Planetary health: protecting human health on a rapidly changing planet

Samuel S Myers

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Department of Environmental Health, The Harvard T H Chan School of Public Health, Boston, MA, USA (S S Myers MD) **and the Planetary Health Alliance, Harvard University Center for the Environment, Cambridge, MA, USA** (S S Myers)

Correspondence to: Dr Samuel S Myers, Planetary Health Alliance, Harvard University Center for the Environment, Cambridge, MA 02138, USA **smyers@hsph.harvard.edu**

The impact of human activities on our planet's natural systems has been intensifying rapidly in the past several decades, leading to disruption and transformation of most natural systems. These disruptions in the atmosphere, oceans, and across the terrestrial land surface are not only driving species to extinction, they pose serious threats to human health and wellbeing. Characterising and addressing these threats requires a paradigm shift. In a lecture delivered to the Academy of Medical Sciences on Nov 13, 2017, I describe the scale of human impacts on natural systems and the extensive associated health effects across nearly every dimension of human health. I highlight several overarching themes that emerge from planetary health and suggest advances in the way we train, reward, promote, and fund the generation of health scientists who will be tasked with breaking out of their disciplinary silos to address this urgent constellation of health threats. I propose that protecting the health of future generations requires taking better care of Earth's natural systems.

The Anthropocene

On Christmas Eve, 1968, Bill Anders looked out the window of the first manned spacecraft ever to orbit the moon and took a photograph of Earth rising above the moon's horizon. It was the first time a human being had been far enough away to view our home as a separate entity, whole and distinct. And it was breathtaking. Anders would write later: "We came all this way to explore the moon, and the most important thing is that we discovered the Earth".[1]

The photograph that Anders took, and others from subsequent Apollo missions (figure 1), became iconic images of the environmental movement and the first Earth Day in 1970. They came to symbolise Earth's beauty, isolation, fragility, and apparently unique capacity to support life.

The same awesome technological mastery that propelled us to the moon had been fuelling a massive expansion of humanity's global ecological footprint—the sum total of our impact on our planet's natural systems and resources. At about the same time that Bill Anders was bringing back photographs of Earth from space, we were entering a new geological epoch—the Anthropocene—in which humanity had become the dominant force shaping our planet's biophysical conditions.

Since then, we have been living in what Steffen and colleagues[2] have termed The Great Acceleration, where human impacts on Earth's natural systems have been intensifying nearly exponentially. Whether depicting human appropriation of fresh water resources, the proliferation of motorised vehicles, consumption of fertilisers, production of paper or plastics, or primary energy use, graphs showing the scale of human consumption all reveal a similar, nearly exponential pattern in the past several decades (figure 2).

Not surprisingly, related graphs showing human impacts on natural systems (loss of biodiversity, exploitation of fisheries, concentrations of carbon dioxide (CO_2) in the atmosphere, acidification of the oceans, or loss of tropical forests) show similarly steep accelerations since the 1950s and 1960s (figure 3).

Driven by rapid increases in the size of the human population and even steeper growth in per-capita consumption, the scale of human impacts on our planet's natural systems is hard to overstate: to feed ourselves, we annually appropriate about 40% of the ice-free, desert-free terrestrial surface for pastures and croplands,[4] we use about half of the planet's accessible water, largely to irrigate our crops[2], and we exploit 90% of global fisheries at, or beyond, their maximum sustainable limits.[5] In the process, we have cut down 7–11 million km² of the world's forests[6] and dammed more than 60% of its rivers.[7] The quality of air, water, and land is diminishing in many parts of the world because of increasing global pollution.[8] These and other processes are driving species to extinction at roughly 1000 times baseline rates[9] while reducing population sizes of mammals, fishes, birds, reptiles, and amphibians by half in the past 45 years.[10]

Paradoxically, these trends have been accompanied by steady improvements in most measures of human health.[11] Many of the same scientific and technological advances that have magnified our impact on Earth's natural systems have increased our access to plentiful, inexpensive energy, increased per-capita food production despite rapid human population growth, and reduced poverty worldwide. As a result, life expectancy has increased from 47 years in 1950–55 to 69 years in 2005–10, whereas worldwide mortality in children younger than 5 years has decreased from 214 deaths per 1000 livebirths in 1950–55 to 59 deaths per 1000 livebirths in 2005–10.[12] In 2015, The Rockefeller Foundation–*Lancet* Commission on Planetary Health[12] addressed this apparent ecological paradox: that the state of human health and that of our planet's natural systems have been trending in opposite directions. We concluded that "As a Commission, we are deeply concerned that the explanation is straightforward and sobering: we have been mortgaging the health of future generations to realise economic and development gains in the present. 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".[12] Growing evidence that, indeed, the pace and scale of human disruption of Earth's natural systems is driving an increasing share of the global burden of disease has given rise to a new field of research: planetary health.

Planetary health

Planetary health asserts that the scale of the human enterprise has outstripped the resources available to it from the only habitable planet we know. Human activities are driving fundamental biophysical change at rates that are much steeper than have existed in the history of our species (figure 4). These biophysical changes are taking place across at least six dimensions: (1) disruption of the global climate system; (2) widespread pollution of air, water, and soils; (3) rapid biodiversity loss; (4) re-configuration of biogeochemical cycles, including that of carbon, nitrogen, and phosphorus; (5) pervasive changes in land use and land cover; and (6) resource scarcity, including that of fresh water and arable land. Each of these dimensions interacts with the others in complex ways, altering the quality of the air we breathe, the water we have access to, and the food we can produce. Rapidly changing environmental conditions also alter our exposures to infectious diseases and natural hazards such as heat waves, droughts, floods, fires, and tropical storms. These changes in the conditions of our lives ultimately affect every dimension of our health and wellbeing, including nutritional outcomes, infectious disease, non-communicable disease, displacement and conflict, and mental health outcomes (figure 3).

A few examples of such effects across several dimensions of human health are illustrative.

Nutrition

Human activity is altering environmental conditions that underpin nearly every aspect of the global food production system: temperature, precipitation patterns, atmospheric composition, water availability, quality and quantity of arable land available, the biology of pollinators as well as that of agricultural pests and the species that control them, and plant pathogens. The effects of these changing conditions on the quality and quantity of food we can produce are still highly uncertain, but a few datapoints are coming into focus. Staple food crops grown in open field conditions at elevated CO_2 concentrations (concentrations we are expected to reach by about mid-century) have lower amounts of iron, zinc, and protein than do the same cultivars of the same crops grown at ambient CO_2 concentration.[13] The impacts of this nutritional impoverishment on human health are likely to be large. About 150–200 million people are likely to experience new onset of zinc deficiency, and a similar number will be pushed into protein deficiency as a result of anthropogenic CO_2 emissions.[14,15] These effects are in addition to the more than 1 billion people with existing deficiencies who will be further stressed. And 1·4 billion children younger than 5 years and women in their childbearing years, in whom the prevalence of anaemia is greater than 20%, are expected to lose more than 3·8% of dietary iron as a result of rising CO_2 concentrations.[16]

Figure 1: **View from the Apollo 11 spacecraft of Earth rising above the moon's horizon.**
Source: NASA.

As a primary greenhouse gas, rising CO_2 has important effects on global food production apart from its direct effects on crop nutrient content. Through a variety of mechanisms, climatic change is expected to disrupt global food production, and recent analyses have emphasised particular vulnerabilities for growing populations in the tropics.[17] Insect pollinators are also in trouble: changes in land cover, climatic disruption, and pollution are reducing their numbers around the globe. Recent findings[18] indicate that widespread pollinator declines could lead to large global burdens of disease as a result of reduced intake of vitamin A, folate, and food groups such as fruit, vegetables, and nuts and seeds that protect against non-communicable diseases. Indeed, the total collapse of animal pollination services could lead to 1·4 million excess deaths annually. A different type of biodiversity loss, the loss of wild-harvested fish, is also an important threat to human nutrition. Roughly 1 billion people live near a threshold of sufficient intake of nutrients that they are receiving in large quantities from wild-harvested fish.[19] This leaves them vulnerable to the current trend that wild fish harvests have been in decline by roughly 1% per year for more than 20 years,[20] whereas 90% of monitored fisheries are being exploited up to, or beyond, their limits.[5] Other anthropogenic trends threaten food production as well: increasing con-

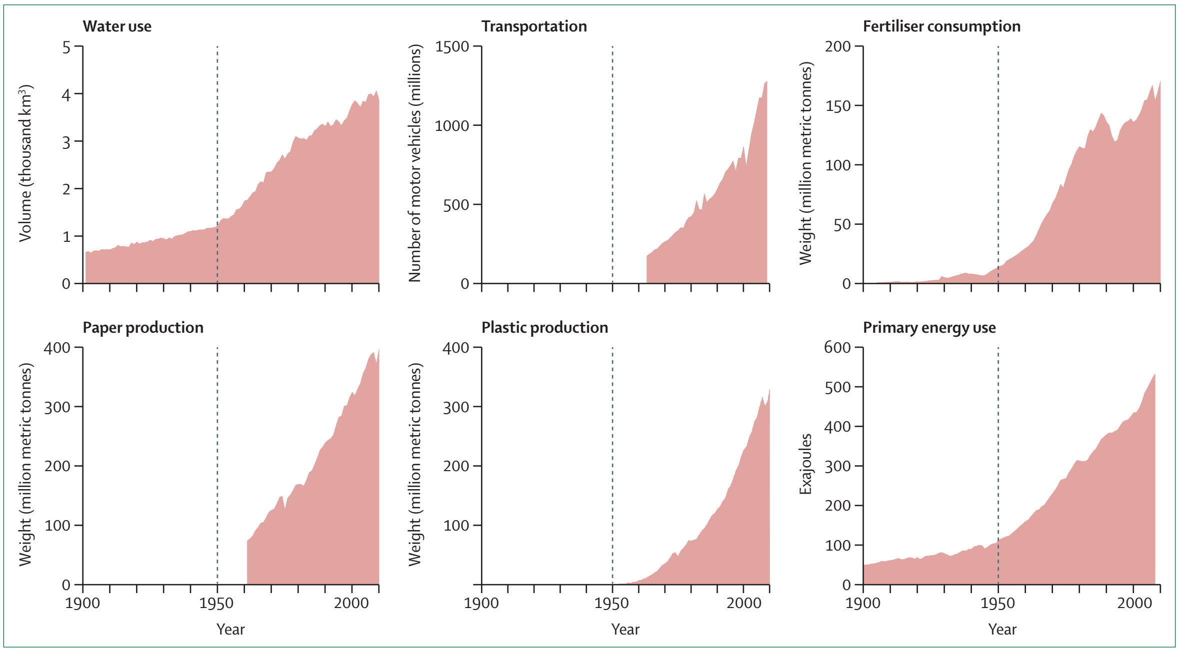

Figure 2: **Measures of consumption over time**

Water use: annual sum of irrigation, domestic, manufacturing and electricity water withdrawals from 1900–2010 and livestock water consumption from 1961–2010. Transportation: global number of new motor vehicles per year. Fertiliser consumption: annual sum of nitrogen, phosphate, and potassium fertiliser consumption. Paper production: annual global total paper production. Plastic production: sum of annual global polymer resin, synthetic fibre, and plastic additive production. Primary energy use: annual global primary energy equivalent from all combustible and non-combustible sources. Source: data originally collected by Steffen et al (2015),[2] except global plastic production from Geyer (2017).[3]

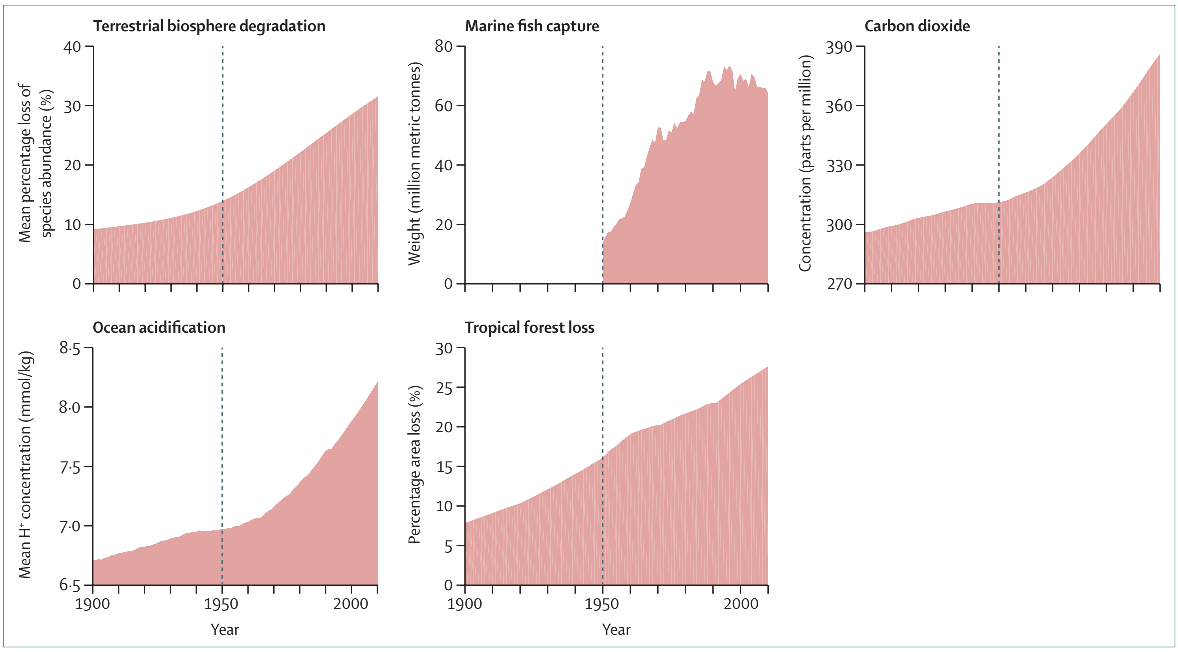

Figure 3: **Measures of human impact on natural systems**

Terrestrial biosphere degradation: percentage decrease in mean species abundance relative to abundance in undisturbed ecosystems using GLOBIO3 model of impact of land-use change on biodiversity. Marine fish capture: annual global marine fish capture production (sum of coastal, demersal, and pelagic marine fish species). Carbon dioxide (CO_2): historical instrumental records from Cape Grim, Australia and Antarctic ice core reconstructions of prehistoric levels. Ocean acidification: global mean surface ocean hydrogen ion concentration; estimated prior to 2005 using CMIP5 and atmospheric CO_2 concentrations; thereafter RCP8.5. Tropical forest loss: change in forest cover relative to 1700 using map-based land-use reconstructions. Source: data originally collected by Steffen et al (2015).[2]

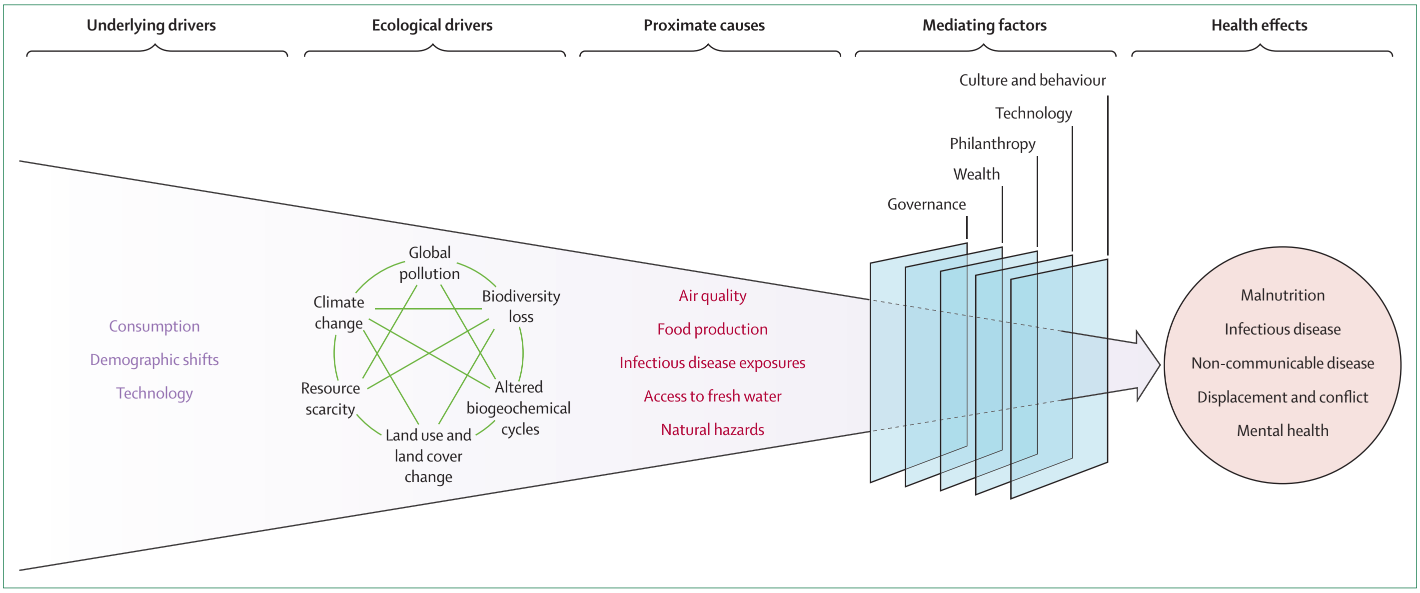

Figure 4: **Schematic illustrating impacts of anthropogenic change on human health**

centrations of ground-level ozone not only threaten human respiratory health but also reduce yields of several important food crops.[21] Increasing water scarcity and arable land loss further constrain production.[22,23] These challenges are emerging at a time when we will need to maintain the steepest increases in food production in human history to keep up with the demand projected over the next half century.[17]

Infectious disease

An array of interacting biophysical changes is also altering the landscape of infectious disease exposures. Consider: a farmer in upland Belize applying fertiliser on his fields causes runoff of nitrogen and phosphorus into local water ways. These nutrients are ultimately carried hundreds of miles downstream to lowland Belize, where they help trigger a shift in the type of reedy vegetation in local wetlands. This shift creates habitat less conducive to *Anopheles albimanus* but ideal for *Anopheles vestipennis*, a mosquito that, because of its feeding preferences, is better suited to transmit malaria to human beings.[24] The uplands farmer has, unwittingly, put his lowland compatriot at higher risk of malaria. Belize is not an isolated example. In a survey of 41 different pathogens on six continents, nutrient enrichment led to ecological changes that resulted in increased disease exposure 95% of the time.[25]

The research field of disease ecology is revealing a host of analogous mechanisms whereby anthropogenic change substantially alters the risk of exposure to infectious diseases. The warming temperatures and changes in precipitation and soil moisture associated with climate change are altering exposure to many important vector-borne diseases by changing the habitat, life cycles, and feeding behaviour of vectors.[26] Deforestation, dams, and irrigation projects have had large impacts on exposure to malaria, schistosomiasis, and other infectious diseases.[27] Human encroachment into wildlife habitat, including bushmeat hunting and agricultural expansion, has increased risk of exposure to zoonotic diseases such as HIV and Ebola.[28] Biodiversity loss appears to increase exposure to infectious disease in most systems where it has been analysed. For reasons that remain somewhat unclear, species that persist after habitat fragmentation or other drivers have reduced the total number of species in a system appear to be the most competent hosts of many vector-borne diseases. Although this is not universally true, empirical observation shows it to be true more often than not.[29]

Displacement and conflict

In 2016, the United Nations High Commission[30] documented the largest number of displaced people in the history of its record keeping. 65·6 million people, half of them children, were forced to leave their homes. The role of accelerating environmental change in driving displacement or conflict is uncertain, and the total numbers of people being forced to move because of rising sea levels, failing crops, resource scarcity, extreme weather events, or the civil conflicts that can be generated by all of these events remains unknown. Most analysts see anthropogenic environmental change as a threat magnifier in situations that have complex and multifactorial aetiologies. The civil war in Syria that has displaced millions of people, for example, was a product of failed governance, population growth, poor agricultural and environmental policies, and the worst

3-year drought in the instrumental record. Evidence suggests that the drought itself was made much more likely by human disruption of the climate system.[31] It stands to reason that increasingly severe extreme events, rising sea levels, additional periods of extreme heat, and reduced crop yields in the tropics, when coupled with growing water scarcity and land degradation, will drive increasing numbers of people, often with few resources, to seek new homes. The impacts of forced displacement on human health are large, with high associated risk of malnutrition, epidemic infectious disease, physical, sexual, and psychological trauma, and mental illness.[32–35] Displacement and conflict might be responsible for some of the largest burdens of disease associated with global environmental change, and more robust research to understand and quantify these dynamics is urgently needed.

Non-communicable disease

Although the effects of global environmental change on non-communicable diseases might be less intuitive than for nutrition, infectious disease, or displacement, they are a concern nonetheless. Planetary scale pollution is perhaps the single greatest threat with respect to non-communicable diseases. According to the *Lancet* Commission on Pollution and Health,[8] an estimated 9 million excess deaths resulted from global pollution of air, water, and land in 2015. 71% of these deaths were caused by non-communicable diseases. According to the Commission's report,[8] pollution caused 21% of deaths from cardiac disease, 23% of deaths from stroke, 8% of deaths from chronic obstructive pulmonary disease, and 25% of deaths from lung cancer. Environmental change is probably affecting the prevalence of non-communicable diseases in other ways. The greatest associated burdens of disease from global pollinator declines are expected to arise from heart disease, stroke, certain cancers, and diabetes as a result of reduced consumption of foods that protect against non-communicable diseases.[18] The reduction of protein in the global food supply and its replacement with starch as a result of rising CO_2 concentrations might further exacerbate non-communicable diseases.[14] The effects of this dietary substitution were tested in a study in the USA,[36] where replacing protein in the diet with carbohydrates, mostly from whole grains, caused increased blood pressure, worsening lipid profiles, and an increased estimated cardiovascular risk.

Even sea level rise could be altering risk of non-communicable diseases in ways that would have been hard to anticipate. In Bangladesh, a combination of sea level rise, an increase in frequency of extreme storms, damming upriver, and poor water resource management are increasing ground water salt concentration.[37] Investigators have found a linear relation between ground water salinity in coastal communities in Bangladesh and prevalence of pre-eclampsia and gestational hypertension in pregnant women.[38] Increased ground water salinity has also been shown to correlate directly with increased blood pressure in coastal dwellers.[37]

Mental health

The mental health impacts of rapidly changing environmental conditions are only just coming into focus. Direct effects of natural disasters associated with changing environmental conditions (eg, sea level rise and more extreme storms, fires, floods, heatwaves, and droughts) are known to include stress, anxiety, depression, and post-traumatic stress disorder (PTSD).[39] Displacement comes with large mental health burdens as well. In a study of resettled refugee children and adolescents,[32] the prevalence of PTSD was 30–75%. However, anxiety, depression, and despair about the loss of cherished ecosystems—termed solastalgia by Australian philosopher Glenn Albrecht[40]—or even the threat of future loss of such systems might be a more universal effect. What is the mental burden of knowing your children or grandchildren will not know the place you call home because it will be under water or otherwise uninhabitable? What are the mental health costs of fearing your children will never see the astonishing beauty of a flourishing coral reef or never encounter species like elephants or rhinoceroses? Subtler still, what is the mental burden of knowing that our own consumption practices are putting some of the world's most vulnerable people in harm's way? These are questions that the nascent field of psychiatric epidemiology might tackle with urgency.

More exhaustive treatments of the human health impacts of environmental change exist,[12,41,42] but my goal here is to illustrate that every dimension of human health is vulnerable to rapidly changing environmental conditions on our planet. Additionally, a few overarching themes emerge from these examples.

Surprises and unintended consequences

Sometimes the health effects associated with disrupting natural systems are direct and intuitive. More extreme storms combined with sea level rise and degradation of coastal barrier systems will leave coastal populations more vulnerable to floods and trauma. Arable land degradation and water scarcity will create headwinds for food production. But planetary health science is also revealing many surprises. It would have been difficult to anticipate 15 years ago that anthropogenic CO_2 emissions would impoverish the global food supply with respect to nutrients. We wouldn't have guessed that sea level rise and water resource management decisions in Bangladesh would increase the risk of gestational hypertension and pre-eclampsia in mothers. And the upland farmer in Belize would be surprised to learn that his fertiliser applications were placing his compatriot in the lowlands at risk of malaria. We can expect many more such surprises as we continue our vast global experiment, rapidly altering most of the biophysical conditions on the only habitable planet we know.

Reducing vulnerability is crucial

Human disruption of natural systems affects some people more than others. In part, this is because environmental conditions change differently in different places, but it is also because vulnerability to a particular set of biophysical changes in the environment is determined by characteristics of the population itself. Good governance, wealth, robust technology and infrastructure, access to philanthropy, and aspects of culture and behaviour can protect populations from the worst effects of disrupted natural systems (figure 4). Needless to say, communities that can build a sea wall in response to rising sea levels or air condition their homes during a heat wave fare better than those who cannot. Food trade protects local communities from local crop failures but only when they have resources to access food markets. Although the root causes might be environmental transformation, in the short term it is often these mediating factors that can be most effectively addressed to reduce the vulnerability of particular populations confronted by worsening health risks. As highland communities in sub-Saharan Africa experience increasing risk of malaria with warming, for example, providing them with access to bednets is more tractable, at the community level, than slowing climate change.

There are winners and losers

Human activities that disrupt natural systems would generally not take place unless they benefited someone. We dam rivers to generate power or provide water for irrigation. We burn fossil fuels to generate energy. We cut forests and appropriate fresh water to grow crops. We mine minerals to manufacture the conveniences of modern life. But there is often a stark contrast between those who benefit from these activities and those who pay the price in degraded health. While a city or town might realise the benefits of clean energy from a new dam, nearby villagers will experience only a rapid increase in their exposure to schistosomiasis. While an entire region might benefit from the energy produced by a new coal-fired power plant, the downwind population will experience an increase in air pollution, and future generations bear the brunt of a disrupted global climate. In this context, health impact assessments that evaluate the distribution of costs and benefits for different groups over time and explicitly address equity become essential.

New ethical terrain

The science of planetary health places us in new ethical terrain. It teaches us that each person on the planet, those alive today and those coming in future generations, is connected to everyone else. Every decision we make about what we eat, how we move around, where we go on vacation, what we purchase, whether or not we own a pet, or even whether we have a child, affects our planet's natural systems and, as a result, the health and wellbeing of every other person on the planet. The impact of each individual decision is infinitesimally small, but the collective impact is enormous.

Planetary health science also highlights the closely related issue of equity. In most instances, the poorest people in the world with the fewest institutional, cultural, governmental, or philanthropic resources to help them are the most vulnerable to rapidly changing environmental conditions. It is the poorest people with the least diverse diets who will be pushed into worsening nutrient deficiencies by CO_2 concentrations that are increasing in response to wealthy world carbon emissions. Future generations will suffer the consequences of today's unsustainable consumption patterns. This disconnect between those who reap the benefits and those who suffer the consequences is deeply unfair. Redoubling our efforts to get humanity on a new trajectory in our management of natural systems becomes, in this light, not just an urgent health priority, but a moral imperative.

Quantifying externalities

One important result of planetary health research is that it quantifies health costs that have previously been only vague externalities. Most of human transformation of natural systems is the result of economic activity at a variety of scales, but in assessing the costs and benefits of these activities, the health effects of environmental transformation have mostly been left out. Whether determining the social cost of carbon emissions, the impact of palm oil production in Indonesia, or the value of a project to dam a river in west Africa, understanding and quantifying the health implications of these activities often changes the equation of costs versus benefits considerably. Industries that are using fire to clear land (palm oil, timber, logging, agriculture) lost some of their lustre as we discovered that those fires led to roughly 100 000 excess deaths in southeast Asia in 2015.[43]

Stewardship

Perhaps a quieter voice is whispering through these examples as well. James Irwin, the eighth man to walk on the moon, described his view of Earth: "That beautiful, warm, living object looked so fragile, so delicate, that if you touched it with a finger it would crumble and fall apart. Seeing this has to change a man, has to make a man appreciate the creation of God".[44] During the Enlightenment, much of Western civilisation embraced a Cartesian dualism, emphasising the realm of the material and scientifically accessible over the spiritual. The explosion of scientific understanding and technological mastery that followed has engendered enormous benefits for humanity, but it might also have blinded us to other ways of knowing. Astronauts looking back on Earth from space have not extolled the power of the science and technology that got them there (although they had every reason to do so); rather, they expressed awe and reverence. Developed societies have generally moved away from such awe and reverence for the natural world that sustains us, or relegated it to days of worship and a separate dimension of our lives, not part of our everyday activities. It might be that indigenous and aboriginal cultures and many faith traditions have an important role in reconnecting us with that other important way of knowing that is more consistent with stewardship of our natural systems.

Looking forward

I remember as a young medical resident at San Francisco General Hospital feeling a deep sense of futility as I watched the same patients return to the hospital with the same conditions for which we had just treated them: alcoholic hepatitis in alcoholics, chronic obstructive pulmonary disease exacerbations in smokers, cellulitis in intravenous drug users, pneumonia in the homeless. How could we meet these patients' needs, I wondered, in ways that better addressed root causes? I remember feeling that we needed to go much further upstream, expand our notion of what it meant to be a doctor. Today, the field of public health needs a similar expansion: we need to go even further upstream. Vaccinations, vitamin A supplementation, prenatal care, smoking cessation programmes, and seatbelts are critically important, but they are not enough. We need to expand the realm of public health to include how we manage our planet's natural systems: the types of cities we construct, how we produce energy, how we feed ourselves, and how well we protect our marine and terrestrial biodiversity. In the context of planetary health, the boundaries between public health and nearly every other facet of human activity become more porous. In short, we need a new paradigm.

This paradigm identifies a new set of health threats and requires a new science to address research priorities. How will multiple, interacting biophysical changes, from biodiversity loss to land and water scarcity to climate change, affect the quality and quantity of food we can produce, and whose health is most at risk? How will changes in global climate and land use affect future exposures to infectious disease? How much displacement and conflict should we anticipate as a result of interactions between sea level rise, increased frequency of extreme natural hazards, crop failures, and resource scarcity, and what can be done to assist the most vulnerable people?

These questions require researchers and public health practitioners to work across disciplines and embrace partnerships that will take them well outside the traditional boundaries of public health. Land use planners, urban designers, ecologists, civil engineers, and agronomists are as much the partners of a planetary health practitioner as doctors, nurses, and epidemiologists. Preparing a next generation of planetary health scientists requires fundamental changes in training, career pathways, and funding. Young scientists need strong disciplinary training, but they also need to be encouraged to break out of a narrow allegiance to disciplinary boundaries and work in partnerships to address real world challenges. Too often the incentive structure of promotions and job security drives next generation investigators to turn inward to address academic questions restricted to their disciplines instead of turning outward to seek partnerships in addressing societal challenges. To address some of the most pressing global health challenges we face, schools of public health will need reorganisation to encourage their faculty and students to work across departments and across schools, building collaborations with colleagues in the natural sciences and beyond.

Funding for planetary health science is inadequate to the scale of urgent research questions we face. Government funders that fund only within disciplinary siloes or with a focus on particular diseases or organ systems handicap themselves in addressing some of society's most urgent priorities. They could break out of these siloes to create cross-agency collaborations or set up distinct institutes to fund planetary health. In the shorter term, private foundations play a crucial part in catalysing the research that is remaking our understanding of how our management of the planet's natural systems is central to future health and wellbeing.

As it defines a new set of problems, the planetary health paradigm must embrace a new class of solutions. Fires used to clear land in Indonesia, particularly on carbon-rich peatlands, have been generating enormous amounts of air pollution for decades. This pollution kills people. By modelling the relation between biomass burning and population-level exposure to particulate air pollution, we have been creating decision-support tools that allow policy makers to calculate the public health costs or benefits of their land-use decisions. Now we are starting to work with the newly created Peatlands Restoration Agency in Indonesia to identify peatlands conservation approaches that will optimise health outcomes. In west Africa, the reintroduction of native river prawns to dammed rivers is helping control schistosomiasis while providing new sources of income and nutrient-dense food.[45] Planetary health solutions involve characterising and quantifying the health effects associated with changes in a particular natural system and then working with communities, governments, businesses, non-governmental organisations, and international organisations to improve management of that system so as to optimise health outcomes.

In the Rockefeller Foundation–*Lancet* Commission report on planetary health,[12] we made broad recommendations for both policy and practice to help us get on track. One recommendation that we might have emphasised more would be the requirement that new projects undertake planetary health impact assessments that integrate environmental impacts with health impacts to explicitly evaluate how environmental changes might affect long-term health and how costs and benefits might be distributed across different populations over time. A second recommendation is the opportunity for health-care professionals to take an important role as educators and advocates. We could expand our role to include educating our patients on the urgency of decarbonising our economy, rethinking our diets and the broader food system, designing green and healthy buildings, neighbourhoods, and transportation systems, and more. Many of these efforts have immediate health benefits (eg, reducing animal-source food consumption, increasing exercise, improving air quality,) and move us onto a more sustainable path.

In the end, achieving planetary health will require a renaissance in how we define our place in the world. A new narrative will reject the one streaming into our homes—that happiness comes from relentlessly acquiring more things—and embrace what we know: that what truly makes us happy is time spent with those we love, connection to place and community, feeling connected to something greater than ourselves, taking care of each other.

It is hard to know what was going through Bill Anders' mind when he described going to the moon to discover Earth. Perhaps one of the reasons so many of us are mesmerised by those self-portraits from space is not only the swirling beauty of patterns of blue and green and white, but also a new awareness that they evoke. From space, our planet is beautiful and unique, yes, but it is also small and somewhat shockingly contained. These are not images consistent with limitless resources or unlimited capacity to absorb our waste. They evoke awe but also an instinct to protect and nurture. Another American astronaut, the sixth person to walk on the surface of the moon, Edgar Mitchell, described Earth rise from the moon's surface. "Suddenly, from behind the rim of the moon, in long, slow-motion moments of immense majesty, there emerges a sparkling blue and white jewel, a light, delicate sky-blue sphere laced with slowly swirling veils of white, rising gradually like a small pearl in a thick sea of black mystery. It takes more than a moment to fully realize this is Earth...home."[46] Russian cosmonaut, Alexei Leonov reflected, "The Earth was small, light blue, and so touchingly alone, our home that must be defended like a holy relic".[47] When Anders wrote that he "discovered the Earth",[45] perhaps he meant that we discovered a new relationship to our planet, that our home is both awe-inspiring and fragile and that, just as it nurtures us and all other living things, it also requires our care.

Declaration of interests

I declare no competing interests.

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