETI Institute), have we not encountered signs of alien civilizations? One explanation, known as the Great Filter theory, is that extraterrestrial civilizations may emerge, develop, and destroy their environments, and hence themselves, too quickly for us to find them, or vice versa. In other words, the Milky Way may be sprinkled with extinct alien civilizations that were wiped out by self-induced environmental destruction.

1.9 How did things get this bad?

Promoting the vital need to develop a deeper awareness of our relationship with the environment and assisting students to make informed decisions for action are the ultimate objectives of this book. While there is mounting concern over the ways anthropogenic environmental change is putting human health at risk, the specific rationale for this volume is the inadequate consideration given to the special risk of ecocrises interaction in the existing environmental literature.

The following chapters trace the history of that risk, beginning with the sweeping environmental and social changes launched by the Industrial Revolution. These changes were so immense that many environmental scientists see them as constituting a new geological epoch, one that highlights the dominant role now played by human activity in shaping the very geology and ecology of Earth. Referred to as the Anthropocene, it was triggered in the late eighteenth century with the invention of the steam engine, followed in relatively short order by the production and use of fossil fuels, which contributed to an intense rise in the amount of carbon dioxide and other pollutants in the atmosphere and the oceans. Industrial production, in turn, contributed to an array of other environmental crises, including fuel spills, waste dumping and leakages (Fig. 1.4), deforestation, the spread of infectious diseases, loss of biodiversity, and the devastation of marine life.

But how did all of this come about? What steps along the way pushed our arrival at this troublesome destination? Having come to this point, how can we avoid catastrophe? To adequately address these urgent questions, it is necessary to tease apart and rigorously examine a linked set of environmental, biological, social, political, and economic issues in historic context. This is the approach taken in explicating the health perils of ecocrises interaction in this volume.

Fig. 1.4 Toxic waste barrel. *Source:* EliasSch/Pixabay.

1.10 Age of the Anthropocene

The term "Anthropocene" unites the word *anthropo*, ancient Greek for "humankind", with the root *-cene*, the standard suffix to denote an epoch in geologic time. Another Greek term of relevance is *kairos*, which signifies a "moment of transition." As Moore (2016) remarks, "the Anthropocene concept [is] the most influential concept in environmental studies over the past decade." But the Anthropocene is more than a concept: it also increasingly constitutes a major influence on the lived experience of Earthlings of all species (Kelly & McDonald 2018), including playing a role in the ending of such experience through species extinction.

While "global-scale human influence on the environment has been recognized since the 1800s, the term Anthropocene . . . has only recently [during the 21st century] become widely, but informally, used in the global change research community" (Steffen *et al.* 2011). It was first introduced by the Nobel Prize-winning atmospheric chemist Paul Crutzen and the biologist Eugene Stoermer (Crutzen & Stoermer 2000; Crutzen 2002). A primary driver of its acceptance as a meaningful and needed concept is the multiple Earth-changing effects of climate change. But "climate change is only the tip of the iceberg" (Steffen *et al.* 2011). Human actions have also changed the life-sustaining cycles of key elements such as nitrogen, phosphorus, and sulfur. The nitrogen cycle has been altered through the production and use of fertilizer, deforestation, and the burning of fossil fuels. The massive amounts of nitrogen that humans produce—they at their highest level today for 2.5 billion years—are reshaping the world's ecosystems (Lewis & Maslin 2015). The phosphorous cycle has been changed by fertilizer use and the rearing of livestock (especially hogs), as well as by the use of detergents containing sodium tripolyphoshate. The sulfur cycle has been changed by the burning of fossil fuels, which increases the amount of sulfur in both the atmosphere and the oceans. Moreover, human activities have altered the terrestrial water cycle via dam building, river course modification, and the elimination of riverside wetlands, as well as through changes in land cover that modify the flow of water vapor from the land to the atmosphere. Another human impact is an acceleration of species extinctions to such a degree that it has raised questions about whether we are on the threshold of a mass extermination on par with the one that nearly eliminated the dinosaurs (nearly, and not totally, because the dinosaur ancestors of modern birds survived). In short, human activities are so widespread and so profound in the ways they are changing Earth that they have begun to threaten the very life-support systems upon which we and all other species depend (Steffen *et al.* 2005; Waters *et al.* 2016). The concept of the Anthropocene was developed to call attention to this human-driven quantitative shift in the geochronology of the planet. As Meyer (2018) comments, "[i]t is a stirring idea: that humans are not a momentary blip in the long procession of Earth's history, but a new and fundamental driver of planetary change, equal in stature to volcanoes and tectonic plates." In terms of the actual effects we are having on the planet, it also is a disturbing one.

How do earth scientists determine geochronology? The process involves ongoing data collection, international expert discussion, and committee consensus. Critical components occur within the International Union of Geological Sciences (IUGS), an international nongovernmental organization concerned with promoting international cooperation in the scientific field of geology. The Union manages six international commissions, including the International Commission on Stratigraphy (ICS), which is responsible for setting the stages and boundary markers of the geochronology of Earth history and for naming geological eras. In the language of the ICS, a historical epoch is defined as a subdivision of the geologic timescale that is longer than an age but shorter than a period. By way of analogy, in measuring the dimension of length, a foot is longer than an inch but shorter than a yard.

The establishment of an epochal change the geologic timescale generally is based on the identification of significant changes in the rock layers of Earth's stratigraphy. The conceptualization of the Anthropocene hinges on the idea that the geological epoch known as the Holocene (Greek for "entirely recent"), which began approximately 11 650 calendar years before the present, has ended, because "humankind has become a global geological force in its own right" (Steffen *et al.* 2005). The ICS has not as yet accepted the Anthropocene as a formally defined geological unit within the Geological Time Scale, though its Anthropocene working group has concluded that it is a plausible new layer in Earth geochronology. Establishing the Anthropocene as an accepted geologic unit of time requires that the ICS either: 1) identify a specific location in rock, sediment, or glacier ice that marks the transition to a new epoch (e.g., the Precambrian–Cambrian boundary marker has been placed at Fortune Head, Newfoundland, where there is clear fossil evidence of a life-form transition); or 2) agree on a date for this transition, based on a survey of the available stratigraphic evidence. Various dates, such as the beginning of the Industrial Revolution, with its ever-accelerating level of fossil fuel use and abundant greenhouse gas emissions (Crutzen 2002), or the period between 1945 and 1988, when nuclear weapons were tested with such frequency that their worldwide fallout left an identifiable mark in the chemostratigraphic record (Zalasiewicz *et al.* 2015), have been proposed.

One of the most curious features in the evidence for the Anthropocene involves the common domestic broiler chicken, the source of everything from buffalo wings to pre-sliced deli meat chicken sandwiches. While thus far no individual taxa have been suggested as the distinct marker of the Anthropocene, Bennett *et al.* (2018) propose *Gallus gallus domesticus* as the best choice. Driving the rise and global spread of this heavily engineered bird are human population growth, commercially impacted human consumption trends, and drops in the populations of wild animals. It is now by far the most numerous bird species around, with an estimated population of almost 23 billion individuals. This is an order of magnitude larger than stocks of the most abundant existing wild bird species, such as house sparrows, common pigeons, and red-billed quelea, as well as the extinct passenger pigeon, and is likely the largest population size ever achieved by a single species in the 160 million-year history of birds. Because of selective industrial breeding, the broiler chicken is distinctive in overall size, weight, bone size, genetic make-up, and appearance from its wild progenitor, the red jungle fowl. In 2016, over 65 billion broilers were consumed globally. Production and consumption data mean "that the potential rate of carcass accumulation of chickens is unprecedented in the natural world" (Bennett *et al.* 2018). Much of this global accumulation finds its way into landfill sites by way of domestic garbage removal systems. Organic materials like chicken bones are often well preserved in landfills because their anaerobic conditions tend to mummify organic deposits (Rathje & Murphy 2001). Consequently, the broiler chicken produces a particularly widely distributed and distinctive biostratigraphic signal in the sedimentary record, allowing it to serve as a key fossil index taxon of the Anthropocene.

While the ICS has not recognized the Anthropocene (Finney & Edwards 2016; Gibbard 2018), many scientists have. The concept has gained de facto authority even if it is not officially sanctioned, as reflected in the launching of multiple new academic journals, such as *The Anthropocene*, *The Anthropocene Review*, *Elementa: Science of the Anthropocene*, and *Anthropocene Coasts,* the organization of professional conferences sponsored by universities and scholarly groups, and the publication of an ever-growing international and multidisciplinary scientific literature on the topic (e.g., Zalasiewicz *et al.* 2017; Hughes *et al.* 2018; Steffen *et al.* 2018; Tucker *et al.* 2018).

Ultimately, whether or not the ICS decides that the Anthropocene meets the criteria for the establishment of an epoch in Earth history, it does not change the reality of the "perfect storm" of interacting human impacts on the planet, its global processes and ecosystems, and its lifeforms. For those at gravest risk from ecocrises interaction, whether their loss of access to adequate food, breathable air, survivable temperatures, or dry land occurs during a particular scientifically defined segment of geological time on ICS' International Chronostratigraphic Chart is of negligible importance. What does matter is the utility of Anthropocene recognition in spurring useful new research and practical political and social action to avert a slide into hothouse Earth conditions.

1.11 The hottest year on record

Most significant among the ecological crises Earthlings now face is global warming. Earth's temperature has risen by 1.4 °F over the last 100 years, and is predicted to rise to 11.5 °F in the next few decades. Despite various disagreements about regional and temporal variations in temperature, the vast majority of climate scientists recognize both that the planet is getting hotter and that fossil fuel technology is playing a fundamental role in this risky process. Today, the carbon dioxide level in the atmosphere is the greatest it has been in 400 000 years, having jumped from about 280 parts per million (ppm) before the Industrial Revolution to about 410 ppm today. In the final report of The Lancet Commission on Managing the Health Effects of Climate Change (Costello *et al.* 2009), the warming of Earth was labeled "the biggest global health threat of the 21st century," a conclusion affirmed by the Commission in 2015 (Watts *et al.* 2015). The WHO (2018) estimates there will be approximately 250 000 additional deaths due to climate change per year between 2030 and 2050, due to malnutrition, malaria, diarrhea, and heat stress. People living in coastal regions, megacities, island communities, and mountainous and polar regions are particularly vulnerable, especially children and elderly people. Notably, disproportionate morbidity and mortality rises due to climate change will affect the poorest and least powerful global citizens (Singer 2018).

The hottest year on record was 2016, with 2014, 2015, 2017, and 2018 representing the next four hottest since the measurement of annual records began 139 years ago. As Climate Central (2018) points out "[w]ith the five warmest years occurring during the past five years—and the 20 warmest occurring over the past 22—a consistent warming trend couldn't be clearer." The trend continues. June of 2019 was the warmest June ever recorded. For climate scientists like Sarah Green, an environmental chemist at Michigan Technological University, "[a]t this point, the inexorable increase in global temperatures is entirely predictable" (quoted in Kaufman 2019).

1.12 Organization of this book

The following chapters lay out an environmental health approach to ecocrises interaction that is informed by anthropology, ecology, climate science, history, and political economy. This begins in Chapter 2 with a dive into the intricacies of planetary ecosystems and the rise of the field of ecological study. Under consideration is the nature of nature, specifically the interrelationships among species in an environmental context, as well as biodiversity and environmental regional and planet-wide structures (e.g., air currents, hydraulics). Chapter 3 examines the social, economic, and technological bases of the contemporary environmental crisis, including the role played by the ongoing development of capitalism and the growth of a class of wealthy polluting elites, who represent the primary drivers of catastrophic environmental pollution. Chapter 4 provides an overview of the environment catastrophe unfolding during the Anthropocene, including the patterns of sweeping change reshaping life on the planet: pollution of the water, the air, and the land; habitat restructuring and ecological simplification; species movement; and species die-offs and extinctions. Chapter 5 offers a specific investigation of the major environmental crises endangering Earth as our planetary home, including the manifold expressions of contemporary environmental disruption. Building on this background, Chapter 6 explores the nature and threat of ecocrises interaction and presents several case studies of the physical, chemical, and biological factors involved in these perilous processes. Chapter 7 addresses the mechanisms and pathways of adverse interaction. Chapter 8 provides a detailed examination of climate change as the primary driver of ecocrises interaction. To explicate our response to climate change and why it progresses despite growing awareness of the risks it is ushering in, Chapter 9 scrutinizes the growth of climate change denial and the offensive against environmental science generally. Chapter 10 looks at how we continue to cross vital thresholds and approach identified planetary boundaries for human life as we know it. Finally, Chapter 11 offers a consideration of how you can participate in seeking to avoid the worst perils we face based on a review of human movements for change and alternative models for a sustainable future.

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