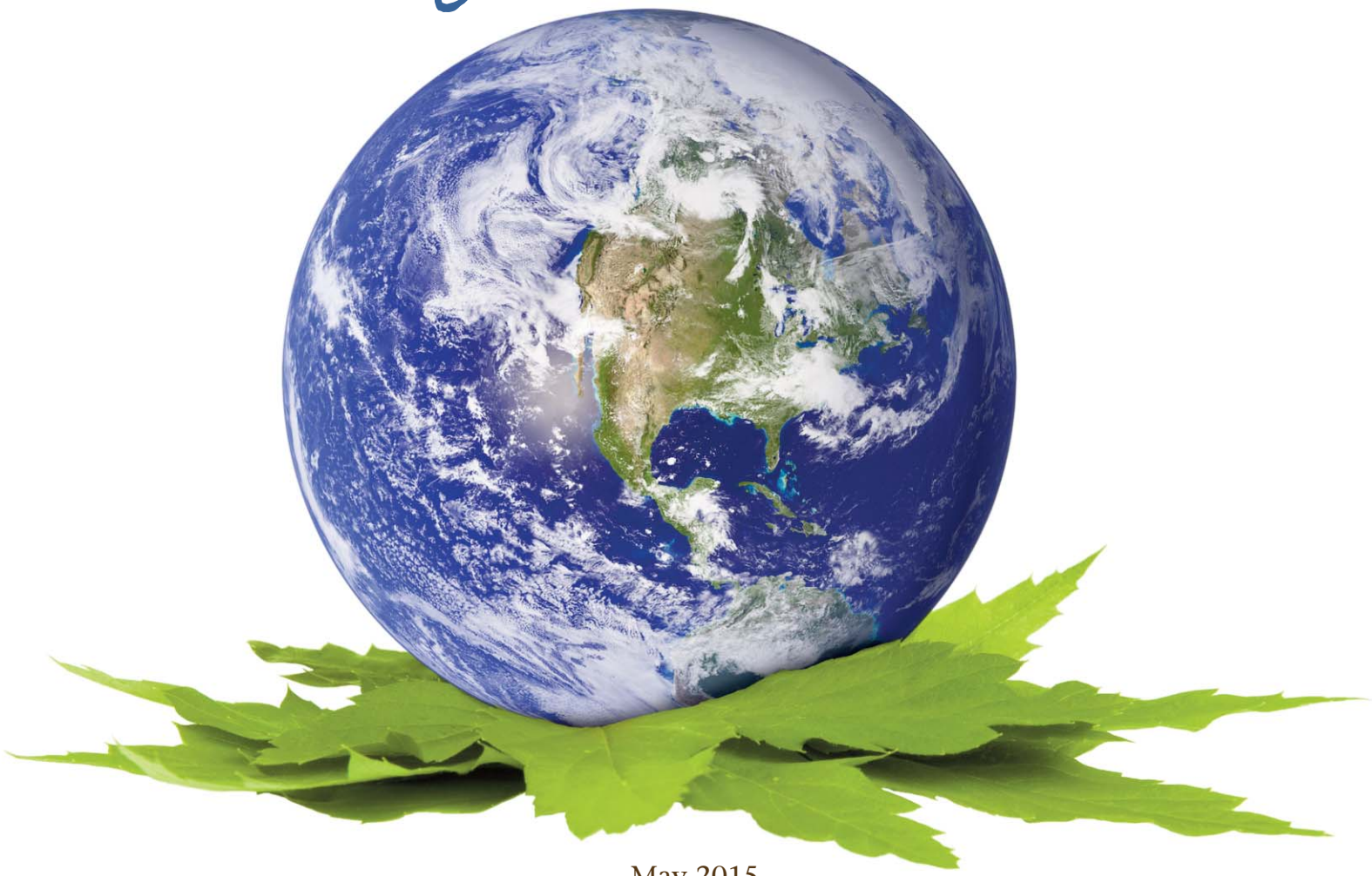
CANADIAN PUBLIC HEALTH ASSOCIATION
DISCUSSION PAPER

Global Change and Public Health:

Addressing the Ecological Determinants of Health



May 2015

Founded in 1910, the Canadian Public Health Association (CPHA) is the independent voice for public health in Canada with links to the international community. As the only Canadian non-governmental organization focused exclusively on public health, CPHA is uniquely positioned to advise decision-makers about public health system reform and to guide initiatives to help safeguard the personal and community health of Canadians and people around the world. CPHA is a national, independent, not-for-profit, voluntary association. CPHA's members believe in universal and equitable access to the basic conditions which are necessary to achieve health for all.

Our Vision

A healthy and just world

Our Mission

CPHA's mission is to enhance the health of people in Canada and to contribute to a healthier and more equitable world.

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Canadian Public Health Association
Discussion Document

Global Change and Public Health: Addressing the Ecological Determinants of Health

May 2015

Foreword

The future of life on Earth cannot be taken for granted as our species has the capacity to influence that future – for good or ill. Armed with a new understanding of key principles, concepts and values, we can create a healthier, more just, more sustainable future. Fortunately, a vast informal movement is already at work for the common good and a better future with goals that reflect the essence of the public health tradition to galvanize public health workers and organizations in Canada and around the globe.

This discussion document is based on a 2015 report about the ecological determinants of health developed by a Canadian Public Health Association (CPHA) working group.[1] The first two chapters of the report address the context for thinking about the ecological determinants of health, while chapters 3 through 5 identify the challenges we face – the main ecological changes, the social forces behind those changes and their health implications. Chapters 6 and 7 turn from a review of the past and the troubling health implications of declining ecological functions to consider the reasons for finding hope for the future. Chapters 8 and 9 describe an agenda for action. This document reflects the structure and summarizes the key elements of that report.

This paper is not the definitive word on the topic of the ecological determinants of health. Its goal is to begin a conversation, stimulate debate and ultimately motivate the public health community to action. The 100-page condensed version of the working group's complete 350-page technical report can provide readers with considerable detail on the topics touched upon here.

Many people were involved in the development of this body of work. CPHA's Board of Directors gratefully acknowledges the contributions of the members of the working group, reference group, volunteers and student practicum placements. See Appendix A for a complete list of contributors.

Table of Contents

Executive Summary iv
Introduction 1
Humanity, nature and the Anthropocene 2
Ecological determinants of health 2
Global ecological change 3
Key areas of global change 5
Climate change 5
Ecotoxicity 6
Resource depletion 6
Species extinction 6
Oceans in trouble 6
Unprecedented challenges 6
Societal and human forces driving change 7
Twenty years of business-as-usual 7
Population growth 7
Urbanization 8
Economic growth and development 8
Technological change 9
Social values and social change 9
Implications for population health 10
Health impacts of climate change 11
Pollution and ecotoxicity 11
Resource depletion 12
Loss of species/biodiversity 12
Looking at future impacts 12
Imagining a better future 13
First steps towards the future we prefer 14
Finding hope 14
Rethinking development and economics 15
Health and other co-benefits of a more sustainable society 16
Advances at the local level 17
Towards transformative change 17
An agenda for action 18
1. Expand the guiding principles of public health 18
2. Understand and address the ecological determinants of health 18
3. Walk the talk: Environmentally responsible health care 19
4. Change social norms and values 19
5. Change the focus of development and the way it is measured 19
6. Strengthen ethical purchasing and investment policies 19
7. Protect people and communities from harm and health inequity 19
8. Protect people and communities from the adverse impacts of ecological change 19
9. Work with others to establish policies and practices that create more ecologically sustainable and healthy societies and communities. 20
References 21

Appendix A: Acknowledgements 25
Appendix B: From Ideas to Action 26

Executive Summary

The relationship between human beings and the ecosystems of which they are a part is profound. The links between health and the environment are as old as human culture. Human evolution takes place within ecosystems, and there are deep psychological, social and cultural connections to ecosystems that go well beyond mere physiological needs.

In the late 20th and early 21st centuries, myriad threats to the health of the Earth's environment have become apparent. There is a growing recognition that the Earth is itself a living system and that the ultimate determinant of human health (and that of all other species) is the health of the Earth's life-supporting systems. The ecosystem-based 'goods and services' that we get from nature are the ecological determinants of health. Among the most important of these are oxygen, water, food, fuel, various natural resources, detoxifying processes, the ozone layer and a reasonably stable and habitable climate.

Public health in the 21st century must augment its scope to address the natural world; encompass concepts such as One Health and Ecohealth; and specifically target the health challenges of human-induced global climate change, resource depletion, ecotoxicity and loss of biodiversity.

Our knowledge of the health impacts of global ecological change is surprisingly limited. What we know is imprecise, preliminary and often speculative; we have some idea of the big picture, but the details are lacking. Even in the case of climate change, we have only a modest sense of the potential health impacts, although this has been the focus of some well-resourced research over the past few decades, both globally and in Canada.

We do know that the indirect health effects of global ecological change – those mediated through natural and human systems – are likely to be much greater than the direct effects (such as heat waves), although they are harder to quantify and attribute directly to a specific global change. This difficulty in quantifying the indirect health effects is part of the uncertainty with which we must deal.

The key human forces driving changes in ecosystem functioning are population growth and urbanization, economic growth and development, technological changes and advances, and social changes and movements aligned to these forces. Underlying and shaping these drivers are societal and cultural values, which for the past 200 to 300 years have emphasized 'progress' or modernization, transforming human societies from rural and agrarian to secular, urban and industrial. The long history of modernization helps us to understand our current social, political, economic and cultural conditions, and, perhaps, to anticipate a post-modern society that enables us to stabilize and reverse these harmful ecological changes.

We will need some fundamental shifts in societal values, and with that new principles, and new ways of knowing, measuring and governing. Fortunately, we do not have to invent these from scratch as we have precedents and newly-emerging practices that can help provide a foundation for the new future we need to create. The fields of health promotion and Ecohealth offer conceptual and procedural guidance to catalyze a transformation toward public health equity for future populations.

If we understand the forces that shape us and the future we face, we are better equipped to make choices, express our values in a vision and then work to create it. Within public health, we need to explore scenarios of plausible futures, and help people create visions describing their preferred future.

CPHA's vision of healthier, more sustainable, more just societies and communities will not be achieved in isolation from wider social processes. Realizing any such vision will demand transitions both within and outside public health and the larger health sector, including an explicit re-engagement with the values of public health.

Introduction

The relationship between human beings and the ecosystems of which they are a part is profound. The links between health and the environment are as old as human culture. For thousands of years, Indigenous peoples have viewed the Earth as Mother and have understood health in the context of community and the environment. Two and a half thousand years ago, Hippocrates wrote "On Airs, Waters, and Places", investigating the relationships between places, health and disease. Human evolution takes place within ecosystems, and there are deep psychological, social and cultural connections to ecosystems that go well beyond mere physiological needs.

In more recent history, modern public health originated in the struggle to overcome sickening environmental and social conditions that resulted from urbanization and industrialization. The emphasis was on sanitation and hygiene, water supply and treatment, improved living and working conditions and later on immunization, domestic hygiene, and improved nutrition.

The 1974 Lalonde Report that positioned socioeconomic factors as determinants of health, the World Health Organization's (WHO) 'Health for All' approach of the late 1970s and the rise of health promotion in the 1980s ushered in a 'new' public health, based in a socio-ecological model. Health promotion recognized stable ecosystems and sustainable resources as prerequisites for health and championed healthy public policy and a settings approach, launching the Healthy Cities and Communities approach.[2] In the early 1990s, the concept of population health emerged in Canada with a focus on the determinants of health nationally and internationally, and specifically on the 'social' determinants that include housing and the built environment. These movements culminated in the WHO Commission on the Social Determinants of Health, which tabled its final report in 2008 on avoidable health inequalities and social justice.

In the late 20th and early 21st centuries, myriad threats to the health of the Earth's environment have become apparent. The first United Nations (UN) Conference on the Environment was held in Stockholm in 1972, when the UN Environment Program was established (led by a Canadian, Maurice Strong). The UN has worked hard to maintain that focus on and voice for the global environment, with the World Commission on Environment and Development (WCED, referred to as the Brundtland Commission) declaring the importance of sustainable development so that we can "meet the needs of the present without compromising the ability of future generations to meet their own needs."[3] Subsequent international organizations, reports and events, such as the Intergovernmental Panel on Climate Change, the Millennium Ecosystem Assessment, as well as the 1992 Rio and 2012 'Rio + 20' Earth Summits have tried to demonstrate the human health implications of global ecological change.

As this work unfolds, there is a growing recognition that the Earth is itself a living system and that the ultimate determinant of human health (and that of all other species) is the health of the Earth's life-supporting systems. The ecosystem-based 'goods and services' that we get from nature are the ecological determinants of health. Among the most important of these are oxygen, water, food, fuel, various natural resources, detoxifying processes, the ozone layer and a reasonably stable and habitable climate.

In recent years, public health has expanded its scope beyond its traditional environmental concerns with domestic and community hygiene and sanitation, infectious disease control, air and water pollution, food safety and toxic chemicals to address (or more accurately, renew our understanding of) the health implications of the built environment. We recognize, for example, that North Americans are 80-90% urbanized and spend 90% of their time indoors. Now we need to deepen and broaden our analysis, acknowledging that we live 100% of the time on a small planet and within natural ecosystems that constitute the ecological determinants of health. Public health in the 21st century must augment its scope to address the natural world; encompass concepts such as One Health and Ecohealth; and specifically target the health challenges of human-induced global climate change, resource depletion, ecotoxicity and loss of biodiversity.

Critical to the success of these efforts is the understanding that the changes in the Earth's ecological systems are driven principally by our social and economic systems, and by the collective values and institutions that support them. As such, we see that the social and ecological determinants of health intertwine and interact, influencing each other and ultimately the health of people, communities and societies, along with the health of countless other species with whom we share the planet.

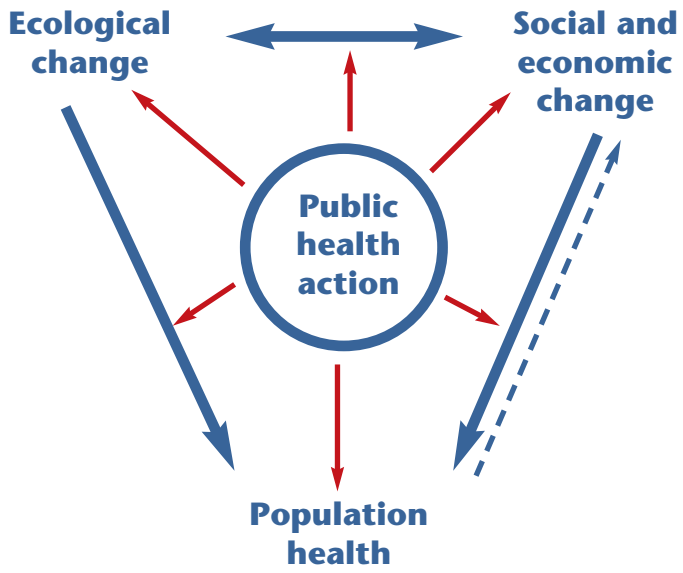

Figure 1: An Ecosocial Framework for Public Health Action

Faced with both growing social inequities and an ecologically unsustainable way of life, public health is now being called upon to adopt what can be best described as an 'ecosocial' approach to health (see Figure 1). We are well positioned to articulate and catalyze a wide range of partners from the public, non-profit, and private sectors, and the faith and academic arenas to address the social and ecological determinants of health from the local to global levels.

Humanity, nature and the Anthropocene

For most of human history, the natural world has been viewed with a mixture of reverence, awe and fear. But over time, humans have developed an attitude of superiority to nature; all too often it is considered something separate from us that we attempt to subdue and control. Our efforts to tame nature have been significant enough to influence, unofficially, the naming of the present geological epoch in which we now live as the 'Anthropocene',[4] reflective of humanity's power over nature.

"The term Anthropocene suggests: (i) that the Earth is now moving out of its current geological epoch, called the Holocene and (ii) that human activity is largely responsible for this exit from the Holocene, that is, that humankind has become a global geological force in its own right."[4]

Nature remains bountiful, with its ecosystems providing the basic necessities of life as they always have. But this bounty is becoming strained, particularly over the past 100 years. As Duwamish Chief Seattle is reported to have said in the mid-19th century, "Man did not weave the web of life; he is merely a strand in it. Whatever he does to the web, he does to himself." In the face of the ecological disturbances we now confront, we may think that the environment is threatening us, but we would be wrong. It is our species that is behind today's global environmental change, the warming of the Earth, the harming of the lifecycles of many species, and the threatening of the Earth's fundamental life-supporting functions. It is we who are creating mass extinctions and depleting both renewable and non-renewable resources. Our ongoing damage to Earth's ecological integrity is being returned, as Chief Seattle said, to harm us. Urgent attention needs to be given to this matter so that we can reverse damaging trends, prevent further declines and avoid potential disaster.

Ecological determinants of health

There are many ecological processes and natural resources essential for the health and well-being of humans and other species. They constitute Earth's life-supporting systems, which serve the needs of humans and of all life. The view that humans are inherently more important than other forms of life ignores the reality that human survival fundamentally depends on a diversity of other life forms, which in turn are interdependent themselves.

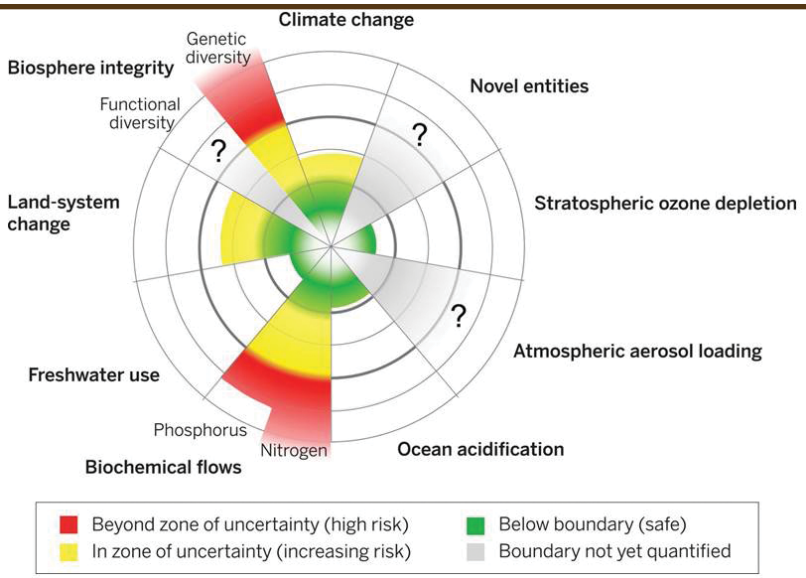

Figure 2: Safe operating boundaries
Source: Steffen et al, 2015.[6]

We recognize that all life plays a role in maintaining human health and, as such, we need to take into account how our actions affect the natural world and deepen our respect, care and sensitivity towards the diversity of life on the planet. Our health and our continued existence as a species depend on healthy natural ecosystems, and on the interdependent web of life comprising these ecosystems.

The ecological determinants of health upon which life depends include at the most basic level adequate amounts of:

- oxygen;
- water; and
- food.

Other vitally important ecological processes and natural resources include the:

- ozone layer that protects Earth's surface from high levels of UV radiation;
- nitrogen and phosphorus cycles that circulate nutrients needed for plants and thus for all our food;
- systems to detoxify wastes through natural processes; and
- abundant fertile soil, fresh water and marine aquatic systems to grow food and other plants.

For humans, particularly for the development of human cultures and civilizations, three further requirements are:

- materials to construct our shelters and tools;
- abundant energy; and
- reasonably stable global climate with temperatures conducive to human and other life forms.

Collectively, the natural systems that produce these ecosystem 'goods and services' are the fundamental determinants of human health and well-being.

Global ecological change

Global ecological change is a normal process in the geological and biotic evolution of the Earth. What makes it a concern today is the unprecedented speed and scale of declines in ecological functioning that are attributable to human activity over the past century, and especially over the last 50 years.[5] We are approaching, and sometimes exceeding, critical ecological thresholds that presage ecosystem collapse. We have passed the boundaries for rate of biodiversity loss (extinctions per million species-years, E/MSY), disruption of the nitrogen and phosphorus cycles, land system change and climate change, with the first two in a high-risk zone and the other two in a zone of increasing risk (see Figure 2).[6]

Another form of change is possible in ecosystems and is even more alarming. State shift, or rapid non-linear change, is an emergent property of many complex, adaptive living systems. Examples on a global scale of rapid shift in status include the 'Big Five' mass extinctions in geological history when abnormally large numbers of species died out simul-

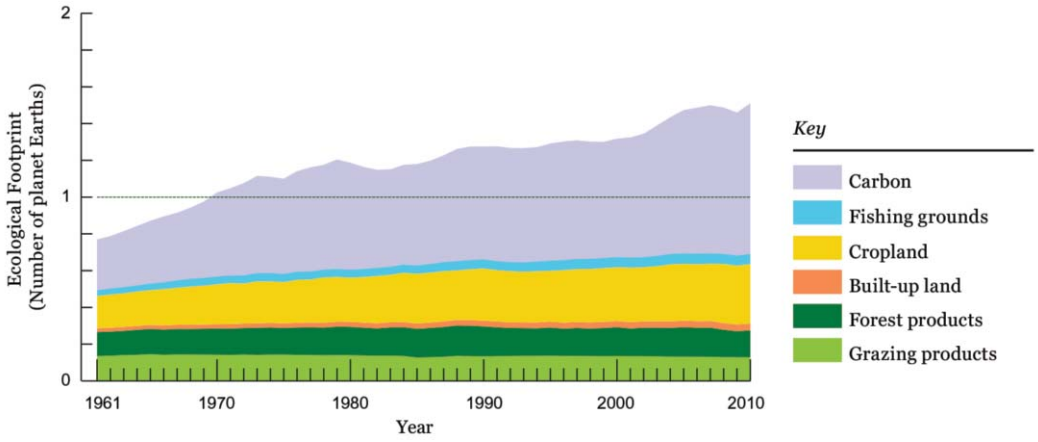

Figure 3: Global ecological footprint, 1961-2010
Source: WWF Living Planet 2014 Report: Summary, p. 10.[12]

taneously,[7] the loss of Arctic sea ice, and the potentially catastrophic release of methane from thawing permafrost or undersea methane hydrates.[8]

The prospect that humans can trigger transitions on this scale is worrying. Science cannot predict such changes as we have no prior data upon which to base forward projections. We do know that indefinite growth of resource consumption in a finite system, such as Earth, is not sustainable; it harms and can severely damage the Earth's ecosystems. Our planet is unique, it is finite, and it contains all we have. We must live within the limits of its resources, capacity and functioning ecosystems.

In the more than 20 years since the first CPHA report on human and ecosystem health,[9] the state of our planetary ecosystems and natural resource sustainability have declined substantially. The 2005 report of the United Nation's Millennium Ecosystem Assessment found that "approximately 60% (15 out of 24) of the ecosystem services examined during the Millennium Ecosystem Assessment are being degraded or used unsustainably… ."[10] In summarizing the report, the Board of the Millennium Ecosystem Assessment wrote:

"At the heart of this assessment is a stark warning. Human activity is putting such strain on the natural functions of Earth that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted."[11]

Two key global summary indicators are the Ecological Footprint (EF) and the Living Planet Index (LPI). The global EF measures the amount of biologically productive land and water required to produce all the resources consumed, and absorb the waste produced, by a given population. The EF has increased steadily and dramatically from 7.6 billion global hectares (gha) in 1961 to 18.1 billion gha in 2010. Even though global biocapacity has increased over that same period (from 9.9 to 12 billion gha), it has not kept pace with either population growth or rising consumption levels. Consequently, per capita biocapacity has declined from 3.2 to 1.7 gha, and we currently use the regenerative capacity of 1.5 Earths each year (see Figure 3).[12] Wealthier countries and wealthier populations have larger footprints than poorer ones. If the entire world had the same EF as does the United States or Denmark, our global footprint would be the equivalent of almost four planets.

The LPI tracks the state of the world's biological diversity based on average changes in vertebrate species from terrestrial, freshwater and marine habitats. Globally, it declined by an astonishing 52% between 1970 and 2010 (see Figure 4), but by 58% in low-income countries and by 18% in middle-income countries, while increasing 10% in high-income countries.[12] This suggests that the high-income countries may be restoring their biodiversity by exploiting the resources of the low- and middle-income countries, leading to a massive decline in their LPI.

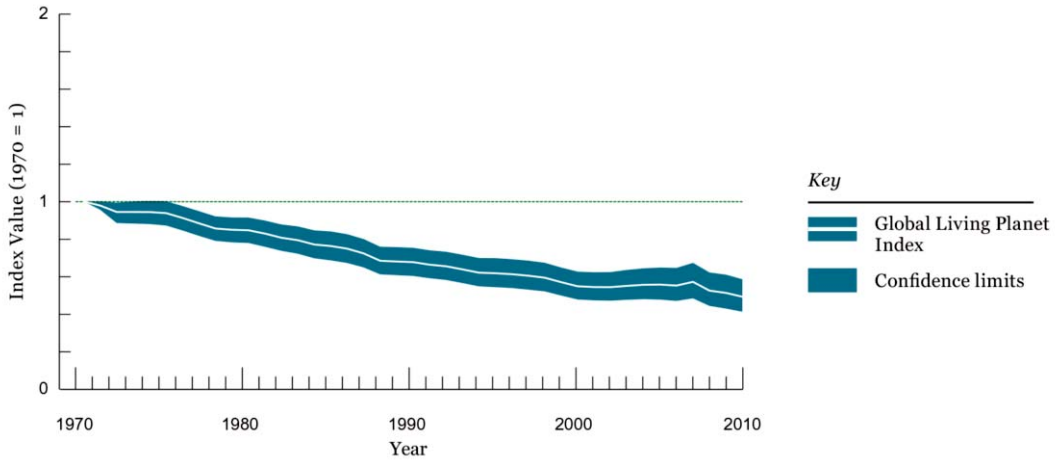

Figure 4: The Living Planet Index, 1970-2010
Source: WWF Living Planet 2014 Report: Summary, p. 8.[12]

Canada's EF and LPI have also been determined. As expected for a high-income country, the Canadian EF is large, but marked differences in EF exist within Canada, based on income, with the EF of the richest 10% of the population being nearly 2.5 times larger than that of the poorest 10%.[13] Canada's LPI is based on a smaller sample of species, with 1,057 population trends from 393 vertebrate species. While the LPI slowly increased from 1970 until 1995, there was a worrying decrease of almost 25% between 1995 and 2003.[14]

More generally, in Canada, there is serious concern with several aspects of our environmental performance, including weaknesses in monitoring, research, information management and reporting on biodiversity.[15] Canada's Commissioner of the Environment and Sustainable Development recently noted concern with respect to the federal government's actions on environmental assessment and public engagement processes.[16]

Key areas of global change

Climate change

Average annual global carbon dioxide (CO_2) emissions increased by 52% from 1992 to 2012,[17] and between 2012 and 2013, they increased more than during any other year since 1984.[18] "The amount of CO_2 in the atmosphere reached 396.0 parts per million (ppm) in 2013. The atmospheric increase of CO_2 from 2012 to 2013 was 2.9 ppm, which is the largest annual increase for the period 1984-2013."[12] As a result, the average annual global temperature (January-December) has increased from 14.19°C in 1992 to 14.60°C in 2013.[19] The US National Oceanic and Atmospheric Administration reported in January 2015 that "[t]he globally averaged temperature over land and ocean surfaces for 2014 was the highest among all years since record keeping began in 1880."[20] In Canada, the average temperature increased by 1.6°C over the past 66 years.[21]

Urgent action is needed as evidenced by recent reports of the Intergovernmental Panel on Climate Change (IPCC). In 2013, the IPCC reported that "[m]ost aspects of climate change will persist for many centuries even if emissions of CO_2 are stopped. This represents a substantial multi-century climate change commitment created by past, present and future emissions of CO_2."[22] A year later, the IPCC stated that "human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems. … [moreover, the] continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems."[23]

In Canada, the Commissioner of the Environment and Sustainable Development reported in 2014: "In 2012, we concluded that the federal regulatory approach was unlikely to lead to emission reductions sufficient to meet the 2020

Copenhagen target. Two years later, the evidence is stronger that the growth in emissions will not be reversed in time and that the target will be missed."[24]

To keep global warming advances below the 2°C threshold, it has been estimated that no more than about 1 trillion metric tons of carbon can be added to the atmosphere. Already we are past the halfway mark, and if current trends persist, we will pass the trillion metric tons mark in the 2040s.[25] It is important to understand that if the total resource base of fossil fuel were burned, we would greatly exceed that 2°C threshold, which leads to suggestions that about 80% of known fossil fuel reserves should never be burned.[26] A recent report suggests that in Canada, even with carbon capture and storage technologies in place, 74% of oil reserves , 99% of 'unconventional oil' (i.e., Alberta's oil sands), 71% of unconventional gas reserves (i.e., hydraulic fracturing, or "fracking") and 75% of coal is 'unburnable'.[27] This 'unburnable' carbon becomes a stranded asset and represents a major liability for the fossil fuel industry and those who invest in it, notably pension funds. [28]

Ecotoxicity

We have created many toxic organic chemicals in the past century that are novel for which no natural detoxifying mechanisms exist.[5] Many of these chemicals are designed to be stable and thus will persist in the environment, with the effects of their persistence remaining largely unknown. We do know that tiny amounts of persistent chemicals, and some heavy metals, already spread widely in the environment, can have enormous biological effects as they become bio-concentrated up the food chain, reaching levels in top predators (including humans) millions of times higher than in the source. This means that everyone born or living since World War II carries a lifelong body burden of multiple and persistent organic pollutants with health consequences that are unknown. [29]

Resource depletion

Resource depletion refers to the gradual loss of resources provided by nature that humans use to meet their needs. These resources include, water, land, soil, forests, energy, minerals, fish and other wildlife. Some resources, such as water, forests, soil, and foods such as fish, are renewable as long as their exploitation does not exceed the rate of renewal and as long as the necessary ecosystem services can enable that renewal.

Renewable resources are unlikely to peak and decline, but they could peak in functional availability or because competing interests limit access to them. If this 'peak' occurs, the cost of these resources will be driven up, becoming unaffordable to the majority of people on Earth. Other resources, particularly metals and fossil fuels, are non-renewable on any scale relevant to humans; there is a finite supply of retrievable/extractable resources. Our society may be reaching limits in the global production of many non-renewable resources; thus, we face peak oil,[30] gas,[31] coal,[32] phosphorus,[33] uranium,[34] minerals,[35] and from the perspective of journalist and educator Richard Heinberg, "peak everything".[36]

Species extinction

Experts report that the rapid loss of species we are experiencing today is between 1,000 and 10,000 times higher than the natural extinction rate. The combination of all the human-driven ecological changes outlined above, as well as human intrusion and destruction of habitats, is creating the sixth mass extinction of species –the first to be induced by humans.[37]

Oceans in trouble

One of the consequences of the higher levels of CO_2 is the acidification of the oceans,[38] which could have significant consequences in altering species composition, disrupting marine food webs and ecosystems, thus affecting marine-based diets of people worldwide.[39] Recent comprehensive reviews have found that overall, marine degradation is happening at a faster rate and at a greater scale than was previously believed.[40] In particular, while marine defaunation (destruction of animal species) began later in the oceans than on land. "Humans have profoundly decreased the abundance of both large… and small… marine fauna".[41]

Unprecedented challenges

Clearly, we – and more particularly our descendants – face some daunting challenges that are compounded by the fact that these global ecological changes interact and their collective impacts may be far greater.[42] For example, the Millennium Ecosystem Assessment coordinated by the United Nations Environment Programme (UNEP) designed four scenarios exploring ecosystem changes to the year 2050. Under all four scenarios, the projected changes in the underlying driving forces result in significant growth in the consumption of ecosystem services, continued loss of biodiversity and further degradation of some ecosystem services.[43]

We are facing novel challenges, unprecedented in human history, and we can only 'feel our way' towards solutions. The ecological decline that is already underway will continue for decades to come, even if we were to start doing everything right today. But, we know we will not do everything right from now on, given the inertia and time lag built into our social systems, so we will continue to create an ecological deficit.

Moreover, this decline is not likely to be a smooth, linear and predictable affair. The potential for rapid non-linear change – state shift – exists. Should that happen, ecosystem decline would become collapse, thus dooming the human societies that are embedded within and dependent upon those ecosystems.[44] Therefore, we must view ecological decline as a present-day reality, not as an improbable future to ignore or wish away. Prudence and concern for future generations should guide us to take responsibility and adopt a precautionary approach and assume the worst. If we assume the worst and are found wrong, the cost to society is far less than the price of doing nothing and facing collapse unprepared.[45]

We know that making the necessary changes will be slow and difficult, which is why we have a sense of urgency. It could be decades before beneficial social changes become widespread, and even longer before beneficial ecological changes are seen. Thus, the time for public health action on the ecological determinants of health is now!

Societal and human forces driving change

The key human forces driving changes in ecosystem functioning are population growth and urbanization, economic growth and development, technological changes and advances, and social changes and movements aligned to these forces. Underlying and shaping these drivers are societal and cultural values, which for the past 200 to 300 years have emphasized 'progress' or modernization, transforming human societies from rural and agrarian to secular, urban and industrial.[46] The long history of modernization helps us to understand our current social, political, economic and cultural conditions, and, perhaps, to anticipate a post-modern society that enables us to stabilize and reverse these harmful ecological changes.

Twenty years of business-as-usual

In 1992, the CPHA report on global change and public health was published as a clarion call for transforming our society from unsustainable growth to sustainable progress. Regrettably, the past two decades have been marked by a business-as-usual societal posture, with little attention to the ecological determinants of health on the part of population and public health professionals and organizations as a whole.

The Earth's population is growing and migrating. Focused on growth, world economies cycle between booms and busts. Resources and natural environments are exploited and degraded, and technology is advancing rapidly, outstripping society's ability to keep pace with the ramifications of these innovations. Social conditions and values are transforming, some strengthening the harmful aspects of economic growth and development, while others counter them.

The rate and scale of change of the socio-economic forces that drive ecological change grew rapidly in the past century, especially in the past 50 years.[5] The enormous growth of human impact (see Figure 5)[47] over roughly the last century can be understood as a function of population growth (P), multiplied by affluence (A) and by technology (T).[48] These societal forces and their underlying social values are briefly discussed below.

Population growth

Global population is projected to reach 8.1 billion in 2025, 9.6 billion in 2050 and 10.9 billion by 2100.[49] But this growth is not uniform; in the recent past, most growth has occurred in the Global South. While population increased in the more developed regions by about 50% from 1950 to 2005, it more than tripled in the less developed parts of the world.[50]

Canada's population grew from 29.6 million in 1996 to 35.1 million in 2013, an increase of 18.6% in 17 years. The annual growth rate over the past 30 years has averaged 1.1%, which is roughly the same as the world population's rate of growth. From 2009 to 2036, Canada's population is projected to grow from 33.7 million to between 40.1 million and 47.7 million.[51] A more recent and longer-term projection is that Canada's population will grow to 51 million people by 2063.[52]

Urbanization

For the first time in human history, we live in an urban world. At the start of the 21st century, more than 50% of the

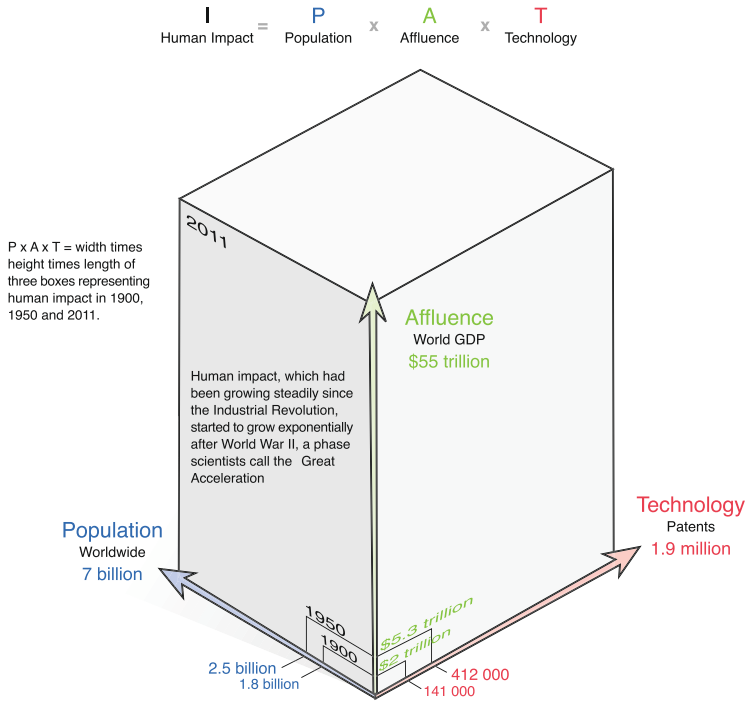

Figure 5: A depiction of the I = P x A x T formula for human impact
Source: Steffen et al, 2011.[47]

world's population are urbanites; and by 2050, 67% of the globe's population will be living in urban settings, with 86% urbanized in more developed regions and 64% in less developed regions.[53] Almost a billion people, one third of the world's urban population, live in slums and informal settlements.[54] These residents bear the burden of ever-widening inequalities in income within countries, inequitable distribution of wealth, and a greater burden of environmental hazards.

Moreover, many cities are located in areas of natural hazard – severe and extreme weather and climate events. The number of people exposed to these hazards is exacerbated by two factors: the growth of cities into areas of hazard, and the expansion of the zones of hazard due primarily to the impacts of climate change, including rising sea levels, more severe weather events and drought.[53] Those at greatest risk are mainly the poor in the Global South.

Urbanization has very complex effects on Earth's natural systems. Often these effects are harmful, but paradoxically, well-designed and planned sustainable cities can have significant environmental benefits,[55] while simultaneously providing significant economic and social benefits.[56] Clearly, we are tasked with making our cities ecologically sustainable. An important means is to limit urban sprawl, especially given its harmful health effects.[57] If done well, urbanization holds out the promise of reducing ecological harm and economic costs, while improving health.

Economic growth and development

Economic affluence underlies the damaging human impact on the planet in several ways. Most often measured as either income or wealth, affluence beyond the meeting of reasonable needs becomes a negative force because of the inherent consumption and waste, as well as the fact that increased affluence does not result in increased well-being.

The most common measure of economic activity is the Gross Domestic Product (GDP), although its developer cautioned against its use as a measure of social welfare.[58] The world's GDP increased four-fold between 1961 and 2001.[59] In the past twenty years, it has increased 75%, which, once population growth is taken into account, represents an increase of 40% in GDP per capita (GDPpc). However, this growth is unevenly distributed, with the GDPpc increasing much more (80%) in low- and middle-income countries between 1992 and 2010, a necessary accomplishment if people are to be lifted out of poverty. Nonetheless, a six-fold difference exists in GDPpc between low- and middle-income

countries and high-income countries.[38] In Canada, total GDP more than doubled from $568 billion CAD in 1992 to $1.33 trillion in 2010, while GDPpc almost doubled in that same period from just over $20,000 CAD in 1992 to $39,170 in 2010.[60] By 2013, the GDP (in 2013 USD) was estimated to be $1.5 trillion and GDP per capita was $43,100.[62]

Much of the ecological footprint of wealthier countries, and richer populations within all countries, is their carbon footprint resulting mostly from fossil fuel energy consumption. Therefore, growth in GDP also means likely growth in ecological impact. Since GDP growth remains a prime objective for all nations, the massive scale of such growth has troubling environmental and health implications. In its World Economic Outlook, the International Monetary Fund (IMF) projected a growth in world GDP (Purchasing Power Parity or PPP-adjusted) from $79 trillion in 2011 to almost $116 trillion in 2018 (an increase of 46%).[61,62,63] The same report series projected that Canada's GDP would grow from $1.42 trillion in 2011 to almost $1.9 trillion in 2018, a 31% increase. Overall, the world's economy is expected to almost quadruple in the next half century.[64] While not all of this growth will translate into resource extraction, pollution production or loss of species and biodiversity, much of it will.

On another front, growth in economic activity is generally considered good, because economic development is seen to lift people out of poverty, and there is good evidence that this is true for low- and middle-income countries. However, above $20,000 GDPpc, there is no relationship at all between GDP per capita and life expectancy or a number of other health and social measures. What matters much more for middle- and high-income countries is the degree of social equity, given that health and social problems are worse in countries that are more unequal.[65] Interestingly, GDP growth has been accompanied by growing inequity. One study found that the global Gini Index (a key measure of inequality) grew from 43.0% in 1820 to 56.0% in 1870, grew only slowly from 1950 (64.0%) to 1980 (65.7%) and then jumped to 70.7% in 2002.[66] This increase in inequality is also seen in Canada, where the Gini Index rose markedly in the 1990s and has continued to rise, albeit more slowly, in the 2000s.[67]

Thus, the GDP is a poor means for measuring the well-being of society because it includes harmful economic activity (such as the tobacco industry or the clean-up costs of pollution or a disaster event) and excludes all the non-monetized contributions that people make to social progress, such as volunteerism, growing our own food, caring for family and friends, and so on. In short, GDP puts the economy before any considerations of society or the environment.[68]

Technological change

Technological change is a key characteristic of our times and is driven by economic imperatives and social values. The effects of technological change are mixed; it is clearly part of the problem, but also can be part of the solution. Three characteristics distinguish our technological development over the past two hundred years: its power, scale and pervasiveness. Technology's power is now enormous, and both impressive and scary, while the scale at which it operates is global, and is simultaneously awesome and awful. Finally, the sheer pervasiveness of technology means that our chemicals, nanoparticles and genetically-engineered organisms are becoming ubiquitous in the Earth's natural ecosystems with unknown consequences. Together, their combined impact is what underlies the designation of our current era as the Anthropocene.

On the other hand, the emergence of the Internet and social media has had powerful and important social consequences. One example is Telehealth, which links patients to physicians remotely. It can reduce emissions, increase safety and improve patient access to services; Canadian experience is confirmed by similar results in Australia and Portugal.[69,70] While the full consequences remain unknown, what is clear is that the social movements and social changes these technologies facilitate will be fundamental in shaping society in the 21st century.

Social values and social change

While changes in population, affluence and technology are important, the underlying social and cultural values and norms will drive positive change, as they underlie economic and social beliefs and practices as well as technology usage. Without changes in values and norms, there is little prospect for change in our:

- Social and economic activities and goals;
- Understanding of our relationships with and responsibilities for other people, other species and the Earth;
- Understanding of growth and development; and
- Openness to engage in what we may perceive today as radical change.

The Earth Charter – "a universal expression of ethical principles to foster sustainable development" - is one document that addresses these concerns in full.[71]

The problem is – and we know this from our experience in public health –there is little evidence that values can be changed through simple education or appeals to 'right living', or that changes in values will necessarily result in shifts in behaviour. However, we have also learned that the effective shifting of social norms is feasible, even though it may take decades to occur.

If society is to become more just, sustainable and healthy, public health needs to challenge the prevailing economic norms within society, governments and corporations that increasingly shape public policy. In particular, it means challenging the financial interests that steer economic growth and promote it as the solution to today's problems in ways that rarely consider population or ecosystem health. [72, 73,74]

This is why the power and policies created by some corporations needs to be challenged, particularly because governments appear to prefer protecting these corporations rather than the public. Legitimate confrontational strategies can be used in protecting the health of the public and Earth's natural systems; these techniques have worked in the past and can be applied in the future. Similarly, public health can support, encourage and showcase forward-thinking corporations that demonstrate social and ecological innovations.

Equally importantly, if, as the Brundtland Commission puts it, "the needs of the present are to be met without compromising the needs of future generations,"[3] we must develop a new societal paradigm, one that has been described as post-materialist. Such values are emerging, although it is by no means certain that they will prevail. Studies of global and Western countries' values have shown some evidence that an intergenerational shift from materialist to post-materialist priorities is occurring. However, evidence also exists that the shift towards a post-materialistic culture has tapered off in the wealthy and industrialized West, suggesting no major shift towards de-growth is likely to occur, while materialistic values are on the rise in the rapidly growing and industrializing South.[75] If this is so, the pressures on the world's ecosystems will increase even more. Again, a change in values and a shift in the world's dominant paradigm are needed if we are to live fairly, well and within the limits of the Earth's natural systems.

Implications for population health

While this discussion paper is directed mainly to Canadian public health professionals and educators, and the organizations for which they work, the biophysical and societal effects described here are global. These effects will probably be more extreme in lower-income countries; however, Canadians do not and cannot stand in isolation of those impacts, both on basic moral grounds and because the negative consequences of ecological change felt elsewhere will also affect us.

Our knowledge of the health impacts of global ecological change is surprisingly limited. What we know is imprecise, preliminary and often speculative; we have some idea of the big picture, but the details are lacking. Even in the case of climate change, we have only a modest sense of the potential health impacts, although this has been the focus of some well-resourced research over the past few decades, both globally and in Canada.

We do know that the indirect health effects of global ecological change – those mediated through natural and human systems – are likely to be much greater than the direct effects (such as heat waves), although they are harder to quantify and attribute directly to a specific global change. This difficulty in quantifying the indirect health effects is part of the uncertainty with which we must deal.

Also, we know that massive change is occurring, across multiple ecosystem components and at all scales from the cellular to the global; that the rate of change is rapid, in ecological and geological terms, and to some degree even in human terms; and that we are unprepared. Given the novel conditions we are experiencing, our level of ignorance is likely greater than we recognize. Equally troubling is the level of human denial of the problem, which seriously hinders active efforts towards adaptation and mitigation.

Despite all this uncertainty, the seriousness with which the health community is beginning to take this issue is exemplified by *The Lancet*'s recent publication of a manifesto for planetary health and the joint establishment with the Rockefeller Foundation of a Planetary Health Commission.[76,77]

Some key health impacts of global ecological change are briefly discussed here. Table 1 shows the estimated numbers of people,

Category of health risk	Size/proportion of populations at risk	Types of GECs involved
Malaria	40% of world population	Climate change and land use change
Dengue fever	3 billion	Climate change, urbanisation, world trade
Diarrhoeal diseases (associated with water quality/quantity)	1 billion people	Climate change, land cover change, pollution, irrigation and freshwater shortage, urbanisation
Malnutrition (especially food shortages)	840 million	Climate change, land use, freshwater shortage, biodiversity change
Health consequences of desertification: malnutrition; respiratory diseases; impacts of population displacement	250 million people	Climate change, land use, land cover change
Skin cancer, eye disorders, immune system depression	Mid-high latitude populations (1-2 billion)	Stratospheric ozone depletion

Table 1: The global estimated numbers of people at risk from selected major examples of the adverse health impacts of global environmental changes
Source: Global Environmental Change and Human Health, 2007.[78]

globally, at risk from selected adverse health impacts of global environmental changes.[78] It is obvious that a multitude of impacts stem from a variety of causes, and that the populations at risk are very large, ranging from hundreds of millions to billions of people. The health impacts of some of these key areas of global environmental change are worth highlighting.

Health impacts of climate change

The most recent report by the Intergovernmental Panel on Climate Change (IPCC) assesses the probability of major increases in ill health by the mid-21st century due to climate change as follows:

- Very high confidence
  - Greater risk of injury, disease and death due to more intense heat waves and fires
  - Increased risks of food-borne and water-borne diseases
- High confidence
  - Increased risk of under-nutrition due to diminished food production in poor regions
  - Consequences for health of lost work capacity and reduced labour productivity in vulnerable populations
- Medium confidence
  - Increased risks of vector-borne diseases[79]

The IPCC also points out that health co-benefits exist from reducing emissions of other climate-altering pollutants released by fossil fuel combustion, that have important implications for policy in the areas of energy, transportation and agriculture.

One estimate is that climate change already causes 400,000 deaths annually, while another 4.5 million deaths annually are linked to air pollution, hazardous occupations and cancer associated with our carbon-intensive energy system. This could rise to 700,000 and 6 million annual deaths respectively by 2030.[80] In addition, the economic losses due to heat-induced lost productivity could be very large.[81] One study found that by 2050 there could be 30 million work years lost annually just in the East Asia region.[82]

Pollution and ecotoxicity

According to a recent assessment published by the WHO, the most important health effects at a global level that arise from pollution are:

- Diarrhoeal disease, of which 94% is due to unsafe drinking water and poor sanitation;
- Lower respiratory infections (LRTIs), of which 42% in low- and middle-income countries and up to 20% in high-income countries are due to indoor air pollution, largely from burning biomass indoors for cooking and heating and to a lesser extent outdoor air pollution; and
- Malaria, of which 42% may result from policies and practices regarding land use, deforestation, water resource management, settlement siting and house design.[83]

The WHO also notes that our knowledge of the health impacts of ten chemicals of major public health concern is limited.[84] This is a concern because environmental pollution

has been a public health concern for decades and in the case of some pollutants, for centuries. The reasons for this lack of knowledge are manifold, but three key reasons are:

- Continued use of a reductionist scientific approach to assess health effects;
- Chemicals' commercial value and potential bias in detecting adverse effects; and
- Our ignorance of what to look for, how to measure it, and how to interpret the findings.

Our ignorance of ecotoxicity – the hazards of simultaneous life-long exposures to many chemicals, which interact in unknown ways – is even greater.[29] In fact, such an assessment is likely beyond our abilities. For example, the (US) President's Panel on Cancer examined the impact of environmental factors on cancer risk and concluded that "the true burden of environmentally induced cancer has been grossly underestimated".[85] In addition, almost 800 chemicals are known or suspected to be endocrine-disrupting chemicals (EDCs), but very few have been properly tested, even though ample evidence exists of widespread and simultaneous exposure of both humans and wildlife to multiple EDCs.[86]

Of particular concern is the exposure to persistent organic pollutants (POPs) and EDCs, as well as heavy metals *in utero* and during childhood, especially puberty, because the developing foetus, infants and young children are particularly vulnerable to toxic chemicals.[87] Yet, while finding some evidence for the health impacts of prenatal and childhood exposure, two recent Canadian reviews of the literature found many associations had limited or inadequate evidence, mainly because of an insufficient number of studies or methodological problems such as small sample size, a limited range of exposure or poor exposure indices.[88,89]

Resource depletion

Many resources necessary for continued social and economic functioning are in decline or starting to decline, while the global population is growing and societal expectations are rising. A recent study suggests that for 16 of 27 global resources, peak rates of use centred on 2006 (1989-2008) and "18 of the 20 renewable resources have passed their peak rate of appropriation".[90] Some resource losses will pose inconveniences, but for others such as energy, water, fisheries and soil, the effects will be catastrophic locally and potentially globally. As with other global changes, the impacts of resource scarcity will be felt most in low-income countries and among low-income and disadvantaged populations around the world. Among the major concerns are the depletion of water, soil, agricultural land and fisheries, since they provide the most basic requirements for life and health. They are also intimately linked with the issue of energy supply. An integrated strategy to address the nexus of the key resource issues of energy, food and water is needed.[91]

For example:

- Inadequate water supply may be a major factor in determining population health in many parts of the world, not least because of its impact on food production.[10] Yet we know of many proven ways to reduce water consumption in agricultural, resource extraction, industrial and domestic settings; we simply need to apply what we already know.
- World food production will need to double within the next 50 years, yet it is threatened by inadequate water supply, soil degradation and loss, as well as threats to the ocean and to fish stocks. Again, we have many tested strategies that are not fully applied, including better storage, more equitable distribution and less waste.
- Seventy-five percent of the world's agricultural land is used for raising animals. This is problematic because an animal-based diet is a much less efficient way of providing food than a plant-based diet. A shift to a low-meat or vegetarian diet would have a number of direct health benefits.[92]

In addition, energy, especially fossil fuel energy and electricity, is a major determinant of health in our modern world. But fossil fuel energy is at risk of depletion in the relatively near future or subject to drastically curtailed use if we heed concerns about the planetary carbon budget.[93] Fossil energy has driven the vast majority of social and economic development for the past 200 years; the effects of its loss are difficult to imagine yet we must plan for such loss.

Again, we know what to do; the potential of energy conservation and efficient use is well established. "Increasing energy end-use efficiency – technologically providing more desired service per unit of delivered energy consumed – is generally the largest, least expensive, most benign, most quickly deployable, least visible, least understood, and most neglected way to provide energy services."[94] Just as there are health benefits from a shift to a low-meat or vegetarian diet, so too health benefits will accrue from a shift from fossil fuels to conservation and renewable energy. The opportuni-

ty cost of failing to invest in energy efficiency "may represent a cost that we cannot afford to bear."[95]

Loss of species/biodiversity

Many of the ecosystem goods and services on which we depend are created through the actions of other species, from bacteria and phytoplankton to corals, insects and birds.[96] The Sixth Great Extinction currently underway represents the most profound, most difficult to quantify, and least understood threat to human health. Humans must pay attention to the health of other species and populations, not just our own. A recent report from the Secretariat of the Convention on Biological Diversity and WHO has started to address this question in more detail.[97]

Looking at future impacts

In 1994, the Canadian Global Change Health Panel reported, "there is no comprehensive approach to health aspects of global change in Canada."[98] This statement is still largely true. We have little good data on the environmental burden of disease in Canada, never mind the burden of disease related to ecological change. For example, the terms 'ecosystem' and 'ecological' do not occur in a recent report on the environmental burden of disease in Canada.[99]

However, we do not lack knowledge. A recent Canadian government report on climate change and human health found stronger evidence since the previous assessment in 2008 that "a wide range of health risks to Canadians are increasing as the climate continues to change".[100] Health Canada has been monitoring environmental chemicals in Canadians since 2007.[101] One area of particular concern is the high level of persistent organic pollutants in the food chain and the bodies of Inuit living in the Arctic.[102]

Canada is a large, wealthy and highly industrialized nation, and as such is able to protect itself somewhat from the impacts of many forms of global ecological change, at least in the short to medium term. But we share the planet as part of a global community and global economy, so there is a real limit to self-protection.

As hard as it is to measure the current health effects of global ecological change, it is even more difficult to provide good estimates of future health impacts. Many social, political and economic factors constituting the social determinants of health will influence those impacts, along with the degree of societal development, the commitment to social solidarity and equity, as well as local geography and environmental conditions.

Given the trends in ecosystem functioning described here and the unremitting pressures of growing populations, growing per capita demand, more powerful and pervasive technology and the dominant paradigm of modernization, it is likely that adverse health impacts will worsen. However, the real danger lies in sudden, rapid and largely unpredictable, non-linear changes triggered as we pass ecological boundaries, or tipping points. Varying degrees of ecological collapse, from local to global, and aligned societal decline or collapse will have large, sudden and difficult to resolve health impacts. Moreover, we know those health impacts will be inequitably distributed, in inverse relationship with power, money and resources. In fact, ecological decline is likely to widen inequalities in power, wealth, access to resources and the related level of health.[103]

Such a future need not be inevitable. As we have seen time and again, when faced with extraordinary situations, people, communities and nations are capable of extraordinary actions. Whether it is the industrial slums of 19th century England, the choking smog of early 20th century industrial cities or the disappearance of the stratospheric ozone layer, we have risen to the challenge. But we must act decisively and soon to create a different society, based on different values. Public health has been in the forefront of action to address previous massive threats to the health of populations, and must play that vital role again in confronting what is the largest threat to health that humanity has ever seen.

Imagining a better future

Issues arising at the interface of health, ecosystem sustainability and social justice constitute what some call a 'wicked problem'. Such problems challenge the way a society operates and call for changes in that society.[104] We will need some fundamental shifts in societal values, and with that new principles, and new ways of knowing, measuring and governing. Fortunately, we do not have to invent these from scratch as we have precedents and newly-emerging practices that can help provide a foundation for the new future we need to create.

First and foremost, we acknowledge the precedents and insights offered by Canada's Indigenous communities. It is imperative to build on the rich traditions and wisdom of First Nations, Métis and Inuit communities' holistic understanding of the interconnectedness of individuals, communities and the environment. Secondly, we draw on public health's long history of leading social, urban and political reform that accompanied industrialization and urbanization in the past. We have precedents and foundations in research, education and practices in the fields of Ecohealth and One Health, resulting from decades of leadership by Canadian and international scholars and practitioners. Finally, we can draw upon the social and ecological practices rooted in communities across Canada (and the world) addressing issues such as the cod fishery collapse in Newfoundland; the Sydney tar-ponds in Cape Breton, Nova Scotia; asbestos mining in Asbestos, Quebec; chemical pollution in Sarnia, Ontario affecting the Walpole Island First Nation; radiation pollution in Port Hope, Ontario; oil sands development affecting First Nations and Métis in northern Alberta; and forestry practices affecting First Nations in Clayoquot Sound, British Columbia, to name but a few.

The fields of health promotion and Ecohealth offer conceptual and procedural guidance to catalyze a transformation toward public health equity for future populations. Public health is in an ideal position to lead the integration of the social determinants of health, which focus on health equity of current populations, with the ecological determinants of health. In order to do this, we need:

- **New ways of knowing and of gaining knowledge** – Complexity means being or becoming comfortable with ambiguity. More important than just gaining knowledge is gaining wisdom, so that the knowledge we have is used appropriately.

- **New understanding of development** – Development needs to be understood as more than growth in an economic context, expanding to embrace the development of human potential, which is society's greatest resource. Progress should be measured in terms of the growth in human (not economic) development and potential.

- **New form of economics** – The economy is a social construct intended to serve humanity, not the other way around. Alternative approaches to economics, new understandings of capitalism in the 21st century and new ways to measure social progress are hopeful signs and provide an important way of (re)connecting the social and ecological determinants of health.

- **New forms of governance** – Governance is "the sum of the many ways individuals and institutions, public and private, manage their common affairs",[105] collectively solving their problems and meeting society's needs. The 'Health in All Policies' approach is a re-working of the health promotion strategy to create healthy public policies. If we understand that health has ecological as well as social determinants, then public health will need to involve those working in urban planning, agriculture and food security, environment, natural resource extraction, energy policy, forestry and all related issues.[106,107]

That said, appeals to loftier values or the pursuit of technical solutions, while necessary are unlikely to be sufficient engines of change if the underlying dynamics of inequitable power relations, wealth accumulation and exploitation remain unaddressed.[108] Fortunately, public health has a strong set of precedents in linking health, equity and sustainability concerns from local level work that that has explicitly sought to integrate social and physical environments, including settings approaches and neighbourhood-focused work (e.g., healthy schools, workplaces, communities).

First steps towards the future we prefer

If we understand the forces that shape us and the future we face, we are better equipped to make choices, express our values in a vision and then work to create it. Within public health, we need to explore scenarios of plausible futures, and help people create visions describing their preferred future.[109, 110] Scenarios are useful because each one embodies a set of implicit values, which people understand as they engage with them. They can then assess which scenario best fits their own values, and thus constitutes for them a vision of their preferred future.

We need a transformative approach, where we do better things rather than simply doing the same things better. This involves recognizing the limits to what we know (or think we know) and working in partnership with many other disciplines. Opportunities can be found and gains can be made even during dramatic and unexpected change. In these situations, resilience is not the ability to bounce back to the

former (problematic) situation, but to bounce forward to a new, more sustainable and healthy future.

We anticipate both opportunity and tension to arise as the public health community considers building on its existing work and developing new approaches. We must explicitly account for the ecological as well as the social determinants of health when we start visioning – and consciously changing – the future.

Finding hope

The challenges we face are daunting, and can even seem overwhelming. But hope can be thought of as "the commitment to positivity in the face of adversity".[111] We seek a happy medium between starry-eyed optimism based on a naïve belief in the ability of science and technology to overcome all of our problems, and a deep pessimism that says we are all doomed. The helplessness and despair people may feel in the face of the ecological crisis can be addressed through a process called 'Active Hope'.[112] This requires us to:

- Take in a clear view of reality;
- Identify our vision for what we hope will happen; and
- Take active steps to help bring that vision about.[113]

In fact, the shift to a more ecologically sustainable society could result not only in health gains from avoiding harm, but also in a healthier way of living. In working towards a more healthy future, there are messages of hope specifically for the public health community:

- We have successfully helped to create major societal shifts in favour of health numerous times before. We know how to do it, and we can do it again. While the changes we seek are large, and the forces we face are powerful, that was also the case in the long struggle to address the health problems created by the industrial revolution in the 19th century.

- We are not alone. We have many partners among environmental and community organizations and municipalities, private sector businesses and some state/provincial and national governments.

- For the most part we have a good sense of what should be done and daily we learn more. We have known the general direction to take for a long time; that we have not yet succeeded in making the necessary changes is regrettable, but no reason to give up. Indeed, it can strengthen our resolve to keep trying.

- We have already made some progress. Many examples exist of people, organizations, businesses, communities, cities, and entire nations doing the right things and setting examples. Now we need to adopt these practices within our public health and health care organizations and help our partners scale up these activities.

We see signs of hope at a societal and community level in three key areas:

- The conceptual and strategic rethinking going on internationally with respect to development and economics;
- The anticipated health benefits of a more sustainable society; and
- The many inspiring efforts at the local level to build on local capacity and create healthier, more sustainable and more just communities.

While there is no question that when one looks at the global situation and the extent and rapidity of ecological change there is much to worry about, as we look locally, there is cause, if not for great optimism, then at least for hope.

Rethinking development and economics

There are several major developments in the transformation of our concepts of development and economics. In its 1986 Declaration on the Right to Development, the UN General Assembly stated that "the human person is the central subject of development" and followed that with the 1990 creation of the Human Development Index (HDI) and its adoption by the UN Development Program.[114]

Then in 1987, the World Commission on Environment and Development championed sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".[3] The Commission's work spawned a large and sustained effort that continues today among NGOs, governments at all levels, many corporations and individuals. In recent decades, an increasing number of corporations have moved towards sustainability, social justice and equity. International efforts such as the ISO standards for environmentally responsible business practice, corporate reporting on sustainability and the emergence of the concept of corporate social responsibility are all desirable steps that must be encouraged and supported.

There is also a long history of the creation of alternative, human-centred, socially just and ecologically sustainable economic models.[68, 115, 116] A key tenet of these forms of ecological economics is that at least five forms of capital exist: natural, social, human, economic and built capital. Moreover, much of the world's true wealth lies in its natural, social and human capital.[117] Of these, human capital (which includes health and well-being) is the major concern of health and human development professions. Together, these comprise community capital at the local level.[118]

As stated earlier, the GDP is a poor measure for our purposes as it emphasizes economic rather than human development and progress. It fails to account for the harmful impacts of economic activity and excludes non-monetized contributions to social welfare. Below are several alternative measures of progress more suited to measuring sustainable social well-being and human development.

- The **Genuine Progress Indicator (GPI)** starts with the same personal consumption data that underlies the GDP and adjusts for factors such as income distribution, adds factors such as the value of household and volunteer work, and subtracts factors such as the costs of crime and pollution.[119] A recent study compared the GDP and GPI for 17 countries for the period from 1955 to 2005. While global GDP has increased more than three-fold since 1950, the GPI has decreased since 1978. Moreover, beyond about $7,000 GDP per capita, further increases in GDP per capita are negatively correlated with GPI.[120]

- The **Canadian Index of Wellbeing (CIW)** "tracks changes in eight quality-of-life categories. From 1994 to 2010, while Canada's GDP grew by 29%, our CIW improved by only 5.7%."[121]

- The UK New Economics Foundation's **Happy Planet Index** measures environmental impact on well-being, with country ranking on the number of long and happy lives they produce per unit of environmental input.[122] In 2012, the top three countries were Costa Rica, Vietnam and Colombia; Canada placed 65th with an ecological footprint more than 2.5 times as large as Costa Rica's.

- A radical alternative indicator of progress is **Gross National Happiness (GNH)**. This measure, developed in the Buddhist Kingdom of Bhutan, is calculated from 124 weighted indicators collected in 33 clusters, which are based in one of nine domains.[123] Countries, regions and communities around the world are working on versions of this indicator.

Health and other co-benefits of a more sustainable society

There are very large health costs to our current way of life, and thus very large potential health benefits from a shift to a more sustainable society. The application of a health and sustainability lens to public policy would result in healthier public policies and healthier societies and communities. The key policy areas with significant health and sustainability co-benefits include energy, agriculture and food, urban design and transportation.

The direct global health impacts of energy systems have been likened in scale to tobacco, alcohol, and high blood pressure, and exceeded only by malnutrition. One study estimated they "directly cause as many as five million premature deaths annually and more than 5% of all ill health when measured as lost healthy life years."[124] Numerous studies have reached similar conclusions: renewable energy (wind and solar) and conservation have much smaller health and environmental impacts.[125,126] Clearly, very significant health benefits may result if we move away from carbon-based energy use, with conservation and renewable energy systems offering a much healthier future. In addition, recent reports have pointed to the significant economic benefits of energy efficiency,[95] a reduction of greenhouse gases and a shift to a 'new climate economy'.[22,57]

Our current food system provides a highly processed diet that is low in fibre and high in animal protein and is based on an environmentally harmful agricultural system. If we are to dramatically increase global food production to meet growing populations and demands, and simultaneously reduce environmental harm, we need a very different agricultural system and diet. There are important health benefits to a low-meat diet and an agricultural system based on ecological principles: conservation of land, soil, water and biodiversity, reduction of greenhouse gas emissions and pesticide and herbicide use; and direct health benefits, including reduced rates of cardiovascular disease, diabetes and cancer.[94]

The health impacts of urban design, specifically of urban sprawl, have become more widely understood in recent

years. Health impacts of urban sprawl include those of climate change because urban sprawl is energy-inefficient,[58] requiring the use of a car for many of the daily activities of life.[127] There is a growing body of evidence on the health benefits of improved urban design; indeed, the health benefits of Smart Growth (a key urban development solution to urban sprawl) have been likened to a "medical miracle."[58] Moreover, the economic benefits of building "better connected, more compact cities based on mass public transport" are very significant.[57]

In short, a more environmentally-sustainable way of life brings with it many health benefits that are often overlooked. Public policies and community and societal actions in the areas of energy, transportation, urban planning, architecture, agriculture, fisheries, food and many other policy areas that move us in the direction of a more sustainable society are in fact healthy public policies.

Advances at the local level

The local level, where we lead our lives, provides visible signs of hope. Commonly, in these settings, small groups "think globally and [mainly] act locally."[128,129,130] The remarkable achievements of many small groups and the community-based organizations that nurture them are inspirational. Small local actions have great power when they become linked into larger networks at the national and international levels. As Margaret Mead stated: "Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it's the only thing that ever has."[131]

Local community groups are in fact a major component of a community's assets and form the basis for asset-based community development (ABCD), which is an important contributor to hope at the local level. ABCD is an approach that empowers both individuals and communities by focusing on community strengths and on the assets and skills of community members. Instead of concentrating on needs, problems and services, communities look at the capacities, skills and assets of people, community organizations and institutions and the physical assets of their neighbourhoods. By shifting to a capacity-oriented emphasis, communities take ownership of their issues.[130]

Community-level action is very important for public health, since most public health staff work at the local level. As well, public health has made many important contributions, and until recently, was closely related to local government. The Healthy Communities approach has been around as long as the concept of sustainable communities and linkages between health and sustainability at the community or municipal level have been proposed for at least twenty years.[132] Most healthy community or healthy city initiatives include a strong focus on sustainability, which remains a key theme in the WHO Europe Healthy Cities network and in the provincial Healthy Community initiatives in Canada. There are numerous examples of policies and programs that advance the cause of health and sustainability, and many resources are available. In addition, other settings (homes, schools, workplaces, hospitals, etc.) should be engaged as integral parts of these community initiatives.

It is not, however, just about having the right policies, they must also be implemented effectively by using processes that engage communities, their relevant governing agencies, and their citizens. Experience has shown that this involves a formal political commitment, community engagement and asset-based community development, multi-sectoral collaboration and healthy public policy.[133]

Towards transformative change

There are more grounds for optimism when we look at how far we have come. In the case of ecologically sustainable development, we have seen the concept and practices become commonplace in some parts of governments and the private sector, and we have seen standards and guidelines developed and become the norm. We have even seen some national governments begin to question basic concepts behind our current economic models and our measures of progress, and we have seen major international organizations make sustainable human development their central concern.

Above all, we have seen millions of people in countries around the world working to create healthier, more sustainable and more just communities and societies. There is a sense that we are poised not only on the cusp of disaster, but also on the cusp of transformative change. Our task as public health professionals is to take our place in this vast movement and help ensure we embrace transformative positive change.

An agenda for action

CPHA's vision of healthier, more sustainable, more just societies and communities will not be achieved in isolation from wider social processes. Realizing any such vision will demand transitions both within and outside public health and the larger health sector, including an explicit re-engagement with the values of public health.

This agenda for action on the ecological determinants of health is designed for public health professionals and organizations. The emphasis is on individual public health professionals because we firmly believe that unless each of us better understands and accepts the reality of the health challenges posed by human-induced ecological changes identified here, we will not be effective as members of public health organizations in working with others to address these issues.

There are nine major categories of recommended actions.

1. **Expand the guiding principles of public health**
   We view the following six guiding principles as fundamental for our collective future, while noting their origin in the values, knowledge and actions of Indigenous peoples over millennia. These principles should guide societal and public health action with respect to the ecological determinants of health:

   - Expand our thinking from one centring on humans to one that considers all life – a combination of anthropocentrism and ecocentrism. While we maintain a concern for human health and well-being, we need to view humans as part of the web of life, and understand that human health depends on the effective functioning of ecosystems, the health of other species and the sustainable use of available resources.

   - Embrace intergenerational equity. We have a duty towards future generations to ensure that they can expect a decent quality of life and good health.

   - Acknowledge and enshrine the right of present and future generations to a healthy environment by supporting calls for the Canadian Constitution to be amended to recognize the right to a healthy environment.

   - Adopt the principle of environmental justice, which means ensuring that disadvantaged groups or communities do not suffer damaged ecosystems and increased health risks because of their disadvantaged status.

   - Adhere to the prevention imperative that requires us to avoid further harm to ecosystems that impairs their functioning and thus undermines our own life-supporting systems. This will involve reconsidering our needs, lifestyles and economic system.

   - Apply the precautionary principle (as defined in the Rio Declaration),[134] already present in some public health legislation, to the ecological determinants of health. Public health organizations and practitioners should use the legislative powers available to them to support and apply the precautionary principle in addressing global ecological change and its implications for population health.

   In addition, the application of two key mechanisms are required in societal decision-making:

   - Apply comprehensive impact assessments that address the ecological, social, health and economic impacts of all major public policies and private sector developments.

   - Apply the concept of full-cost accounting for ecological change throughout our economy, as well as the principle that when harm is done, the polluter pays.

   These principles and mechanisms should be adopted by public health organizations, incorporated in the Public Health Core Competencies and professional codes of practice, and taught as part of the core public health curriculum.

2. **Understand and address the ecological determinants of health**
   Public health professionals and organizations must improve their capacity to understand and address the ecological determinants of health and how they interact with the social determinants of health. Accordingly, we propose the following set of strategies to enact the principles and mechanisms noted above:

   - **Integrate the ecological determinants of health into population health frameworks:** We need to revise our population health frameworks to become true socio-ecological models that give greater weight to

the ecological determinants of health and to interactions between them and the social determinants of health.

- **Educate public health professionals about the ecological determinants of health:** To do so, we must revise our core competencies, our training and licensing curricula and foster an interdisciplinary and multi-sector approach to social change.

- **Monitor, assess and report regularly on the ecological determinants of health with respect to immediate and longer term public health needs:** We must identify and promulgate key health indicators for conditions plausibly related to ecological change, for use within impact assessments and as early-warning or sentinel conditions to be monitored.

- **Fund and support research into the ecological determinants of health:** A significant and ongoing, long-term commitment to supporting research on the health impacts of ecological change is required. This will include research on the relationship between the ecological and social determinants of health, and effective strategies and interventions for the prevention and mitigation of health impacts and adaptation to ecological change. The goal here is to strengthen knowledge translation and exchange.

- **Establish a UN Commission on the Ecological Determinants of Health:** We call upon the UN to establish a Commission on the Ecological Determinants of Health to undertake work and continue the important investment in knowledge, similar to that of the Commission on the Social Determinants of Health.

For specific suggestions for action, see Appendix B.

3. Walk the talk: Environmentally responsible health care

Public health organizations and their parent health care organizations should apply the principles and practices of environmentally responsible health care, consistent with established national and international standards and codes of practice (e.g., Leadership in Energy & Environmental Design (LEED), International Organization for Standardization (ISO), etc.).

For specific suggestions for action, see Appendix B.

4. Change social norms and values

Public health must join others in working towards a fundamental shift in the values and social norms of Canadians in order to create change and effectively address the emerging ecological crisis. To do this, public health organizations and practitioners need to listen to and learn from those already working toward more positive futures, and foster alliances with other efforts that demonstrate socio-ecological approaches to the health of present and future generations.

For specific suggestions for action, see Appendix B.

5. Change the focus of development and the way it is measured

Public health professionals and organizations must consistently and persistently argue for measurement of social development and progress, at all levels, that reflect the ecological determinants of health and are focused on sustainable health, wellbeing and human development. Public health should champion a pan-sectoral focus under the banner of "Health in All Policies".

For specific suggestions for action, see Appendix B.

6. Strengthen ethical purchasing and investment policies

All public health organizations should develop ethical and ecological purchasing and investment policies and criteria to exclude receiving financial benefits from those economic activities deemed to be the most harmful to local or global ecosystems.

For specific suggestions for action, see Appendix B.

7. Protect people and communities from harm and health inequity

Public health practitioners and organizations should examine how to use public health legislation to address the public health impacts of ecological change, and should request the Minister, Provincial Health Officer or other appropriate public health officials to initiate an inquiry or investigation where their Public Health Act requires or enables such an action.

For specific suggestions for action, see Appendix B.

8. Protect people and communities from the adverse impacts of ecological change

The public health sector at all levels must address real and potential adverse impacts of ecological change

using two main approaches: first, to reduce vulnerability and protect the vulnerable, and secondly to increase resilience and adaptation.

For specific suggestions for action, see Appendix B.

9. Work with others to establish policies and practices that create more ecologically sustainable and healthy societies and communities.

Public health must find allies and forge partnerships with those individuals and organizations at all levels and in all sectors of society that share our vision to create a more just, sustainable, and healthy society. Policies and practices in the public and private sectors should be examined from a population health perspective, as part of comprehensive impact assessments. Those that are consistent with improving or not harming the ecological determinants of health should be adopted or encouraged, those that would do harm must be amended or dropped. As a general principle, public health should support the transfer of public subsidies and tax incentives from economic activities that worsen the ecological crisis to those that improve ecological functions and resource sustainability.

For specific suggestions for action, see Appendix B.

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Appendix A: Acknowledgements

This discussion document is based on the report *Global Change and Public Health: Addressing the Ecological Determinants of Health: The Report in Brief* developed by a Canadian Public Health Association (CPHA) working group.

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Many people were involved in the development of this body of work. CPHA's Board of Directors gratefully acknowledges the contributions of the members of the Working Group, Reference Group, volunteers and student practicum placements.

This body of work was also shaped and influenced by two public forums held at the 2012 and 2013 CPHA annual conferences, and we are grateful to all those who took part and provided input and comments.

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Appendix B: From Ideas to Action

Public health professionals and organizations need to improve their capacity to understand and address the ecological determinants of health and how these interact with the social determinants of health. The following recommendations for action aim to enact the principles and mechanisms noted in this discussion paper. They provide a starting point for in-depth discussions within the public health community and among the various stakeholders on the way forward.

Understand and address the ecological determinants of health

Educate public health professionals about the ecological determinants of health:

- Update Canada's set of Core Competencies for Public Health to give greater prominence to the ecological determinants of health, ensuring that public health practitioners have the ability to address both the ecological and social determinants of health;
- Revise the curricula in Canada's Schools and Programs of Public Health to reflect a broader understanding of population health and its determinants, incorporating core concepts or courses that address the ecological determinants of health and links with social determinants;
- Encourage awareness of combined approaches to ecological and social determinants of health that will align public health with a range of existing movements spanning environmental, Indigenous, conservation, labour, social justice, climate change efforts, etc. and;
- Include learning of a wide range of change-oriented practices employed by diverse actors involved in complexity science, community organizing, social practice theory, interdisciplinary work on governing societal transitions, transformative learning, Theory U, generative dialogue, etc.

Monitor, assess and report regularly on the ecological determinants of health with respect to immediate and longer term public health needs:

- The Public Health Agency of Canada, the Canadian Institutes for Health Information (CIHI), and Statistics Canada should develop and test a set of indicators of the ecological determinants of health to be used to monitor and report on these issues across all four orders of government (i.e., federal, provincial, municipal and First Nations) and to guide more comprehensive impact assessments of the ecological, social, health and economic impacts of major public policies and private sector developments. Specifically, to:
  - Identify health indicators for conditions plausibly related to ecological change for use within impact assessments and as early-warning or sentinel conditions to be monitored;
  - Revise the core set of indicators of health used in Canada to include indicators to measure key ecological determinants of health, the socio-ecological system and sentinel health conditions associated with ecological change;
  - Ensure that public health reports at all levels include indicators of ecological determinants of health in routine reports, and report specifically on them on a regular basis, reflecting local, regional, provincial, national, indigenous and global contexts; and
  - Assure that as much effort and profile are applied to the collection and publication of data on the state of the environment as on the state of the economy. This sustained activity will build capacity for full-cost accounting of ecological change throughout the economy and create knowledge to ensure when harm is done, the polluter pays.

Fund and support research into the ecological determinants of health:

- CIHR and other research funding bodies should make a significant and long-term commitment to funding research on the health impacts of ecological change, the relationship between the ecological and social determinants of health, and appropriate strategies and interventions for the prevention and mitigation of health impacts and adaptation to ecological change.
- CIHR should establish an Institute for Environment and Health, as a tri-council institute in conjunction with the Social Sciences and Humanities Research Council (SSHRC) and Natural Sciences and Engineering Research Council of Canada (NSERC), in order to more fully address the broader dimensions of a socio-ecological approach to population health.
- A dedicated fund should be established within the Canadian Global Health Research Program for research on the health impacts of anticipated ecological changes globally.
- Governments should re-invest substantially in Canada's capacity to monitor, undertake research, manage information, conduct impact assessments and report on ecological

change in Canada and globally. This will require investment in personnel, programs and technology.
- Research must be directed to the important tasks of knowledge translation and exchange, moving knowledge of ecological determinants of health into actions, policy and mechanisms to address these issues, and working in conjunction with relevant organizations to address this.

Establish a UN Commission on the Ecological Determinants of Health

- The UN should establish a Commission on the Ecological Determinants of Health to undertake work and continue the important investment in knowledge, similar to that of the Commission on the Social Determinants of Health.

Walk the talk: Environmentally responsible health care

- Public health organizations and their parent health care organizations should be members of the Canadian Coalition for Green Health Care and should apply the principles and practices of environmentally responsible health care, consistent with established national and international standards and codes of practice (e.g. LEED, ISO, etc.).
- The Cochrane Collaboration should be asked to undertake a review of the various green/sustainable health care initiatives.

Change social norms and values

- Develop and maintain a public dialogue on the Ecological Determinants of Health, because public participation is required to develop new values and social norms and to support broad national and international actions.
- Public health should work with interested individuals, organizations and communities to develop a shared vision of what a healthier, more just and sustainable future might look like, and how to achieve it, such as contained in The Earth Charter.[135]
- Public health should join others in working towards a fundamental shift in the values and social norms of the population in order to create change to address the emerging ecological crisis. To do this, public health organizations and practitioners need to listen to and learn from those already working toward alternative, more positive futures, and to foster alliances with other efforts that demonstrate socio-ecological approaches to the health of present and future generations.

Change the focus of development and the way it is measured

- Public health professionals and organizations must persistently argue for measurement of social development and progress, at all levels, that reflect the ecological determinants of health, sustainable health, wellbeing and human development, using the Canadian Index of Wellbeing or international alternatives such as the Genuine Progress Indicator, the Happy Planet Index, or Gross National Happiness.
- Public health organizations should incorporate measures of human and social development in health status reports, as well as advocating for such measures to be used in the wider governmental and societal context.
- "Health in All Policies" must be a major focus for public health, including to actively develop capacity to engage in intersectoral conversations that have implications for ecological and social determinants of health.

Strengthen ethical purchasing and investment policies

- Public health professionals and organizations should consider the ethical and ecological implications of their own purchasing and investment decisions, and develop ecological purchasing and investment policies including criteria to exclude receiving financial benefits from economic activities deemed to be the most harmful to local or global ecosystems.
- Public health organizations should partner with and accept funding only from industries that adhere to practices that will move us towards the sustainable, just and healthy future we seek. .
- Public health professionals and organizations must call for disinvestment, including by public pension funds, from ecologically harmful businesses.

Protect people and communities from harm and health inequity

- Public health practitioners and organizations should examine how to use public health legislation to address the health impacts of ecological change, and should request the Minister, Provincial Health Officer or other appropriate public health officials to initiate an inquiry or investigation where their Public Health Act requires or enables such an action.
- If the Public Health Act in a given jurisdiction does not require or enable public health officials to initiate an inquiry or investigation, public health practitioners and organizations should advocate for changes to the Act.

Protect people and communities from the adverse impacts of ecological change

- There are two main strategies: Reduce vulnerability and protect the vulnerable, and increase resilience and adaptation.
- The public health sector at all levels and the health care system in general must identify its own vulnerability with respect to its own mandate to protect and promote public health.
- Public health practitioners and organizations should expand their work with others to prevent, prepare for and respond to emergencies arising from ecological changes. This includes to:
- Identify the vulnerability of individuals and communities to increasing frequency and severity of floods, fires, storms, urban heat events and other climate-related events;
- Identify and protect the most vulnerable populations;
- Set up mechanisms to manage ecological decline; and
- Increase the resilience of the communities with which they work.

Work with others to establish policies and practices that create more ecologically sustainable and healthy societies and communities.

- Public health professionals and organizations need to support collaboration across government departments at all levels and across different sectors of society to help create a more just, sustainable and healthy society.
- Public health professionals and organizations must find allies and forge partnerships among those individuals and organizations in all levels and sectors of society that share our vision.
- Policies and practices in the public and private sectors should be examined from a population health perspective, as part of comprehensive impact assessments. Policies and practices that are consistent with improving or not harming the ecological determinants of health should be adopted or encouraged; those that would do harm must be amended or dropped.
- As a general principle, public health should support the transfer of public subsidies and tax incentives from economic activities that worsen the ecological crisis to those that improve ecological functions and resource sustainability.
- Public health organizations and professionals working at the local level should:
- Adopt an asset-based approach to community development around health and sustainability issues;
- Encourage and support existing sustainable community initiatives (e.g. Transition Towns, ecovillages, ecohousing applications, community gardens, and other related initiatives);
- Encourage and support linkages and collaboration between existing healthy community and sustainable community initiatives; and
- Work to establish healthy and sustainable community initiatives, in partnership with other key groups and organizations, including the efforts of municipal, regional and First Nations governments.

Founded in 1910, the Canadian Public Health Association (CPHA) is the independent voice for public health in Canada with links to the international community. As the only Canadian non-governmental organization focused exclusively on public health, CPHA is uniquely positioned to advise decision-makers about public health system reform and to guide initiatives to help safeguard the personal and community health of Canadians and people around the world. CPHA is a national, independent, not-for-profit, voluntary association. CPHA's members believe in universal and equitable access to the basic conditions which are necessary to achieve health for all.

Our Vision

A healthy and just world

Our Mission

CPHA's mission is to enhance the health of people in Canada and to contribute to a healthier and more equitable world.

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