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Key Points:
- Global environmental change is an urgent threat to human health
- Action-focused, transdisciplinary research to optimize the health of people and ecosystems is needed
- The emerging field of Planetary Health/GeoHealth aims to build a scientific evidence base to support more robust policy decisions

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A case for Planetary Health/GeoHealth

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Abstract Concern has been spreading across scientific disciplines that the pervasive human transformation of Earth's natural systems is an urgent threat to human health. The simultaneous emergence of "GeoHealth" and "Planetary Health" signals recognition that developing a new relationship between humanity and our natural systems is becoming an urgent global health priority—if we are to prevent a backsliding from the past century's great public health gains. Achieving meaningful progress will require collaboration across a broad swath of scientific disciplines as well as with policy makers, natural resource managers, members of faith communities, and movement builders around the world in order to build a rigorous evidence base of scientific understanding as the foundation for more robust policy and resource management decisions that incorporate both environmental and human health outcomes.

1. Introduction

What does it really mean to us that 2016 was Earth's warmest year on record [*National Oceanic and Atmospheric Administration (NOAA)*, 2016], that the animals that pollinate plants are disappearing worldwide [*Potts et al*., 2010], that atmospheric carbon dioxide levels are rising at a record pace [*NOAA*, 2017], and that we use about half of the planet's livable surface to feed ourselves [*Foley et al*., 2007]? We are increasingly bombarded by overwhelming facts that are difficult to rationalize and whose scales are incomprehensible within our daily lives. Yet the truth is that these unprecedented changes in our global environment have dramatic and *tangible* implications for our health and that of our children. Development and innovation in manipulating the environments around us have led to tremendous improvements for human health and livelihoods in much of the world—consider the prevention of widespread food shortages and famine predicted in the 1960s made possible by the "Green Revolution" where the combination of expanding land cultivation, synthetic fertilizers, irrigation, mechanization, and development of high-yielding crop hybrid varieties allowed a dramatic explosion in global food production [*Pingali*, 2012]. Consider how malaria death rates around the world were reduced by half between 2000 and 2015, declining fastest among children through the intentional removal of mosquito breeding habitats along with the increased use of pesticides and bed nets [*WHO and UNICEF*, 2015]. And consider how mortality rates due to heat waves, the deadliest type of severe weather event in the United States [*NOAA*, 2013], have declined with help from technological innovations including air conditioning [*Nordio et al*., 2015] and improved heat forecasts and warnings.

Whether intentional or unanticipated, humanity's persistent sculpting of the environment, particularly by those in the developed world, has accelerated due to a combination of exponential human population growth and unsustainable consumption patterns and is now having impact at scales that are difficult to overstate. Most measures of human impact on ecological systems show similar patterns of a great acceleration, starting with a gradual rise at the start of the nineteenth century with a very steep rise in impact around 1950 and continuing today [*Steffen et al*., 2015]. These anthropogenic transformations include placing dams on roughly 60% of the world's rivers [*World Commission on Dams*, 2000], clearing nearly half of the temperate and tropical forests globally [*WWF*, 2016], and annually appropriating roughly one half of accessible freshwater for human uses [*Pingali*, 2012]. In short, we are remaking the fundamental characteristics of our life support systems: our global food production system, the quality of the air we breathe, the water we drink, our exposure to infectious disease, and even the habitability of the places where we live.

Concern has been spreading through the global health community that this pervasive human alteration of Earth's natural systems has become a threat to the health of humanity. There is growing recognition that

the scale of these impacts, and their trajectory, are likely to drive the majority of the global burden of disease over the coming century [*Whitmee et al*., 2015]. The wheels are clearly already in motion, as we are increasingly encountering examples of the aforementioned environmental changes tangibly affecting our health: with consecutive "warmest" years on record, this year there is a devastating possibility of four famines breaking out at once due to drought—in Somalia, South Sudan, Nigeria, and Yemen—endangering more than 20 million lives [*Gettlemen*, 2017]. Looking forward, the worldwide disappearance of the insects, birds, and mammals that pollinate plants and the subsequent loss in yield of essential food crops could cause up to 1.4 million excess deaths annually due to noncommunicable and malnutrition-related diseases inflicted by such dietary changes [*Smith et al*., 2015]. Other essential staple food crops grown under the elevated carbon dioxide levels anticipated for the middle of this century will have lower levels of protein, zinc, and iron, thereby pushing hundreds of millions of people worldwide into deficiencies of these nutrients, and worsening existing deficiencies among the roughly two billion people already affected [*Myers et al*., 2014]. In Indonesia, the use of fires to clear land for agriculture in just one year (2015) led to roughly 100,000 excess deaths of Indonesians, Malaysians, and Singaporeans from cardiorespiratory disease associated with the related air pollution exposures [*Marlier et al*., 2015]. These are the types of environmental change-driven mass-scale health impacts that are causing the health and environmental science communities to sound the alarm.

2. The Emergence of the "Planetary Health" and "GeoHealth" Fields

In recognition of these challenges, institutions around the world have started to respond. The Rockefeller Foundation was the first foundation to launch a series of strategic investments to catalyze the field of Planetary Health. By 2014, the Foundation and the medical journal *The Lancet* had formed *The Rockefeller Foundation-Lancet Commission on Planetary Health* to explore the scientific basis for creating this new transdisciplinary field at the intersection of accelerating global environmental change and human health. The Commission was composed of leading researchers and policy makers from academic, government, multilateral and civil society institutions across eight countries and released its "Safeguarding Human Health in the Anthropocene Epoch" white paper in mid-2015. With unplanned but powerful convergence, Pope Francis released his "On Care for Our Common Home" encyclical on environment and health around the same time [*Francis*, 2015]. In the meantime, the Wellcome Trust has developed a large research funding initiative called "Our Planet, Our Health: Responding to a Changing World" to fund pilot projects investigating the connections between environmental change and health; the University of Sydney has recently named its first Professor of Planetary Health, and other universities around the world are rapidly developing curriculum and training opportunities in Planetary Health; the first issue of *The Lancet Planetary Health* has just been released; the Rockefeller Foundation launched a "Planetary Health Alliance" to build a community of practice in planetary health education, research, and policy; the United Nations Framework Convention on Climate Change has recently announced a Planetary Health track, and the United Nations Environment Program and the World Health Organization have been collaborating on using a Planetary Health lens to address the Sustainable Development Goals.

In parallel, leaders in the ecological, earth, and space sciences including the Ecological Society of America, United States Geological Survey, and the American Geophysical Union have launched complementary initiatives (Earth Stewardship Initiative, Environmental Health Mission Area, GeoHealth Initiative, respectively) to foster scientific investigation of the drivers of environmental change at local-to-global scales and methods to mitigate impacts on human health. In August 2016, in an effort to support research rapidly emerging at the intersection of Earth sciences, ecology, and health sciences, the American Geophysical Union announced the launch of a GeoHealth initiative and journal. With its community's growing appreciation of the deeper insight that Earth and space science provides into health and disease in both people and ecosystems, AGU is investing considerable resources to support compelling research at this intersection.

The call to arms by leading institutions across scientific disciplines and much of civil society reflects a widespread recognition of the need for action-focused, transdisciplinary research at the intersection of human health and environmental change. The simultaneous emergence of "GeoHealth" and "Planetary Health" signals acknowledgement that this need will not be met by just a renewed focus on a topical area but will necessitate a new scientific field that will transcend our traditional approach to research in order

to tackle intimidatingly complex problems. This emerging scientific field must be an applied science, and research must be designed in partnership with those decision makers whom we seek to assist, increasing genuine participation and the chances of policy uptake of science-based recommendations. This field aspires to inform policy at every scale from local to global, to provide the basis for natural resource managers to optimize human health and environmental stewardship objectives, and to educate a global public about implications of their decisions on Planetary Health/GeoHealth.

Creating what former Rockefeller Foundation President Judith Rodin described as "Public Health 2.0," a "new operating system for health and the planet" [*Rodin*, 2015], will not be easy. Current constraints due to largely canalized research funding streams must be changed and the very intellectual structures of universities must be rethought, dismantling the divides between disciplines and fostering deeply integrated research and policy programs to tackle these complex questions and train the next generation of scientific as well as political leaders. The power unleashed by such a transdisciplinary approach and collaborative community is that we will be better equipped to handle the surprises that emerge as we begin to unravel the tightly interconnected web linking human health to natural systems. And there will, undoubtedly, be such surprises. For example, a recent study investigating the underlying factors causing an increase in preeclampsia and hypertension in pregnant women in coastal communities in Bangladesh observed higher disease risk in those women drinking high salinity groundwater [*Khan et al.*, 2014] caused, in part, by the intrusion of salt water with sea level rise. The dynamic and unanticipated health challenges posed by environmental change are not just intellectual curiosities, but a matter of life and livelihood. The hardest-hit countries tend to be the poorest and are often not the primary drivers of environmental change but nonetheless are burdened by the downstream consequences of the consumption patterns of developed countries. These inequities are not confined to the developing world—vulnerable communities exist in many developed countries—or to those of us on Earth today; the sheer immorality of the *intergenerational inequities* that implicitly accompany today's mismanagement of the planet's natural systems is clear.

3. Where We Are Going

The proposition that human disruption of Earth's natural systems represents a threat to human health is not a new idea [see *Hippocrates*, 400 Before Common Era]. Pioneers in the fields of conservation medicine, One Health, and EcoHealth have articulated versions of this concept and constructed an impressive edifice of understanding about the human health impacts of climate change, biodiversity loss, land use change, nutrient enrichment, urbanization, and many other ongoing anthropogenic environmental changes. What may be different about the emergence of Planetary Health and GeoHealth is that the scale of human disruption of Earth's natural systems has reached a level where it threatens to drive the majority of the global burden of disease. Mainstream scientific communities are embracing the Planetary Health/GeoHealth framework out of recognition that it is becoming an urgent global health priority to develop a new relationship between humanity and our natural systems—if we are to prevent a backsliding from the past century's great public health gains.

Achieving meaningful progress along this new trajectory will require collaboration across a broad swath of scientific disciplines as well as with policy makers, natural resource managers, members of faith communities, and movement builders around the world. Only through forging this collaboration can we build a rigorous evidence base of scientific understanding as the foundation for more robust policy and resource management decisions that incorporate both important environmental and human health outcomes. Cultivating a new relationship between humanity and our natural systems ultimately requires collective behavioral change to minimize our demands on environmental resources, and this may well depend on a genuine societal epiphany: a healthy environment is the foundation for human health, for sustainable development, and for a future we would all like to see.

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Erratum

In the originally published version of this paper authors Christopher D. Golden and Samuel S. Myers should have had Department of Environmental Health, Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA, added to their affiliations. Also, author Steven A. Osofsky should have had Planetary Health Alliance, Cornell University, Ithaca, New York, USA, Department of Population Medicine and Diagnostic Sciences, Cornell University College of Veterinary Medicine, Ithaca, New York, USA added to his affiliations. These errors have since been corrected and this version may be considered the authoritative record.