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Feature

Public Health Emergency on Planet Earth: Insights from the Millennium Ecosystem Assessment

Simon Hales[1] and Carlos Corvalan[2]

[1]*Department of Public Health, University of Otago, Wellington School of Medicine, Mein St, Wellington, New Zealand*
[2]*Department of Public Health and Environment, World Health Organization, Ave Appia, CH-1211 Geneva 27, Switzerland*

Human health is related to ecosystem functioning in complex ways. Human societies are fundamentally dependent upon ecosystem services—most obviously, the provision of food and clean water supplies. Less tangibly, but no less importantly, other aspects of ecosystem function that underpin human health include: soil formation; recycling of wastes; some degree of regulation of infectious diseases; and stabilization (buffering) of local environments against catastrophic physical disruption. These benefits that humankind derives from well functioning ecosystems have largely been taken for granted in the past. Increasingly, however, it is recognized that the human impacts on Earth's natural systems threaten the ecosystem services on which we depend.

Three overlapping categories of causal mechanisms linking human well-being and ecosystem status can be described (Table 1).

1. Local exposure → local health impact
   Local, short-term, often direct-acting effects on human health are the most familiar. This category includes, for example, direct health impacts of water quality and availability; local air pollution, or extreme climate events.
2. Ecosystem change → change in regional ecosystem service → regional health impact
   A second category of mechanism involves indirect effects on human health via changes in ecosystem services. These mechanisms are characteristically, though not exclusively, regional in scale. Examples include overfishing, leading to collapse of fish populations; and the transfer of infectious diseases from farm animals to humans.
3. Social systems: population, consumption ↔ global ecosystems: ecosystem services
   The third category of impact involves the complex interaction of human societies and ecosystems at global scale, including feedbacks and implications for ecological sustainability. Global climate change is the best known example in this category; the (interlinked) sustainability of food and water supplies is another example with critical importance for human health.

The health impacts caused by local, direct mechanisms are relatively well understood and the best quantified (Table 2). Indirect effects on human health mediated via changes in ecosystems are less well studied and generally have not been quantified. A major reason for this is that these mechanisms are highly context-dependent, rendering them technically difficult to study.

The Millennium Ecosystem Assessment was carried out from 2001–2005 to describe the relationship between human well-being and ecosystem status, assess the consequences of ecosystem change and summarize the scientific basis for actions to promote the ecological sustainability of human societies. For more information, see: http://www.maweb.org/en/index.aspx

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Correspondence to: Simon Hales, e-mail: simon.hales@otago.ac.nz

Table 1. Ecosystem Changes and Human Well-being and Health

	Typology of causal mechanisms		
Ecosystem services	Local, short-term, often direct-acting	Mediated by regional ecosystem changes	Global, long-term, complex processes
Water circulation, quality	Water quality, availability (e.g., rainfall changes; depletion of aquifers)	Regional water cycling (e.g., rain forests). Water quality (cleansing by wetlands)	Sustainability of water supplies, especially for irrigation (currently expanding)
Energy sources; climate system	Biomass fuels; transport modes (local air pollution) extreme climate events (heat wave, storm, drought, flood)	Regional climate regulation; buffering of extreme events: storm surges, runoff, etc. (e.g., by forests, mangroves, coral reefs)	Energy production, trade, distribution and security; industrialization/urbanization; climate change greenhouse gases (sources and sinks)
Food/agriculture	Subsistence foods; nutritional quality	Productive ecosystems; over-exploitation (soil fertility, desertification, fisheries collapse)	Global food security: sustainability of food production, trade systems
Stabilize infectious diseases	Food- and water-borne infectious diseases	Zoonoses, vector-borne diseases, harmful algae	Pandemic diseases, due to large-scale environmental and social changes
Waste processing and detoxification	Local contaminants	Nutrient cycling, bioremediation	Global contaminants (POPs)
Culture (products, spirituality, aesthetics)	Reduction in cultural resources	Traditional foods and medicines	Cultural diversity

Table 2. Health Impacts of Ecological Changes and Relevance to the Millennium Development Goals (MDGs)

	Local, short-term, often direct-acting	Mediated by regional ecosystem changes	Global, long-term, complex processes
Water	1 billion people lack improved water supplies. The burden of disease from inadequate water, sanitation, and hygiene totals 1.7 million deaths and the loss of more than 54 million healthy life years. MDG 1,4,5,6	Regional climatic conditions, including rainfall are influenced by changes in ecosystems and landscapes, especially deforestation and desertification. MDG 4,5,6,7	Over 2 billion people live in countries experiencing water stress. This number will increase as both population size and per capita water demand grow—reflecting the escalating use of fresh water for irrigated agriculture, livestock production, industry, and cities.
Timber, fiber, and fuel	More than 3 billion people use solid fuels for cooking, leading to an estimated 1.6 million deaths annually from indoor air pollution. MDG 1,4,5,6	Poor women and children in rural communities often are those most affected by a scarcity of fuel wood, leading to increased vulnerability to illness and malnutrition from consuming (unboiled) water and improperly cooked food. Timber exploitation has contributed to species' loss and ecosystem degradation in many regions of the developing world, affecting traditional livelihoods, microbial ecology, and causing other health-related risks. MDG 2,3,4,5,6,7	External air pollution is caused predominantly by the combustion of nonrenewable fossil fuels for electricity generation, transport and industry. Globally, urban air pollution causes an estimated 800,000 deaths per year, mostly from heart and lung disease.
Climate	Extreme weather events (including heat waves, floods, storms and droughts) and sea level are anticipated to increase as a result of climate change. These events have local and sometimes regional effects: directly through deaths and injuries and indirectly through economic disruption, infrastructure damage, and population displacement. MDG 1,4,5,6	Human health is affected indirectly by climate-induced changes in the distribution of productive ecosystems and in the availability of food, water, and energy supplies. These changes affect the distribution of infectious diseases, nutritional status, and patterns of human settlement. MDG 4,5,6,7	Each of the ecosystem services described here is sensitive to climatic conditions and therefore will be affected by human-induced climate change. In turn, these ecosystem changes will affect the well-being and health of human populations. Meanwhile, climate change itself does, and will, affect human health.
Food/ Agriculture	Local food production is critical in preventing hunger and promoting rural development. MDG 1,4,5,6	Regional food security is threatened by over-exploitation of productive ecosystems. MDG 4,5,6,7	Global aggregate food production currently is sufficient to meet the needs of all. Yet, over 800 million are malnourished; a similar (increasing) number are overfed. Over 1 billion people live with chronic micronutrient deficiency. MDG 1,4

(Continued)

Table 2. Continued

	Local, short-term, often direct-acting	Mediated by regional ecosystem changes	Global, long-term, complex processes
Infectious disease regulation		Ecosystems regulate certain infectious diseases, although their overall contribution to prevention has not been quantified. Infectious disease risks are affected by destruction of, or encroachment into, wildlife habitat (particularly through logging and road building); changes in the distribution and availability of surface waters (dam construction, irrigation, and stream diversion); agricultural land-use changes; uncontrolled urbanization; resistance to pesticide chemicals used to control vectors; and loss of biodiversity. MDG 4,5,6,7	Infectious disease risks are affected by global factors including climate change; migration; international travel and trade; and the accidental or intentional human introduction of pathogens.
Waste processing	Humans are at risk from inorganic chemicals and persistent organic chemical pollutants in food and water. Such exposure can occur when human actions release toxic chemicals into the environment (for example, through pesticide use). MDG 1,4,5,6	Disruption in nutrient cycling can impair soil fertility, resulting in reduced crop yields. This can impair the nutritional status of households. Macro- and micro-nutrient deficiencies harm children's physical and mental development. In turn, this can impair the livelihoods of farmers and limit the options open to their children. MDG 2,3,4,7	Exposure to low concentrations of some chemicals (such as PCBs, dioxins, and DDT) may cause endocrine disruption by interfering with normal human hormone-mediated physiology and impairing reproduction.
Culture	Millions of people depend partly or fully on natural products collected from ecosystems for medicinal purposes. Although synthetic medicines (over half of which originated from natural precursors) are available for some purposes, the global need and demand for natural products persists. MDG 1,4,5,6	Communities obtain many nonmaterial benefits from ecosystems. Ecosystems provide sites and opportunities for tourism, recreation, aesthetic appreciation, inspiration, and education. Such services can improve mental health, enhance a subjective sense of culture or place; and also enrich objective knowledge of natural and social sciences. MDG 1,2,3,4,7	Ultimate fate of human civilizations: collapse or sustainability revolution?

MDGs: *1*, eradicate extreme poverty and hunger; *2*, achieve universal primary education; *3*, promote gender equality and empower women; *4*, reduce child mortality; *5*, improve maternal health; *6*, combat HIV/AIDS, malaria and other diseases; *7*, ensure environmental sustainability; *8*, develop a global partnership for development

Changes in the structure and functioning of ecosystems in the past half century have been more rapid than at any other time in human history. These changes have, in part, been essential to meet increasing human needs for food and water, but have not benefited all sections of society equally, and have been achieved at increasing cost to ecosystems. Affluent populations exert proportionately greater pressure on the environment but are less vulnerable to the consequences of ecosystem degradation (Corvalan et al., 2005).

Social inequalities within and between countries have generally increased over the past half century. On both global and national scales, poverty is associated consistently with exposure to health risks such as malnutrition, contaminated water supplies, and lack of sanitation, shelter, or other public services. In some regions, poverty, hunger, and ill health have been exacerbated by migration to urban slums or marginal drought-prone lands. Poor communities are more directly dependent on local ecosystem services and are highly vulnerable to ecosystem or economic changes, yet are less able to prioritize conservation of ecosystem services ahead of immediate needs. In these circumstances, further degradation of ecosystem services can trap poor communities in a downward spiral of poverty and poor health.

As part of the Millennium Ecosystem Assessment, scenario-based modeling of future global trends and developments to the 2050s was carried out. Under all scenarios considered, there was an increase in pressures on ecosystems, leading to continued loss of biodiversity and ecosystem degradation. In particular, demand for food was projected to increase by 70%–80% and demand for water by 30%–85%. Human societies cannot continue to increase per capita consumption, total population, and social inequality without risking irreversible damage to global ecosystems. More bluntly, the trajectory of human societies over the past 50 years, if extrapolated into the next 50, would be ecologically unsustainable. The effects on human health would be catastrophic.

This implies that measures to safeguard ecological sustainability are a critical aspect of public health policy. However, what role the health community can or should play in safeguarding ecological sustainability is still a matter for debate. Mitigation of ecosystem degradation and adaptation to past changes can sometimes go together. Avoiding, limiting, or remedying ecological damage is preferable in principle and is the only available approach in the case of certain poorly defined ecological thresholds. Examples include the minimum level of biodiversity required to maintain essential ecosystem services, or the maximum amount of greenhouse gases that can be emitted without causing irreversible destabilization of the climate system. Such global ecological thresholds are interdependent: for example, the sustainable level of greenhouse gas emissions will depend on the extent of biodiversity loss, while biodiversity is also sensitive to the degree of climate destabilization.

Provision of basic necessities of life is the first priority for public health; but if we degrade ecosystems in the process, this only postpones public health problems for future generations to manage. More equitable distribution of food and energy supplies has the potential to simultaneously improve public health and reduce pressure on ecosystems. For example, a reduction in the consumption of animal products and refined carbohydrates in rich countries would have benefits for human health and for ecosystems. Similarly, better transport systems and practices could reduce adverse health impacts (including injuries, obesity, cardiovascular and respiratory diseases) via improved safety and physical fitness, healthier balance of energy input and output at the individual level, and reduction in local and global air pollution.

In the future, achievement of the Millennium Development Goals (MDGs) will depend upon the sustainability of ecosystem services. Important links between MDGs and mechanisms of health impact are referenced in Table 2. The communities confronted with the greatest challenges in achieving the MDGs are those where needs for ecosystem services are already close to or beyond the rate of sustainable supply (dryland regions are a prime example here). On a global scale, ecologically unsustainable use of ecosystem services threatens improvements to water supplies, malnutrition, infectious diseases, maternal and child mortality, and poverty, all of which are necessary for the achievement of the MDGs.

There are unavoidable uncertainties about the exact magnitude, scope, and timescale of the health impacts of global change. This means that precautionary action is the only way to safeguard human health in the long term: anything less would be "playing games with our children's future."

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Reference

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