



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

THE REPORT IN BRIEF

**WORKING GROUP ON THE ECOLOGICAL
DETERMINANTS OF HEALTH**

APRIL 2015

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(Editors)**

DEDICATIONS

This report is dedicated to the memory of Dr. Anthony (Tony) J. McMichael AO, Professor emeritus of Population Health at the Australian National University, who died September 26th 2014. Dr. McMichael was a brilliant environmental epidemiologist and advocate, a giant of public health, an eminent scientist, a generous mentor and a visionary leader who inspired his colleagues and generations of students. Among his many accomplishments he was the leader of the Health Effects Committee of the Intergovernmental Panel on Climate Change from 1993 - 2001, wrote the seminal text on global ecological change and its health impacts for the general public (*Planetary Overload, 1993*) and made numerous other contributions to scientific and human understanding of the health implications of tobacco, the health risks from lead production, uranium mining, rubber production, and ozone depletion as well as climate change. In addition to the Order of Australia, he was an Elected member, US National Academy of Sciences; Fellow, Australian Faculty of Public Health Medicine; Honourary Professor of Climate Change and Health at University of Copenhagen; Honourary Fellow of the London School of Hygiene and Tropical Medicine; Fellow of Australian Academy of Technological Sciences, and a former President of the International Society of Environmental Epidemiology.

The report is also dedicated to Dr. John M. Last OC, Emeritus Professor of Epidemiology and Community Medicine at the University of Ottawa (and another Australian, by birth). John has been an internationally renowned and respected Canadian public health specialist, teacher and author for many years. He too led by example for many years, inspiring us to be passionate about public health. He wrote a Dictionary of Public Health (2006) and was editor for 4 editions of Public Health and Preventive Medicine (1980, 1986, 1991, 1998), eponymously known as "Maxcy-Rosenau-Last" and the foremost public health textbook in the world, and is editor-emeritus of the latest edition in 2007. He was one of the first to sound the alarm about the health impacts of global change, writing an important text (*Public Health and Human Ecology, 1988, 1996*) and in 2002 he was editor for WHO of papers on 'Sustainable development and health' for the UN Summit on Sustainable Development in Johannesburg. His many honours and recognitions include the Defries Award, the highest honour of the Canadian Public Health Association in 2006 and the Sedgwick Memorial Medal for Distinguished Service in Public Health from the American Public Health Association in 2008. He is an honorary life member of the International Epidemiological Association, the American College of Epidemiology, the American Public Health Association, the UK Society for Social Medicine, the Royal Australasian College of Physicians and the British Medical Association. We have been honoured to have him as a member of our Reference Group.

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Note to Readers

This is a condensed version of the full 350-page report that was prepared as the background document to support the CPHA Discussion Document on the ecological determinants of health. While we believe the full report is a valuable resource, with each of its 8 main chapters fully referenced and footnoted, and packed with figures, tables and text boxes, we recognise it is more than many people will want to read. So we present here a precis of the report, including references to the sources cited and a few of the key figures and tables; for the remainder of the figures, tables and text boxes readers are referred to the main report, which we hope will be available later in 2015.

In addition, these technical reports form the basis for the CPHA Discussion Document that was released in May 2015.

The views expressed herein are solely those of the authors and do not necessarily reflect the official policies or positions of the Canadian Public Health Association.

TABLE OF CONTENTS

PREFACE: Words of caution, words of hope	9
Ten key messages	11
Imagine two alternative futures	12
INTRODUCTION	13
CHAPTER ONE – UNDERSTANDING ECOSYSTEMS AND HUMAN HEALTH	15
CHAPTER TWO: THE ECOLOGICAL DETERMINANTS OF HEALTH	17
Biogeochemical cycles	17
Food, land, soil and water	19
Energy	21
CHAPTER THREE: GLOBAL ECOLOGICAL CHANGE: THE RECENT PAST, PROSPECTS FOR THE FUTURE	23
Key ecosystem changes in the past 20 years	26
Ecosystem changes in Canada	28
A more detailed examination of selected ecological changes	29
Climate change	29
Ecotoxicity	32
Resource depletion	32
Species extinction	33
Oceans in trouble	33
Projected changes in global ecosystems	34
CHAPTER FOUR: THE SOCIETAL & HUMAN FORCES DRIVING CHANGE	37
Twenty years of business-as-usual	39
Population growth	40
Urbanization	41
Economic growth and development	42
Technological change	45
Social values and social change	46
CHAPTER FIVE: GLOBAL ECOLOGICAL CHANGE - THE IMPLICATIONS FOR POPULATION HEALTH	48
Population health from a systems and ecological perspective	48

The limits to knowing	49
Key health impacts of global ecological change	50
The health impacts of global geo-climatic system changes	51
Ozone layer destruction	53
Pollution and ecotoxicity	53
Resource depletion	54
Loss of species/biodiversity	57
Health impacts in Canada	58
Looking to the future	60
CHAPTER SIX: IMAGINING A MORE SECURE, HEALTHIER FUTURE	60
Foundations for (re)connecting social and ecological determinants of health	61
Toward shared governance: Crossing intersectoral boundaries in pursuit of health	63
Healthy, just, and sustainable public health approaches – across settings and scales	64
Thinking about and creating the future we prefer	66
CHAPTER SEVEN: SIGNS OF HOPE	69
Rethinking development and economics.	70
The health and other co-benefits of a more sustainable society	73
Finding hope at the local level	75
Towards transformative change	77
CHAPTER EIGHT: AN ACTION AGENDA FOR PUBLIC HEALTH	79
Thinking about and understanding the ecological determinants of health	79
Public health ethics and the ecological determinants of health	79
An expanded concept of public health ethics	80
Action to change and improve our thinking on population health	81
Public health action	82
Walk the talk: Environmentally responsible health care	83
Change social norms and values	84
Change the focus of development and the way in which it is measured	84
Challenge corporate power	85
Ethical purchasing and investment, boycotts and divestment	85
Protect people and communities from social and economic policies and practices that harm health or widen health inequity	87
Protect people and communities from the adverse impacts of ecological change ..	87

Work with others to establish policies and practices that create more ecologically sustainable and healthy societies and communities_.....	89
An agenda for action	89
An expanded concept of public health ethics	89
Action to change and improve our thinking on population health	90
Walk the talk: Environmentally responsible health care	92
Change social norms and values	92
Change the focus of development and the way in which it is measured	92
Challenge corporate power	92
Ethical purchasing and investment, boycotts and divestment	92
Protect people and communities from social and economic policies and practices that harm health or widen health inequity	93
Protect people and communities from the adverse impacts of ecological change ..	93
Work with others to establish policies and practices that create more ecologically sustainable and healthy societies and communities_.....	93
CHAPTER NINE: RECOMMENDATIONS FOR CPHA	95

Appendices

Appendix A: Changes in key global ecosystem components, approx. 1992 – 2012	99
Appendix B: The potential/current and anticipated health impacts of global ecological change	103
Appendix C: Three narratives: Making sense of what is happening and what is possible	108

Figures

Figure 1: A, Eco-Social Framework for Public Health Action	14
Figure 2: Status and trends in global land degradation	20
Figure 3: Key Global Trends, 1961 – 2008 (Indexed to 1 in 1970)	23
Figure 4: Trends from 1750 to 2010 in indicators for the structure and functioning of the Earth System	24
Figure 5: Safe operating boundaries	25
Figure 6: World Ecological Footprint, 1960 – 2010	27
Figure 7: Living Planet Index for high, middle and low income countries, 1960 – 2010 ..	28
Figure 8: Trends from 1750 to 2010 in globally aggregated indicators for socio-economic development	38
Figure 9: A depiction of the $I = P \times A \times T$ formula for human impact	39
Figure 10: World population growth	40

Figure 11: Waves of innovation	45
Figure 12: Integrating healthy and green settings	65
Figure 13: Community capital	71
Figure 14: Adjusted global GPI/capita & GDP/capita, 1945 – 2005	72
Figure 15: Canadian Index of Wellbeing – Composite Index, 1994 – 2010	72

Tables

Table 1: The global estimated numbers of people at risk from selected major examples of the adverse health impacts of global environmental changes	51
Table 2: Patterns of principles for re-engaging with the socio-ecological context for health converging toward health equity for future populations	62
Table 3: Characteristics of the Three Alternative Narratives	67

Text Boxes

In 1968 our world-view changed	13
World Bank on the ‘new climate normal’	30
Right now we’re stealing the future	42
The multiple benefits of Telehealth in BC	46
Our lack of knowledge	49
The benefits of energy efficiency	57
Public health action on climate change	59
Transition Town Peterborough	77

PREFACE: Words of caution, words of hope

The content of this report is intended to provide both a warning and a sense of hope. While for the most part it is worrying, it is not a message of doom and gloom. The hope lies in the fact that we do have options, in fact attractive options – individually and collectively – that, if embraced, could lead to a more just, more sustainable and healthier future for all. Moreover, many actions already being undertaken by people around the world to create that better future form a basis for hope, which is “the commitment to positivity in the face of adversity”.¹

The global ecological changes underway, changes that the human enterprise is now driving, pose major challenges to the health of the global population as well as its social, economic, and cultural institutions. While this is not the first time that public health has faced a massive challenge, the challenges presented by these ecological changes are unprecedented in scope, duration, intensity, and potential for destruction. To address these challenges, we need to use all the knowledge and wisdom gained from our experiences with other public health challenges. As well, we must recognize the considerable ignorance we have regarding how our earth functions under normal circumstances let alone how it will respond to the physical and biological changes resulting from ecosystems stressed by human actions.

As in the past, we need to proclaim and act upon our values, find our allies and partners, speak out and work together to create the best future we can. Our history of improving health is a proud one, and we can learn from that history and do it again. This may be the most important struggle for public health we have faced, but for the most part, we know – and have known for some time – the changes that we need to make. We can and we must succeed

Many parts of this report are bound to be depressing, in much the same way that getting a diagnosis of a chronic, life-threatening disease is depressing. But just as we do not believe that denial is an appropriate response to such a diagnosis at a personal level, neither is it appropriate at a collective global level. On the contrary, as a society we tend to believe that when faced with such a diagnosis we first need to become informed, understand and accept the diagnosis and its implications (the prognosis). Then we need to decide how we intend to cope with this new reality, how we wish to lead our lives, and what actions we will take, both for ourselves and for our family and friends.

Indeed it is no different with the global changes to the ecological determinants of health now underway, as documented in this report. These changes constitute a chronic condition (in human time scales, although, in planetary and geological terms, a rather acute and rapidly progressing condition) that threatens our health as a society, as communities and as a species. So we need first to understand ecosystems and to become informed about the ecological determinants of health and the changes underway in planet Earth’s natural systems (Chapters 1 - 3 of this Report). Then we need to understand the drivers of those changes (Chapter 4) and the health implications of the changes we describe (Chapter 5), before deciding how to cope with this (Chapter 6 describes some alternative approaches). Chapter 7 identifies some grounds for hope, and this leads to suggestions for the actions we need to take (Chapters 8 and 9).

We expect that the material we present here will arouse a range of emotions: Sadness at what we are doing to our only home, planet Earth, to our fellow species and to ourselves; outrage at the short sighted corporate and political leadership that is leading the charge in the wrong direction; and feeling overwhelmed, even despairing at the scale of the problems we need to address - but

1. Dutt, Monika and Brcic, Vanessa (2014) Medicare can still rise to meet its challenges *Times Colonist* 9 Aug, p A 11

also excitement and anticipation at the physical, mental, and spiritual challenges we will face. These and similar sentiments are understandable – and not all bad: What we are collectively doing is saddening, but both sadness and outrage and the anticipation of a challenge are powerful tools for change.

What we must not succumb to is despair, we must not give up. Public health has faced seemingly overwhelming problems before, from the desperate plight of the urban slums of the 19th century to the scourge of smallpox, polio and HIV/AIDS to the toll of preventable death and disease from tobacco and air and water pollution – we have pulled together, mobilized our energy and the energy of others, faced the challenge and dealt with it, or at least made significant progress.

So yes, the situation is bad, but this is a time for resolve, determination and the nourishing of hope as we face this unprecedented global threat to the health of the public. We must begin to regard ecological decline as a present-day reality, not an improbable or undesirable future that we should try to ignore or wish away. Prudence and a concern for future generations should guide us. We need to take a precautionary approach and assume the worst, because the price of assuming the worst and being wrong is far less than the price of doing nothing and facing decline or collapse unprepared.

While we will need to devise new approaches, methods, and skills, and retain and retool old skills in the face of resource depletion and uncertain economies, the good news is that we already have some effective approaches to use.. There are different and better, healthier, more just and more sustainable ways of living, of organising our communities and societies and we are not alone in our efforts to serve public health. Pioneers in communities around the world are working to make a healthier, more sustainable and more just future for our children and their descendants. We need to share with them the power and passion, the knowledge and skills, the values and experience of public health professionals and organisations that make up the public health movement in Canada and around the world. Together we can and we must work to maintain the levels of public health that we already have and aim to create an even better, more sustainable, more just and a healthier future for all.

Hope is better than fear. Optimism is better than despair. So let us be loving, hopeful and optimistic. And we'll change the world.

Jack Layton

Ten key messages

1. We live in a socio-ecological system that has two interacting components: A human-created social system and a natural ecosystem consisting of all of Earth's life support systems.
2. Earth's natural systems provide key 'ecosystem goods and services' (e.g. oxygen, water, food, waste decomposition and recycling, climate stability) that are fundamental determinants of the health of humans and other species. We call these the ecological determinants of health.
3. The combination of population growth, economic growth, rising expectations, over-consumption and powerful technologies (our social system) is harming a number of key Earth systems, in some cases at or beyond critical levels.
4. This human-induced decline in the optimal functioning of key Earth systems, if it continues, will most probably result in social decline (and in some cases, collapse) at all levels, and in all regions of the Earth. It is the most important global threat to health that humanity has ever faced.
5. The harmful health impacts of this decline will not be experienced equally. Disadvantaged people, communities and nations will experience more severe health impacts. However, over time and with greater global change, all peoples will be affected.
6. In the face of this decline, and the resulting health impacts and health inequity, business as usual, never mind an acceleration of business as usual, is not an option.
7. Fortunately, alternative, less harmful forms of social development and economic activity are in general both known and available. The transition to a sustainable, just and healthy future, while not easy, is possible – and necessary.
8. Public health's role is to protect and promote health, prevent disease and injury and reduce inequalities in health. Encouraging and supporting the transition to a sustainable, just and healthy future is entirely consistent with this role.
9. Specifically, public health practitioners and organizations can and must take the lead locally, provincially, nationally and internationally in:
 - understanding and reporting on the health implications and impacts of our current unsustainable forms of development;
 - undertaking research into the health implications of ecological change and the health benefits of alternative approaches;
 - proposing healthier public policies and private and community sector actions that support the transition; and
 - communicating effectively with key stakeholders (including the rest of the health care system and the general public) the importance of this issue, the health implications of our present path and the health benefits of the transition we require.
10. To be effective, public health must ally itself at all levels with those working to bring about the transition to a sustainable, just and healthy future, recognizing that in many cases these partners have many decades of experience to share with us. While public health can provide an important health perspective and can provide leadership within the health care system, we need to support those experienced partners from other disciplines that, in many cases, will correctly continue to take the lead in the wider community and society.

IMAGINE TWO ALTERNATIVE FUTURES: *one in which we have taken the actions called for in this report, and the other in which we continue life as usual, refusing to take the actions called for in this report*

Imagine ourselves first in 2020, or 2030, or perhaps even 2040. We had been forewarned about the calamitous harms that could befall us because of human-induced changes in our global ecological and life-supporting ecological systems *unless* we acted to change our ways. Alternatives were provided to us, but were dismissed by us as impractical and unnecessary. Imagine that these warnings were brought repeatedly to our attention, collectively and individually – but that we ignored these warnings again, and again, and again.

We ignored them on the first, on the second, and again on the third occasion ... and even on the fourth and fifth occasions when the warnings were even more compelling. We ignored them repeatedly.

Then, because of our individual and collective *inaction*, calamitous harms rain down upon us, some slowly, and some more abruptly. Imagine what then. Imagine how we might feel.

On the other hand, imagine instead that we take the actions now urgently called for in this report. Imagine that we averted the predicted and calamitous consequences of inaction.

Consider your situation then, and that of your family and friends, and how you might feel.

This report is designed to rivet our attention so that we might act now to avert the calamitous scenario presented in this report. After all, as public health researchers and practitioners we are all concerned with preventing harms and conserving the public's health, across Canada and wherever in the world we might be.

Imagine the difference in what we would tell our children and grandchildren under the scenario of action, rather than that of inaction. Imagine under the scenario of action the celebration of life that we would feel. Imagine, alternatively, the desperate scenario resulting from inaction, and the sense of guilt, loss and blame that would fall onto our shoulders and the shoulders of others who knew and did not act.

This report has been written by public health researchers and practitioners. It is directed not only to their colleagues but to all individuals, agencies, and institutions interested in the future of human society. It provides essential information to help all citizens minimize the likelihood of the alternative, plausible but largely preventable scenario of extreme societal disruption and failure from coming to pass.

It is certain that there will be changes in how humans live. Many of these changes, even if everything works to our advantage, will not initially be viewed as 'progress' as commonly interpreted today; however, over time it will become apparent that humankind can adapt and live sustainably, securely and equitably under the new and different circumstances required if the consequences of global change are to be averted. Adaptation will be far preferable to the alternative of catastrophic collapse.

There are many roles to play at all levels of society, and public health should take a key place in the lineup. After all, we in public health know how the actions of public health on other social issues have been so fruitful in preventing harms and in conserving life, despite forces to the contrary. This report asks us to rise to the demands of public health's single greatest global challenge: preventing or minimizing the public health impacts of human-induced global ecological change, a phenomenon recognized as "The Anthropocene".

INTRODUCTION

“The establishment of ecological public health as crucial to modern public health is overdue” - McMichael, Butler and Dixon, 2015²

This report updates and considerably expands the Canadian Public Health Association’s 1992 report on human and ecosystem health,³ but with a heightened sense of urgency, because of the relentless, dramatic, and compounding impact of human activity on our ecosystems since then. Many major reports since then have documented the public health implications of global ecological change, most notably Tony McMichael’s groundbreaking 1993 book *Planetary Overload*,⁴ the 1999 WHO EURO Discussion Document *Global Ecological Integrity and ‘Sustainable Development’: Cornerstones of Public Health*⁵ and the 2005 Millennium Ecosystem Assessment.⁶

The basic premise underlying this report is that, as stated in the Ottawa Charter for Health Promotion⁷, the fundamental determinants of health include “a stable ecosystem and sustainable resources”. But because of human activity, the functioning of ecological systems is changing at a rate that compromises the ability of most life to adapt to these changes. These changes are underway globally and at all levels of ecosystem functioning.

This will very likely affect the health of the human population at least as much as do the social determinants of health. In earlier times, this was not a problem; Earth’s systems could cope with the demands placed upon them by humans. But this situation no longer applies; we are at a stage in human history, the Anthropocene,⁸ where humanity is an independent geophysical force of sufficient effect as to place these systems at high risk of failure.

We need to act with the knowledge and understanding that both the social and natural systems



In 1968 our world-view changed – literally and forever. Photographs from moon orbit let us see ourselves in true perspective, as invisible inhabitants of a beautiful, fragile planet spinning in the vast black emptiness of space . . . now, for the first time, we could truly both think and see globally. It has been an important change of view; surely no one who has seen the earth, our home, viewed from space can fail to be moved. The harm that we are doing to this living planet – Gaia – and thus to ourselves, should also move us to sadness, perhaps to anger, but most of all, to action.

CPHA (1992) Human & Ecosystem Health: Canadian Perspectives, Canadian Action

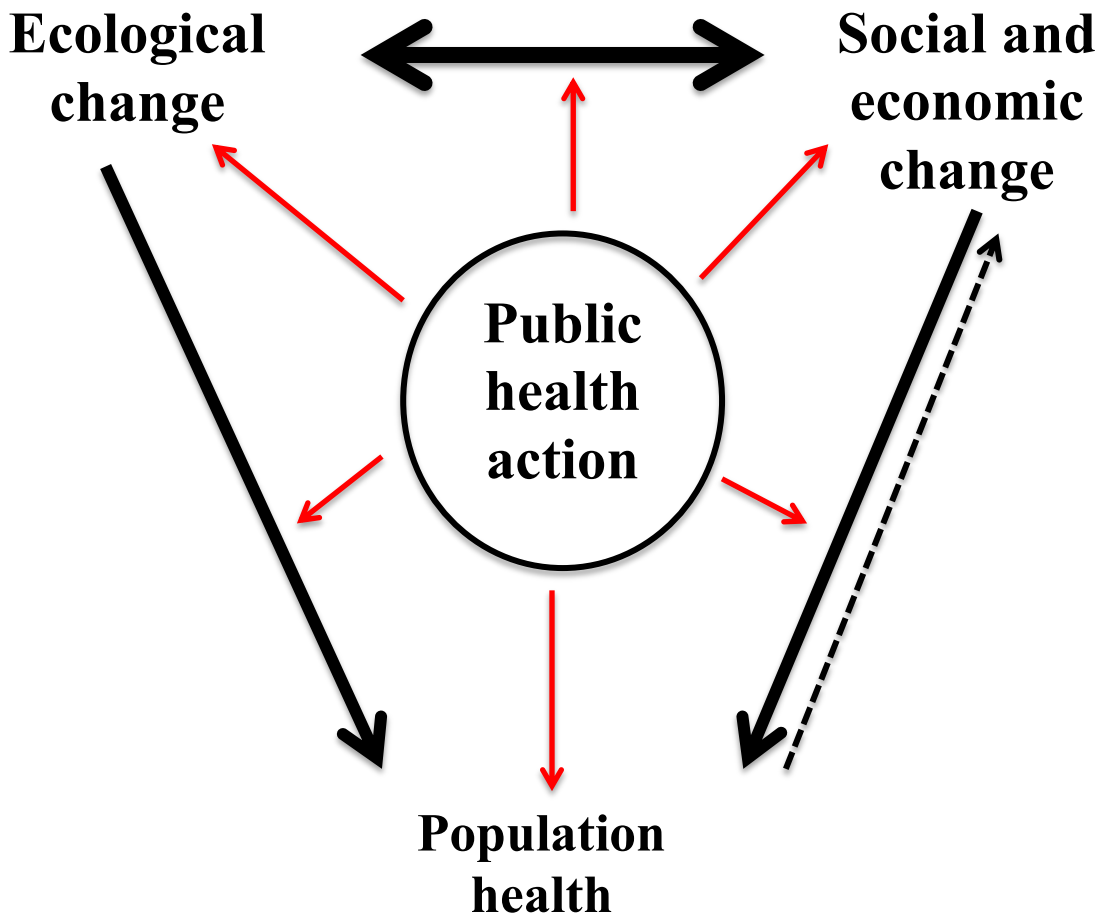
2. McMichael AJ, et al. (2015) Climate change, food systems and population health risks in their eco- social context *Public Health* <http://dx.doi.org/10.1016/j.puhe.2014.11.013>
3. CPHA (1992) *Human & Ecosystem Health: Canadian Perspectives, Canadian Action* Ottawa: The Association
4. McMichael, A. (1993) *Planetary Overload* Cambridge: Cambridge University Press
5. Soskolne, Colin L and Bertollini, Roberto (1999) *Global ecological integrity and ‘sustainable development’: cornerstones of public health.* (A Discussion Document) World Health Organization, European Centre for Environment and Health,
6. Millennium Ecosystem Assessment, (2005). *Ecosystems and Human Well-being: Synthesis.* Island Press, Washington, DC. Available at www.unep.org/maweb/documents/document.356.aspx.pdf
7. WHO (1986) *Ottawa Charter for Health Promotion* Copenhagen: WHO Europe
8. Steffen W, Grinevald J, Crutzen P, McNeill J. (2011) The Anthropocene: conceptual and historical perspectives. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences.* 369(1938): 842-867

within which we live are important and that they interact as a single socio-ecological system. As the Ottawa Charter stated:

“Our societies are complex and interrelated. Health cannot be separated from other goals, the inextricable links between people and their environment constitutes the basis for a socio-ecological approach to health.”

Accordingly, we have developed a model that emphasizes both the ecological and socio-economic determinants, their interactions, the implications of change for the health of the human population, and the role of public health in responding to these circumstances. Figure 1 presents this model as a Framework for public health action. This Framework both reflects and guides our approach in this report.

Figure 1: An Eco-Social Framework for Public Health Action



CHAPTER ONE: UNDERSTANDING ECOSYSTEMS AND HUMAN HEALTH

Trevor Hancock, Donald W. Spady

A “cultural shift in understanding and priorities . . . is a precondition for all the other necessary and wide-ranging changes across the system.”

Stephen Boyden⁹

Although many people living in highly developed societies seem oblivious to the fact, an essential, profound, and close relationship exists between human beings and the ecosystems of which they are a part. Human evolution took place within those ecosystems, and there are deep psychological, social and cultural connections to our ecosystems that go well beyond mere physiological needs. There is a growing recognition – and evidence to support it – that our need to connect with nature is an integral element of human wellbeing.

In many indigenous traditions in North America and around the world, the Earth is often considered as our Mother. This view is seen also among the ancient Greeks and other ancient civilizations and reflects the acknowledgment that this living system, the Earth, is where all life, including humans, evolved and was nurtured. The Earth is also our home, our only home; there are no other livable planets within our reach, so we must live here on Earth, and within the limits of Earth’s ability to nurture life.

For most of human history, nature has been viewed with a mixture of reverence, awe and fear; reverence for nature’s beauty and bounty, awe for nature’s power, and fear of what that power can do to humans. But over time, humans have developed an attitude of superiority to nature, so that while we humans still view nature as seemingly infinitely bountiful, we all too often consider it as something separate from us, something we have learned to subdue and eventually control. Our efforts to subdue nature have been so successful that the time in which we now live has been called the Anthropocene,¹⁰ reflecting the powers that humanity has over nature.

As long as nature remains bountiful, it’s ecosystems will continue to provide the basic necessities of life for us as they always have. However, our relationship with nature has changed adversely and quite dramatically in the past century. As Chief Seattle¹¹ is reported to have said more than a hundred years ago, “we are part of the web of life, and whatever we do to the web of life, we do to ourselves.” In the face of the disturbance in ecological functioning that we now confront, we may think that the environment is threatening us - but we would be wrong. We are the species that is forcing the climate to change, that is changing and harming the great cycles of life and threatening the fundamental functions of life. We are creating a mass extinction and depleting both renewable and non-renewable resources. This harm to the environment we have done and continue to do is coming back to haunt us, and to harm us.

However, it is a mistake to fear that we will destroy the planet, or life on Earth, or even human life – we will not. Given time, the Earth will repair the damage we do to it, while life on Earth has survived far worse, albeit with the extinction of a high proportion of species. As for humans, we are an intelligent, tough and resilient species, and it seems unlikely that we would easily become extinct, although of course species do become extinct, so it is not impossible. The same is not true

9. Boyden, Stephen (2011) *Our place in nature: Past, present and future* Canberra ACT: Nature and Society Forum

10. Steffen W, Grinevald J, Crutzen P, McNeill J. (2011) *op. cit*

11. Chief Seattle was a Duwamish Chief in the Pacific Northwest. The text of his speech, some time around 1854, was written down much later, and after several translations.

of our societies and civilisations, many of which have declined, collapsed, even disappeared over the course of human history.¹²

Our actions can lead to great harm to the health of millions of people living today and to future generations. As well, our actions have grievously harmed, and continue to harm, the other species with whom we share planet Earth. To avoid these harms, or to minimize their impact, we must re-establish the reverence and awe for nature we currently ignore, and we must act in accordance with and not in opposition to nature.

Earth is itself a living system: Lovelock's Gaia hypothesis is that "living matter on the earth collectively defines and regulates the material conditions necessary for the continuance of life".¹³ The relationship between organisms and their environments constitute ecosystems, which are complex adaptive systems. This means that we need to apply systems thinking and analysis to the things we study and interact with them.

There are some key principles of ecological systems¹⁴ which include:

- **Networks**
All living things in an ecosystem are interconnected through networks of relationship. They depend on this web of life to survive.
- **Nested Systems**
Nature is made up of systems that are nested within systems. Each individual system is an integrated whole and — at the same time — part of larger systems.
- **Cycles**
Members of an ecological community depend on the exchange of resources in continual cycles. Cycles within an ecosystem intersect with larger regional and global cycles.
- **Flows**
Each organism needs a continual flow of energy to stay alive. The constant flow of energy from the sun to Earth sustains life and drives most ecological cycles.
- **Development**
All life — from individual organisms to species to ecosystems — changes over time. Individuals develop and learn, species adapt and evolve, and organisms in ecosystems co-evolve.
- **Dynamic Balance**
Ecological communities act as feedback loops, so that the community maintains a relatively steady state that also has continual fluctuations. This dynamic balance provides resiliency in the face of ecosystem change.

When it comes to studying the relationship between humans and their environments, we have to deal with two interacting environments – the natural environment and the human-created social and built environment, which together create what we can think of as a human ecosystem. The study of the human ecosystem is human ecology, and an understanding of humans in these terms, and of public health as part of human ecology, has important implications for the way in which we approach population health issues and practice public health.

12. Diamond, Jared (2005) *Collapse: How Societies Choose to Fail or Succeed* New York: Viking Press

13. Oxford English Dictionary

14. Centre for Ecoliteracy: Core Ecological Concepts <http://www.ecoliteracy.org/philosophical-grounding/core-ecological-concepts> Accessed 20 July 2013

CHAPTER TWO: THE ECOLOGICAL DETERMINANTS OF HEALTH

Donald W. Spady, Trevor Hancock

This is a short introduction to the ecological determinants of health - Earth's life supporting-systems - which illustrates how the normal cycles of life function and how they can become disordered by human action. Space precludes a discussion of all the support systems, or even the cycles of all the very important elements. However, it is evident that these cycles in their natural state have maintained and nourished life - including the human species - for millions of years, albeit with some dramatic periods, such as the ice ages and the rare catastrophic hit by asteroids. Today it is equally evident that human action can alter these cycles. To a large degree such action has been inadvertent and reflects humanity's efforts towards a materially better life, a process currently termed 'progress'. Much of this progress has been directed to a more complex way of living and to creating the necessary human environment to enable this.

There are many ecological processes and natural resources essential for the health and wellbeing of humans and other species. They constitute Earth's life-supporting systems, and they are there not only to meet human needs but the needs of all life. It is only from the human perspective that humans are inherently more important than other forms of life, but that perspective ignores the fact that human survival fundamentally depends on the actions of a diversity of other life forms, which in turn depend on even more diverse life forms down to the microscopic level. This report recognizes that all life plays a role in maintaining human health and that we humans must consider how our actions affect the natural world and must act within that world with due respect and care, because our health, our civilisation and our continued existence as a species is dependent on the healthy functioning of Earth's ecosystems, and on the entire web of life comprising these ecosystems.

The ecological determinants of health include adequate amounts of oxygen, water and food upon which life depends. Other vitally important ecological processes and natural resources include the ozone layer that protects Earth's surface from high levels of UV radiation; the 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, freshwater and marine aquatic systems within which 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, a source of abundant energy and a 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 wellbeing.

This chapter reviews briefly and selectively only a few key compounds and systems that support life, in the broad categories of biogeochemical cycles (nitrogen, carbon, ozone, water, wastes), food (both land and water based sources) and energy (mainly as fossil fuel energy). The intent is not to provide extensive details of their functioning but to provide some examples of how normal functioning can be disturbed, and the adverse consequences that can arise.

Biogeochemical cycles

The chemicals and elements function via various integrated biogeochemical cycles to meet the services required. While each element or compound — e.g. nitrogen, carbon, oxygen, phosphorus, water — has its own natural cycle, they also interact with each other as necessary. We now know

that these cycles — and the life-supporting systems that they support — can be disturbed by human action, with significant consequences.

- In the early 1900s humans learned how to fix atmospheric **nitrogen** (N) using natural gas. This has led to the production of far more N than by natural processes, and in 2005, this N accounted for more than twice that of naturally fixed N.¹⁵ Most biogeochemical cycles sequester unneeded material and draw on it as necessary, but in the case of N, there is no place to sequester the extra N being released and this has led to significant water, land, and air pollution.¹⁶
- **Carbon** moves through the carbon cycle mainly as carbon dioxide (CO₂). Atmospheric CO₂ plays an important role in maintaining global mean temperatures at levels conducive to life, but in the past 200 years or so (since the advent of the industrial revolution), the release of carbon through the combustion of fossil fuels has led to a rise in CO₂ levels to nearly 400 ppm (the highest levels in almost a million years) and a consequent rise in the mean temperature of Earth; i.e. global warming.¹⁷ This is a prime example of a significant human-made global threat to a life-supporting system. Moreover, CO₂ is also dissolved in the oceans, making carbonic acid and thus acidifying them, with serious consequences.¹⁸
- **Ozone** is a third example of a human altered biogeochemical cycle, but in this instance humankind recognized the problem and acted to mitigate the effects. It is a success story and may provide some guidance in our response to the bigger problem of global warming¹⁹ and other global ecological problems. The ozone layer in the stratosphere screens out UV radiation that would be harmful to many life forms. In the 1980s, scientists discovered that human-made chemicals were entering the stratosphere and thinning the ozone layer, resulting in increased levels of harmful UV radiation at ground level. This was seen as such a serious threat to the health of humans and other species that the global community came together to take action. By 2012, 98% of the historic levels of production and consumption of ozone-depleting substances had been phased out of use. The ozone hole has decreased in size, but a return to 'normal' (pre-1980) levels is not expected until mid-century, and 15 years later than that over the Antarctic.²⁰ This is some 80 years after the Protocol was adopted and almost 100 years from when the problem was detected and provides some sense of the length of time it can take to 'fix' ecosystem problems.
- **Water** is essential for nearly all life-supporting systems, at least on Earth. It plays a role in most chemical reactions and is an important component of all cells. In otherwise healthy humans, a lack of water leads to death within days. Globally, there is plenty of water, but for humans and other non-ocean going life, this must be fresh water. Only 2.5% of the water on Earth is freshwater and of that, only 2% is available for ready use; the remaining

15. Bobbink R, Hicks K, Galloway J, Spranger T, Alkemade R, Ashmore M, et al. Global assessment of nitrogen deposition effects on terrestrial plant diversity: a synthesis. *Ecological Applications*. 20(1): 30-59

16. Vitousek PM, Aber JD, Howarth RW, Likens GE, Matson PA, Schindler DW, et al. (1997) Human alteration of the global nitrogen cycle: Sources and consequences. *Issues in Ecology*. 1(Spring): 2-16\

17. IPCC (2013) Summary for Policymakers. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* Available at <http://www.climatechange2013.org/report/>

18. Rice, KC, and Herman JS (2012) Acidification of Earth: An assessment across mechanisms and scales. *Applied Geochemistry*. 27(1): 1-14

19. UNEP Ozone Secretariat (2014) *Montreal Protocol - Achievements to date and challenges ahead* Available at http://montreal-protocol.org/new_site/en/MP_achievements_challenges.php

20. UNEP Ozone Secretariat (2014) *Montreal Protocol - Achievements to date and challenges ahead* Available at http://montreal-protocol.org/new_site/en/MP_achievements_challenges.php

98% is bound in ice or is deposited in deep underground aquifers.²¹ Water is obviously necessary for human life and health. Unfortunately, the industrial revolution plus a growing human population has led to increased demands for freshwater to such a degree that much of the world's population faces water insecurity either regularly or intermittently. Water insecurity will increase as demands for food production and energy increase. Meeting those demands will be complicated by economic influences, climate change, energy demand and geopolitical considerations. Over the coming decades, water security will be a growing source of global and local concern and perhaps conflict.²²

- The **detoxification and recycling of wastes** through natural processes form another life-supporting system; the wastes generated by natural processes are broken down for use elsewhere, recycled, or sequestered within Earth's natural systems. In fact, these processes are part of many life-supporting systems and provide a good illustration of how systems work together. But since "*There's no away to throw to*" (Hardin's Second law of Human Ecology), whatever we generate as waste is re-incorporated within the natural systems of which we are a part. This process of incorporation or degradation may require decades to millennia, during which the waste can cause great harm.

Hardin's Law was recognized too late in human history to prevent considerable levels of global pollution in the atmosphere, in fresh and ocean waters, on the land, and in the bodies and cells of organisms. This is well exemplified by the phenomenon of ecotoxicity - the widespread presence of persistent organic pollutants (POPs) and heavy metals that become bio-concentrated in our food chains - and humans sit at the top of many food chains. Thus not only is there no 'away' to throw anything to, but what we do put out into nature may be returned to us in a more concentrated form; we are polluting ourselves as well as other forms of life.

Food: Land, soil and water

There are two major food sources: plants or animals. Plants store solar energy as carbohydrate, but animals, lacking a capacity for photosynthesis, ultimately depend on plants. Humans die within days or weeks without food, and inadequate food results in physical and mental stunting and sub-optimal human development.

Food comes either from the land or from freshwater or marine sources. In both cases, the productivity and sustainability of these sources depends upon the state of the ecosystems of which they are a part. Thus any threat to these ecosystems, or any unsustainable use of plant or animal species on which we feed, threatens food production and in turn human life and health are threatened.

An imminent problem is that, due to population growth and the increasing demands for a higher meat diet, especially in low and middle income countries, food production must increase by 70% to 100% by 2050.²³ This will place great demands on energy, water, nitrogen and phosphorus, and

21. Gleick PH, Palaniappan M. (2010) Peak water limits to freshwater withdrawal and use. *Proc Natl Acad Sci.* 107(25):11155-11162

22. U.S. National Intelligence Council (2012). *Global Water Security* [Internet] Feb 2; Available from: <http://www.fas.org/irp/nic/water.pdf>

23. Foley JA, Ramankutty N, Brauman KA, Cassidy ES, Gerber JS, Johnston M, et al. (2011) Solutions for a cultivated planet. *Nature* 478(7369): 337-42

the need for suitable land at a time when such resources are diminishing. Meeting this food demand will be complicated also by global warming, which will likely reduce yields globally.²⁴

Agriculture is now the single largest global land use, covering about 38% of the Earth's ice-free land surface. But 25% of agricultural land is highly degraded and a further 8% is moderately degraded (see Figure 2).²⁵ The basis for all agriculture is good soil, but while it can take decades to create 2.5 cms of topsoil, that 2.5 cms, and many more, can be lost in hours, due to erosion, flooding or dust-storms, and in a little longer time because of land clearing, deforestation and mismanaged agriculture, and the expansion of human habitat, such as for highways, airports, suburbs and industry.

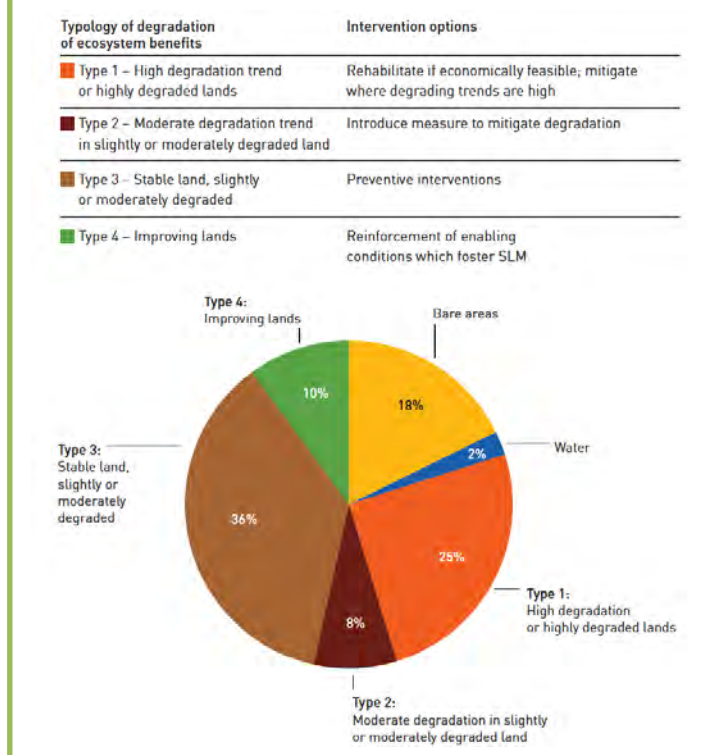
Agricultural practices can lead to compaction, waterlogging, excessive salinity, pollution and the loss of biodiversity and essential nutrients within the soil. In fact, globally, only half the nutrients that crops take from the soil are replaced, and soil has been called a threatened natural resource.²⁶

Fish and other forms of aquatic life, as well as some seaweed and other aquatic plants, are also an important source of food for millions of people, especially along major river and lake systems and marine coastal areas. But these ecosystems are themselves under threat from a combination of freshwater withdrawals, pollution and unsustainable rates of resource extraction, leading to the collapse of some fisheries. Some indication of the extent of the degradation of freshwater and marine aquatic ecosystems can be found in the 2014 and the 2012 Living Planet Reports which examined the Living Planet Index (LPI) in both of these aquatic ecosystems (both reports) and in temperate and tropical zones and by country income group (the 2012 report only). The results are revealing:

- The global freshwater LPI declined a staggering 76% between 1970 and 2010.²⁷
 - Separate data for the freshwater LPI by climate zones were not included in the 2014 Living Planet Report, but the 2012 report²⁸ found that while the freshwater LPI had

Figure 2: Status and trends in global land degradation

Source: FAO, 2011 (Footnote 25)



24. World Bank (2013). *Turn down the heat: Climate extremes, regional impacts, and the case for resilience*. Washington DC: World Bank. pp xvi

25. FAO (2011) *The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk*. Rome: Food and Agriculture Organization of the United Nations and London: Earthscan

26. International Soil Research Information Centre (n.d.) *Soil threats* <http://www.isric.org/about-soils/soil-threats> Accessed 28 July 2014

27. WWF (2014) *Living Planet Report 2014: Species and spaces, people and places* Gland, Switzerland: WWF International

28. WWF (2012) *Living Planet Report 2012: Biodiversity, biocapacity and better choices* Gland, Switzerland: WWF International

increased 36% in the temperate zone between 1970 and 2008, it had declined by 70% in the tropical zone.

- The global marine LPI has declined 39% between 1970 and 2010 (2014 report)
 - The temperate zone marine LPI had increased 53% while declining by 62% in the tropical zone between 1970 and 2008 (2012 report).

The implication of these declines for global food supply, and especially for food supply in tropical countries, is clear and alarming.

Energy

Until very recently, when humans harnessed atomic power, the sun was the source of virtually all energy. In early human history, fire from various types of plant biomass was the most common form of non-food energy. Today, the most common form of energy is fossil fuels (coal, oil, gas); they provide about 80% of all the energy used by humankind today.²⁹ While they bring many benefits, they also bring many challenges, notably in the form of global warming, but also in the forms of air pollution, water pollution, ecotoxicity, occupational disease and injury and many other harmful impacts. While initially fossil fuel energy was not essential to human life, it has now become so embedded within virtually all levels of society and all regions of the planet that it - or socially acceptable replacements providing similar levels of energy - is essential for our current way of life. Thus a drastic reduction in fossil fuel use would, at the present, be socially unacceptable and nearly impossible to implement, as we have seen in the ongoing - and to date largely unsuccessful - efforts to halt global warming. Thus, humanity finds itself between a rock and a hard place and must decide what to do: Cut fossil fuel use and face dramatic, uncertain, and very likely adverse social, economic, and political change, or continue to use fossil fuels and face unacceptable, and possibly unliveable, global warming by the end of the century.

Although not strictly a 'life-supporting system', a **reasonably stable global climate and suitable temperatures** are clearly essential for the development and maintenance of human society.³⁰ Many natural ecosystems and the species comprising them have adapted to the relative climate stability of the past few thousand years and the rapid changes in climate seen today are placing them in jeopardy.³¹ From the human perspective, where life is generally more complex but still ultimately dependent on an intact natural environment, the consequences of an unstable climate are a significant threat to human enterprise.

More broadly, for humankind, stability is particularly necessary and provides an essential form of human security. Yet rapid and even sudden changes in the biogeochemical cycles, in water and food supply and climate stability, undermine that stability, and with it, our sense of security. Knowing that the air is clean, the water safe, the sun will shine, the rain will fall, and the seasons will cycle predictably is important and provides the reasonable expectation that if you plant a crop, or cast a net into the water, you will return a harvest. We expect to be able to sleep safely, be warm, grow food, live, learn, work, worship, vote and make decisions, dream, be resilient in the face of illness and tragedy, visit, enjoy life, spend time in and commune with nature, love, marry, and have children in the knowledge that they will grow and develop and play and learn what they need to learn and anticipate their own future without undue anxiety.

29. IEA (2011). *World Energy Outlook 2011* [Internet] 131. (Available from: <http://www.iea.org>)

30. Dumanoski D. (2009) *The end of the long summer*. New York: Three Rivers Press

31. Hansen, J., Sato, M., & Ruedy, R. (2012). Perception of climate change. *Proc Natl Acad Sci* 109(37): E2415-23.

One thing appears certain; security, and the stability underlying it, is in peril, and the reason for this peril is largely man-made.³² We are facing a time of global ecological change that brings with it physical, biological, and societal consequences. We thus must ask ourselves whether we are approaching or surpassing the limits for any of the fundamentally important ecological processes or natural resources. That is the topic of the next chapter.

32. Spady DW, and Lautensach AK (2013) Why Human Security Needs Our Attention. In: *Human Security in World Affairs*. Vienna, Austria: Caesarpress; (p. 17-33)

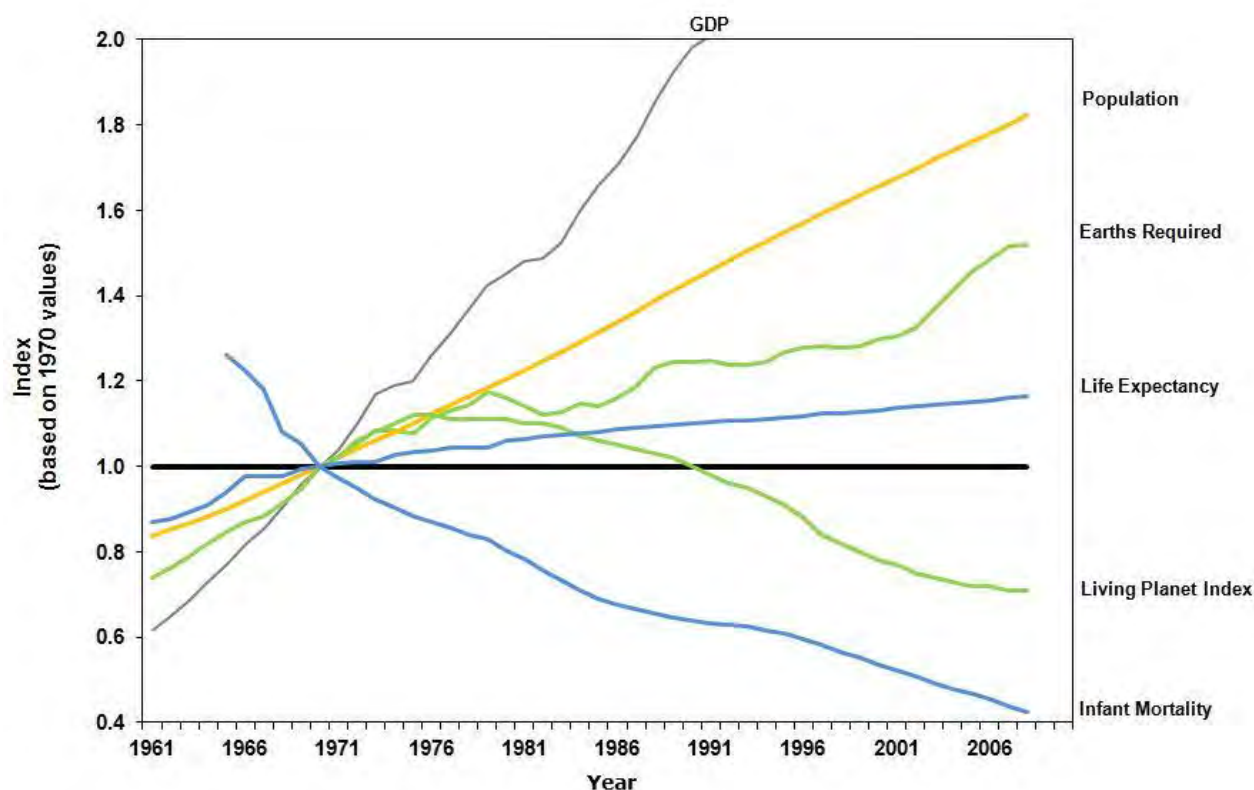
CHAPTER THREE: GLOBAL ECOLOGICAL CHANGE: THE RECENT PAST, PROSPECTS FOR THE FUTURE

Trevor Hancock, George McKibbin, Colin L. Soskolne, Donald W. Spady

Global ecological change is a normal process in the geological and biotic evolution of the Earth system. What makes it a major concern today is the unprecedented rate and scale of global ecological declines in functioning resulting from human activity since the industrial revolution, and especially over the past 50 years.³³ The changes in 12 key ecosystem indicators since 1750 are shown in Figure 4 (next page); the ‘Great Acceleration’ since 1950 is apparent in almost all of them. Figure 3, below, combines the trends in some key global indicators over the past 50 years. The growth in both GDP and population is very clear (global GDP actually increased to 3.37, off the chart), and their combined impact is clear. The inverse relationship between ‘Earths required’ (global Ecological Footprint divided by global biocapacity) and the Living Planet Index is also clear. While infant mortality has declined dramatically, global life expectancy has increased only modestly over this 50 year period.

Figure 3: Key Global Trends, 1961 – 2008 (Indexed to 1 in 1970)

Source: Daniel Rainham³⁴

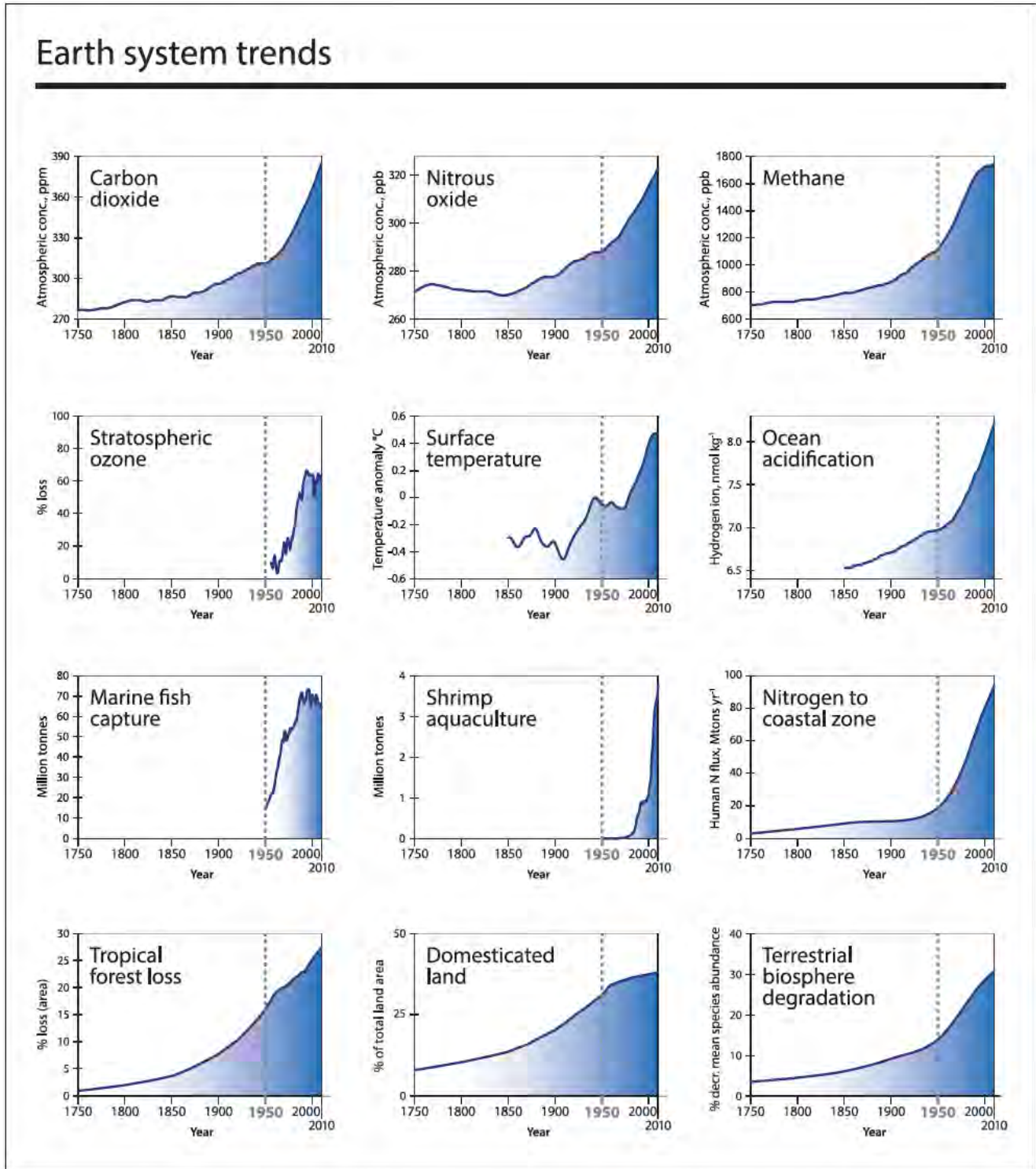


Sources: World Bank, 2013; United Nations (Population Division), 2010; Global Footprint Network, 2011

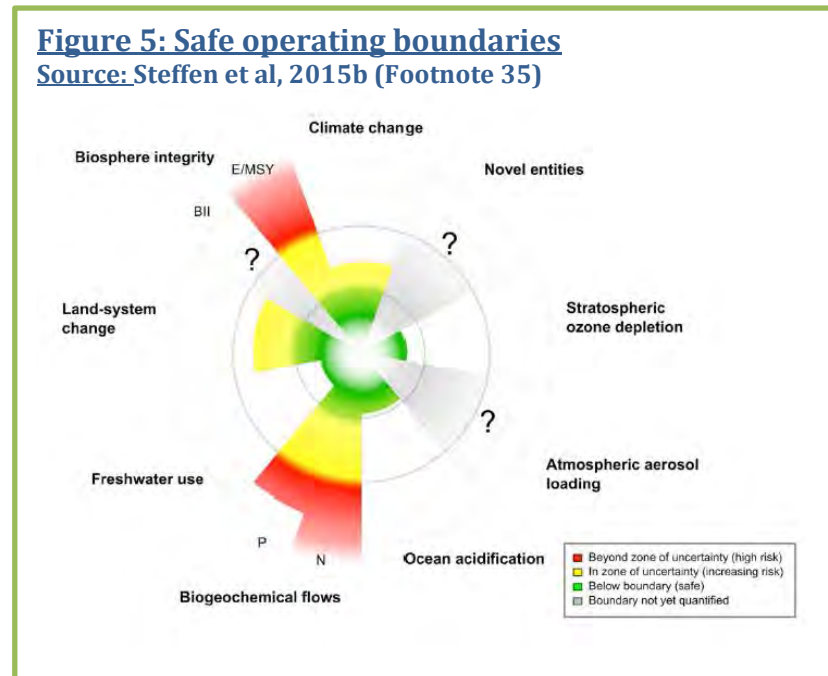
33. Steffen, W., et al. 2004. *Global Change and the Earth System: A Planet under Pressure*. Springer-Verlag, New York, New York, USA and Steffen, Will; Broadgate, Wendy; Deutsch, Lisa; Gaffney, Owen and Ludwig, Cornelia (2015a) The trajectory of the Anthropocene: The Great Acceleration *The Anthropocene Review* 2(1) 81–98
34. Chair in Sustainability and Environmental Health, Environmental Science Research Associate, Atlantic Health Promotion Research Centre (AHPRC), Dalhousie University

Figure 4: Trends from 1750 to 2010 in indicators for the structure and functioning of the Earth System

Source: Steffen et al, 2015a (Footnote 33)



As a result, we are beginning to approach, and sometimes exceed, planetary boundaries that should never be passed, because doing so leads to ecosystem malfunction, failure, and even collapse. In fact with respect to nine key components of the Earth system 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 risk³⁵ - see Figure 5). Moreover, for some of the key earth system processes (loss of functional biodiversity, atmospheric aerosol loading and novel entities³⁶), we lack sufficient knowledge or data to even determine the boundaries. Nonetheless, it is clear that we will need to limit or even reverse the growth in our use of resources and the harm we are doing to various life-supporting ecosystem components.



We sometimes overlook the profound impact of seemingly small and slow changes. For example, economic growth of 3 percent means a doubling time of roughly 23 years. So in an 80-year lifespan a consistent economic growth rate of 3 percent per annum would mean that the economy - and in general its demand for resources and impact on the ecosystem - would increase in size 10.6 times.

Dramatic though continual rates of growth can be, there is another form of change which is even more alarming: 'state shift, or rapid non-linear change. This is an emergent property of many complex adaptive systems. Examples at a global scale include the 'Big Five' mass extinctions in geological history,³⁷ the loss of Arctic sea ice, and the potentially catastrophic release of methane from thawing permafrost or undersea methane hydrates.³⁸

Unfortunately, we may not have any warning about some of these changes. The prospect that humans might be triggering a transition on this scale is extremely worrying and should be used to focus our collective attention. Science cannot predict much of this change because humanity has, in fact, embarked on a novel experiment with nature and thus for which we have no prior data upon which to base predictions.

35. Steffen, Will et al (2015b) Planetary boundaries: Guiding human development on a changing planet *Science* 347: 1259855. DOI: 10.1126/science.1259855

36. 'Novel entities' is a new category of earth system change, defined as "new substances, new forms of existing substances and modified life-forms that have the potential for unwanted geophysical and/or biological effects" e.g. POPs, heavy metals, nanoparticles, genetically engineered organisms

37. Barnosky et al (2012) Approaching a state shift in Earth's biosphere *Nature* 486 (7 June): 52-

38. Climate Change Science Program (2008) *Abrupt Climate Change: Final Report, Synthesis and Assessment Product 3.4*. Reston, VA: U.S. Geological Survey

A key fact underlying the concept of the limits to growth is a very simple one: Our planet is unique, it is finite, and it contains all we have and all we can get. We have to live within the limits of Earth's resources, capacity and ecosystem functioning. This necessarily puts limits on the resources we can use and the environmental harm we can inflict; indefinite growth of resource consumption and waste production in a finite system is not possible.

In 1972 an international think-tank called the Club of Rome published "The Limits to Growth", which looked at five major trends of global concern.³⁹ Troublingly, the original forecasts produced by the MIT group, which predicted a substantial collapse of the global ecosystem and economy during the mid-21st century period, appear to be on track forty years after they were generated.⁴⁰ Unfortunately the report – and many others since – was disparaged and marginalised by mainstream economists, corporate interests and political leaders. The result is that the opportunity to make a slow and gradual shift to a more sustainable (and healthier) society over the past 40 years has been largely squandered.

The limits to growth raises another key issue: that of equity and human development. As long as the pie is growing, one can hold out hope that people will get a larger piece, in absolute terms, even if their share did not increase. But if the pie cannot grow, at least in terms of material resources, then the only way that those who have next to nothing can get more is through redistribution of the limited resources available.

Key ecosystem changes in the past 20 years

The range of global ecological change issues is extensive, and more than can be covered in depth in a report such as this. In this section, we provide a more detailed review of four forms of global ecological change that are expected to have health impacts: Global and atmospheric change, pollution and ecotoxicity, resource depletion, and loss of habitat, species and biodiversity.⁴¹

In the more than 20 years since the first CPHA report on human and ecosystem health, the state of our planetary ecosystems and the sustainability of our natural resources have in general significantly declined. The UN's 2005 report of the 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 . . ."*⁴²

In summation, 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."*⁴³

Similarly, the report prepared by the UN Environment Program (UNEP) for the Second Rio Conference on Sustainable Development in 2002 found that in the 20 years since the first Rio Conference in 1992 (and the time when CPHA's last report on this topic was done) most major

39. Meadows, Donella; Meadows, Dennis; Randers, Jorgen and Behrens, William (1972) *The Limits to Growth* New York, Universe Books

40. Turner, G. (2008). *A Comparison of the Limits to Growth with Thirty Years of Reality* Canberra: CSIRO

41. Based on Davies, Kate and Hancock, Trevor (1997) *The Health Implications of Global Change: a Canadian Perspective* (A paper for the "Rio +5" Forum prepared for Environment Canada under the auspices of The Royal Society of Canada's Canadian Global Change Program) Ottawa: The Royal Society of Canada

42. Millennium Ecosystem Assessment, (2005). *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC. Available at www.unep.org/maweb/documents/document.356.aspx.pdf

43. Millennium Ecosystem Assessment (2005) *Living Beyond Our Means: Natural Assets and Human Well-being* <http://www.unep.org/maweb/documents/document.429.aspx.pdf>

indicators are trending in the wrong direction, a few are showing improvement, while others are open to debate (see Appendix A). In a Foreword the Executive Director of UNEP stated:

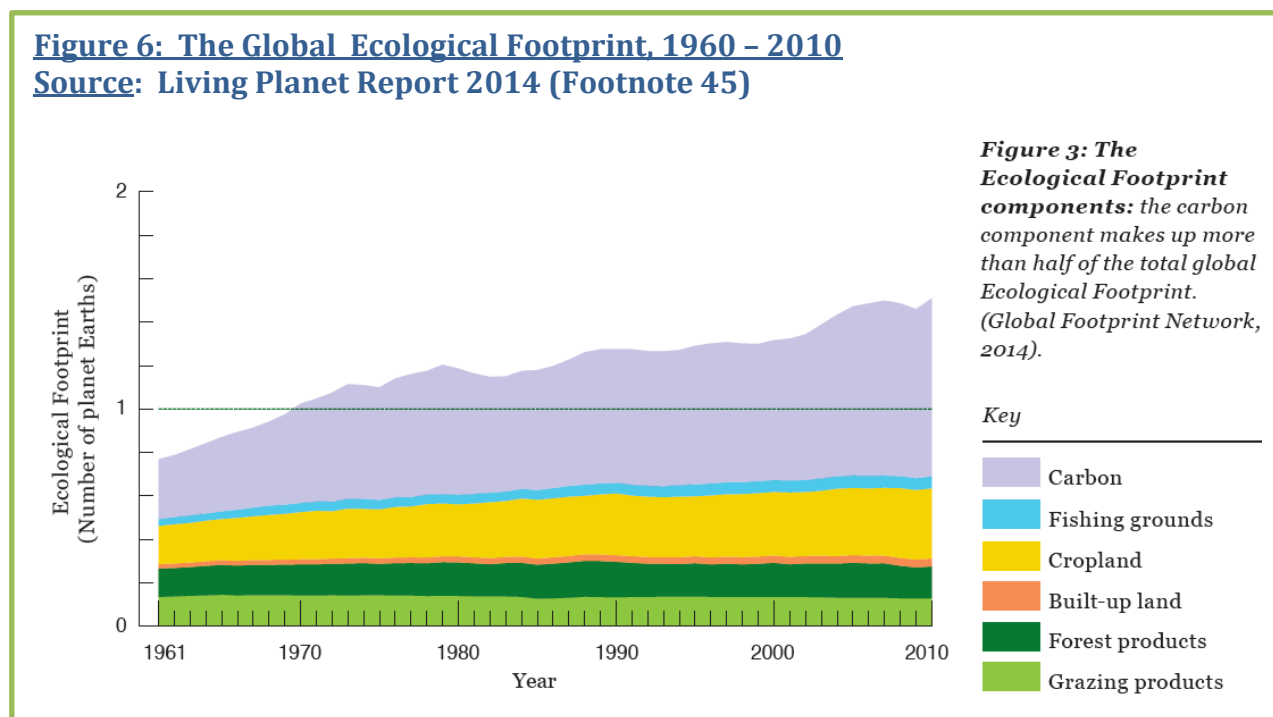
“Without concerted and rapid collective action to curb and decouple resource depletion and the generation of pollution from economic growth, human activities may destroy the very environment that supports economies and sustains life.”⁴⁴

Two key global summary indicators are the Ecological Footprint (EF) and the Living Planet Index (LPI)

- The global 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 Figures 5).⁴⁵ Wealthier countries and wealthier populations have larger footprints than poorer ones; if the entire world lived at the same level of demand as does the US or Denmark, our global footprint would be the equivalent of almost 4 planets.

Figure 6: The Global Ecological Footprint, 1960 - 2010

Source: Living Planet Report 2014 (Footnote 45)



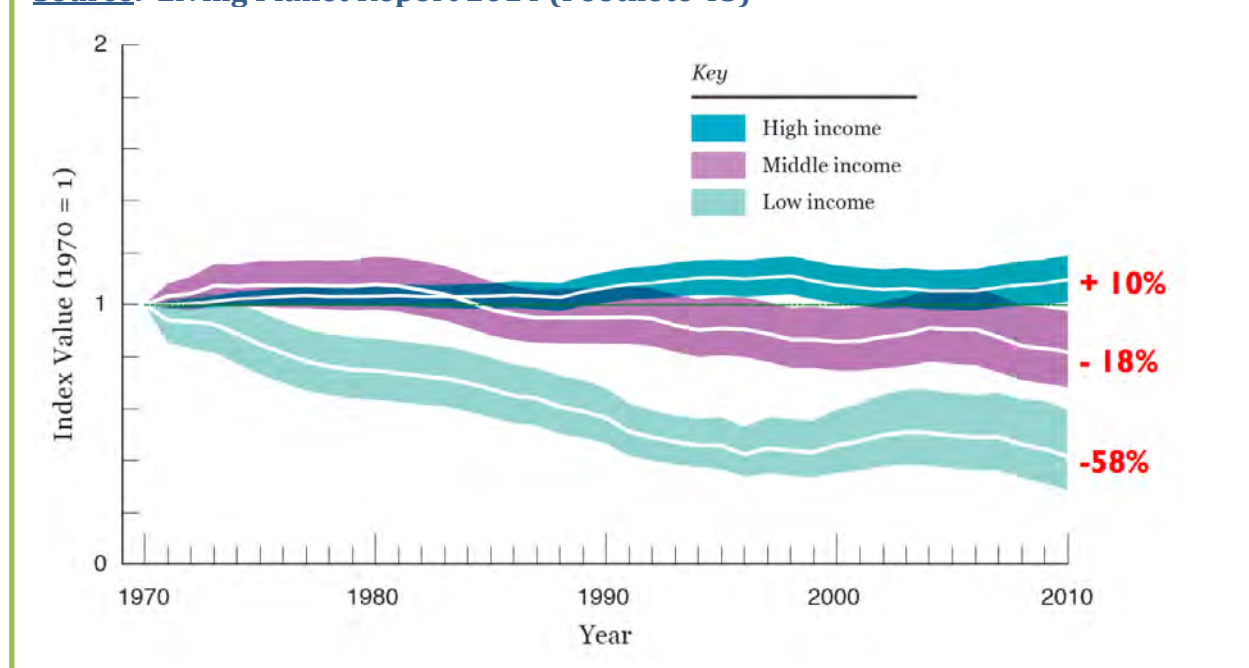
44. UNEP (2012) *Keeping Track of Our Changing Environment: From Rio to Rio+20 (1992-2012)* Available at <http://ourworld.unu.edu/en/the-environment-in-numbers-1992-2012/>

45. WWF (2014) *Living Planet Report 2014: Species and spaces, people and places* Gland, Switzerland: WWF International

- The LPI tracks average changes in vertebrate species populations from around the world. Based on trends in 10,380 populations of 3,038 mammal, bird, reptile, amphibian and fish species, the overall global LPI has declined by an astonishing 52% between 1970 and 2010. This decline is not uniform. It has declined by 58 % in low-income countries and 18% in middle-income countries, but has increased 10% in high-income countries (see Figure 7).⁴⁶ This suggests that the high-income countries are improving their biodiversity by exploiting the resources of the middle and low-income countries, leading to a massive decline in their LPI.

Figure 7: Living Planet Index for high, middle and low income countries, 1960 - 2010

Source: Living Planet Report 2014 (Footnote 45)



Ecosystem changes in Canada

Canada's EF and LPI have also been determined.

- The Canadian EF is large, consistent with its status as a high-income country. But there are marked differences in EF 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%.⁴⁷ In fact, the footprint of the richest 10% of Canadians in 2002 was 25% greater than that of the country with the largest footprint in 2009.
- Canada's LPI is based on a smaller sample of species; 1,057 population trends from 393 vertebrate species. While the LPI slowly increased from 1970 to about 1995, there was a decrease of almost 25% between 1995 and 2003.⁴⁸

46. WWF (2012) *Living Planet Report 2012* Gland, Switzerland: WWF International

47. Mackenzie, Hugh; Messinger, Hans and Smith, Rick (2008) *Size Matters: Canada's Ecological Footprint, By Income* Ottawa: Canadian Centre for Policy Alternatives

48. Mitchell, Shawn et al (Eds) (2012) *Canadian Living Planet Report 2007* Toronto: WWF Canada

These disturbing trends are reflected in a Federal, Provincial and Territorial Governments' report on Canadian biodiversity in 2010.⁴⁹ The good news is that some marine and coastal ecosystems are healthy and improving, as are some protected areas and some cases of nutrient loading and algal blooms, and some forests are healthy, while the stewardship role is also improving. The bad news is that there are signs of distress or impairment everywhere, most trends are negative, and there are some important information gaps.

Moreover, the report also notes that when it comes to monitoring, research, information management and reporting on biodiversity in Canada, there is also cause for concern, with some improvement and some worsening. Given that this report was completed prior to the recent federal governments cuts to environmental science, that cause for concern must be higher today.

Many of these same concerns – including the concern about the lack of monitoring – were also expressed in a 2011 report on the environment for the Canadian Index of Wellbeing.⁵⁰ Most recently, Canada's Commissioner of the Environment and Sustainable Development has noted several problems with the performance of the federal government, including a weak environmental assessment process, restricted stakeholder engagement in that process, and deficiencies in surveying and charting of the Canadian Arctic.⁵¹

A more detailed examination of selected ecological changes

Several key areas of global change are discussed here in more detail.

Climate change

- Average annual global CO₂ emissions increased by 52% from 1992 to 2012⁵² and then “increased more between 2012 and 2013 than during any other year since 1984”⁵³
 - “The amount of CO₂ in the atmosphere reached 396.0 parts per million (ppm) in 2013. The atmospheric increase of CO₂ from 2012 to 2013 was 2.9 ppm, which is the largest annual increase for the period 1984-2013.”¹²

Canadian greenhouse gas emissions in that same period increased by 16.5%.⁵⁴ Canada is not on track to meet its own targets for GHG in 2020; in 2012 Canada was 26% above its now abandoned Kyoto target and is failing to meet even its new, higher target for 2020.⁵⁵ The Commissioner of the Environment and Sustainable Development reports that

49. Federal, Provincial and Territorial Governments of Canada (2010) *Canadian Biodiversity: Ecosystem Status and Trends 2010* Canadian Councils of Resource Ministers. Ottawa, ON

50. Morgan, Alexis (2011) *Environment: A report of the Canadian Index of Wellbeing* Waterloo: Canadian Index of Wellbeing, University of Waterloo

51. Commissioner of the Environment and Sustainable Development (2014) *2014 Fall Report of the Commissioner of the Environment and Sustainable Development: The Commissioner's Perspective* Ottawa: The Commissioner

52. Oliver JGJ, Janssens-Maenhout G, Muntean M and Peters JAHW (2013), *Trends in global CO₂ emissions; 2013 Report*, The Hague: PBL Netherlands Environmental Assessment Agency; Ispra: Joint Research Centre.

53. World Meteorological Organization (2014) *Greenhouse Gas Bulletin # 10* (9 September) Geneva: WMO

54. Environment Canada – Greenhouse Gas Emissions Data - <http://www.ec.gc.ca/indicateurs-indicators/default.asp?n=BFB1B398> Accessed 19 July 2014

55. Environment Canada (2013) *Canada's Emission Trends* Ottawa: Environment Canada

- *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.*⁵⁶
- In May 2013, at the long-term atmospheric CO₂ monitoring site on the summit of Mauna Loa in Hawaii, CO₂ levels, passed 400 ppm for the first time in at least 800,000 years;⁵⁷ in April, May and June 2014 the monthly average was above 401 ppm.⁵⁸
- The average annual global temperature (January – December) has increased from 14.19°C in 1992 to 14.60°C in 2013.⁵⁹ The (US) NOAA National Climatic Data Center reported in January 2015 that “The globally averaged temperature over land and ocean surfaces for 2014 was the highest among all years since record keeping began in 1880.”⁶⁰
 - In Canada, the average annual temperature has increased by 1.6°C over the past 66 years.⁶¹
- In May 2014, NASA reported that glaciers in West Antarctica’s Amundsen Sea Embayment have “passed the point of no return”, It was noted that “they contain enough ice to raise global sea level by 4 feet (1.2 meters) and are melting faster than most scientists had expected”, although it was also noted that “it could take several centuries for all of the ice to flow into the sea.”⁶²
- In Canada, a recent study using a high-resolution regional glaciation model found that “by 2100, the volume of glacier ice in western Canada will shrink by 70 +/- 10% relative to 2005”. This will leads to peak flows into streams and rives in the 2020 – 2040 period, with

World Bank on the ‘new climate normal’

“There is growing evidence, that even with very ambitious mitigation action, warming close to 1.5°C above pre-industrial levels by mid-century is already locked-in to the Earth’s atmospheric system and climate change impacts such as extreme heat events may now be unavoidable. If the planet continues warming to 4°C, climatic conditions, heat and other weather extremes considered highly unusual or unprecedented today would become the new climate normal—a world of increased risks and instability. The consequences for development would be severe as crop yields decline, water resources change, diseases move into new ranges, and sea levels rise. The task of promoting human development, of ending poverty, increasing global prosperity, and reducing global inequality will be very challenging in a 2°C world, but in a 4°C world there is serious doubt whether this can be achieved at all.”

World Bank (2014) *Turn Down the Heat: Confronting the New Climate Normal*. Washington, DC: World Bank

56. Commissioner of the Environment and Sustainable Development (2014) *op.cit.*

57. NOAA, Earth System Research Laboratory <http://www.esrl.noaa.gov/news/2013/CO2400.html> Accessed 10 Feb 2014

58. NOAA, Earth System Research Laboratory ftp://aftp.cmdl.noaa.gov/products/trends/co2/co2_mm_mlo.txt Accessed 19 July 2014

59. Calculated from “Global Land-Ocean Temperature Index in 0.01 degrees Celsius (base period: 1951-1980)” available from NASA’s Goddard Institute for Space Studies at http://data.giss.nasa.gov/gistemp/tabledata_v3/GLB.Ts+dSST.txt Accessed 19 July 2014

60. NOAA National Climatic Data Center (2015), State of the Climate: Global Analysis for December 2014, published online January 2015, retrieved on January 17, 2015 from <http://www.ncdc.noaa.gov/sotc/global/2014/12>

61. Environment Canada - *Climate Trends and Variations Bulletin - Annual 2013* <http://www.ec.gc.ca/adsc-cmda/default.asp?lang=En&n=8C7AB86B-1> Accessed 10 Feb 2014

62. Principal author Eric Rignot, quoted in a NSA press release (<http://www.nasa.gov/press/2014/may/nasa-uci-study-indicates-loss-of-west-antarctic-glaciers-appears-unstoppable/#.VHdkA6hZ9-B>) The study was published as Rignot, Eric et al (2014) Widespread, rapid grounding line retreat of Pine Island, Thwaites, Smith, and Kohler glaciers, West Antarctica, from 1992 to 2011 *Geophysical research letters* 41(10): 3502 - 9

subsequent declines. The authors found that by 2100 “few glaciers will remain in the Interior and Rockies regions”, with serious implications for “aquatic ecosystems, agriculture, forestry, alpine tourism and water quality”.⁶³

In 2013 the Intergovernmental Panel on Climate Change⁶⁴ reported that

- *Most aspects of climate change will persist for many centuries even if emissions of CO₂ are stopped. This represents a substantial multi-century climate change commitment created by past, present and future emissions of CO₂.*

In 2014 the Intergovernmental Panel on Climate Change⁶⁵ reported 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.*
- *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. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks.*

It has been estimated that to keep global warming to less than 2°C, no more than about 1 trillion metric tons of carbon can be added to the atmosphere. We are already past the halfway mark, and if current trends persist, will pass the trillion metric tons mark in the 2040s.⁶⁶

- If the total resource base of fossil fuel were burned, we would be way past that threshold, leading to suggestions that about 80% of fossil fuel reserves cannot be burned.⁶⁷
- A recent report suggests that in Canada, even with carbon capture and storage technologies in place, 74% of oil reserves (and 99% of ‘unconventional oil’, i.e. Alberta’s tarsands), 71% of unconventional gas reserves and (i.e. fracking) and 75% of coal is ‘unburnable’.⁶⁸
- This unburnable carbon is a ‘stranded asset’ and represents a major liability for the fossil fuel industry and those who invest in it, notably pension funds.⁶⁹

63. Clarke, Garry K. C.; Jarosch, Alexander H.; Anslow, Faron S.; Radic, Valentina and Menounos, Brian (2015) Projected deglaciation of western Canada in the twenty-first century *Nature Geoscience | Advance Online Publication* DOI: 10.1038/NNGEO2407

64. IPCC (2013) Summary for Policymakers. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* Available at <http://www.climatechange2013.org/report/>

65. IPCC (2014) *IPCC Fifth Assessment Synthesis Report - Summary for Policymakers* Cambridge UK: Cambridge University Press

66. Allen, Myles et al (2009) - Warming caused by cumulative carbon emissions: towards the trillionth tonne *Nature* 458: 1163-1166

67. Leaton, James; Ranger, Nicola; Ward, Bob; Sussams, Luke and Brown, Meg (2013) *Unburnable Carbon: Wasted Capital and Stranded Assets* London: Carbon Tracker and Grantham Research Institute, LSE

68. McGlade, Christophe and Ekins, Paul (2015) The geographical distribution of fossil fuels unused when limiting global warming to 20C *Nature* 517: 187 - 190

69. Lee, Marc and Brock Ellis, Brock (2013) *Canada’s Carbon Liabilities: The Implications of Stranded Fossil Fuel Assets for Financial Markets and Pension Funds* Vancouver BC: Canadian Centre for Policy Alternatives

Ecotoxicity⁷⁰

- We have created many novel and toxic organic chemicals in the past century⁷¹ for which there are no natural detoxifying mechanisms. As well, many of these chemicals are designed to be stable and thus persist indefinitely in the environment.
- Tiny amounts of persistent chemicals, including some heavy metals, spread widely in the environment can have enormous biological effects, especially as they become bio-concentrated up the food chain, reaching levels in top predators (including humans) millions of times higher than in the source water.⁷²
- The food chain, not water or air, is the main source of these contaminants. For example, for selected organochlorines and PCBs, Ontario adults eating Ontario grown food receive 88 percent (range = 68 - 100%) of their exposure from food.⁷³
- As a result, everyone born or living since World War II carries a lifelong body burden of multiple persistent organic pollutants. The lifetime health consequences of this are unknown.

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 still function to enable that renewal. By their nature, renewable resources are not likely to 'peak' and decline, but they could 'peak' in functional availability or because competing interests limit access. If so, their cost will be driven up, becoming unaffordable to the majority of people on Earth.
- Other resources, particularly metals and fossil fuels, are non-renewable; there is a finite supply of the resource and when it is gone, nothing remains (although in the case of metals, they can be recycled). Our society may be reaching limits in global production of many non-renewable resources; thus we face peak oil,⁷⁴ gas,⁷⁵ coal,⁷⁶ phosphorus,⁷⁷ uranium,⁷⁸ minerals,⁷⁹ and from the perspective of Richard Heinberg, peak everything.⁸⁰

70. Hall, Ross and Chant, Donald (1979) *Ecotoxicity: Responsibilities and Opportunities* Ottawa: Canadian Environmental Advisory Council

71. As well as mobilizing heavy metals, creating nano-particles and genetically modified organisms, collectively described as 'novel entities' (see Steffen et al, 2015: *op. cit.*)

72. Gilbertson, Michael (1998) Linking Water Quality to Wildlife and Human Health *Focus* 23(3): 18 - 19

73. Davies, K (1990) Human exposure pathways to selected organochlorines and PCBs in Toronto and southern Ontario *Adv Environ Sci Technol* 23: 525 - 540

74. Sorrell S, Miller M, Bentley B, and Speirs J. (2010) Oil futures: A comparison of global supply forecasts. *Energy Policy* 38(9): 4990 - 5003

75. Aleklett K, and Campbell CJ. (2003) The peak and decline of world oil and gas production. *Minerals and Energy - Raw Materials Report* 18(1): 5-20

76. Zittel W, and Schindler J. (2007) *Coal: Resources and future production*. (EWG-Series No 1/2007) Ottobrunn: Energy Watch Group

77. Cordell D. and White S (2011) Peak Phosphorus: Clarifying the Key Issues of a Vigorous Debate about Long-Term Phosphorus Security *Sustainability* 3(10): 2027-2049

78. Dittmar, M (2013) The end of cheap uranium *Science of The Total Environment* 461-2: 792-798

79. Diederer A. (2009) Minerals scarcity: A call for managed austerity and the elements of hope. *The Oil Drum: Europe*

80. Heinberg R. (2007) *Peak everything: waking up to the century of declines*. Gabriola, BC: New Society Publishers

- Peak rates of global resource use appear to be occurring or have occurred roughly simultaneously, according to a recent study⁸¹ that “found 21 resources [and the 2 global drivers of resource use - population and economic activity (world GDP)] experienced a peak-rate year, and for 20 resources the peak-rate years occurred between 1960-2010”. The authors comment that this synchronization “poses a greater adaptation challenge for society than previously recognized”.

Species extinction

- The combination of all the human-driven ecological changes outlined above, as well as human intrusion into, alteration of and destruction of habitats, is creating the sixth mass extinction of species - and the first to be induced by humans.
- The rapid loss of species we are seeing today is estimated by experts to be between 1,000 and 10,000 times higher than the natural extinction rate.⁸²
- Recent evidence suggests that the Permian extinction 252 million years ago may have been due to relatively abrupt ocean acidification, probably due to rapid and large CO₂ emissions from massive volcanic eruptions,⁸³ perhaps also linked to a ‘methanogenic burst’ in which methane-producing microbes converted the carbon to methane, resulting in anoxic, acidic conditions in the oceans and toxic levels of hydrogen sulphide in the atmosphere.⁸⁴

Oceans in trouble

- An important consequence of the higher levels of CO₂ is the acidification of the oceans; the pH of the oceans has fallen from 8.11 in 1992 to 8.06 in 2007.⁸⁵ The IPCC (2014) reports with high confidence that “*the pH of ocean surface water has decreased by 0.1, corresponding to a 26% increase in acidity*”.⁸⁶
- This could have significant consequences, altering species composition, disrupting marine food webs and ecosystems and thus affecting marine-based diets for billions of people worldwide.⁸⁷
- The global phenomenon of plastics pollution harms marine life by entanglement with nets or ingestion of plastic particles, with fatal consequences; it has been called the ‘plastisphere’.⁸⁸ Concern is also emerging about plastic nano-particles entering the marine food chain, with largely unknown but potentially serious consequences.⁸⁹

81. Seppelt, R.; Manceur, A. M.; Liu, J.; Fenichel, E. P. and Klotz, S. (2014) Synchronized peak-rate years of global resources use. *Ecology and Society* 19(4): 50

82. WWF – Biodiversity. http://wwf.panda.org/about_our_earth/biodiversity/biodiversity/ Accessed 6 March 2014

83. Clarkson, M. O. et al. (2015) Ocean acidification and the Permo-Triassic mass extinction *Science* 348(6231):229-232 DOI: 10.1126/science.aaa0193

84. Rothman, D. H., et al. (2014) Methanogenic burst in the end-Permian carbon cycle. *Proc Nat Acad Sciences* 111(15): 5462–5467, doi: 10.1073/pnas.1318106111

85. UNEP (2012) *Keeping Track of Our Changing Environment: From Rio to Rio+20 (1992-2012)* Available at <http://ourworld.unu.edu/en/the-environment-in-numbers-1992-2012/>

86. IPCC (2014) *op.cit.*

87. UNEP (2010) *Environmental consequences of ocean acidification: A threat to food security* Available at www.unep.org/dewa/pdf/Environmental_Consequences_of_Ocean_Acidification.pdf

88. Zettler, Erik R.; Mincer, Tracy J.; Amaral-Zettler, Linda A. (2013) Life in the “Plastisphere”: Microbial Communities on Plastic Marine Debris *Environmental Science & Technology* 47: 7137–7146

89. Wegner, A.; Besseling, E.; Foekema, E.; Kamermans, P., and Koelmans, A (2012) Effects of nanopolystyrene on the feeding behavior of the blue mussel (*Mytilus edulis* L.) *Environ. Toxicol. Chem.* 31: 2490–2497

- A recent comprehensive review found that overall, marine degradation is happening at a faster rate and at a greater scale than was previously believed.⁹⁰ While marine defaunation (destruction of animal species) began later in the oceans than on land, “humans have already powerfully changed virtually all major marine ecosystems”; in particular “Humans have profoundly decreased the abundance of both large . . . and small . . . marine fauna”.⁹¹

Projected changes in global ecosystems

- A recent review of global environmental, social, economic, technological and political megatrends by the European Environment Agency⁹² concluded that these long-term trends are highly interdependent and are increasing the vulnerability of Europe’s environment, with significant consequences and potential risks for the resilience and sustainable development of Europe's economy and society.
- The Millennium Ecosystem Assessment developed four scenarios to explore ecosystem changes to the year 2050. Under all four scenarios the projected changes in the underlying driving forces result in significant growth in consumption of ecosystem services, continued loss of biodiversity and further degradation of some ecosystem services.⁹³

Of particular concern is the potential for abrupt, non-linear change, particularly with respect to climate change. A 2008 US Geological Survey report⁹⁴ examined the potential for four different triggers of abrupt climate change, which

“takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades, and causes substantial disruptions in human and natural systems.”

They examined

1. *rapid change in glaciers, ice sheets, and hence sea level;*
2. *widespread and sustained changes to the hydrologic cycle;*
3. *abrupt change in the northward flow of warm, salty water in the upper layers of the Atlantic Ocean . . . ; and*
4. *rapid release to the atmosphere of methane trapped in permafrost and on continental margins.*

Of these, they saw the latter two as “very unlikely”. However, ongoing studies in Siberia and along the Siberian coast suggest that methane release is beginning to rapidly increase.⁹⁵ Since methane is about 84 times more potent than CO₂ as a greenhouse gas, over a 20 year period (and 28 times

90. Rogers, Alex and Laffoley, Dan (2013) Introduction to the special issue: The global state of the ocean; interactions between stresses, impacts and some potential solutions. Synthesis papers from the International Programme on the State of the Ocean 2011 and 2012 workshops *Marine Pollution Bulletin* 74(2): 491 - 4

91. McCauley, Douglas J; Pinsky, Malin L; Palumbi, Stephen R; Estes, James A; Joyce, Francis H. and Warner, Robert R. (2015) Marine defaunation: Animal loss in the global ocean *Science* 347(6219) DOI: 10.1126/science.1255641

92. European Environment Agency (2011) *The European environment — state and outlook 2010: assessment of global megatrends*. Copenhagen: The Agency

93. WHO (2005) *Ecosystems and human well-being: health synthesis: a report of the Millennium Ecosystem Assessment* Geneva: WHO

94. Climate Change Science Program (2008) *Abrupt Climate Change: Final Report, Synthesis and Assessment Product 3.4*. Reston, VA: U.S. Geological Survey

95. Shakhova, Natalia et al. (2010) Extensive Methane Venting to the Atmosphere from Sediments of the East Siberian Arctic Shelf *Science* 327 (5970): 1246-1250

more potent over 100 years)⁹⁶ this is worrisome, because it may trigger a positive feedback loop – more warming leads to more release, which leads to more warming.

Clearly we - and especially our descendants - face some daunting challenges in the years ahead, not only with respect to the natural ecosystems we inhabit and depend upon, but also to our health and wellbeing. The various global ecological changes reviewed here interact, , sometimes in unanticipated ways, so the nature and totality of their impacts is greater than the sum of their parts⁹⁷ and may be hard to predict. These challenges are unprecedented in human history and thus we need to 'feel our way' towards solutions.

Ecological decline is well underway, and given the inertia and time-lag built into the planet's natural systems, it will continue for decades to come, even were we to start doing everything right today. But there is no prospect of that, given the inertia and time-lag inherent in our social systems. We continue to create an ecological deficit and are moving towards an an ecological cliff that makes their fiscal equivalents pale in comparison.

Our rate of movement towards this cliff is unlikely to be a smooth, linear and predictable affair. On the contrary, there is a real possibility of rapid non-linear change or state shift. Should that happen, decline could slide off precipitously into collapse, and when ecosystems decline or collapse, so too do the communities and societies that are embedded within and dependent upon them.⁹⁸

Given that bleak reality, it is vital that we begin to treat ecological decline as a present-day reality, not an improbable or undesirable future that we should try to ignore or wish away. Prudence and a concern for future generations must guide us; we need to take a precautionary approach and assume the worst, because the price of assuming the worst and being wrong is far less than the price of doing nothing and facing decline or collapse unprepared.⁹⁹

We know change may not come quickly or easily, which is why we have a sense of urgency; even if we start today, it could be many years before beneficial social changes become widespread, and more years after that before beneficial ecological changes are seen. The time for public health action is now!

96. IPCC (2014) *Climate Change 2014: IPCC Fifth Assessment Synthesis Report* Box 3.2, Table 1

97. Millennium Alliance for Humanity and the Biosphere (2013) *Scientists' Consensus on Maintaining Humanity's Life Support Systems in the 21st Century: Information for Policy Makers* Available at <http://mahb.stanford.edu/consensus-statement-from-global-scientists/>

98. Diamond, Jared (2005) *Collapse: How Societies Choose to Fail or Succeed* New York: Viking Press

99. Hancock, Trevor (2014) "Managing decline: Global change requires local action" in Butler, Colin; Dixon, Jane and Capon, Tony (Eds) *Healthy Work, Health Places, Health Planet* (A Festschrift publication in honour of Prof. Tony McMichael, ANU) (In press)

CHAPTER FOUR: THE SOCIETAL & HUMAN FORCES DRIVING CHANGE

Sandra Allison, Sherilee Harper, Blake Poland, Trevor Hancock

The key human forces driving the changes in ecosystem functioning described above are population growth and urbanization, economic growth and development, technological changes and advances, and the social changes and movements that drive change. In turn, these changes have been catalyzed by the availability and human exploitation of abundant amounts of cheap, portable energy provided largely by fossil fuels. Underlying and shaping these drivers are a set of societal and cultural values which for the past 200 to 300 years have emphasized the concept of 'modernization'; "the transformation from a traditional, rural, agrarian society to a secular, urban, industrial society".¹⁰⁰ The history of modernization and what it means gives us the context within which to understand our current social, political, economic and cultural conditions and the changes underway that affect these conditions. This history perhaps may give us some insight into the potential nature of a 'post-modern' society and the circumstances that might enable us to make the changes needed to stabilise and reverse the harmful ecological changes discussed

Modernization began in the 16th century in northwestern Europe and has now spread around the world. The underpinnings of modernization are the religious and scientific transformations that began there. These include the Protestant Reformation, with its attendant values relating to work (the Puritan work ethic), which led to modern capitalism, and the Scientific revolution that was based on rationalist thought and the scientific method. These transformations, and the growth in wealth, resources and power for the nations of the West that resulted, led to a belief in (the inevitability of) progress.¹⁰¹

Fundamental elements of modernization include a commitment to economic growth; abundant cheap energy; industrial urbanization; individualism and the undermining of family and community ties; bureaucratization and secularism. But modernization has two faces, that of social progress but also the emergence of new social pathologies and an increasing loss of ecological integrity.

The scale and pace of modernization at a global scale over the past 260 years is shown in Figure 8, which displays 12 key indicators of socio-economic development. As with its companion Figure 4, the impact of the 'Great Acceleration' since 1950 is apparent.

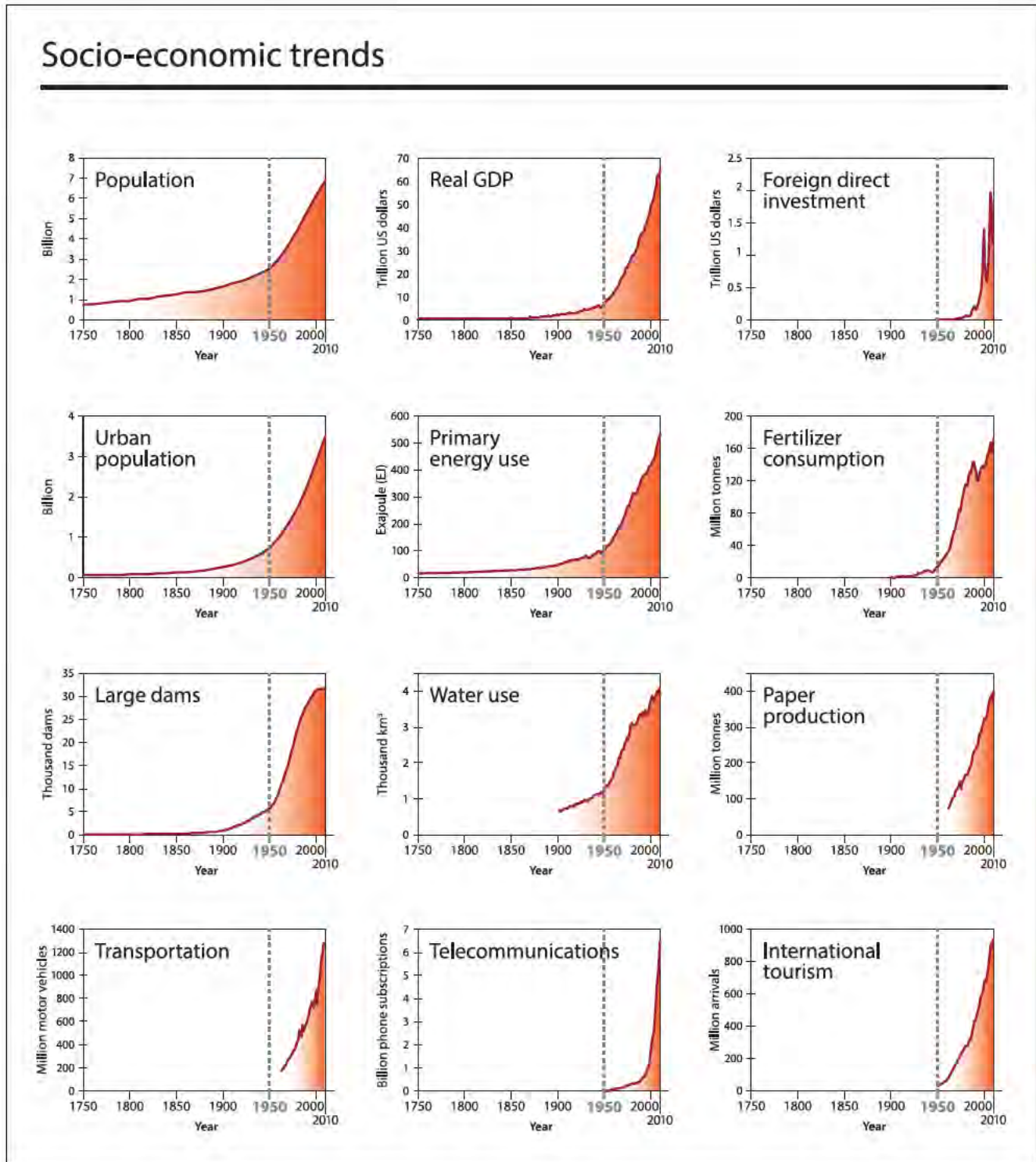
This is the paradigm within which our societies and communities operate in Canada, the 'West' and increasingly throughout the world. An understanding of the process of modernization helps us understand why and how things are the way they are. It can also help us to support the emergence of a post-modern society that might enable us to make the changes needed to stabilise and reverse the harmful ecological changes and trends discussed above.

100. Kumar, Krishan (n.d.) Modernization, in *Encyclopedia Britannica* Available at <http://www.britannica.com/EBchecked/topic/387301/modernization> Accessed 10 March 2014

101. Kumar, *op cit*

Figure 8: Trends from 1750 to 2010 in globally aggregated indicators for socio-economic development

Source: Steffen et al, 2015 (Footnote_33)



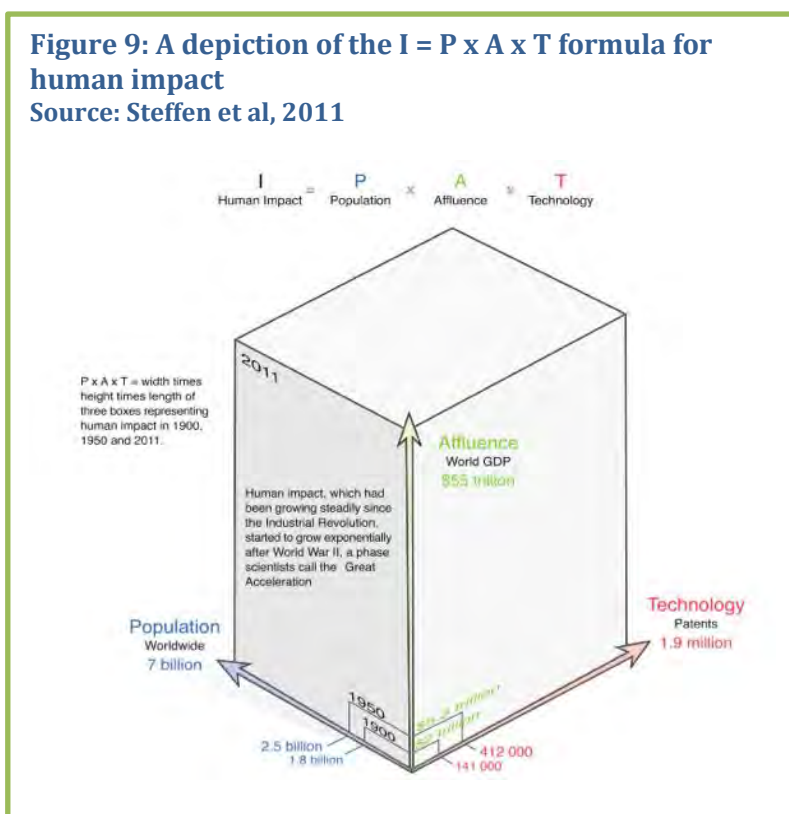
Twenty years of business-as-usual

More than 20 years have passed since the original CPHA report on global change and public health was released in 1992. That report was intended as a clarion call to motivate public health to contribute to the work of moving our society and our communities from an unsustainable path to a sustainable path. Instead, the past 20 years have been marked by a dogged determination to maintain the *status quo* societally, and a lack of attention to the ecological determinants of health on the part of population and public health professionals and organisations as a whole. Indeed, over the past 20 years, instead of seeing significant societal transitions toward sustainability, we have seen an increased pace of large-scale ecological change, with relatively little movement towards sustainability.

Earth's population is growing and migrating. World economies are committed to growth and they cycle between booms and busts, with the ever-present threat of economic collapse. Resources and natural environments are being exploited and degraded, and technology is advancing at breakneck speed, outstripping society's ability to keep pace with the moral and ethical ramifications of the new technologies. Finally, social conditions and values are changing rapidly, often strengthening the harmful aspects of economic growth and development, but sometimes countering them.

The rate and scale of human impact on the planet grew rapidly over the past century, and even more so over the past 50 years (Figure 8). Human impact can be understood as a function of population growth x affluence x technology¹⁰² (see Figure 9¹⁰³). To provide some perspective, consider the changes that children born in Canada today would see over their lifetime (currently, about 80 years). They would see:

- A 1% annual growth in population that would result in a 2.2-fold increase in population over that 80 years, while an annual growth in real GDP of 3% would result in a 10.6-fold increase in GDP over that same period. Together these would result in an increase in impact during their lifetime of more than 23 times the starting point (2.2 x 10.6).



102. Ehrlich, P. and J. Holdren. 1972. Impact of population growth. In *Population, Resources, and the Environment*, edited by R.G. Riker. Washington DC: U.S. Government Printing Office. pp. 365–377.

103. Steffen W, et al (2011). The Anthropocene: From Global Change to Planetary Stewardship. *AMBIO: A Journal of the Human Environment* 40(7):739-761

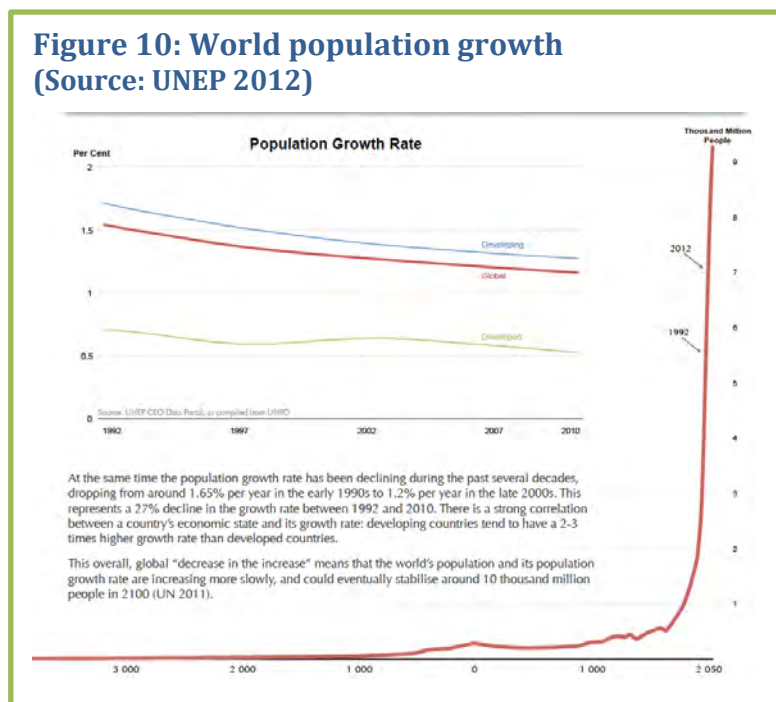
- Even if our technology became 5-times more efficient in terms of resource use and pollution reduction, the human impact over this child's lifetime would more than quadruple.

Moreover, as Jevons paradox (also known as the rebound effect) observes, greater efficiency can be overtaken by rising production or demand. In the case of energy, for example, while in the short-run producing energy savings, energy efficiency may not result in lower energy use.¹⁰⁴ A similar example is seen in the Alberta tar sands, where improved energy intensity (efficiency), while reducing CO₂ emissions per barrel of oil extracted, does not result in an overall reduction in emissions. Thus pursuing energy intensity goals, as the Canadian and Alberta governments and the oil industry have done, does not solve the problem.¹⁰⁵

Population Growth

While world population continues to rise, the mean annual growth rate has slowed to 1.2% in 2010,¹⁰⁶ a doubling time of 58 years. Global population is projected to reach 8.1 billion in 2025, 9.6 billion in 2050 and 10.9 billion by 2100.¹⁰⁷ But population growth is not uniform (see Figure 10); much of the population growth in the recent past has occurred in the Global South. While the population increased in the more developed regions by about 50% from 1950 to 2005, it more than tripled in the less developed regions.¹⁰⁸

- 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%, about the same rate of growth as that of the world population. The 5.3% increase in population between 2006 and 2011 was the highest growth rate among the G8 countries. Net international migration has been the main source of population growth since 1993/4, amounting to two-thirds of Canada's population growth in 2012/13.¹⁰⁹
- From 2009 to 2036, Canada's population is projected to grow from 33.7 million to between



104. Herring, Horace (2006, updated 2011) Jevon's paradox. *The Encyclopedia of Earth* <http://www.eoearth.org/view/article/153953/>

105. Huot, Marc and Grant, Jennifer (2012) *Clearing the air on oilsands emissions* Pembina Institute: <http://www.pembina.org/reports/clearing-the-air-climate-oilsands.pdf>

106. UNEP (2012) *op cit*

107. United Nations, Department of Economic and Social Affairs, Population Division (2013). *World Population Prospects: The 2012 Revision, Key Findings and Advance Tables*. Working Paper No. ESA/P/WP.227

108. United Nations, Department of Economic and Social Affairs, Population Division (2005). *World Population Prospects: The 2004 Revision, Key Findings and Advance Tables*. Working Paper No. ESA/P/WP.193

109. Statistics Canada (2013) *Canada's total population estimates, 2013* Statistics Canada - <http://www.statcan.gc.ca/daily-quotidien/130926/dq130926a-eng.htm?HPA>

40.1 million and 47.7 million.¹¹⁰ A more recent and longer term projection is that Canada's population will grow to 51 million people (range: 40 – 63.5 million) by 2063; "In all scenarios, migratory increase would remain the key driver of population growth over the next 50 years, as has been the case since the early 1990s".¹¹¹

The issue of population growth intersects with issues of development, poverty, affluence and increasing demand in complex ways. There is a tendency in the Global North to decry the growth in population in the Global South as a threat to the planet's ecosystems and natural resources. But because of the much higher Ecological Footprint of high income countries, a child born in a high income country commonly has a footprint as much as 3 or 4 times greater – and thus more demanding, and more harmful - than does a child born in a middle or low income country.

Moreover, we cannot deny to others their aspirations to have a (material) quality of life similar to ours. However, we know this is not possible; the earth cannot handle it. So, it seems that we should reduce our own aspirations somewhat and at the same time work towards global population control so that those in the global South can raise their quality of life much closer to that of ours. We need to find a happy medium. An important aspect of the solution is development because the evidence is clear that development, bringing with it improved living conditions and education, female emancipation, access to family planning and increased child survival, is in fact the key to reducing fertility rates and population growth.¹¹²

Urbanization

For the first time in human history we now live in an urban world. Globally, the 50% mark was passed early in the 21st century and by 2050 it is expected that the urban population will be 67% of the total population, reaching 86% in more developed regions and 64% in less developed regions.¹¹³

A major concern is that almost a billion people, one third of the world's urban population, live in the 'Hidden Cities' of slums and informal settlements.¹¹⁴ These residents bear the burden of ever-widening inequalities in income within countries, inequitable distribution of wealth and he, and a greater burden of environmental hazards; these overt social injustices must be reckoned with.

Moreover, many cities are located in areas of natural hazard, and the number of people exposed to these hazards is exacerbated by three factors: the growth of cities – especially the slums and informal settlements – into areas of hazard, and the expansion of the zone of hazard due primarily to the impacts of climate change, including rising sea levels, more severe weather events and drought.¹¹⁵ As always, those at greatest risk are mainly the poor in the Global South, who are driven to live in the most vulnerable, least desirable and thus least expensive locations. They will be the principal urban victims of climate change and other global ecological changes.

110. Statistics Canada (2010a) *Population Projections for Canada, Provinces and Territories, 2009 to 2036* (91-520-X) Ottawa: Statistics Canada

111. Statistics Canada (2014) *Population projections: Canada, the provinces and territories, 2013 to 2063* The Daily, Wednesday, September 17, 2014 Available at <http://www.statcan.gc.ca/daily-quotidien/140917/dq140917a-eng.htm>

112. Bryant, John (2007) Theories of Fertility Decline and the Evidence from Development Indicators *Population and Development Review* 33(1): 101-127

113. United Nations, Department of Economic and Social Affairs, Population Division (2012). *World Urbanization Prospects: The 2011 Revision - Highlights*. Working Paper No. ESA/P/WP.224

114. WHO and UN Habitat (2010) *Hidden Cities* <http://www.hiddencities.org/>

115. UN Population Division (2012) *op cit*

- Canada urbanized in the late 19th and early 20th century, passing the 50% mark in the early 1920s, reaching 81% in 2011.¹¹⁶ Today Canada's three largest metropolitan areas - Toronto, Vancouver, and Montréal - make up just over one third of Canada's entire population.¹¹⁷ As is the case globally, Canada's cities suffer from areas of urban blight and cultural disruption, especially affecting Aboriginal people and immigrants. Also like other cities around the world, Canadian cities are vulnerable to natural hazards, as recent experience has shown (e.g. flooding in Alberta in 2013, in Saskatchewan and Manitoba in 2014, post-tropical storms in Atlantic Canada, ice storms in Ontario and Quebec, and the anticipated major earthquake on the west coast).

The impact of urbanization on the Earth's natural systems is complex. On the one hand, the demand for resources, the encroachment on forests or farmlands, the blighting of rivers, lakes and oceans and other impacts on natural ecosystems can be extremely harmful, at least at a local or regional level. But paradoxically, cities – or at least well-designed and planned 'sustainable' cities – can have significant environmental benefits.¹¹⁸ As well, more sustainable cities can yield significant economic and social benefits, as noted by a recent report from the Global Commission on the Economy and Climate.¹¹⁹ The report notes that by focusing on more compact growth and connected infrastructure

“the world's 724 largest cities could reduce greenhouse gas emissions by up to 1.5 billion tonnes of carbon dioxide equivalent (CO₂e) annually by 2030, primarily through transformative change in transport systems”

while at the same time reducing “urban infrastructure capital requirements by more than US\$3 trillion over the next 15 years”.

Clearly must make our cities as ecologically sustainable as possible; the main way to do that is to limit urban sprawl, especially as urban sprawl also has a number of harmful health effects.¹²⁰ The process of urbanization – if done well - holds out the promise of reducing ecological harm and economic costs while improving health.

Economic growth and development

The second major driving force is affluence, which is generally measured in economic terms as either income or wealth. The most common measure of economic activity is the Gross Domestic Product or GDP, which was developed in the US in 1934. Ironically, its creator warned against its use as a measure of social welfare,¹²¹ although only too often that is what it has become.

“Right now we're stealing the future and we're selling it in the present, we're calling it GDP.”

Paul Hawken, 2009 Commencement Address at the University of Portland

<http://www.up.edu/commencement/default.aspx?cid=9456&pid=3144>

116. Statistics Canada (2011) Population, urban and rural, by province and territory (Canada) Available at <http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/dem62a-eng.htm> Accessed 24 Feb 2014

117. Employment and Social Development Canada (2014) *Canadians in Context* Available at <http://www4.hrsdc.gc.ca/d.4m.1.3n@-eng.jsp?did=6> (Accessed 26 Feb 2014)

118. UNEP (2002) *Global Environment Outlook 3: Past, present and future perspectives* London: Earthscan Publications

119. The Global Commission on the Economy and Climate (2014) *Better Growth, Better Climate: The New Climate Economy Report* London: The Commission (Chapter 2 – Cities) Available at <http://newclimateeconomy.report/>

120. Frumkin, H; Frank, L and Jackson, R (2004) *Urban Sprawl and Public Health: Designing, planning and building for healthy communities* Washington: Island Press

121. Kuznets, S., (1934) *National Income, 1929–1932* 73rd US Congress, 2d session, Senate document no. 124, page 7. <http://library.bea.gov/u/?SOD,888>

The world's GDP increased four-fold between 1961 and 2001;¹²² within the 20-year period that is the focus of this report, the world's GDP has increased 75%, an increase of 40% in GDP per capita (GDPpc) once population growth is taken into account. This growth is unevenly distributed, with the GDPpc increasing much more (80%) in developing countries between 1992 and 2010. However, given the six-fold difference in GDPpc between developing and developed countries, the large gap persists.¹²³

- In Canada, total GDP more than doubled from \$568 billion CAD in 1992 to \$1.33 trillion in 2010 while GDPpc almost doubled from just over \$20,000 CAD in 1992 to \$39,100 in 2010. ¹²⁴ By 2013, the GDP (in 2013 USD) was estimated to be \$1.5 trillion and GDP per capita was \$43,100.

Growth in economic activity is generally considered to be 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. A key issue in international development has been recognizing the need for societal development for the world's poorest – which requires a certain level of economic development - while minimizing the ecological impacts of this development. The functional characteristics of contemporary globalization have led to deep structural inequalities and inequities between the global North and the global South.

There is good reason to doubt the value of the 'economic imperative' as the most important guiding principle for societal development and public policy, whether nationally or globally. If we are to reduce the wealth gap between rich and poor countries, then contraction of the high income country economies and at the same time investment in development in low- middle-income countries will be needed to see a convergence between the richer and poorer nations and a narrowing of the gap.

When we examine life expectancy against income per capita, we find that although there is a marked increase in life expectancy as GDPpc increases up to about \$10,000 per capita, but there is not much of an increase in life expectancy (or a broader index of wellbeing) beyond about \$10,000 and above \$20,000 there is no relationship at all. What seems to matter much more for middle and high-income countries is the degree of social equity; health and social problems are worse in more unequal countries.¹²⁵

As noted above, the GDP is a very poor proxy for the wellness of society, because it includes harmful economic activity (such as the tobacco industry or the clean up costs of pollution or a disaster), but excludes all the non-monetised contributions that people make to social progress, most notably volunteer activity, but also growing our own food, caring for family and friends when they are ill and so on. In short, GDP puts the economy before any considerations of society or the environment.¹²⁶ As a result a number of alternatives to the GDP are gaining currency as more valid measures of societal progress; they are discussed later.

While GDP may be an inappropriate measure of development, wellbeing and progress, it is a reasonably appropriate measure of economic activity, which is in turn linked to ecological impact. Richer countries, and richer populations within countries, have higher ecological footprints, a

122. World Bank. (2001). *World Development Indicators* (CD-ROM). Washington, DC.

123. UNEP (2012) *op cit*

124. International Monetary Fund - *2011 World Economic Outlook* (Data are expressed as purchasing power parity in Canadian dollars) and *CIA World Factbook* (Data are expressed as purchasing power parity in 2013 US dollars). Accessed 12 April 2015 at [http://www.indexmundi.com/canada/gdp_per_capita_\(ppp\).html](http://www.indexmundi.com/canada/gdp_per_capita_(ppp).html)

125. Wilkinson, R., & Pickett, K. (2010). *The Spirit Level: Why Equality is Better for Everyone* London: Penguin.

126. Victor, P. A. (2008). *Managing Without Growth: Slower by Design, Not Disaster*. Northampton, MA: Edward Elgar

large part of which is their carbon footprint (due largely to their fossil fuel energy use). Thus growth in GDP is likely to result in growth in ecological impact – and since GDP growth remains a prime objective globally and nationally, the anticipated scale of economic growth, which is massive, has troubling environmental – and thus health – implications.

In its World Economic Outlook, the IMF (2011, 2012, 2013) projected a growth in world GDP (PPP adjusted) from \$79 thousand trillion in 2011 to almost \$116 thousand trillion in 2018 (an increase of 46%).¹²⁷

- The same reports 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.¹²⁸ While not all this growth will translate into resource extraction, pollution production or loss of species and biodiversity, much of it undoubtedly will. The impact of such growth on a planet many of whose natural ecosystems and resources are already strained could be disastrous.

Troublingly, GDP growth has also been accompanied by growing inequity. One study found that the global Gini Index¹²⁹ (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 2002.¹³⁰

- This increase in inequality is also seen in Canada, where it rose markedly in the 1990s and has continued to rise, albeit more slowly, in the 2000s.¹³¹

It seems we are losing the 'war on poverty', and this has both social and environmental health implications, given that the poor are the most vulnerable to deteriorating ecological conditions. In particular, unacceptable social, political, cultural, and economic inequities between Aboriginal/Indigenous and non-Aboriginal/Indigenous peoples exist not only in Canada but globally.

- In Canada, Aboriginal people are more likely to suffer from environmental injustice, but on the other hand, they generally have a strong link to the land - their land – and they are often living on or claiming land that corporations and governments want to use for resource extraction or other purposes. While generally welcoming economic development as a route to overcome the many challenges they face, they also are often vocal in their desire to protect 'the land'; and as recent events have shown in Canada, they can be both legally and constitutionally effective in asserting their rights to protect our planet, the Earth.

127. Wikipedia – "List of countries by future GDP (PPP) estimates" Accessed 14 March 2014 at [http://en.wikipedia.org/wiki/List_of_countries_by_future_GDP_\(PPP\)_estimates](http://en.wikipedia.org/wiki/List_of_countries_by_future_GDP_(PPP)_estimates)
Sourced from IMF WEO 9/2011 <http://www.imf.org/external/pubs/ft/weo/2011/02/pdf/text.pdf> ; WEO Update 1/2012 <http://www.imf.org/external/pubs/ft/weo/2012/update/01/pdf/0112.pdf> ; WEO 4/2013 <http://www.imf.org/external/pubs/ft/weo/2013/01/pdf/text.pdf>

128. World Bank Press Release No: 2005/108/ESSD
<http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:20263094~pagePK:64257043~piPK:437376~theSitePK:4607,00.html>

129. Note that these figures reflect Global inequality, which is extreme; in-country inequalities are less extreme but still worrisome. Gini indices are generally higher in low-income countries than they are in high-income countries.

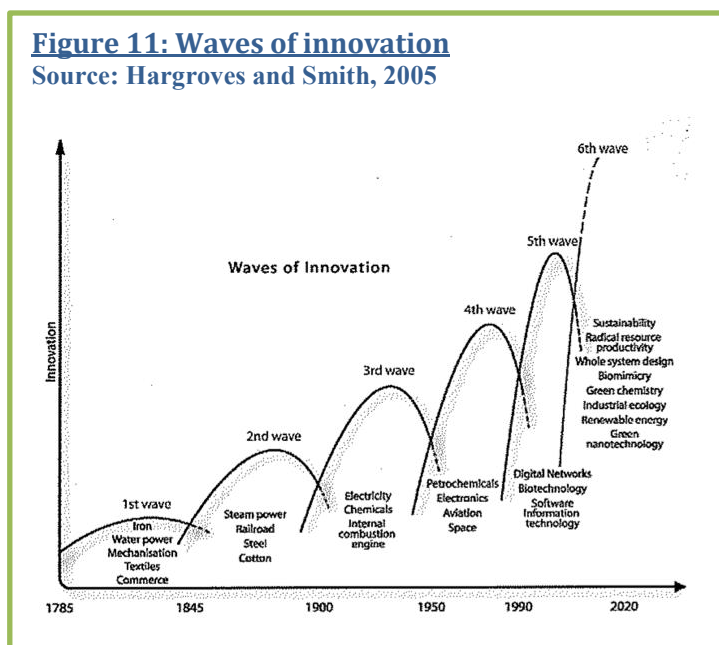
130. Milanovic, 2009, cited in Ortiz, Isabel and Cummins, Matthew (2011) *Global Inequality: Beyond the Bottom Billion – A Rapid Review of Income Distribution in 141 Countries* New York: United Nations Children's Fund (UNICEF). Note that in his study Milanovic expressed the Gini Index as a fraction of 100, rather than its usual presentation as a range from 0 (perfect equality) to 1 (perfect inequality), so 43.0 is the same as 0.43.

131. Conference Board of Canada (2011) – *Hot Topic: Canada Inequality* Available at <http://www.conferenceboard.ca/hcp/hot-topics/caninequality.aspx> Accessed 22 July 2014

Technological change

Technology, i.e. the practical application of science to commerce or industry, is not an independent force or driver of change: technological development is itself driven by the kinds of economic imperatives described above and the social values described below. But it is a key characteristic of our times and its impacts are pervasive and powerful, for better or for worse; it is clearly part of the problem, but also may well be part of the solution. Following the ages of coal and steam, fossil fuel, electricity and petrochemicals, and more recently digital technology and biotech, we may be entering the 6th wave of technological advancement, characterised by sustainability, radical resource productivity, green chemistry, bio-mimicry, renewable energy, and other types of ‘green innovation’ (Figure 11)¹³² – although not all these innovations are necessarily ‘green’, as we are seeing with respect to nano-particles, for example, as noted elsewhere. But while we may be entering the 6th wave, it is the impacts of the other waves we are dealing with today, and will be dealing with for decades to come.

Leaps in technology have enabled travel, resource exploitation, and expanded food production, each with their own associated societal and ecological consequences. What perhaps most distinguishes our technological development over the past two hundred years are three characteristics: its power, its scale and its pervasiveness. The power of our technology is now enormous, and at some level both impressive and scary, while the scale at which we use it is global, and is simultaneously awe-full and awful. Finally, the sheer pervasiveness of our technology means that our chemicals, our nanoparticles and our genetically engineered organisms - the ‘novel entities’ noted in Chapter 3 - are becoming ubiquitous in Earth’s natural ecosystems, with unknown consequences. Our ability to develop and use technology has far outstripped our ability to recognize the potential dangers of its unrestrained use. The impact of this use is what underlies the designation of our current era as the Anthropocene.



132. Hargroves, K., and Smith, M.H. (eds) (2005) *The Natural Advantage of Nations: Business Opportunities, Innovation and Governance in the 21st Century* London: Earthscan (p 17)

The global village that has emerged from advances in transportation, electronics and telecommunications has benefits and drawbacks. The emergence of the Internet and social media has had powerful and important social consequences. One example is Telehealth (see Text Box), which can reduce emissions, increase safety and improve patient access to services; Similar results have been found in Australia and Portugal.¹³³

At a societal level, a well-organized and connected society has the potential to influence our relationship with Earth through mobilization, action, and even revolution.¹³⁴ On the other hand, while the Internet has brought people together in a 'global village',¹³⁵ it has also helped exacerbate social and political cleavages while enabling legal and illegal state-sanctioned surveillance of communications and of personal geographic movement.

While the full consequences of social media remain unclear, what is clear is that the social movements and social changes they facilitate will play a key role in shaping society in the 21st century.

Social values and social change

While changes in population, affluence and technology are important, in many ways it is the underlying social and cultural values and norms that are of greatest importance, because they drive our economic and social beliefs and practices as well as our use of technology. Without changes in our underlying values and norms, there is little prospect for change in our social and economic goals; our understanding of our relationships with and responsibilities towards other people, other species and the Earth; and our understanding of societal growth and development. The Earth Charter – “a universal expression of ethical principles to foster sustainable development” - is one document that addresses these concerns in full.¹³⁶

The problem is – and our experience in public health has surely taught us this - there is little evidence that values can be changed through simple education or moral appeals to 'right living' or that changes in values will necessarily result in shifts in behavior. On the other hand, what we have learned in public health is the importance, the feasibility and the effectiveness of shifting social norms, although we know this can take years, even decades.

The multiple benefits of Telehealth in BC

Telehealth is a technology allows physicians to consult with patients and their local care providers remotely.

These programs save a lot of travel. In BC, where it is widely used, Island Health reported their patients “have saved more than 3.7 million kilometers of travel to appointments”. An Interior Health study estimated just one of its Telehealth programs saved 8,4 million patient miles and hundreds of thousands of kms of consultant travel over 2 years, while reducing GHG emissions by more than 2000 tonnes of CO₂.

This is a large saving in patient travel costs and a reduction in GHGs and other air pollutants. But it also reduces the potential for road injuries, both for patients and families and for staff, especially as some of that travel (in Canada) would be in winter road conditions. Clearly by removing the need to travel we can reduce emissions, increase safety and improve access.

133. Oliveira, T.C; Barlow, J; Goncalves. L and Bayer, S (2013) Teleconsultations reduce greenhouse gas emissions *J Health Serv Res Policy* 18(4) 209–214 and Smith, C; Patterson, V and Scott, R (2007) Reducing your Carbon Footprint: How telemedicine helps *BMJ*. 2007 Nov 24; 335(7629): 1060. See also Island Health (2013) *Interior Health celebrates 10th anniversary of Telehealth* (Press Release, 18 Dec 2013) and Island Health (2013) *Telehealth Reaches Milestone of 10,000 Vancouver Island Health Consultations* (Press release, 27 August 2013)

134. Klein, Naomi (2013)

135. Wheatley, M. J. (2012). *So Far From Home: Lost and Found in Our Brave New World* San Francisco Berrett-Koehler.

136. <http://www.earthcharterinaction.org/content/>

Modernisation, as discussed earlier, has become the dominant cultural narrative of North America, the 'Western world' and more broadly the industrialised societies of the world (three inter-related paradigms or cultures of which Canada is a part) has come to dominate the world. This narrative and its related values underpin our industrial society, and are widely held and promoted by the corporate and political elites that hold power globally. Not all of them by any means are malevolent, but the one aspect of these values where an eco-social approach to population and public health parts company with the paradigm of modernization is with respect to the economy. The problem, as noted earlier, is that "fundamentally, it is the economic changes that most dramatically affect industrial society"; those economic changes include "economic growth as the central defining feature of an industrial . . . economy".¹³⁷

This means that if society is to change, to become more just, sustainable and healthy, public health needs to challenge the prevailing economic norms within society, within governments and within the corporations that increasingly shape, influence and even direct public policy. In particular it means challenging the enormous power and influence of the corporate sector, whose huge financial interests promote the idea of economic growth as the solution to today's problems in ways that rarely consider population or ecosystem health. This is to be expected, as the objectives of corporations differ from those of individuals; however, when it comes to human health and survival, this dissonance requires resolution, the process of which must not be decided by power and money but by reason and ethics and by determining the priorities governing health and sustainable life.

But while corporations must be challenged and changed, and the economic imperative of society likewise, what must happen if we are to live sustainably on the Earth - if as the Brundtland Commission put it, the needs of the present are to be met without compromising the needs of future generations?¹³⁸ A key response is that we need to develop a new societal paradigm, one that has been described as post-materialist.

Some countries in the South may be the early models for a new society, one that has a high level of human development with low levels of social injustice and a small and sustainable ecological footprint; these countries place high on the Happy Planet Index, as noted later. Moreover, a decline in the materialistic lifestyles of citizens in the Global North, which would not impair and indeed may improve the quality of life for those citizens, would enable more development in the South by reducing the ecological footprint of the North, which in effect redistributes the share of the Earth's resources. As Gandhi said, "*Earth provides enough to satisfy every man's need, but not every man's greed*".

There is some evidence that such post-materialist values may be 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 has been occurring; however, there is also evidence that this shift has tapered off in the wealthy and industrialized West. This suggests no major shift towards 'de-growth' is likely to occur. As well, there is evidence of a strong materialistic set of values in the rapidly growing and industrializing South.¹³⁹ If this is the case, the pressures on the world's ecosystems will continue to grow. Nonetheless, we still argue that a change in values and a shift in the world's dominant paradigm is what is essential if we are to live fairly and well within the limits of the Earth's natural systems.

137. Kumar (n.d.) *op cit*

138. World Commission on Environment and Development (1987) *Our Common Future* Oxford: Oxford University Press

139. Inglehart, Ronald (2008) Changing Values among Western Publics from 1970 to 2006 *West European Politics* 31(1-2): 130 - 146

CHAPTER FIVE: GLOBAL ECOLOGICAL CHANGE - THE IMPLICATIONS FOR POPULATION HEALTH

Colin L. Soskolne, Donald W. Spady, Trevor Hancock

This chapter addresses the central question for public health practitioners and others interested in improving the health of the population and reducing inequalities in health: “What are the implications for population health of global ecological change?”

The health impacts are described in terms of the four broad categories used in Chapter 3: Climate and atmospheric changes (including stratospheric ozone depletion and acid emissions), pollution and ecotoxicity, resource depletion and loss of biodiversity.

While this report is directed mainly to Canadian public health professionals and educators, the biophysical and societal effects we describe here are global and thus both the global and Canadian effects are addressed. In fact, these effects will probably be more extreme in lower income countries; however, Canadians do not and cannot stand in isolation of those impacts, on basic moral grounds and because effects primarily felt elsewhere will also affect us. Indeed, Canadians have already felt and will continue to experience negative consequences from global ecological change.

Population health from a systems and ecological perspective

A population is a complex system consisting of people who interact in multiple ways. It shares many system characteristics and, like any system it can and does have various emerging properties. The health of a population relates in part to the degree to which these properties interact with the community to maintain, promote, and renew their health as a community. So in considering population health, we need to refer not only to its health status but also its system properties and dynamics. As we consider the implications of global change for population health, we must consider those properties of a society and the human ecosystems created by society, such as the built and social infrastructures, that both influence health and can be affected by human and environmental circumstance.

An important property is resilience. It is an important property that is distinctive of both healthy individuals and ecosystems, although it gets little emphasis in definitions of population health. Resilience refers to the ability of a population to respond to adverse events, to repair the damage, to adapt and to eventually return to a satisfactory state of health (a fuller discussion of resilience can be found in Chapter 7).

Public health’s focus is the health and well-being of humans, and while often acknowledging that the environment must be protected, the value system inherent in public health practice and in society in general places the needs and many of the desires of people above those of nature. While always problematic, this was perhaps an understandable and acceptable position when our populations were small and the scale of our operations and the power of our technologies were modest. But with the advent of a consuming, industrializing, and overpopulating world, our impact is now massive and pervasive.

Putting people above and apart from nature has placed Earth’s ecosystems in jeopardy, and with it, humanity’s own wellbeing. Humanity needs now to embrace a biocentric or ecocentric stance comparable to and complementary with our anthropocentric stance, because the wellbeing of all humans at every level of society depends ultimately on the ‘ecosystem goods and services’ provided to us by nature and the health of the other species that make up the web of life. In that

sense, our notion of which populations we refer to when we discuss ‘population health’ needs to expand to take in at least those non-human populations that are important to our health.

The limits to knowing

It is important to understand the limitations we face with respect to our knowledge of the health impacts of global ecological change, because our knowledge is surprisingly limited. What we know about the health impacts of global ecological change is sketchy, preliminary, and often speculative; we may have a fair sense 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.

Beyond climate change, while we may understand in general terms the public health implications of some forms of pollution, specifically some forms of atmospheric and water pollution, our general state is one of relative ignorance, (see Text Box¹⁴⁰), while our knowledge of the human health effects of ecotoxicity is largely non-existent, as will be discussed later. A troubling prospect is that these changes often interact, multiplying adverse effects and affecting the whole system. Thus knowledge of the health impacts has to reflect comprehension of overall system change and its health impacts.

One thing that is clear is 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, although they are harder to quantify and attribute directly to a specific global change. This difficulty in quantifying the indirect health effects of poorly understood changes is part of the uncertainty with which we must deal.

For a number of reasons, the direct and indirect health effects of global change are less well studied or understood in Canada than they are at the global level. These reasons include:

- Canada is a large country, with a wide range of eco-zones, climates and land forms, so effects are not uniform; moreover, modeling (e.g. climate modeling) is less precise at smaller scales
- Many health effects may be attenuated because we are a wealthy country with a fairly robust social and technical infrastructure. So we can afford to and doubtless will spend significant

Our lack of knowledge

“. . . to date there has been little formal description and study of the relationships between global environmental changes (GEC) and human health, and of the ways in which social institutions and processes modulate those relationships. For several human-induced global environmental changes, particularly changes to the world’s climate system and to the ultraviolet radiation-filtering functions of the stratosphere, there has been a recent increase in research into the main health risks. But for most other GECs little formal research on the risks to human health has been carried out. Indeed, among the practitioners of the various scientific disciplines engaged in studying the processes and impacts of GECs – including environmental sciences, ecology, geography, economics, etc. – there has been relatively little recognition that ecosystem disruptions, species extinctions, degradation of food-producing systems, the perturbation of cycling of elements and nutrients, and prevailing forms of urbanisation pose risks to the wellbeing and health of human populations.”

Global Environmental Change and Human Health (2007), p 1

140. Global Environmental Change and Human Health (2007) *Science Plan and Implementation Strategy*. Earth System Science Partnership (DIVERSITAS, IGBP, IHDP, and WCRP) Report No.4; Global Environmental Change and Human Health Report No.1 Available at http://www.gechh.unu.edu/FINAL_GECHH_SP_UPDATED.pdf

resources adapting our infrastructure to global change, unless change happens very suddenly and dramatically.

- Large swathes of the country are sparsely populated, so changes in those regions, while significant for those who live there, will be comparatively small, in terms of national health statistics.
- Canada has a federal government that does not act as if the environment is important or that global change (climate change in particular) is a global emergency, nor does it recognize the need to alter its priorities and policies so as to address those consequences of environmental change that have already and will inevitably continue to affect Canadians.

Ignorance aside, we do know that massive change is occurring, that it is happening across multiple ecosystem components and at all scales from the cellular to the global, that the rate of change is rapid and unprecedented 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 far greater than we recognize. Equally troubling is the level of human denial of the problem, which seriously hinders active efforts toward a shared understanding as a basis for adaptation and mitigation.

Key health impacts of global ecological change

The main known or suspected health impacts of global change globally and in Canada are presented in the table “The potential/current and anticipated health impacts of global ecological change” found in Appendix B. It is important in reviewing this Table to be clear that this is not the definitive description of the health impacts of global ecological change, either globally or in Canada. That is a large task that is beyond the capacity of this volunteer group of writers to undertake.

Instead, we have necessarily taken what might be called the bird’s eye view, since we believe it is important to understand the big picture. What we present is the considered opinion of a range of experts within our team who have been involved with this work for many years, both in Canada and globally. As expert opinion, therefore, the reader is advised to view any score with a certain degree of skepticism, save to say that the consequences of any ‘effect’ mentioned in the table are considered to be serious.

Our purpose is not to provide definitive data regarding anticipated mortality or morbidity rates, but to show the wide range and extent of potential health impacts resulting from global change. Our ultimate message is that the population health impacts of the ecological determinants of health are large compared to the impact of the social determinants of health. We thus need to give the Ecological Determinants of Health comparably serious attention.

Moreover, it is the combined and interacting impacts of both the ecological AND the social determinants that is of concern; hence the need for an ecosocial approach to the challenges we face. Thus, one of our key recommendations is that both in Canada and globally a serious effort must be made to understand more clearly the health implications of the full range of global ecological changes, much as has been done for climate change.

But despite all this uncertainty, the seriousness with which the health community is now beginning to take this issue is exemplified by the fact that *The Lancet* has published a manifesto for

planetary health¹⁴¹ and established together with the Rockefeller Foundation a Planetary Health Commission.¹⁴²

Table 1 shows the estimated numbers of people, globally, at risk from selected major examples of the adverse health impacts of global environmental changes. From this it is apparent that there are a many impacts stemming from a variety of causes, and that the numbers of people at risk is very large, ranging from hundreds of millions into the billions of people. The health impacts of some of these key areas of global change are highlighted below.

The health impacts of global geo-climatic system changes

Higher mean global temperature will result in:

- An increase in heat deaths, especially among the urban poor and manual/outdoor laborers, and among the frail elderly, shut-ins without air conditioning, and the socially isolated with few independent social-support systems. The impact will be large in lower income and tropical countries.
- Diminished worker productivity, especially amongst outdoor laborers and agricultural workers;¹⁴³ the economic losses due to heat-induced lost productivity could be very large.¹⁴⁴ One study found that by 2050 there could be 30 million work years lost annually just in the East Asia region.¹⁴⁵
- Diminished agricultural productivity, especially in the tropics, approaching a drop of 5-15% per degree C rise; this will contribute to problems maintaining adequate food supplies.¹⁴⁶

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 & Human Health, 2007 ¹¹⁸

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

141. Horton, Richard; Beaglehole, Robert; Bonita, Ruth; Raeburn, John; McKee, Martin and Wall, Stig (2014) From public to planetary health: a manifesto *The Lancet* 383: 847

142. Horton, Richard (2014) Offline: Reimagining the meaning of health *The Lancet* 384: 218

143. Dunne JP, Stouffer RJ, and John JG. (2013) Reductions in labour capacity from heat stress under climate warming. *Nature Climate Change* 3(6): 563 -

144. Kjellstrom, T; Kovats, R Sari; Lloyd, Simon J; Holt, Tom; and Tol, R (2009) The Direct Impact of Climate Change on Regional Labor Productivity *Arch Env Occup Health* 64(4): 217 - 227

145. Kjellstrom, T., Lemke, B. and Venugopal, V. (2013) Occupational Health and Safety Impacts of Climate Conditions. *Climate Vulnerability: Understanding and Addressing Threats to Essential Resources*. Elsevier Inc., Academic Press, 145–156 pp.

146. Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-being: Biodiversity Synthesis*. Washington, D.C: World Resources Institute

- Increased water-borne, food-borne, and vector-borne diseases, with increases in malaria, dengue fever and other diseases in low-income countries due to wider distribution of insect vectors.¹⁴⁷

Sea level rise and inundation, particularly when exacerbated by more severe weather events, will likely result in displacement of very large numbers of people.

The most recent report on health impacts by the Intergovernmental Panel on Climate Change assesses the probability of major increases in ill-health by mid-21st century due to climate change as follows:¹⁴⁸

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

The IPCC also points out that there are health co-benefits from reducing emissions of other climate-altering pollutants released by fossil fuel combustion, with 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 2030.¹⁴⁹

A recent WHO report¹⁵⁰ found somewhat smaller impacts:

“Compared with a future without climate change, the following additional deaths are projected for the year 2030: 38 000 due to heat exposure in elderly people, 48 000 due to diarrhoea, 60 000 due to malaria, and 95 000 due to childhood undernutrition. . . . Under a base case socioeconomic scenario, we estimate approximately 250 000 additional deaths due to climate change per year between 2030 and 2050.”

However, the authors caution that “These numbers do not represent a prediction of the overall impacts of climate change on health, since we could not quantify several important causal pathways.” In particular they could not account for “major pathways of potential health impact, such as the effects of economic damage, major heatwave events, river flooding and water scarcity”,

147. McMichael, A. J.; Nyong, A. and Corvalan, C. (2008) Global Environmental Change and Health: Impacts, Inequalities, and the Health Sector *BMJ* 336(7637): 191-194

148. IPCC (2014) *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Chapter 11. Human Health: Impacts, Adaptation and Co-Benefits) Cambridge UK: Cambridge University Press

149. DARA and the Climate Vulnerable Forum (2012) *Climate Vulnerability Monitor 2nd Edition. A Guide to the Cold Calculus of a Hot Planet* Madrid: DARA

150. WHO (2014) *Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s*. Geneva: WHO

nor could they include the health impacts of climate change-induced migration or conflict, or “major discontinuities in climatic, social or ecological conditions”.

Ozone layer destruction

There are four potential areas of health impact due to stratospheric ozone depletion and resultant increases in UV radiation: effects on the skin, including skin cancer; effects on the eye, including cataracts; effects on immunity, including increased susceptibility to infection, and indirect effects on health due to the harmful effects of UVR on plants and phytoplankton, which would impact food supply.¹⁵¹

Even with improvements as a result of the phasing out of ozone-depleting substances under the Montreal Protocol, it has been estimated that there are and will continue to be health effects due to increased UV radiation, including a 5 – 10% relative increase in total skin cancer incidence by 2050 in ‘European’ populations in the temperate North and the USA, as well as possible but uncertain effects on cataract formation and immune system functioning. The health impacts of changes to plants and phytoplankton are not well understood.¹⁵²

However, these conclusions are hedged with uncertainty, and it is recognized that good public health action could prevent much of the potential harm.

Pollution and ecotoxicity

According to a recent assessment published by WHO,¹⁵³ the most important health effects at a global level that arise from pollution are:

- Diarrhoeal disease, 94% of which is due to unsafe drinking water and poor sanitation;
- An estimated 42% of lower respiratory tract infections (LRTIs) in developing (sic) countries, and up to 20% of LRTIs in developed countries due to indoor air pollution (largely from burning biomass indoors for cooking and heating) and to a lesser extent outdoor air pollution;
- As much as 42% of malaria may result from policies and practices regarding land use, deforestation, water resource management, settlement siting and modified house design.

Disturbingly, with respect to 10 chemicals of major concern for public health identified by WHO,¹⁵⁴ knowledge of their health impacts is limited. This is both surprising and troubling because, unlike issues such as climate change, resource depletion or loss of biodiversity, the health impact of environmental pollution has been a public health concern for many decades and in the case of some pollutants, for centuries. The reasons for this lack of knowledge are manifold and reflect the common reductionist scientific approach used to assess their health effects, their commercial nature – and thus potential biases in detecting adverse effects - and our ignorance of what to look for, how to measure it, and how to interpret the findings.

If the hazards of exposure to individual chemicals are not well known, we know even less about ecotoxicity - the hazards of simultaneous life-long exposures to many chemicals, which interact in unknown ways. In fact, such an assessment is likely beyond our abilities. For example, the (US)

151. McMichael, A.J.; Lucas, R; Ponsonby, A.-L. and Edwards, S.J. (2003) Stratospheric ozone depletion, ultraviolet radiation and health In McMichael, AJ et al (Eds) *Climate change and human health: Risks and Responses* Geneva: World Health Organization

152. McMichael, A.J.; Lucas, R; Ponsonby, A.-L. and Edwards, S.J. (2003) *ibid*

153. Pruss-Ustun, Annette and Corvalán C. (2006) *Preventing disease through healthy environments: towards an estimate of the environmental burden of disease (Executive summary)* Geneva: WHO

154. WHO (2010) *Action is needed on chemicals of major public health concern* Geneva: WHO Available at http://www.who.int/ipcs/assessment/public_health/chemicals_phc/en/

President's Panel on Cancer examined the impact of environmental factors on cancer risk. In its 2010 report the Panel noted that "with nearly 80,000 chemicals on the market in the United States . . . exposure to potential environmental carcinogens is widespread" but that "the true burden of environmentally induced cancer has been grossly underestimated".¹⁵⁵

In addition, almost 800 chemicals are known or suspected endocrine-disrupting chemicals (EDCs), but only a small fraction have been properly tested, even though there is evidence of widespread and simultaneous exposure of both humans and wildlife to multiple EDCs.¹⁵⁶

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 for a variety of reasons the developing foetus, infants and young children are particularly vulnerable to toxic chemicals.¹⁵⁷ Our lack of knowledge about these chemicals is underscored by two recent Canadian reviews of the literature, which found some evidence for health impacts of prenatal and childhood exposure, but also found many associations where there is limited or inadequate evidence, mainly because of an inadequate number of studies or methodological problems such as small sample size, a limited range of exposure or poor exposure indices.^{158, 159}

Given the dearth of information about the potential impacts on population health of ecotoxicity, we and our descendants continue to be unwilling participants in what is, in effect, a massive, worldwide, unauthorized experiment to see what happens when entire human populations and their ecosystems are exposed to these chemicals – an experiment to which there has been no consent, let alone informed consent!

Resource Depletion

Many of the resources necessary for continued social and economic functioning of society are declining, or are expected to decline in the near future, and yet population growth and societal expectations are rising. Moreover, 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".¹⁶⁰

Some resource losses will pose inconveniences, but the loss or shortages of several of these resources, such as energy, water and soil, will be catastrophic, at least locally, and potentially more widely. As with other global changes, the impacts of resource scarcity will be felt most in low-income countries and among low income and disadvantaged population around the world.

Among the major concerns are the depletion of water, soil, foodlands and fisheries, since they provide the most basic requirements for life and health. They are also intimately linked with the

155. The President's Cancer Panel (2010) *Reducing Environmental Cancer Risk: What We Can Do Now* Bethesda MD: National Cancer Institute

156. Bergman, A; Heindel JJ; Jobling S; Kidd KA, and Zoeller RT (2012) *State of the Science of Endocrine Disrupting Chemicals - 2012*. Geneva: WHO and UNEP Available at <http://www.who.int/ceh/publications/endocrine/en/>

157. Landrigan PJ, and Goldman LR (2011) Children's vulnerability to toxic chemicals: a challenge and opportunity to strengthen health and environmental policy. *Health Affairs* 30(5): 842-50

158. Wigle DT, Arbuckle TE, Walker M, Wade MG, Liu S, and Krewski D. (2007) Environmental hazards: Evidence for effects on child health. *J Toxicol Environ Health B Crit Rev* 10(1-2): 3-39.

159. Wigle DT, Arbuckle TE, Turner MC, Berube A, Yang Q, Liu S, and Krewski D. (2008) Epidemiologic evidence of relationships between reproductive and child health outcomes and environmental chemical contaminants. *Journal of Toxicology and Environmental Health. Part B, Critical reviews* 11(5-6): 373-517

160. Seppelt, R.; Manceur, A. M.; Liu, J.; Fenichel, E. P. and Klotz, S. 2014) Synchronized peak-rate years of global resources use. *Ecology and Society* 19(4): 50

issue of energy supply; we need an integrated strategy to address the nexus of the key resource issues of energy, food and water.¹⁶¹

Fresh water supply is threatened by a combination of climate change (with some food-growing areas becoming drier due to a combination of less precipitation and, in some cases, the loss of glaciers) and the drawing down of aquifers in many parts of the world (in effect, the ‘mining’ of ancient water). Inadequate water supply may be a major factor in determining population health in many parts of the world in the 21st century, not least because of its impact on food production.¹⁶² 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.

- **Food supply:** World food production will need to double within the next 50 years, yet it is threatened not only by inadequate water supply but by soil degradation and loss. In addition, threats to the ocean and to fish stocks, discussed in Chapter 3, are an additional threat to food supply.¹⁶³ Again, we have many known and tested strategies that we do not fully apply, including better storage, more equitable distribution and less waste.

One of the challenges we face with respect to our current system of agricultural production is that 75% of the world’s **agricultural land** is used for raising animals. World average meat consumption per person doubled between 1961 and 2011, from 110 to 230 Kcalories per day (Kcal/p/d). In 2011, people in African countries derived only 88 calories per day from meat, while those in the high income regions derived in excess of 400 calories per day from meat.¹⁶⁴

This is problematic because an animal-based diet is a much less efficient way of providing food than a plant-based diet, requiring more inputs in terms of energy, water and other resources (thus a larger ecological footprint) and a less efficient conversion of plant calories to calories consumed by humans. Moreover, one form of meat production, namely beef production, has a particularly large ecological footprint, at least in North America. A recent study¹⁶⁵ notes that

“environmental costs per consumed calorie of dairy, poultry, pork, and eggs are mutually comparable (to within a factor of 2) [but] beef production requires 28, 11, 5, and 6 times more land, irrigation water, GHG [greenhouse gases], and Nr [reactive nitrogen], respectively, than the average of the other livestock categories.”

Four key strategies have been proposed to dramatically increase global food supply while at the same time making agriculture more environmentally sustainable and our diet more healthy.¹⁶⁶ They are:

- Stop expanding agriculture
- Close yield gaps
- Increase agricultural resource efficiency
- Increase food delivery by shifting diets and reducing waste

161. Webber, Michael (2015) A puzzle for the planet *Scientific American* (February): 63 - 67

162. Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-being: Synthesis*. Washington, DC: Island Press

163. Myers, Samuel S. and Patz, Jonathan A. (2009) Emerging Threats to Human Health from Global Environmental Change *Annu. Rev. Environ. Resourc.* 2009.34(1):223-252

164. Food balance sheets, FAOSTAT. Data downloaded from <http://faostat3.fao.org/download/FB/FBS/E> on 23 Nov 2014

165. Eshel, Gidon; Shepon, Alon; Makov, Tamar and Milo, Ron (2014) Land, irrigation water, greenhouse gas, and reactive nitrogen burdens of meat, eggs, and dairy production in the United States *Proceedings of the National Academy of Sciences*, 111(33): 11996-12001

166. Foley JA, Ramankutty N, Brauman KA, Cassidy ES, Gerber JS, Johnston M, et al. (2011) Solutions for a cultivated planet. *Nature* 478(7369): 337-42

An additional strategy would be to promote organic agriculture. A recent analysis using a meta-dataset of 115 studies found that organic farming yields are only 19.2% lower than those from conventional farming. Moreover, by using multi-cropping and crop rotations, that gap can be reduced to 8 – 9% and might be reduced further.¹⁶⁷

There are important health benefits to such an approach. Not only would land, soil, water and biodiversity be conserved but greenhouse gas emissions and pesticide and herbicide use would drop, while a shift to a low meat or vegetarian diet would have a number of direct health benefits.¹⁶⁸ Moreover, it has been estimated that a diet in the UK that complied with the WHO dietary recommendations would result in a 17% reduction in greenhouse gas emissions, while adding 8 months to average life expectancy.¹⁶⁹

Energy, especially fossil fuel energy as well as electricity - is a major determinant of health in our modern world. But fossil fuel energy is another vital resource where we face the likely prospect of depletion in the relatively near future,¹⁷⁰ or where we may be obliged to dramatically reduce our use, if the concern about the carbon budget is heeded. Indeed, while initially not essential to human life, fossil fuel has now become so embedded within virtually all levels of society and all regions of the planet that it - or socially acceptable replacements providing similar levels of energy - is essential for our current way of life.

We must remember that it is this cheap, abundant fossil energy that has driven the vast majority of human societal and economic development for the past 200 years. The effects of its loss are difficult to imagine and comprehend, and yet we must plan for such a loss. But again, we know what to do; the potential of energy conservation to create, in effect, a new 'supply' of energy is well established. Energy end-use efficiency

The benefits of energy efficiency

Source: Ryan and Campbell (2012)¹⁷²

- At the **Individual level (individuals, households, enterprises)**
 - a. Positive impacts on health and wellbeing
 - b. Poverty alleviation resulting from improved energy affordability and access
 - c. Increased disposable income
- At the **Sectoral level (economic sectors – industrial, transport, residential, commercial)**
 - d. Improved industrial productivity and competitiveness
 - e. Energy provider and infrastructure benefits (e.g. energy providers provide better energy services for their customers, reducing operating costs and improving profit margins)
 - f. Increased asset values
- At the **National level**
 - g. Job creation
 - h. Reduced energy-related public expenditures
 - i. Energy security
 - j. Macroeconomic effects (e.g. increases in GDP, improved trade balance, national competitiveness, and employment support)
- **International level**
 - k. Reduced GHG emissions
 - l. Moderating energy prices
 - m. Improved natural resource management
 - n. Achieving development goals

167. Ponisio L.C., et al. (2014). Diversification practices reduce organic to conventional yield gap. *Proceedings of the Royal Society B: Biological Sciences*, 282, 20141396

168. McEvoy CT, Temple N. and Woodside JV (2012) Vegetarian diets, low-meat diets and health: a review *Public Health Nutr.* 15(12): 2287-94

169. Milner J, Green R, Dangour AD, et al. (2015) Health effects of adopting low greenhouse gas emission diets in the UK. *BMJ Open* 5:e007364.

170. Mohr S. (2010) *Projection of world fossil fuel production with supply and demand interactions*. Newcastle, Australia: University of Newcastle, Australia; 2010. p. 291

- “. . . is generally the largest, least expensive, most benign, most quickly deployable, least visible, least understood, and most neglected way to provide energy services.”¹⁷¹

Moreover, there is a wide range of environmental, social and economic benefits at all levels from the individual to the international (see Text Box), and the opportunity cost of failing to invest in energy efficiency “may represent a cost that we cannot afford to bear.”¹⁷²

At the same time, there are very large health impacts arising from the production of all forms of energy, especially fossil fuel energy and particularly coal. They emanate from the entire energy cycle (exploration, extraction, transportation, processing, use and disposal) and have large public health impacts as well as significant occupational health impacts.¹⁷³ But just as there are health benefits from a shift to a low-meat or vegetarian diet, so too there are health benefits from a shift away from fossil fuels to conservation and renewable energy, as noted later.

Loss of species/biodiversity

The Sixth Great Extinction that is underway represents perhaps the most profound, the most difficult to quantify, and the least understood threat to human health. As part of the web of life, we need to pay attention to the health of other species and populations, not just the health of the human population. 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.¹⁷⁴ For example, birds and bees pollinate many of our plants (hence the huge concern in recent years about colony collapse among bees), while the multitude of microbial species that live in the soil and in or on the plants themselves play a vital role in fixing nitrogen in some species, decomposing wastes, recycling plant nutrients and symbiotically assisting plants in water and nutrient uptake. A wide variety of other organisms – nematodes, insects, reptiles, birds and mammals – are natural pest control agents.

A recent report from the Secretariat of the Convention on Biological Diversity and WHO has started to address this question in more detail.¹⁷⁵ Their report notes that “biodiversity underpins ecosystem functioning and the provision of goods and services that are essential to human health and well-being . . .”. The report then provides numerous examples of how biodiversity contributes to important ecological determinants of health, including water and air quality, food security, microbial diversity in the human microbiome, infectious disease control, pharmaceuticals and traditional medicines and mental, physical and cultural wellbeing.

Small wonder they conclude:

“Thus, biodiversity is a key environmental determinant of human health the conservation and the sustainable use of biodiversity can benefit human health by maintaining ecosystem services and by maintaining options for the future.”

171. Lovins, Amory B. (2005) *Energy End-Use* Amsterdam: Efficiency Inter-Academy Council

172. Ryan, Lisa and Campbell, Nina (2012) *Spreading the Net: The Multiple Benefits of Energy Efficiency Improvements* Paris: International Energy Agency Available at http://www.iea.org/publications/insights/ee_improvements.pdf

173. Smith, K. R.; Balakrishnan, K.; Butler, C.; Chafe, Z.; Fairlie, I.; Kinney, P.; Kjellstrom, T.; Mauzerall, D. L.; McKone, T.; McMichael A. and Schneider, M. (2012) Chapter 4 - Energy and Health. In *Global Energy Assessment - Toward a Sustainable Future*, Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria, pp. 255-324.

174. Chivian, Eric and Bernstein, Aaron (2010) *How our Health Depends on Biodiversity* Cambridge MA: Center for Health and the Global Environment, Harvard Medical School

175. Secretariat of the Convention on Biological Diversity and WHO (2015) *Connecting Global Priorities: Biodiversity and Human Health, Summary of the State of Knowledge Review* Montreal: Secretariat of the Convention on Biological Diversity

Health impacts in Canada

In 1994 the Canadian Global Change Health Panel wrote: “*there is no comprehensive approach to health aspects of global change in Canada.*”¹⁷⁶ Sadly, 20 years later, that is still largely true. Yet in the intervening years global ecological conditions have worsened markedly. However, we do not entirely 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.*”¹⁷⁷ Health Canada has identified seven categories of climate-related impacts, and the potential effects these can have on health and wellbeing. These effects will vary across Canada, reflecting Canada’s size and geophysical characteristics. More frequent and severe extreme weather events should be expected. Some regions will experience wetter trends while others will experience drought conditions. Both drought and floods can affect food security (an issue not noted by Health Canada) while floods can also have more obvious sudden, catastrophic, and costly effects.¹⁷⁸
- The most recent report of the Chief Public Health Officer of Canada¹⁷⁹ includes a section on climate change and health. The report notes that “*climate change can exacerbate many existing health concerns and present new risks to the health of Canadians.*” The report’s conclusions are consistent with some of the recommendations of this report (see Text Box).

One place where climate change has already been seen to have effects is the case of urban heat events, which led a number of cities to prepare ‘heat emergency’ plans, especially to protect the more vulnerable members of the community, while Health Canada has prepared Extreme Heat Events Guidelines.¹⁸⁰
- Health Canada has been monitoring environmental chemicals in Canadians since

Public health action on climate change

Public health can:

- continue research to better understand how changes in climate affect health particularly that of vulnerable Canadians;
- increase awareness among public health professionals and the general public about the health risks of a changing climate;
- be proactive and consider short- and long-term climate changes;
- find ways to adapt to reduce the impacts on health;
- optimize ongoing assessments and share best practices and lessons learned to develop more effective public health adaptation programs; and
- support multijurisdictional, multidisciplinary collaborative approaches to tackle the challenges of climate change in Canada.

Source: Chief Public Health Officer of Canada, 2014 (Footnote 179)

176. Canadian Global Change Health Panel (1994) *Implications of Global Change for Human Health* Ottawa: Canadian Global Change Program, Royal Society of Canada

177. Berry, P., Clarke, K., Fleury, M.D. and Parker, S. (2014) *Human Health*; in Warren, F.J. and Lemmen, D.S., (editors) *Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation* Ottawa, ON: Government of Canada Available at <http://www.nrcan.gc.ca/environment/resources/publications/impacts-adaptation/reports/assessments/2014/16309>

178. Health Canada (2009) *Understanding the Health Effects of Climate Change* Available at <http://www.hc-sc.gc.ca/ewh-sem/sem/impact/index-eng.php> Accessed 27 July 2014

179. Chief Public Health Officer of Canada (2014) *Report on the State of Public Health in Canada, 2014: Public Health in the Future* Ottawa: Public Health Agency of Canada

180. Health Canada (2011) *Extreme Heat Events Guidelines: User Guide for Health Care Workers and Health Administrators* Ottawa: Health Canada Available at <http://www.hc-sc.gc.ca/ewh-sem/pubs/climat/users-guide-utilisateur/index-eng.php>

2007 as part of the Canadian Health Measures Survey; collection for the third cycle (2012 – 2013) was completed in 2013, with the first data release expected in October 2014.¹⁸¹ One area of particular concern in Canada is the high level of persistent organic pollutants in the food chain and thus the bodies of Inuit living in the Arctic. The combination of global distillation of POPs, concentrating them in the North, and a diet based high in the food chain and containing a lot of ‘country food’ (wildlife) has resulted in Inuit – who live far from industrial areas – having some of the highest levels of POPs in the world.¹⁸²

- Disturbingly, a recent report on the environmental burden of disease in Canada does not include the terms ‘ecosystem’ and ‘ecological’, and while the term ‘climate change’ occurs several times, no estimates of environmental burden are given.¹⁸³ In short, we have little good data on the environmental burden of disease in Canada, let alone the burden of disease related to ecological change.
- Given the lack of good data on the health impacts of resource depletion and loss of biodiversity at the global level, it is not surprising that this would also be the case for Canada. But there have been some specific examples in recent times of resource depletion (Atlantic cod and Pacific salmon, for example) that have already had a significant indirect impact on health and social wellbeing in Canada.

One important factor that complicates the picture when considering the health impacts of global ecological change in Canada is the fact that Canada is a large, wealthy and highly industrialized nation. As such, Canada is able to protect itself somewhat from the impacts of many forms of global ecological change, at least in the short to medium-term, so we may succeed to some extent in insulating ourselves from the worst of the impacts, at least for a while.

This also poses a problem in that, being a wealthy nation, the governing leaders of Canada may feel that they do not need to put in place the advance preparations necessary to deal with the uncertain onslaughts of climate change. However, we do all share the same planet, and we are all part of a global community and a global economy, so there is a limit to the extent to which Canada can insulate itself.

Nonetheless, in the immediate future, and perhaps for some time longer, mortality and morbidity are not likely to be greatly affected, although as is common with almost all situations resulting in illness and death, those most affected will be those most vulnerable: the elderly, the very young, the poor, the isolated and others on the fringes of society.

Looking to the future

If it is hard to measure the current health effects of global ecological change in Canada and around the world, it is even harder to provide good estimates of future health impacts. This is because those impacts will be influenced by many social, political and economic factors, especially by the level of development and commitment to social solidarity and equity, as well as by local geography and environmental conditions.

Given the trends in ecosystem functioning described in Chapter 3 and the unrelenting pressures of growing populations, growing per capita demand, more powerful and pervasive technology and the ongoing dominant paradigm of modernization there is every reason to believe that the overall

181. Health Canada (2013) *Second Report on Human Biomonitoring of Environmental Chemicals in Canada* Ottawa: Health Canada

182. Dewailly, Éric (2006) Canadian Inuit and the Arctic Dilemma *Oceanography* 19 (2): 88 - 9

183. E Risk Sciences (2010) *Systematic Review of Environmental Burden of Disease in Canada* (Final Report) Vancouver BC: National Collaborating Centre for Environmental Health

health impacts will grow. But the real danger lies in sudden, rapid and largely unpredictable, non-linear changes that might occur as we pass ecological boundaries (tipping points). Such changes can lead to varying degrees of ecological collapse, from local to global, and under those circumstances, if societies do indeed steeply decline or collapse, the health impacts will be large, sudden and dramatic.

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.¹⁸⁴

Such a future is by no means 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 smogs of early 20th century industrial cities or the disappearance of the stratospheric ozone layer, we have risen to the challenge. But, we must act soon, and we need to create a very different society, based on very different values (see the Earth Charter). Public health has been in the forefront of action to address previous massive threats to the health of the population, and can play a vital role yet again in confronting what is clearly the largest threat to health in centuries. How that might be achieved is the subject of the remaining chapters of this report.

184. McMichael, Nyong and Corvalan (2008) *op cit*

CHAPTER SIX: IMAGINING A MORE SECURE, HEALTHIER FUTURE

Margot Parkes, Andrea Chircop, George McKibbin, Blake Poland, Trevor Hancock

“Vision is values projected into the future”

**Clem Bezold, Founder and President
Institute for Alternative Futures**

Achieving our vision for a *‘healthier, more sustainable, more just society and communities’* is not going to be achieved in isolation from wider social processes. Attaining any such vision will demand transitions both within and outside public health and the larger health sector, as well as an explicit re-engagement with the values of public health.

Working together to achieve an alternative future necessarily draws collaborators into a space beyond their own often narrow sectoral mandates and specific fields of knowledge. Thus public health will be challenged to engage in a new generation of practices, policies and processes. This involves orienting to existing precedents and foundations in public health, considering alternative narratives and scenarios for the future, and addressing some of the opportunities and tensions for public health practice, education and research.

Issues at the interface of health, ecosystem sustainability and social justice, and especially the intersection of these issues, constitute what some call a ‘wicked problem’. Such problems challenge the way a society operates, and call for changes in that society.¹⁸⁵ Among other things, we will need some fundamental shifts in societal values, and with that shift, new ethical principles, new ways of knowing, new ways of measuring and ultimately, new ways of governance will emerge. Fortunately, we do not have to invent these from scratch, because we have a combination of precedents and newly emerging practices that provide a foundation for the new future we need to create.

Foundations for (re)connecting social and ecological determinants of health

The foundations exist for connecting – or more accurately, perhaps, re-connecting - the ecological and social determinants of health in the practice of public health, as well as in the wider communities and society within which public health practice is situated. Some have existed for centuries, even millennia, while some have emerged in recent decades as we come to better understand the converging goals of health, social equity, and ecosystem sustainability.

- First and foremost, we acknowledge the obvious connections with the long-standing precedents offered by Canada’s Aboriginal communities. It is imperative to recognize the opportunity to build on the rich traditions and wisdom of First Nations and Aboriginal communities’ holistic understanding of the interconnectedness of individuals, communities and the environment. The Seventh Generation Principle is attributed to them, requiring that before any decision to act is taken, the consequences of such a decision seven generations hence must be considered and taken into account.
- Within public health itself there is a very strong history, dating back to the 19th and early 20th century, of taking on the massive challenges of the degradation of the built and natural environment and the dramatic social changes that accompanied industrialization and

185. Brown, V., Harris, J., & Russel, J. (2010). *Tackling Wicked Problems: Through the Transdisciplinary Imagination*. Oxford: Earthscan.

urbanization, and of being involved in, indeed sometimes leading, the resulting social, urban and political reforms.

- In the Canadian context we have several recent precedents and foundations in research, education and practices in the broad areas of Ecohealth and One Health. These resulted from decades of leadership by Canadian and international scholars and practitioners.
- Finally, there are the social and ecological practices found in communities across Canada (and around the world) facing issues such as the collapse of the cod fishery in Newfoundland, the Sydney tar-ponds in Cape Breton NS, asbestos mining in Asbestos QC, chemical pollution in Sarnia ON affecting the Walpole Island First Nation, radiation pollution in Port Hope ON, tar sands development in Alberta affecting First Nations, and forestry practices in Clayoquot Sound BC.

We have seen the emergence of ‘**principles**’ to guide how we understand and respond to these issues (Table 2)¹⁸⁶, a distillation of patterns, recurring values and priorities that have consistently emerged in the several decades of work seeking to refine and extend the ambitious socio-ecological orientation of the Ottawa Charter for Health Promotion.

The fields of health promotion and ecohealth offer both conceptual and procedural guidance to inform a shift toward public health equity for future generations. Public health is in an ideal position to lead the move to reintegrate work on the social determinants of health, which are mostly concerned with health equity among current populations, with work on the ecological determinants of health, with their focus on the wellbeing of future generations.

We also need to understand, respect and integrate **new ways of knowing and new ways of gaining knowledge**. Public health will share the challenge of fostering new conceptual, practical and tacit knowledge and skills (such as ‘reasoning together’ and participatory research) and even the ‘transdisciplinary imagination’ required to consider horizontal and vertical integration within and across departments, sectors

Table 2: Patterns of principles for re-engaging with the socio-ecological context for health converging toward health equity for future populations

Six Principles for a Settings Approach to Greening Settings	Six Principles to inform the application of Ecosystem Approaches to Health
<i>From Poland and Dooris 2010</i>	<i>From Charron 2012a, 2012b [1]</i>
Adopt an ecological ‘whole system’ perspective	Systems Thinking
Start where people are (listen to and respect lived experience, diverse forms of knowledge)	Participation
Practice rooted in place	Sustainability
Deepen the social analysis (connect lived experience to that of others and to the practices, structures that create and sustain inequity located in broader context of relations of power)	Transdisciplinary Research
Asset-based / appreciative inquiry approach	Gender and Social Equity
Build resilience (for change) instead of efficiency (for narrow set of operating conditions)	Knowledge to Action

Note: [1] The order of Charron’s principles is adapted to highlight commonalities with Poland & Dooris.

186. Poland, B., & Dooris, M. (2010). A green and healthy future: the settings approach to building health, equity and sustainability. *Critical Public Health* 20(3): 281–298; Charron, D. (2012a). Ecosystem Approaches to Health for a Global Sustainability Agenda. *EcoHealth* 9 (3): 256-266; Charron, D. (2012b). *Ecohealth Research in Practice: Innovative Applications of an Ecosystem Approach to Health*. Springer, New York, NY, USA / International Development Research Centre, Ottawa, Canada.

(governmental and non-governmental), communities and academic disciplines.¹⁸⁷ All this complexity means being or becoming comfortable with ambiguity and a form of knowledge generation that does not necessarily follow a prescriptive methodology or approach. Thus new ways of knowing need to be negotiated and re-negotiated based on skillful dialogue and commitment to learning together.

This is necessary because the ecological circumstances we face are changing what we have assumed to be the normal professional environments from which we make professional judgments, in ways that make acquired knowledge less useful in meeting the challenges that our communities face. More important perhaps than just gaining knowledge is gaining wisdom, so that the knowledge we have is used appropriately

As noted in Chapter 4, we need **a new understanding of the concept of development and a new form of economics**. Development needs to be understood as the development of human potential, which is society's greatest resource, not simply as economic growth. Progress should thus be measured in terms of the growth in human (not economic) development and human potential. This means understanding the economy as a social construct intended to serve humanity, not the other way around. Concepts have been emerging over the past few decades about alternative approaches to economics, new understandings of capitalism in the 21st century and to new ways to measure social progress (discussed in more depth in Chapter 7). These are hopeful signs and may provide an important way of (re)connecting the social and ecological determinants of health.

Toward shared governance: Crossing intersectoral boundaries in pursuit of health

These new understandings, principles and ways of knowing also have important implications for governance, which is “the sum of the many ways individuals and institutions, public and private, manage their common affairs”,¹⁸⁸ including collectively solving their problems and meeting society's needs. In the health area, they have led to the emergence of the concept of ‘governance for health’¹⁸⁹ or ‘healthy governance’, an approach that has been promoted by, among others, the WHO Commission on the Social Determinants of Health.¹⁹⁰

In talking of intersectoral action, we need to recognise and apply at least three forms of such action:¹⁹¹

- **inter-departmental action** (e.g. across departments, ministries, faculties etc.) within a city or national government, or within any single institution at any level);
- **true intersectoral action** (i.e. across sectors beyond the institution - again, at any level); and
- **vertical integration** (not necessarily intersectoral) across multiple levels, which could be within a single sector (e.g. municipal, regional, provincial and national governments

187. Brown, V. (2007). Collective Decision-Making Bridging Public Health, Sustainability Governance and Environmental Management. In C. Soskolne, L. Setra, L. Kotzé, B. Mackey, W. Rees, & R. Westra, *Sustaining Life on Earth: Environmental and Human Health Through Global Governance*. Lanham, MD: Lexington Books; Brown, Harris and Russel, 2010) *op cit*

188. The Commission on Global Governance (1995) *Our Global Neighborhood* Oxford: Oxford University Press

189. Kickbusch I. and Gleicher D (2012). *Governance for health in the 21st century: a study conducted for the WHO Regional Office for Europe*. Copenhagen, WHO Regional Office for Europe

190. WHO Commission on the Social Determinants of Health (2008): *Closing the gap in a generation: health equity through action on the social determinants of health. Final report of the Commission on Social Determinants of Health*. Geneva, World Health Organisation

191. Hancock, T (2008) *Beyond Health: Human Development and Healthy Local Governance* A presentation at the “Seminário: Determinantes Sociais e Ações Intersetoriais em Saúde”, Paulista, Brazil, 17th March 2008

working together) or across both sectors and levels (e.g multi-stakeholder groups at national and international levels working together on, say, an international agreement or initiative).

A key component of this approach is **'Health in All Policies'**, a re-working of the health promotion strategy of creating healthy public policies. If we accept that health has ecological as well as social determinants, then the role of public health will inevitably need to shift within an expanded terrain of "unusual allies". This will require extending beyond traditional partners associated with the social determinants of health, including those associated with ecological and biophysical dynamics of urban planning, agriculture and food security, environment, natural resource extraction, energy policy, forestry and related issues.¹⁹² The public health implications of the social determinants of health can, and should be embedded within the encompassing biophysical environment. This requires an explicit commitment to redressing an ecological and ecosystemic 'blindness' in some of the integrative efforts to date.

However, appeals to loftier values or the pursuit of technical solutions (e.g. governance mechanisms and structures), while necessary, are unlikely to be sufficient engines of change as long as underlying dynamics of inequitable power relations, wealth accumulation, and exploitation remain unaddressed.¹⁹³ Distributional equity and sustainability will require addressing who benefits from systems, laws, policies and practices that have been tailored over time to benefit some more than others through systemic marginalization and disempowerment. This will also require addressing the powerful vested interests that frequently mobilize to block changes designed to bring about greater social equity and ecological sustainability.

Healthy, just, and sustainable public health approaches – across settings and scales

Fortunately, public health has precedents to draw on to envision the links between health, equity and ecosystems across different contexts and at different levels of action, from the local, to the global. A strong set of precedents in linking health, equity and sustainability concerns has emerged from **local level work** that has explicitly sought to integrate social and physical environments – including settings approaches and neighborhood-focused work (e.g. healthy schools, workplaces, communities etc.). Establishing the links between health, equity and ecosystems involves rooting practice in a place; adopting an ecological "whole system" perspective; starting where people are in terms of their understandings and needs; deepening the social analysis by connecting people's lived experience to that of others; using an asset-based/appreciative inquiry approach, and building resilience for change.¹⁹⁴

192. Parkes, M., Bienen, L., Breilh, J., Hsu, L., McDonald, M., Patz, J., et al. (2005). All Hands on Deck: Transdisciplinary Approaches to Emerging Infectious Disease. *EcoHealth*, 2 (4), 258-272; Northern Health. (2012). *Position on the Environment as a Context for Health: An Integrated Settings Approach - Version 2.0*. (July 25) Prince George, BC: Northern Health

193. Baum, F., & Sanders, D. (2011). Ottawa 25 years on: a more radical agenda for health equity is still required. *Health Promotion International* 26 (S2): ii253-ii257.

194. Poland & Dooris (2010) *op cit*

It has become increasingly important to be more explicit about the interactions among 'local' healthy settings (whether healthy schools, workplaces, communities, hospitals or other settings) and the ecosystems on which they depend. This has led to the idea of linking 'healthy settings' with 'green settings' to create a new realm of potential synergies among health, equity and ecosystem considerations¹⁹⁵ -



see Figure 12. Moreover, by rooting public health practices in places inhabited by populations vulnerable to and experiencing health and environmental inequities we establish the necessary link between scales and policy levels.

Shifting from the local to the regional allows a greater recognition of the ecosystem units that are particularly important to the region. Thus we can consider watershed units where drinking water risks or land and water management may be implicated¹⁹⁶ or an airshed where air quality risks may be at issue.¹⁹⁷ An example of boundary-crossing across social and ecological boundaries with implications for health and wellbeing is the new body of work emerging on the 'healthy parks – healthy people' initiatives in Canada and internationally.¹⁹⁸ There is a growing body of evidence and practice about the importance for health of contact and engagement with nature¹⁹⁹ and this too can best be facilitated at the local and regional level.

If we are to engage with the ecological determinants of health in a manner that reflects how nature and living systems manifest, it is critical to consider units that provide ecological and organizational coherence – especially if we are to envision planning processes that genuinely engage with converging objectives of sustainability, equity and health. This regional level approach, sometimes known as bio-regionalism,²⁰⁰ poses both challenges and opportunities for public health, which has traditionally engaged with units and jurisdictions that are socially and politically bounded, but this will be an essential feature of a new generation of integrated planning and governance.

At the national level public health also needs to recognize the importance of integrated action linking sustainability, equity and health. The notions of intersectorality and integrated governance become especially important and challenging at the national level. Many would argue that at this scale monitoring and messaging seem to be the key functions that need to be performed so that public health officials at the regional and local levels have the necessary information and supports to act.

195. Northern Health (2012) *op cit*

196. Parkes MW, Horwitz P. (2009). Water, ecology and health: Exploring ecosystems as a 'settings' for promoting health and sustainability. *Health Promotion International* 24: 94 -102

197. Clean Air Hamilton. (2013). *Annual Report*. Retrieved July 22, 2013, from Clean Air Hamilton: <http://www.cleanair.hamilton.ca/default.asp?id=71>

198. Healthy Parks Healthy People Central - <http://www.hphpcentral.com/>

199. Kuo, F. (2010). *Parks and Other Green Environments: Essential Components of a Healthy Human Habitat*. Ashburn, VA: National Recreation Association

200. Bioregional Congress (2014) *WELCOME HOME!* Accessed 30 June 2014 at <http://wp.bioregionalcongress.net/>

Finally, we need to give explicit attention to how we work together **at the global level**. Here, we can benefit from a growing recognition of the intersectoral challenges for public health in processes such as the Millennium Ecosystem Assessment, and the post-2015 Millennium Development Goals processes,²⁰¹ among others.

Thinking about and creating the future we prefer

If people could explore and understand the forces that shape us, and the possible futures we face, they would be better able to make choices about their own future, express their values in a vision and then work to create it.. Most people and organizations think that ‘business as usual’ is the most probable future and act accordingly. A wider frame of reference suggests we may be facing many possible futures, all the things we can dream of, both good and bad, from a somewhat science-fiction high-tech liberating future to the adverse consequences of the changes described in this document – or worse, But what we most need to do is explore alternative scenarios of plausible futures that can meet our needs and that of future generations within the Earth’s limits, and we then need to help people create visions and scenarios describing their preferred future.²⁰²

Scenarios are important because each alternative scenario embodies a set of implicit values, which people understand as they engage with them. They are then in a position to make some judgments about which scenario best fits with their own values, and thus constitutes for them a vision of their preferred future. The use of scenarios and future narratives is also consistent with the role of collective ‘imagination’ and learning. Scenarios and narratives are especially suited to designing and engaging with the potential of ‘What could be?’ in terms of the future worlds - including the potential social-ecological context within which public health may function in the future.²⁰³

The ‘next generation’ of public health is explored in the main report through three possible narratives about the future, entitled ‘Doing the same things’, ‘Doing the same things better’ and ‘Doing better things’, and each written with the voice of someone looking back from a timeframe of approximately 15 years in the future (~2028-2030). They are not so much predictions of possible futures as they are stories that help us make sense of what is happening and what is possible. Thus each of the scenarios presented in Table 3 embodies a different cultural narrative about this time we are in and a different set of values about where we are headed, and thus how we can be engaged with the work of co-creating the future.

(The three narratives can be found in Appendix C)

201. Horwitz, P., Morrison, K., Parkes, M., Patz, J., & Zinsstag, J. (2012). Integrating Health, Sustainability and Ecosystems in the Post-2015 Development Agenda. *Think Piece for Health in the Post-2015 Development Agenda* <http://www.worldwewant2015.org/node/300226>

202. Henchey, N. (1978) Making sense of future studies *Alternatives* 7: 24-29; Bezold, Clem and Hancock, Trevor (1994) Possible futures, preferable futures *Healthcare Forum Journal* 37(2) 23-29

203. Brown (2007) *op cit*; Brown, Harris and Russell (2010) *op cit*

Viewing all three narratives together prompts reflection that, to a certain extent, all three are already in play, and public health is already engaging implicitly or explicitly with these different potential trajectories.

Moreover, there is in some ways a flow to the three narratives; in the first, we try to carry on as normal, but as that fails, we move to a more rigorous risk management approach, trying to carry on as normal, while imposing some restraints to keep the risk tolerable. Only when that too is seen to be failing are people ready for, and indeed clearly in need of a more transformative approach, where we do better things rather than doing the same things better.

Such an approach, as summarized in Table 3, involves recognizing the limits to what we know (or think we know) and working in partnership with many other disciplines on non-linear and unexpected changes 'beyond the tipping point'. It may be that in this situation that there are gains to be made from such disorder, where resilience is seen not as the ability to 'bounce back' to the former (problematic) situation, but to 'bounce forward' to a new, more sustainable and healthy future.

We anticipate a sense of both opportunity and tension arising as members of the public health community consider building on existing work that explicitly engages with the ecological as well as social determinants of health and, pushing further, a range of related economic, social and cultural challenges that emerge when we start 'thinking about – and consciously changing - the future'. One way of capturing these opportunities and challenges in the Canadian context is in relation to the core competencies for public health in Canada,²⁰⁴ which need to be revised to incorporate this eco-social thinking and ensure the development of the competencies needed to deal with ecological change and its public health implications.

Table 3: Characteristics of the Three Alternative Narratives

Narrative 1: Business as Usual	Narrative 2: Risk Management	Narrative 3: Transition
You know what you know	There are things you know you don't know	There are things you don't know you don't know
You are working in your policy/legislative mandate	You are working with other departments/professions on shared policy/legislative mandates/programs	You are working with a host of other departments/professions/ stakeholders on shared concerns where policy/ legislative mandates may not exist
You are delivering a program	You are working with risk based/actuarial concerns	You are working on matters beyond the "tipping point"
Program delivery by linear measurement and a defined narrative	Program delivery involves increasing inability to predict rare events and broken narratives exist where rare events are concerned	You are working with asymmetries
Fragile ^[2]	Robust	Gains from disorder
Vulnerable (Lack of resilience)	Resilience as capacity to 'bounce back'	Resilience as capacity to 'bounce forward'
Forecasting as projection of current stability	Increasing forecasting uncertainty	Alternative futures definition as a function of partnerships and action plans
Working with theory of general application	Working with theory and place	Working with place and developing theory and new relationships
Doing the same things	Doing the same things better	Doing better things

204. PHAC. (2010) *Core Competencies for Public Health in Canada*. Ottawa: Public Health Agency of Canada. Available at http://www.phac-aspc.gc.ca/php-psp/ccph-cesp/about_cc-apropos_ce-eng.php

Beyond competencies, there are critical design and ‘imaginative’ challenges for the public health community to engage with.²⁰⁵ For example, public health practice, education and research will need to participate in what can be considered a societal ‘design challenge’ of creating appropriate social, cultural and physical infrastructure for a healthy, just and sustainable future. For example, the design of neighborhoods would need to reflect a physical infrastructure conducive to an ecohealth-friendly way of life and, equally important, would need to offer accessible services and amenities necessary to enable equal participation in an ecologically healthy community.

Among the suite of opportunities of public health, fostering our sense of imagination of the future will be critical component of fostering an alternative, more positive future that addresses complex challenges at the interface of health, ecosystems and society. So Appendix C concludes with a narrative imagining the every-day practice for a Public Health Nurse in 2028 in a local community where an eco-social approach to improving health has been widely adopted.

205. Brown, Harris and Russell (2010) *op cit*

CHAPTER SEVEN: SIGNS OF HOPE

Trevor Hancock, Blake Poland, Margot Parkes, Andrea Chircop, George McKibbin

“Hope is . . . the commitment to positivity in the face of adversity”

Dutt and Brcic, 2014²⁰⁶

While it may be true that bad news sells, it does not make for a very positive or hopeful basis for action; in fact it could paralyse us. We know that portraying only the bad news about tobacco, for example, is a poor way to persuade smokers to quit or to scare off non-smokers. But there is a happy medium between a sort of starry-eyed, Polly-Anna-like optimism based on a naïve belief in the ability of science and technology to overcome all our problems and a deep pessimism that says we are all doomed. There is no question that when one looks at the global situation and the extent and rapidity of ecological change there is much cause for concern. But as we look locally, there is cause, if not for optimism, then certainly for hope.

There are several messages of hope for the public health community.

- First, the shift to a more ecologically sustainable society not only results in health gains from avoiding harm, but also positive health gains from what would be healthier ways of living and a healthier environment.
- Second, many times in the past we have successfully helped to create major societal shifts in favour of health. We know how to do it, and we can do it again. And while the changes we seek are large, and the forces we face are very powerful, that was also the case in the long struggle to address the health problems created by the industrial revolution in the 19th century.
- Third, we are not alone; we have many potential partners among environmental and community organisations and municipalities, private sector businesses and some state/provincial and even national governments.
- Fourth, for the most part we know what needs to be done and have known 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 should strengthen our resolve to keep trying.
- Fifth, we have made some progress. There are in fact many examples of people, organisations, businesses, communities, cities, even nations, who are doing the right things and setting an example. Now we need to adopt these practices within our own public health and health care organisations and help our partners scale up these activities.

An example from the 1980s may be helpful. In the face of an overwhelming threat to health from the likely impacts of nuclear war, there was both concerted international health action and a recognition of the sense of powerlessness and despair that people were experiencing. The work of Joanna Macy and others tried to deal with that despair, turning it around into useful energy and action; now those same ideas are being applied to the helplessness and despair people may feel in the face of the ecological crisis, a process called ‘Active Hope’.²⁰⁷ This requires us to

- Take in a clear view of reality

206. Dutt, Monika and Brcic, Vanessa (2014) Medicare can still rise to meet its challenges *Times Colonist* 9 Aug, p A 11

207. Macy, Joanne and Johnstone, Chris (2012) *Active Hope: How to Face the Mess We're in without Going Crazy* New World Library

- Identify our vision for what we hope will happen
- Take active steps to help bring that vision about.²⁰⁸

There are signs of hope in several areas. Here we draw attention to three in particular: The key conceptual and strategic rethinking that has been going on internationally with respect to development and economics; the health benefits of a more sustainable society and some of the many inspiring efforts underway at the local level to build on local capacity and create healthier, more sustainable and more just communities.

Rethinking development and economics

The recognition by the UN General Assembly, in its 1986 Declaration on the Right to Development, that "*the human person is the central subject of development*" was followed in 1990 by the creation of the Human Development Index (HDI) and its adoption by the UN Development Program.²⁰⁹

Apart from the very important focus on human rather than other forms of development, the HDI enables us to ask how countries with very different levels of per capita income can have the same HDI, since this can have important implications: Countries with a lower per capita income normally have a smaller ecological footprint, so from an ecological point of view, achieving a high HDI with a lower per capita income is important, and provides us with useful alternative models of national development that are worth examining.

An environmentally conscious form of development was championed by the World Commission on Environment and Development (1987), which defined sustainable development as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*".²¹⁰ The Commission's work spawned a large and sustained effort that continues to this day among NGOs, governments at all levels, many corporations and individuals. Beyond the concept of sustainable development, there has been a proliferation of other models of development;²¹¹ what they have in common is the meeting of social and ecological goals alongside economic development. They have been field-tested in many regions of the world, but to this point have remained marginal in the face of the dominant paradigm that puts economic development ahead of human development and the environment.

As noted earlier, from an ecological perspective there are serious problems with the current economic model, the concept of the GDP in particular as a measure of the progress, and the commitment to GDP growth. Fortunately, there are several alternative, human-centred, socially just and ecologically sustainable economic models.²¹² A profound implication of these new forms of economics is that if we have reached the limits to growth, and if we need to constrain further growth so as to limit harm to the planet's ecosystems, then economic growth cannot be considered as the solution to the problem of global poverty. If the pie is limited in size and cannot grow, inequality and poverty must be addressed by redistributing its contents; i.e. redistributing the sustainably useable wealth of the world.

208. Active Hope Training - <http://www.activehope.info/styled-4/index.html>

209. UNDP – Human Development Index - <http://hdr.undp.org/en/content/human-development-index-hdi>)

210. WCED (1987) *op cit*

211. There are multiple references in Section 7.2.1 of the main report

212. There are multiple references in Section 7.2.2 of the main report

A key tenet of these alternative forms of ecological economics is that there is more than one form of capital. Ecological economics distinguishes at least five; natural, social, human, financial and built capital, (although some see built capital as part of economic capital); moreover it recognises that much of the world's true wealth lies in its natural, social and human capital rather than in its economic capital.²¹³ Of these, human capital (which includes health and wellbeing) is the major concern of the health professions and others concerned primarily with human development, although public health also recognizes the other forms of capital as determinants of health. Together, at the local level, they comprise 'community capital'²¹⁴ – see Figure 13.

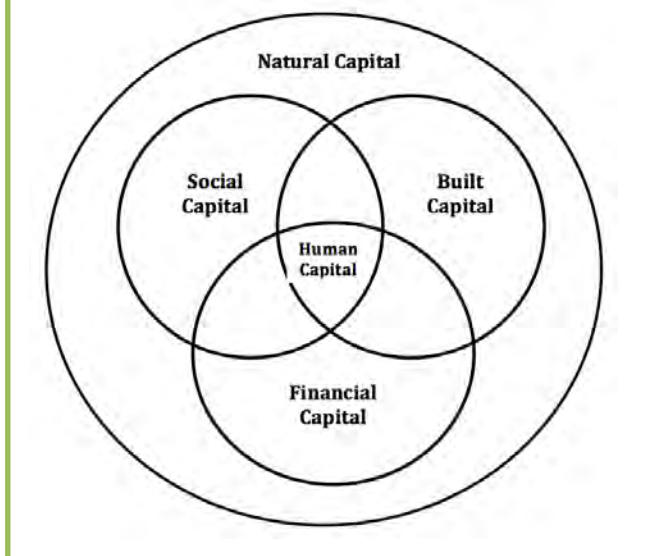
Building one or two forms of capital – financial and built capital – by depleting natural, social and human capital (which is what our current economic system commonly does) is a very destructive form of capitalism. Today we need a new form of capitalism, one that *simultaneously* builds all forms of capital, and which accounts not only for economic costs and benefits but for ecological, social and human costs and benefits.

It was mentioned earlier that corporations need to be challenged for the harm they do to health and to ecosystems. But not all corporations should be painted with the same brush; it is very important to try to work with those that are willing to move in the right direction. Over the past few decades, some corporations and some sectors have moved in the direction of sustainability and even social justice and equity. International efforts such as the ISO standards for environmentally responsible business practice, the emergence of the concept of corporate social responsibility, corporate reporting on sustainability and the Dow Jones Sustainability Index are all steps in the right direction that need to be encouraged and supported.²¹⁵

Another challenge we face is that in many cases the chief measures of a country's or province's progress and success are economic; in particular, great attention is paid to the GDP and to GDP growth. Yet the GDP is a poor measure for our purposes, primarily because it puts the emphasis on economic rather than on human development and progress and fails to account for the harmful impacts of some economic activity while excluding non-monetised contributions to social welfare such as volunteerism.

Figure 13: Community capital

Source: Based on Hancock, 2001



213. World Bank (1995) *Monitoring Environmental Progress (MEP) A Report on Work in Progress* Washington DC: World Bank

214. This is a revised version of the Figure in Hancock, Trevor (2001) People, partnerships and human progress: Building community capital *Health Promotion International* 16 (3): 275-280

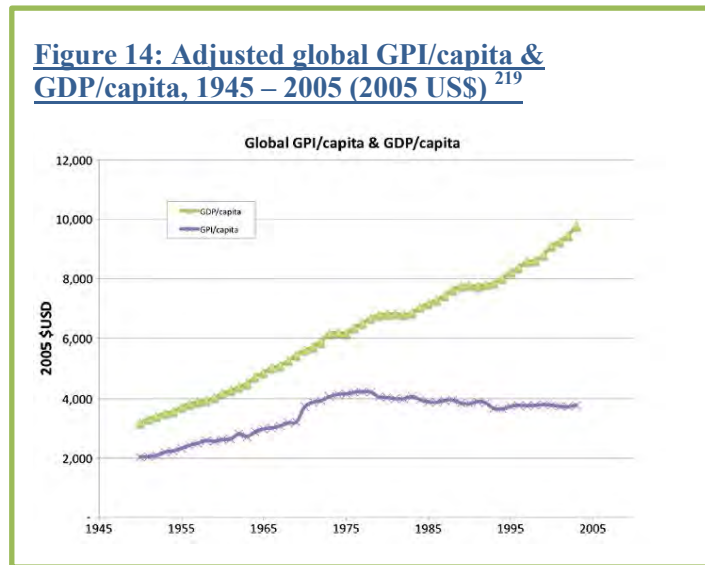
215. See for example the ISO Standards for sustainability (http://www.iso.org/iso/sustainable_development); the Global Reporting Initiative (<https://www.globalreporting.org/information/sustainability-reporting/Pages/default.aspx>) and the Dow Jones Sustainability Index (<http://www.sustainability-indices.com>)

Here too there has been much work to develop alternative measures of progress, work that has attracted interest and attention at the highest levels, including a Presidential Commission in France²¹⁶ and a focus on measuring social wellbeing in the UK.²¹⁷

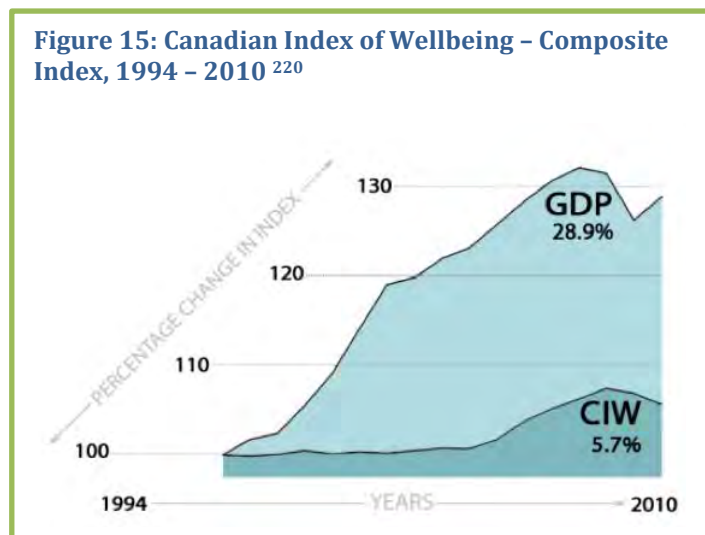
A number of more comprehensive measures of societal wellbeing and progress have been proposed in recent years. These measures are designed to integrate the various forms of capital, to value social cohesion, sustainability, wellbeing and quality of life. We discuss four of them.

- The **Genuine Progress Indicator (GPI)** starts with the same personal consumption data that the GDP is based on, but then makes some crucial distinctions. It 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.²¹⁸

A recent study that compared the GDP and GPI for 17 countries for the period from 1955 to 2005 is both revealing and troubling: While global GDP has increased more than three-fold since 1950, the GPI has actually decreased since 1978. Moreover, beyond about \$7,000 GDP per capita, further increases in GDP per capita are *negatively* correlated with GPI²¹⁹ - see Figure 14.



- In Canada, the **Canadian Index of Wellbeing (CIW)** “tracks changes in eight quality of life categories. In the seventeen year period from 1994 to 2010, while Canada's GDP grew by 29%, our quality of life (CIW) only improved by 5.7%”²²⁰ - see Figure 15.



- A third alternative measure is the **Happy Planet Index**, developed by the New Economics Foundation in the UK. “It is the first index to combine environmental impact with well-being, ranking countries on how many long and happy lives they produce per unit of

216. Commission on the Measurement of Economic Performance and Social Progress (2009) *Report of the Commission . . .* Paris: The Commission Available at <http://www.stiglitz-sen-fitoussi.fr/en/index.htm>

217. Office of National Statistics (2012) *First Annual ONS Experimental Subjective Well-being Results*

218. Redefining Progress (nd) *Genuine Progress Indicator* Available at http://rprogress.org/sustainability_indicators/genuine_progress_indicator.htm

219. Kubiszewski, Ida et al (2013) Beyond GDP: Measuring and achieving global genuine progress *Ecological Economics* 93: 57–68

220. Canadian Index of Wellbeing (n.d.) <https://uwaterloo.ca/canadian-index-wellbeing/our-products/composite-index>

environmental input”.²²¹ The top three countries on the 2012 Happy Planet Index are Costa Rica, Vietnam and Colombia; by comparison, Canada places 65th in this Index, with a life expectancy and level of experienced wellbeing not much higher than that of Costa Rica but an ecological footprint more than 2.5 times as large.

- Perhaps the most radical and maybe the most interesting 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.²²² Countries, regions and communities around the world are working on versions of this indicator.

In short, there are a number of alternative and much better ways of measuring sustainable social wellbeing and human development, and they have from time to time attracted high-level interest. Governments should move immediately to adopt and implement at least one of these measures, preferably internationally.

The health and other co-benefits of a more sustainable society

The health co-benefits of a more sustainable society are limited not only to the largely protective but very important function of minimising the harm to health from global ecological change, important though that is. What is often overlooked is that there are very large health costs to our current way of life, and thus very large potential health benefits resulting from a shift to a more sustainable society. There is a considerable overlap in a large number of policy areas of importance to both health and sustainability. The application of a health and sustainability ‘lens’ to public policy in many areas of policy would result in the creation of healthier public policies and healthier societies and communities.

Among the key policy areas where there are significant health and sustainability co-benefits are energy, agriculture and food, and urban design and transportation.

- The direct global **health impacts of energy systems** (especially but not exclusively those that are fossil fuel-based) 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”.²²³ The health impacts arise largely from air pollution due to the combustion of fossil fuels, but there are also occupational health impacts (especially from coal mining), water and soil pollution, population displacement from dams, large numbers of deaths and injuries resulting from transportation and, of course, the health impacts resulting from climate change.

To be sure, it has been the availability of all that energy over the past 200 years, that has catalysed, directly or indirectly, the high levels of technological, scientific and societal development, food security, shelter, and medical care, all of which contribute significantly to the health of individuals. Losing the use of fossil fuel-based energy (an essential response to climate change) would likely result in significant impairment of health and a rise in mortality, unless it is replaced with alternative forms; fortunately, that is possible.

221. New Economics Foundation (2012) *Happy Planet Index 2012 Report* London: New Economics Foundation

222. For more information, see <http://www.grossnationalhappiness.com/> Accessed 14 July 2014

223. Smith, K. R.; Balakrishnan, K.; Butler, C.; Chafe, Z.; Fairlie, I.; Kinney, P.; Kjellstrom, T.; Mauzerall, D. L.; McKone, T.; McMichael A. and Schneider, M. (2012) Chapter 4 - Energy and Health. In *Global Energy Assessment - Toward a Sustainable Future*, Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria, pp. 255-324.

Numerous studies have reached similar conclusions: The health costs of renewables (wind and solar) and conservation have much smaller health and environmental impacts.²²⁴ Clearly, there are very significant health benefits to be gained from a move away from fossil fuel-based energy use, especially coal, with conservation and renewable energy systems offering a much healthier future. In addition, several recent reports have pointed to the significant economic benefits of energy efficiency,²²⁵ a reduction of greenhouse gases²²⁶ and a shift to a 'new climate economy'.²²⁷

A recent Canadian report by a group of independent scholars²²⁸ states that "Because renewable energy resources are plentiful, we believe that Canada could reach 100% reliance on low carbon electricity by 2035. This makes it possible, in turn, to adopt a long-term target of at least 80% reduction in emissions by the middle of the century". In addition to unanimously recommending putting a price on carbon, they recommend

"1) producing electricity with low carbon emissions sources; 2) modifying energy consumption through evolving urban design and a transportation revolution; and 3) linking transition to a low-carbon economy with a broader sustainability agenda, through creation of participatory and open governance institutions that engage the Canadian public."

There are also health benefits from a less energy dependent and inefficient agri-food system, and from the reduction of motor vehicle use through improved urban design and public transportation systems, as discussed below.

- **Our current food supply** is based on an environmentally harmful agricultural system that provides a highly processed diet that is low in fiber and high in animal protein. 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 a very different diet. Key strategies involve stopping the expansion of agriculture, particularly into tropical forests; closing yield gaps by improving management and productivity; increasing the efficiency with which agriculture uses resources, especially water, nutrients and energy, and increasing food delivery by shifting diets and reducing waste.²²⁹
- There are important health benefits to such an approach. Not only would land, soil, water and biodiversity be conserved and greenhouse gas emissions and pesticide and herbicide use drop, but a shift to a low meat or vegetarian diet would have a number of direct health benefits, including reduced rates of cardiovascular disease, diabetes and cancer.²³⁰
- In Canada, the growth of organic agriculture and local food production systems has reached the point where they are becoming commonplace - although too often still too expensive for lower income groups, which is a major challenge. At a local level, many groups and

224. Smith, Kirk; Frumkin, Howard; Balakrishnan, Kalpana; Butler, Colin; Chafe, Zoe et al (2013) Energy and human health *Ann. Rev Public Health* 34:159-88; Krewitt, Wolfram; Hurley, Fintan; Trukenmüller, Alfred and Friedrich, Rainer (1998) Health Risks of Energy Systems *Risk Analysis* 18(4): 377 - 383

225. Ryan and Campbell (2012) *op.cit.*

226. IPCC (2014) *IPCC Fifth Assessment Synthesis Report - Summary for Policymakers* Cambridge UK: Cambridge University Press

227. The Global Commission on the Economy and Climate (2014) *Better Growth, Better Climate: The New Climate Economy Report* London: The Commission

228. Sustainable Canada Dialogues (2015) *Acting On Climate Change: Solutions from Canadian Scholars* Available at http://biology.mcgill.ca/unesco/EN_Fullreport.pdf

229. Foley JA, Ramankutty N, Brauman KA, Cassidy ES, Gerber JS, Johnston M, et al. (2011) Solutions for a cultivated planet. *Nature* 478(7369): 337-42

230. McEvoy CT; Temple N. and Woodside JV (2012) Vegetarian diets, low-meat diets and health: a review *Public Health Nutr.* 15(12):2287-94

some local governments have been working to create sustainable local food systems that contribute to food security, support healthy diets and strengthen community.²³¹ Not surprisingly, many public health staff, especially community nutritionists, are very involved both at the national level and even more so at the local level.

- **The health impacts of urban design**, and specifically **the health impacts of urban sprawl** have become more widely understood in recent years. There are many health impacts of urban sprawl, including problems related to poor air quality, physical inactivity, injuries and deaths from traffic, water quantity and quality, mental health, social capital and the health concerns of special populations (e.g. seniors, children, people with disabilities).²³² To this list might be added the health impacts of climate change, because urban sprawl is a very energy inefficient urban form, often requiring use of a car for many of the daily activities of life.²³³ Conversely, the health benefits of ‘Smart Growth’ (one of the key urban development solutions to urban sprawl), has been likened to a ‘medical miracle’!²³⁴ There is increasing evidence of the health benefits of improved urban design. Moreover, the economic benefits of building “*better connected, more compact cities based on mass public transport*” are very significant.²³⁵

An important indirect health benefit of many of these more sustainable policies and practices is the creation of large numbers of local jobs with a wide range of job skills needed.²³⁶

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

Finding hope at the local level

It is at the local level where the signs of hope are often most visible, and where inspirational actions are underway. We should recall Margaret Mead’s comment that we should “never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it’s the only thing that ever has”. Most often, those small groups meet locally, and while they may think globally, they mainly act locally.²³⁷

The remarkable achievements of many of these small groups and the community-based organisations that nurture them – or that they become - is inspirational, and the multitude of small local actions can have great power when they become linked into national and even international networks. They are in fact a major component of a community’s assets, and form the basis for asset-based community development, which is an important sign of – and basis for – hope at the local level.

231. See Food Secure Canada - <http://foodsecurecanada.org/who-we-are/what-we-do>

232. Frumkin, H; Frank, L and Jackson, R (2004) *Urban Sprawl and Public Health: Designing, planning and building for healthy communities* Washington: Island Press

233. VandeWeghe, Jared and Kennedy, Christopher (2007) A Spatial Analysis of Residential Greenhouse Gas Emissions in the Toronto Census Metropolitan Area *Journal of Industrial Ecology* 11(2): 133 - 144

234. Frumkin, Frank and Jackson (2004) *op cit*

235. The Global Commission on the Economy and Climate (2014) *op. cit.* (Chapter 2)

236. See for example WHO Europe (2014) *Unlocking new opportunities: Jobs in green and healthy transport* Copenhagen: WHO Europe

237. There are multiple references in Section 7.4 of the main report

Asset-based community development (ABCD) is an approach that empowers both individuals and communities by focusing on community strengths and on individuals' assets and skills. Instead of focusing on needs, problems and services, communities focus on the capacities, skills and assets of people, community organisations and institutions and the physical assets of their neighbourhoods. By shifting to a capacity-oriented emphasis, communities take ownership of the issues.²³⁸

In Canada many organisations support community engagement and asset-based community development. Prominent among them are the Waterloo-based Tamarack Institute,²³⁹ the Coady International Institute at St. Francis Xavier University in Antigonish NS²⁴⁰ and the Canadian Centre for Community Renewal in BC.²⁴¹ Their work forms the basis for the work of creating healthier, more just and more sustainable communities.

For many environmental, social and public health issues, leadership has often been local. Moreover, policy-making and implementation is more proximate, intimate, and immediate at the local level. (Unfortunately it is also more subject to constraints imposed by higher levels of government, and in Canada, weaker powers and a weaker tax base.) Many local governments are attempting to make their communities more sustainable, and have developed and implemented sustainability plans for transportation, waste management, energy, housing and other key community areas.²⁴² The Federation of Canadian Municipalities (FCM) started a Sustainable Communities Awards program in 2000, and also has an annual Sustainable Communities Conference. Municipalities have also been the leaders in Canada in measuring quality of life, supported by the FCM's Quality of Life Reporting System.

Another key movement is Transition Towns, international in scope but with a number of communities involved in Canada - see for example the Text Box about Peterborough Ontario. Transition Town initiatives are a response to the need to transition away from

“our high levels of energy consumption, our high carbon emissions and our massive environmental impact” . . . to . . . “a lower energy future - essential because of climate change and inevitable because of diminishing supplies of fossil fuels (particularly oil).” Transition Initiatives involve *“projects in areas of food, transport, energy, education, housing, waste, arts etc. as small-scale local responses to the global challenges of climate change, economic hardship and shrinking supplies of cheap energy.”*²⁴³

238. Kretzmann, John and McKnight, John (1993) *Building Communities from the Inside Out: A Path Toward Finding and Mobilizing a Community's Assets* Evanston IL: Center for Urban Affairs and Policy Research, Northwestern University

239. <http://tamarackcommunity.ca/>

240. <http://www.coady.stfx.ca/coady/>

241. <http://communityrenewal.ca/>

242. Roseland, Mark (2005) *Toward Sustainable Communities: Resources for Citizens and their Governments* Gabriola Island, BC: New Society Publishers.

243. <http://www.transitionnetwork.org/initiatives/national-hubs>

Community-level action is critical for public health, since most public health staff work at the local level. In particular, public health has made many important contributions at the local level, and until comparatively recently, it 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 20 years.²⁴⁴ Most healthy community or healthy city initiatives include a focus – often a strong focus – on sustainability; it has been and remains a key theme in the WHO Europe Healthy Cities network, for example. 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. After all, a healthy and sustainable community includes healthy and sustainable homes, schools, workplaces, hospitals, and other settings.

But it is not only about having the right policies, they must also be implemented effectively.

Experience has shown that this is done best by engaging 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 the development of healthy public policy.²⁴⁵

Towards transformative change

While there is much room for concern, even pessimism, when we look at the ecological determinants of health, there are also grounds for hope when we look at how much is happening and how far we have come. Much thought and research has gone towards developing an alternative, healthier, more sustainable and more just paradigm. This has been taken up and turned into action at multiple levels by a multitude of community groups, NGOs, some governments (especially at the municipal level) and private sector organisations, and by practitioners across multiple disciplines.

It is only when we look back several decades that we see how much has really changed. In the case of ecologically sustainable development, we see that the concept and practices have become

Transition Town Peterborough

“an all volunteer, non-profit organization focused on reducing our community-wide dependence on fossil fuels while increasing local resilience and self-sufficiency in food, water, energy, culture and wellness with economic localization. With a focus on community building, TTP is made possible by ordinary citizens working toward positive change, and is shaped and guided by all who are able to participate, in whatever capacity they can.”

Its projects include:

- Permaculture
- Transition Skills Forum
- The Greenzine
- Economic Localization
- Heart and Soul
- Purple Onion Festival
- I Love Local Food
- Resilient Peterborough Council
- Dandelion Day
- Buy Local Live Local Expo
- Shift To Local Food

Source:

<http://www.transitiontownpeterborough.ca>

244. Hancock, T. (2000). Healthy communities must be sustainable communities too. *Public Health Reports*, 115 (2-3), 151-156.

245. BC Healthy Communities -

<http://bchealthycommunities.ca/healthycommunities?&PHPSESSID=d701a2f6008f336588602f49759f73f9> Accessed 14 July 2014

commonplace in some parts of governments and the private sector; standards and guidelines have been developed and become the norm; major national governments have at least begun to question some of the basic concepts behind our current economic models and our measure of progress, and some major international organisations have made 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 that we make the move to transformative change.

CHAPTER EIGHT: AN ACTION AGENDA FOR PUBLIC HEALTH

Trevor Hancock, all authors

“Population health is how we think, public health is what we do”

Dr. Chris Mills, former President, CPHA (2002-4)

We come now to the crucial question: In the face of these converging problems and emerging crises, and the threat they pose to the health of everyone in Canada and globally, what does it mean to think about population health from an ecological perspective and what can public health do? How does what has been achieved to enable the needed transition to a sustainable path interact with that which we in public health need to do?

First let us recognize that we are not alone. Individuals, organisations, and communities across Canada and around the world are recognizing and grappling with these issues. Indeed, some have been doing so for many decades. Our presence in and support for these groups is necessary and will be welcomed, because the environmental movement understands that the health impacts of environmental damage are strong motivators for action to prevent harm and improve the environment.

Second, let us also recognize that we have been a bit slow to act. On the whole, public health professionals and organisations have not been fully engaged in efforts globally to create a more sustainable future. We in public health must recognize that we are not going to come riding to the rescue with the answers, nor are we going to lead this movement – but we must join it.

Third, let us recognize that the global ecological threat to health we face is unique, in that past threats reflected more local or regional environmental harms rather than global ecological change. Nonetheless, much of what will be done in response to this threat will still need to reflect local and regional concerns and problems; the solutions will be largely local and regional. This local and regional imperative will be strengthened by the diminishing resources and fragmenting globalization that will make local solutions essential. When it comes to action, we should recognize the wisdom in the statement *“Think globally, act locally”*, and remember that a key aspect of the influence and effectiveness of public health has always been its close connection to the community.

Fourth, we need to broaden how we think about the determinants of the health of the population, as well as how we address the challenges presented. We need to think ecologically and move from a population health model that is largely bio-psycho-social to an expanded model that is eco-psycho-social, one that is consistent with the commitment to a socio-ecological model of health advocated in the *Ottawa Charter for Health Promotion*.

Thinking about and understanding the ecological determinants of health

Ecological thinking is not new to public health, for a long time it was neglected but now it is experiencing a resurgence. This resurgence may be traced to the 1986 *Ottawa Charter for Health Promotion*, which not only proposed “a socio-ecological approach to health” but, for the first time in a WHO document, recognized “a stable ecosystem (and) sustainable resources” as fundamental prerequisites for health.

Yet for the most part, our thinking about population health has been ecologically blind. There is no mention of ecology, ecosystems or environment in the foundational work on population health in Canada, or in the various lists of Determinants of Health put forth by Health Canada, and later the

Public Health Agency of Canada, which include ‘the physical environment’ as but one of a dozen or so determinants, but do not distinguish the built environment from the natural environment, nor recognize ecosystem goods and services as determinants of health. But as we have shown, it is the ecological determinants of health, rooted in the physical limits of Earth, and the optimal functioning (from a human perspective) of Earth’s ecosystems, that are the ultimate upstream determinants of our health.

Thinking ecologically about population health requires that we add an understanding of the ecological determinants of health to our population health model. This includes being acutely aware of the interaction between the ecological and the social determinants of health – and, even more radically - that we think beyond the wellbeing of humans alone. We must recognize the inherent and permanent right of other species, as well as humans, to a safe and healthy environment, and our responsibility to ensure that right. Yet at present, Canada does not even recognise the right of humans to a healthy environment, never mind the right of non-humans to the same. In this, Canada is out of step with the rest of the world: The right to a healthy environment is already enshrined in the constitutions of three-quarters of countries, and is at least implicit in a number of international documents to which Canada is a signatory.²⁴⁶

This calls for a different ethical approach in public health, and for a set of strategies to help change our thinking about population health, and thus the actions we take (see The Earth Charter).

Public health ethics and the ecological determinants of health

The problems we face today are often the direct result of our previous conceptions of and investment in our relation to the environment, natural resources, and public health. The ethical perspectives we gained from our predecessors largely addressed the human viewpoint and the need for a response to immediate and local issues; the thought was remote that our actions could have global impacts and changes far into the future. We know now that our current actions – for example, action on climate change – will have both positive and negative effects on future generations.

Considering justice for both future generations and non-human life necessitates a new ethical perspective in public health, which recently has been very clear in the area of social determinants of health, but now needs to consider equally the ecological determinants of health. The concept of environmental justice applies not just in Canada, where examples abound of disadvantaged, marginalized or impoverished communities experiencing disproportionate and unjust harm because of environmental circumstance, but also applies at the global level.

An expanded concept of public health ethics

We propose six ethical principles to guide societal and public health action with respect to the ecological determinants of health. We view these principles as fundamental for our collective future. We also recognise that they are rooted in the past, and are contained in the values, knowledge and actions that Indigenous peoples have held for millenia. These principles are:

1. We must expand our thinking from one centering on humans to one that considers all life – **a combination of anthropocentrism and ecocentrism/biocentrism** – because while we still have a concern for human health and wellbeing, we need to see humans as a part of the web of life, and understand that human health depends on the effective functioning of ecosystems and the sustained use of available resources.

246. Boyd, David (2012) *The right to a healthy environment : revitalizing Canada's constitution* Vancouver ; Toronto: UBC Press

2. We must recognize **intergenerational equity** - we have an ethical duty towards future generations, to ensure that they can expect a decent quality of life and good health.
3. We must recognize 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**.
4. We must adopt the principle of **environmental justice**, which means ensuring that disadvantaged groups or local communities do not face damaged ecosystems and increased health risks because of these characteristics.
5. **The prevention imperative** requires us to avoid the creation of further harm to ecosystems that impair their functioning and thus undermine our own life supporting systems. This will involve reconsidering our needs, our lifestyles, and our economic system; the First Nations' Seventh Generation Principle comes into play here.
6. We must apply **the precautionary principle**, already present in some public health legislation, to the ecological determinants of health. Public health organisations and practitioners should use the legislative powers available to them to strongly support and apply the precautionary principle in addressing global ecological change and its implications for population health.

In addition to these principles, two key mechanisms important for the application of these principles need to be applied in societal decision-making:

1. We must apply **comprehensive and integrated impact assessments** that address the ecological, social, health and economic impacts to all major public policies and private sector developments.
2. We must 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 ethical principles, mechanisms and underlying concepts need to be formally adopted by CPHA and other organisations of public health professionals, incorporated in Public Health Core Competencies and professional codes of practice, and taught as part of the core public health curriculum.

Action to change and improve our thinking on population health

One of our first tasks is to improve our thinking about population health by understanding the ecological determinants of health and incorporating them in our thinking – and in our reporting. We need to broaden our knowledge of the changes underway in the ecological determinants of health and their actual or potential health impacts, as well as mitigation and adaptation strategies. This calls for **a knowledge development and research strategy**. Specifically, this means:

1. Integrating the ecological determinants of health into our population health frameworks.
2. Educating public health professionals about the ecological determinants of health.
3. Monitoring, assessing and reporting regularly on the ecological determinants of health.
4. Funding and supporting research into the ecological determinants of health.

Given that Canada's capacity to monitor, undertake research, manage information and report on

ecological change in Canada and globally has been virtually crippled in recent years,²⁴⁷ it will also be necessary to re-invest substantially in Canada's capacity to do this.

A fifth strategy, at the global level, is to work with our international partners to ask request that a future World Health Assembly be dedicated to the theme of the ecological determinants of health and to request the UN to establish a Commission on the Ecological Determinants of Health.

Specific recommendations for action can be found in the Action Agenda that follows later in this chapter.

Public health action

We envision a just, sustainable, and healthy future for all, with healthy people living in healthy communities in healthy nations in a healthy world. The public health actions needed to achieve this can be thought of as involving the application of the four forms of prevention²⁴⁸ to the prevention of harm to health arising from human-induced ecological change, and the creation of the healthier future to which we aspire.

- *Primordial prevention* focuses on preventing harmful ecological changes from occurring in the first place. It requires working well upstream in our communities, at the provincial and national levels and internationally to change the fundamental demographic, social, economic and values-based driving forces discussed in Chapter 4. This is often referred to as mitigation of harm, but in a more positive sense - beyond preventing harm - it will help move us to a different form of human and social development that is more compatible with the future we aspire to; it is in that sense a health-promoting strategy.
- *Primary prevention* focuses on preventing harm to human health in the face of human-induced ecological changes that may harm health. It is a protective strategy that involves environmental, social and behavioural adaptations to changing conditions. It requires working with communities to increase both the resilience of their key physical infrastructure such as water and sewer systems or flood protection barriers and their community and personal resilience.
- *Secondary prevention* focuses on early detection of ecological change and/or human health impacts, and prompt intervention. It requires early warning systems to detect potentially harmful ecological changes and/or health consequences, and early interventions to prevent further harm.
- *Tertiary prevention* means working with people and communities that are already experiencing adverse health effects of human-induced ecological change, to minimize the harm and restore them and their communities as much as possible to good function.

At the beginning of this report we proposed a simple model of the interactions between the social and ecological determinants of health and the implications for population health (Figure 1). The model also included public health action at the centre, with an illustration of the range of interventions that could be taken by public health professionals and organisations. It was noted that these actions:

- Can occur at all levels from the personal to the global

247. Federal, Provincial and Territorial Governments of Canada (2010) *Canadian Biodiversity: Ecosystem Status and Trends 2010* Canadian Councils of Resource Ministers. Ottawa, ON

248. Last, John (2001) *A Dictionary of Epidemiology* New York: Oxford University Press.

- Can address all aspects of the interaction between people, social and economic systems and ecosystems.

There are many ways in which public health professionals and organizations can act to move our society and our communities towards a more sustainable, just, and healthy path. Some of these are noted below and public health professionals and other interested organizations and individuals may identify other useful actions that may be relevant. It is important to recognize that these actions are intended to be overlapping and contiguous, and mutually reinforcing.

In all of this, public health professionals and organizations will need to engage with other key societal and community sectors and with the public so that they take the actions necessary to ensure that together we successfully protect and enhance ecosystem functions and prevent or manage the problems that result from impaired or poorly functioning ecosystems.

It is critical that public health organisations ‘walk the talk’ by adopting these policies and practices themselves, and advocating for their parent organizations (usually health authorities) to do the same.

Public health action to address the ecological determinants of health and ensure a healthier, more sustainable, and more just future involves:

- Changing social norms and values.
 - Changing the focus of development and the way it is measured in both the public and private sectors, emphasizing human and social development and environmental sustainability as the new bottom line.
 - Challenging corporate power where it harms ecosystems, societies, communities and the health of the population
 - Changing economic practices by supporting ethical investment and divestment.
- Protecting people and communities from social and economic policies and practices that harm health or widen health inequity
- Protecting people and communities from adverse impacts of global ecological change.
 - Reduce vulnerability and protect the vulnerable
 - Increase resilience and adaptation
- Establishing policies and practices that create more ecologically sustainable and healthier societies and communities.

Each of these areas of public health action is discussed in more detail below, and specific recommendations for action to implement them can be found in the Action Agenda that follows later in this chapter.

Walk the talk: Environmentally responsible health care

Perhaps the best place to begin is for public health to be a champion within its own organisation – be that as a Board of Health, as part of the health care sector or part of municipal government – for environmentally responsible action. After all, we cannot urge others to take action to address the ecological determinants of health if we have not done so ourselves; it would be as hypocritical as permitting smoking within health care facilities while campaigning vigorously against tobacco!

In the context of the health sector, it seems ironic that in attempting to heal patients, the health care system may fail to protect patients, staff, and the community from the harmful environmental impacts of its practices. The health care system is in many ways the antithesis of sustainability; it is very energy intensive; uses many disposable products and generates large volumes of waste. As well, it uses and disposes of a wide variety of toxic products, not always safely.²⁴⁹

So we need to expand our understanding of the ethical principle of *primum non nocere*— first, do no harm – embedded in the Hippocratic Oath from considering only patients to including the obligation to do no harm to natural ecosystems and future generations. Over the past two decades, a worldwide movement for environmentally responsible (or ‘green’) health care has grown, spearheaded by a US-based organization that takes its name directly from this ethical principle – Healthcare Without Harm.²⁵⁰ In Canada, a similar organization, the Canadian Coalition for Green Health Care, was established in 2000.²⁵¹

Change social norms and values

The profound changes in the functioning of our natural ecosystems are being driven by powerful societal forces that are underpinned and driven by societal values. It is these values that must change if we are even to hope to alter the harmful effects of human-driven ecological changes. We need a new set of values, recalling that a vision of a preferable future is in fact a projection of our values into the future.

The field of public health has strong values with respect to the health of the population, health equity, social justice, and collective action for the greater good, but in practice there has not been a strong orientation towards ecological values of sustainability and ecosystem health, in spite of statements to that effect. That too must change; the walk must follow the talk.

Public health has an impressive history of changing public values and social norms, a recent example being those associated with smoking. We have also changed public values and norms about water treatment, immunization, sexually transmitted diseases and many other issues, and we are now starting to change public values and norms about urban design and about obesogenic food systems. Thus it is fitting for public health to seek to change social norms and values with respect to the ecological determinants of public health.

Change the focus of development and the way in which it is measured

In its 1992 report, the CPHA called for a redefinition of sustainable development as follows:

Human development and the achievement of human potential require a form of economic activity that is socially and environmentally sustainable in this and future generations.

Given the extensive re-thinking of development, economics and the measurement of progress documented earlier in this report, the question for public health is ‘what actions can public health workers and organisations take to support and implement these new approaches?’ Recognizing that we are focused on the wellbeing of populations, public health professionals and organisations must insist that development be human-centred, focused on the development of wellbeing and

249. Hancock, Trevor (2001) *Doing Less Harm: Assessing and Reducing the Environmental and Health Impact of Canada's Health Care System* Toronto: Canadian Coalition for Green Health Care

250. See for example *Global Green and Healthy Hospitals Network* <http://greenhospitals.net/en/> - “A Comprehensive Environmental Health Agenda for Hospitals and Health Systems Around the World”. The Global Green and Healthy Hospitals Agenda forms the foundation of the Network, which is a project of Health Care Without Harm.

251. <http://www.greenhealthcare.ca/>

human potential, and that progress be measured in terms of the growth in human (not economic) development and potential.

In addition, public health organisations 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.

Challenge corporate power:

As noted in Chapter 4, corporate power drives much public policy, particularly economic policy, and in particular justifies economic growth and seeks profit, even where this is harmful to ecosystems, societies, communities and the health of the population. Given their power and massive presence in the global economy, it seems unlikely that corporations can easily be changed from outside. Nonetheless, public interest challenges to corporate power and policies are needed, especially because increasingly governments seem more and more interested in protecting corporations rather than in protecting the public. Naming and shaming, ethical purchasing and investments, boycotts, legal challenges, divestment and civil disobedience in the form of demonstrations and blockades, are some of the legitimate tools and strategies to which those who seek to protect the health of the public and the Earth's natural systems have had to resort in the past, and may have to resort to in the future.

This may sound somewhat dramatic, but in fact the need to challenge the economic sector and corporate power is as old as public health itself. Public health officers in Renaissance Italy in the 15th century complained about the hostility of the merchants and the need to effect compromise between public well-being and economic necessity²⁵² and it was certainly an issue for public health officials in the 19th century, as they fought the ills of industrialization and urbanization.

In more recent times there has been a focus on those corporations that market harmful products such as tobacco, alcohol or junk food and those that pollute the environment, but also on the automobile, weapons and pharmaceutical industries or those that promote violence in the media^{253,254, 255} The power of corporations must be challenged²⁵⁶ and the public health implications of international trade agreements and globalisation was one of the key issues for the WCED,²⁵⁷ while even the role and existence of the corporation has been identified as a public health issue.²⁵⁸

Ethical purchasing and investment, boycotts and divestment

At its simplest, ethical investment can be about where we put our money on a daily basis. Many of us already pay attention to the daily purchases we make, choosing to buy local or organic or fairly traded products, for example. On a larger scale, we can work within our organisations to have them develop ethical or 'green' purchasing policies, something many organisations, including some health care organisations, already do.

252. Cipolla, C. (1976) *Public Health and the Medical Profession in the Renaissance*. Cambridge, Cambridge University Press

253. Freudenberg, Nicholas (2014) *Lethal But Legal: Corporations, Consumption, and Protecting Public Health* New York: Oxford University Press

254. Millar, John (2013) The Corporate Determinants of Health: How Big Business Affects Our Health, and the Need for Government Action! *Can J Public Health* 104(4): e327-e329

255. Freudenberg, Nicholas (2014) *Lethal But Legal: Corporations, Consumption, and Protecting Public Health* New York: Oxford University Press

256. Hastings, Gerard (2102) Why corporate power is a public health priority *BMJ* 345:e5124 doi: 10.1136/bmj.e5124

257. Labonté, Ron and Schrecker, Ted (2007) Globalization and social determinants of health: Introduction and methodological background (part 1 of 3) *Globalization and Health* 3:5

258. Wiist, William H (2006) Health and the Anticorporate Movement: Rationale and Recommendations *American Journal of Public Health* 96(8): 1370 - 75

These are not new concepts for some in public health who have campaigned, for example, against pension fund investments in the tobacco industry. But ethical investment goes beyond deciding what not to invest in, and seeks to use investment to do good, as well as to prevent harm. If our values are for socially just, environmentally sustainable and health-enhancing development, then individually and collectively we should invest in businesses that advance that agenda by, among other things, supporting local independent businesses and a vibrant local economy, protecting and enhancing the environment, offering 'fair trade' products or providing a living wage and decent benefits to employees.

In addition, we should insist that our pension funds do the same, investing in energy conservation and renewable energy rather than fossil fuels; in sustainable agriculture rather than environmentally harmful agri-food businesses; in sustainable fisheries and forest industries; in resource recycling and recovery, and so on. In particular, public pension funds and other public investments should not invest in those industries, or at least in those corporations within those industries that are particularly neglectful of their ecological responsibilities.

Existing socially responsible investment funds provide a model for determining which investments are ethically acceptable and which are not. Moreover, investing in more environmentally friendly or less harmful industries may be a wiser investment. A recent report from MSCI,²⁵⁹ a company that produces investment indices used by thousands of pension and hedge funds, found that over the past three years (2012 – 2014) across 23 'Emerging market' and 23 'Developed market' countries, the broad market did not perform as well as the market excluding companies that own oil, gas and coal reserves. So investing in fossil fuels is a less effective investment strategy.

But in addition to choosing where to direct our purchasing and our investments, we also need to look at what we should avoid supporting, through boycotts or divestment. Again, many in public health have been involved over the years in boycotts, whether it be the Nestlé boycotts to protest against the marketing of infant formula or boycotting South African products to undermine the apartheid regime. Carefully targeted boycotts of major contributors to global ecological change should be part of our strategic package.

In addition, many public health organisations have already established criteria to determine from which potential funders they will or will not take funds. Industries commonly excluded are, the tobacco, arms, fast-food/junk food, alcohol, and gambling industries; in some cases, ecologically harmful industries may also be included. Conversely, public health should partner with and accept funding from industries that are developing the new economy that will move us towards the sustainable, just and healthy future we seek.

Beyond boycotts, the strategy of divestment was used in the fight against apartheid, and some organisations are now calling for divestment from fossil fuels, in part on the basis that such investment will result in 'stranded assets' – fossil fuels that cannot be used because of the danger of global warming, and are thus of little or no value.²⁶⁰ A recent Canadian study estimated the

259. MSCI (2015) *MSCI ACWI ex Fossil Fuels Index Available at* http://www.msci.com/resources/factsheets/index_fact_sheet/msci-acwi-ex-fossil-fuels-index-gbp-gross.pdf

260. Ansar, Atif; Caldecott, Ben and Tilbury, James (2013) *Stranded assets and the fossil fuel divestment campaign: what does divestment mean for the valuation of fossil fuel assets?* Oxford: Smith School of Enterprise and the Environment, University of Oxford

‘carbon liabilities’ for the proven reserves of 114 Canadian fossil-fuel companies listed on the Toronto Stock Exchange as \$844 billion, double their assets.²⁶¹

This new campaign is growing rapidly, with the Global Divest/Invest Coalition announcing in September 2014 that “over 650 individuals and 180 institutions, including 50 new foundations added to the 17 who pledged in January [2014]”, and representing over \$50 billion in assets, have pledged to divest from fossil fuels over the next 5 years.²⁶²

Protect people and communities from social and economic policies and practices that harm health or widen health inequity

In the 19th century public health reformers battled the health impacts of urbanization and industrialization, and in the 20th century the tradition continued as they fought the tobacco and alcohol industries, fought against unsafe motor vehicles and polluting industries and, more recently, the fast food and the gambling industries.

In this century public health needs to take a wider perspective, recognizing that it has an obligation to speak up about the inequitable distribution of power, money and resources at all levels. It needs to expose and oppose the failings of an economic ideology that has created policies and practices that pursue growth with minimal concern about the long-term consequences to individuals, communities or the environment.

Public health legislation may provide an opportunity – even an obligation – to inquire into the population health impacts of ecological changes that may result from unsustainable practices, and possibly suggest ways to mitigate or reverse them. Public health legislation in most provinces includes clauses requiring officials, for example, to “*inquire into health hazards and health impediments faced by the population*” (BC)²⁶³ or to “*investigate the situation and take action . . . to prevent, eliminate or decrease the risk*” if they are “*of the opinion that a situation exists anywhere . . . that constitutes or may constitute a risk to the health of any persons*” (Ontario).

Since human-induced global ecological change is a legitimate public health concern and mechanisms exist to inquire into this issue at least in these provinces, and probably in all provinces and at the federal level, public health practitioners and citizens should seek ways to use public health legislation to investigate and report on the health threats of ecological change or those activities that contribute to it, such as fossil fuel extraction.

Protect people and communities from the adverse impacts of ecological change

The best strategy for protecting people is primordial prevention – preventing the ecological changes that may harm human wellbeing. But while we have demonstrably taken effective action to improve ecosystems and health, the reality is that despite our best efforts we cannot avoid ecological changes that will harm our health. The ecological damage already sustained and the momentum behind our current economic paradigm means that over the next decades the dramatic decline in ecosystems functioning will continue and the availability of key resources will become even more acute.

These changes will ultimately have significant and largely negative effects on any country's

261. Lee, Marc and Ellis, Brock (2013) *Canada's Carbon Liabilities: The Implications of Stranded Fossil Fuel Assets for Financial Markets and Pension Funds* Ottawa: Canadian Centre for Policy Alternatives

262. <http://divestinvest.org/wp-content/uploads/2014/09/NYDivest-Invest-Press-Release.pdf> Accessed 29 November 2014

263. The concept of “health impediment” in the BC Public Health Act may be particularly powerful, since its definition includes an activity “the cumulative effects of which, over a period of time, are likely to adversely affect public health”. Fossil fuel extraction, transportation and use would certainly meet that definition.

economy. This is because of the consequences of recurring disasters such as floods, drought, heat waves, sea level rise, food insecurity, and resultant socio-economic disruption. Responding to these disasters taxes the natural, fiscal, and societal resources of any country, even one such as Canada. They also compromise the ability of a country's government to continue to provide services to its peoples and to repair and maintain essential infrastructure such as the transport services provided by road, rail, air and water, maintaining water and sewage services, energy provision and distribution, and food production and distribution.

The provision and maintenance of this basic infrastructure is not normally considered part of the public health care (PHC) system or the acute medical care (AMC) system, and yet their effective functioning is predicated on the services provided by this infrastructure.

- **Thus it is necessary for the PHC and AMC systems to explore in detail their dependence upon and vulnerability to failure of essential infrastructure.** This document does not detail what these dependencies and vulnerabilities are; however, they do exist and it is essential that they be determined and buttressed as necessary.

As this ecological decline continues to gain momentum, public health professionals and organisations will have to promote adaptive change. This means developing flexible, adaptable and resilient urban and community infrastructure, able to cope with changing and potentially unstable environmental conditions, and also flexible, adaptable and resilient people and communities, able to manage any accompanying societal decline, and to prevent decline from becoming collapse. There are two main strategies:

- **Reduce vulnerability and protect the vulnerable:** We are facing what should be considered as a prolonged global disaster of uncertain complexity and temporality, but likely great severity (although unevenly distributed both globally and nationally), and thus it seems logical to learn from the process of disaster preparedness and management that is now a routine part of public health practice. The good news is that unlike a disaster, which is usually sudden, dramatic and to some extent unpredictable, what we need to prepare for and manage is a slower and mostly more gradual decline, albeit with the potential for sudden, non-linear change to occur within that general pattern of decline.

The first challenge is to understand the dimensions of ecological decline and what this means to society, to begin to 'map' this, and to try to understand what might be the early warning signs of impending collapse. The next stage, probably occurring simultaneously, would be to set up 'Decline Management' units and programs, rather as we have set up disaster or emergency management units.

- **Increase resilience and adaptation:** The concept of resilience has emerged and is applied in at least three distinct fields that are relevant to our purpose: ecology, community development, and mental health. While often understood as the ability to 'bounce back' from stressful or damaging situations to some imagined (but increasingly dysfunctional) 'normal', a different and perhaps more hopeful understanding is emerging which positions resilience as the capacity to 'bounce forward' to a different situation by proactively embracing, rather than resisting change. So while the concept of a resilient community can be seen in one way as a protective strategy, intended to return us to the *status quo ante*, it can also be seen, more positively, as a community committed to both managing the challenges it faces and moving forward to create a different and better future for itself and others

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

In the years since the Ottawa Charter for Health Promotion there has been a strong focus on seeing public health not only in terms of protection and prevention, but to place a greater emphasis on health promotion, on a positive and future-oriented approach that recognizes the importance of the environmental, social, economic, cultural and political determinants of health and that builds on existing capacity, assets and strengths to improve the health of the entire population, while at the same time placing special emphasis on reducing inequalities in health.

In virtually every policy area one can think of, from the municipal to the national level, improved health and ecological sustainability can work hand in hand. At the government level, this calls for a 'whole of government' approach at all levels in which various departments collaborate within a guiding framework of a commitment to a more just, sustainable, and healthy society. But beyond government, the process of governance requires that all sectors of society also collaborate and contribute what they can to this task, a process known as intersectoral action.

There are many social movements – locally, nationally and internationally – that are working to achieve the same objectives as those we propose in this report. These movements are our natural allies, especially as their work is rooted in place – in local communities and local action - which is then linked to a national or international agenda. Since the basis of much public health work is local, the experience gained over the past few decades in asset-based community development and the creation of healthier and more sustainable communities, in Canada and around the world, (see Chapter 7), is one of the most important building blocks we have.

An agenda for action

In this concluding section, specific recommendations for action are proposed in all the areas discussed in the previous sections of this chapter. This constitutes an agenda for action on the ecological determinants of health for public health professionals and organisations.

There is a strong emphasis on public health professionals themselves, because we strongly believe that unless we all better understand and accept the reality of the challenges to health posed by the human-induced ecological changes we have identified, we will not be effective as public health professionals or as members of public health organisations in working with others to address these issues.

There are two major categories of recommended actions:

- First, actions to improve the capacity of all public health professionals to understand and address the ecological determinants of health.
- Second, specific actions that public health professionals and organizations can take at the organisational, community and other levels.

A final chapter contains recommendations specific to the CPHA.

An expanded concept of public health ethics

Public health has an ethical duty to advocate for and work to prevent global ecological change, as well as to protect people from harm should those changes occur. We need to expand our concern for human health to a concern with the health of ecosystems and other species, and the health of future generations. This calls for a different ethical approach in public health and for a set of strategies to help change our thinking about population health, and thus the actions we take.

Earlier, we laid out six ethical principles and two mechanisms to guide public health action with respect to the ecological determinants of health. These need to be:

- Formally adopted by CPHA and other organisations of public health professionals;
- incorporated in Public Health Core Competencies and professional codes of practice, and
- taught as part of the core public health curriculum.

Action to change and improve our thinking on population health

Public health professionals and organisations must become as clear in their thinking about the ecological determinants of health as they are becoming in their thinking about the social determinants. We need to become more sophisticated in our understanding of the interactions between the social and ecological determinants of health. Accordingly, we propose a set of strategies to help to change our thinking about population health, and thus to change the actions we take; thoughtful action begins with thought.

1. Integrate the ecological determinants of health into our population health frameworks

- 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 the ecological and social determinants of health.

2. 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 this 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 that combined approaches to ecological and social determinants of health will align public health with a range of existing movements – spanning environmental, Indigenous, conservation, labour, social justice, climate change efforts, and beyond.
 - This should include a willingness to learn from a wider range of change-oriented practices employed by diverse actors that draws on a wider range of sources (complexity science, community organizing, social practice theory, interdisciplinary work on governing societal transitions, transformative learning, and engaging emergence, Theory U, generative dialogue, etc.).

3. Monitor, assess and report regularly on the ecological determinants of health within the context of pressing public health needs now and in the future

- We urge the Public Health Agency of Canada, Canadian Institute for Health Information, and Statistics Canada to develop and test a set of indicators of the ecological determinants of health - and of the socio-ecological system - that can 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.

- 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 in line with the socio-ecological model of health by including indicators of the state of key ecological determinants of health, the socio-ecological system and sentinel health conditions associated with ecological change.
- Public health reports at all levels should include indicators of ecological determinants of health in their routine reports, and should report specifically on the ecological determinants of health on a regular basis, reflecting local, regional, provincial, national, indigenous and global contexts.
- As a general principle, at least as much effort and resources must be put into collecting and publishing data on the state of our environment as is spent on assessing the state of the economy. This will help build capacity for full cost accounting for ecological change throughout our economy, and create knowledge to ensure when harm is done, the polluter pays.

4. *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.
- The CIHR should establish an Institute for Environment and Health. This might be done as a Tri-Council Institute, in conjunction with the SSHRC and NSERC, so that it could 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 must 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.
- Support research attention 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 organisations to address this.

5. *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 a similar task to the important work of the Commission on the Social Determinants of Health.

Walk the talk: Environmentally responsible health care

- Public health organisations and their parent health care organisations 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 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.
- 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 organisations 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 in which it is measured

- Public health professionals and organisations 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, 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 organisations 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.
- The need for “Health in All Policies” must be a major focus for those in public health, including the need for public health to actively develop its capacity to engage in intersectoral conversations that have implications for ecological and social determinants of health.

Challenge corporate power

- Where necessary, public health must act in the public interest – or ally itself with those acting in the public interest – to challenge corporate power, where that power is harmful to ecosystems, societies, communities and the health of the population.

Ethical purchasing and investment, boycotts and divestment

- Public health professionals should consider the ethical and ecological implications of their own purchasing and investment decisions. All public health organisations should develop ethical and ecological purchasing and investment policies and should also develop criteria

to exclude receiving funding from those economic activities deemed to be the most harmful to local or global ecosystems.

- Public health organisations should partner with and accept funding from industries that are developing the new economy that will move us towards the sustainable, just and healthy future we seek.
- It is consistent with the findings of this report and with public health values for public health professionals and organisations to call for divestment, including by public pension funds, in ecologically harmful businesses.

Protect people and communities from social and economic policies and practices that harm health or widen health inequity

- Public health practitioners and organisations that are concerned about the public health impacts of ecological change should examine how to use public health legislation to address this issue, 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 organisations 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 in the face of such emergencies with respect to maintaining its ability to fulfill its own mandate to protect and promote public health.
- Public health practitioners and organisations should expand their work with others in their communities, as well as provincially, nationally and internationally, to prevent, prepare for and respond to emergencies arising from ecological changes. This includes:
 - 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 their 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 organisations need to support collaboration across government departments at all levels and across different sectors of society that will help to create a more just, sustainable, and healthy society.

- Public health professionals and organisations must find allies and forge partnerships among those individuals and organisations 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.
- The removal of energy subsidies and their transfer to support energy conservation and the development of clean, green, sustainable and healthy energy systems is of particular importance. The IMF notes that “energy subsidies are pervasive and impose substantial fiscal and economic costs in most regions”.²⁶⁴ The same report estimates that globally these subsidies amount to some \$480 billion annually, but as much as \$1.9 trillion if the cost of externalities (harm to people and the environment from use of fossil fuels) is included.

Public health organisations 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 - if neither exist locally -
- 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.

264. IMF (2013). *Energy Subsidy reform: Lessons and implications* Available at <http://www.imf.org/external/np/pp/eng/2013/012813.pdf>

CHAPTER 9: RECOMMENDATIONS FOR CPHA

While the preceding section largely contains recommendations for public health professionals and organisations, this is also a policy paper of the Canadian Public Health Association. Thus recommendations specific to CPHA are included as a final chapter. These fall into three broad categories:

- Recommendations for CPHA's own operations
- Recommendations with respect to services for members, and
- Recommendations for CPHA in its role as a national and international organization.

Recommendations for CPHA's own operations

1. CPHA should ensure that throughout its operations it meets the highest standards of environmentally responsible and ecologically sustainable practices, consistent with established national and international standards and codes of practice (e.g. LEED, the ISO green procurement standards, including a shift towards reliance on renewable energy).
2. Where necessary, CPHA should revise its ethical criteria for sponsorship to ensure it does not accept funds from organisations that are undermining the ecological determinants of health in significant ways (e.g. the fossil fuel industry).
3. CPHA should review its investments, including any pension funds it may use, to ensure they meet the highest national and international standards and codes of practice for ethical investments.

Recommendations with respect to services for members

1. Subject to the availability of funding, CPHA should undertake a significant communications and engagement program with its members with respect to this report, its findings and recommendations. This would ideally include:
 - A dedicated website, a social media presence, blogs, on-line forums, webinars etc.
 - Videos on issues of ecological change and health for education and awareness purposes.
 - Development of materials to help public health organisations become "green".
 - Development of tools to help members identify and evaluate issues at the health/society/environment interface to help them put some of the proposed ideas into action.
 - Expand the Frontline Health website from a focus on stories and examples of frontline action focused on the social determinants of health to include action on the ecological determinants of health.

Recommendations for CPHA in its role as a national and international organization

Education and training

1. CPHA should adopt the ethical principles noted in this report as the basis for public health action to address the ecological determinants of health. In doing so, CPHA should recognise that these principles are deeply informed by past efforts, including knowledge and actions that Indigenous peoples have held for millenia.
2. CPHA should work with PHAC, the various National Collaborating Centres (NCCs) for Public Health, other public health professional organisations and all other relevant

stakeholders to revise the Core Competencies for Public Health to include the ecological determinants of health and the interactions between the ecological and social determinants of health, and the ethical principles with respect to the ecological determinants as key areas of competency.

3. CPHA should work with the Schools and Programs of Public Health, its own Student Members section, the Canadian Association of Teachers of Community Health and all other relevant stakeholders to ensure that the curriculum and core courses for Masters in Public Health programs include the ecological determinants of health and the interactions between the ecological and social determinants of health.
 - CPHA might also work with the NCCs and other organisations of health professionals and educational institutions to extend this curriculum content into all health professional education across Canada.
4. CPHA should work with other organisations, already seeking to address ecological determinants of health (such as Canadian Community of Practice in Ecosystem Approaches to Health, the Centre for Environmental Health Equity and the Canadian Partnership for Children's Health & Environment) to strengthen the offerings of and support for the provision of interdisciplinary education and training on the ecological determinants of health and the interactions between the ecological and social determinants of health.

Research

1. Working with its partners in the Coalition for Public Health in the 21st Century, CPHA should:
 - Encourage and support the Tri-Council (CIHR, SSHRC, NSERC) and other research funding bodies to develop 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 mitigation of health impacts and adaptation to ecological change.
 - Call upon the CIHR to remedy the serious omission of environment and health within CIHR by establishing an Institute for Environment and Health, perhaps as a Tri-Council Initiative, with a mandate that includes research on the health impacts of ecological change and the broader dimensions of a socio-ecological approach to population health.
 - Call upon the federal government to establish within the Canadian Global Health Research Program a dedicated fund for research on the health impacts of anticipated ecological changes globally.
 - Seek ways to strengthen the capacity for knowledge translation in the area of the ecological determinants of health, moving knowledge into policy and practice.
2. Call upon the federal and provincial governments to re-invest substantially in Canada's capacity to monitor, undertake research, manage information and report on ecological integrity and change in Canada and globally.

Practice

Monitoring:

1. Working with its partners in the Coalition for Public Health in the 21st Century, CPHA should
 - a. Seek the revision of the core set of indicators of health used in Canada to include indicators of the state of key ecological determinants of health; and
 - b. Encourage the Chief Medical Officer of Health for Canada to include indicators of ecological determinants of health in Canada's reports on population and public health, and to report specifically on the ecological determinants of health on a regular basis (e.g. every five years).
2. Working with its provincial and territorial branches and other relevant stakeholders, CPHA should encourage provincial Chief Medical Officers of Health, regional and local public health departments to monitor and report on locally relevant ecological determinants of health on a routine basis.

Public communications and engagement:

1. CPHA should undertake a significant communications and engagement program with the selected key stakeholders and the general public with respect to this report, its findings and recommendations.
2. CPHA should coordinate its public communications and engagement strategy with its key national partners.

Support for local action

1. CPHA should work with the network of healthy community initiatives in several provinces, with similar social movements and networks of sustainable/green community initiatives and with key national partners such as the Canadian Institute of Planners and the Federation of Canadian Municipalities to bring together the various networks and movements seeking to create more sustainable, just and healthy communities, and seek the capacity and resources to strengthen their effectiveness.

National Partnerships

1. CPHA should identify key national partners in the health, environment and other key sectors and actively foster joint action wherever possible.
2. CPHA should identify and join established national networks and coalitions that are addressing issues of ecosystem sustainability, such as the Canadian Environmental Network.
3. CPHA should encourage the relevant federal and provincial health authorities, including BC's First Nations Health Authority, to perform an assessment of their vulnerabilities to global change and to the significant indirect consequences of global change.

International action

1. CPHA should distribute this report to other national public health associations (perhaps via the World Federation of Public Health Associations), to the Lancet Commission on Planetary Health and other suitable international organisations and seek opportunities to partner with them in addressing the ecological determinants of health internationally

and at a global level.

2. CPHA should partner with other relevant organisations nationally and internationally (e.g. via the WFPHA) in calling upon WHO to:
 - Dedicate a future World Health Assembly to the issue of the ecological determinants of health.
3. CPHA should partner with other relevant organisations nationally and internationally (e.g. via the WFPHA) in calling upon the UN to:
 - Establish a UN Commission on the Ecological Determinants of Health.

Appendix A: Changes in key global ecosystem components, approx. 1992 – 2012

Source UNEP (2012)

Component	Approx 1992	Approx 2012	Change from 1992 (Green = good news)
KEY DRIVING FORCES			
World Population in billions	5.5 billion	7 billion	+ 26%
Urban population (and as % of total population)	2.4 billion (43%)	3.5 billion (50%)	+ 45%
Population living in slums	656 million (46% of urban pop)	827 million (53% of urban pop)	+ 26%
Global GDP (Constant 2000 US dollars)	\$36 trillion	\$63 trillion (2010)	+ 75% (to 2010)
Global GDP per capita (US dollars)	\$6,618	\$9,200 (2010)	+ 39% (to 2010)
Value of internationally traded products (US dollars)	> \$9 trillion	\$28 trillion (to 2009)	+ 311% (to 2009)
SUMMARY GLOBAL INDICATORS			
Living Planet Index²⁶⁵ (Indexed to 1.0 in 1970)	0.84 (1990)	0.72 (2007)	- 16% (to 2007)
Human Development Index	0.52	0.62	+ 19%
Total ecological footprint (EF) in billions of hectares²⁶⁶ (EF/capita x global population)	14.31 (1990)	18.09 (2007)	+ 26% (to 2007)
CLIMATE & ATMOSPHERIC CHANGE			
Global CO₂ emissions in billion tonnes	22 bn tonnes	30 bn tonnes (to 2008)	+36% (to 2008)
<ul style="list-style-type: none"> • Emissions of CO₂ per \$ GDP 			-23% (to 2008)
CO₂ levels measured at Mauna Loa, Hawaii (ppmv)	357 ppmv	389 ppmv (in 2011)	+ 9%

265. Source: Living Planet Report 2010. WWF. http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/

266. Source: www.footprintnetwork.org/atlas 2010 Edition.

Global mean temperature increase (°C)			+ 0.4 °C (to 2010)
<ul style="list-style-type: none"> Ocean temperature deviation from 1901-2000 average 	+ 0.22 °C	+ 0.50 °C (to 2010)	+ 0.28 °C (to 2010)
Arctic sea ice summer minimum	Almost 8 million km ²	4.33 million km ² (2011)	-35% (to 2010)
Glacier mass balance (Ave. annual melting rate in metres of water equivalent for 30 observed glaciers)	0.4 m/year (early 1990s)	0.7 m/year (early 2000s)	Almost doubled in 1 decade
Sea level rise			Approx 25mm (to 2011)
Peak ozone 'hole' in Antarctica (km²)			"A small positive change " (to 2010)
RESOURCE DEPLETION			
Irrigation area			+ 21% (to 2009)
Forests	Losing about 16 million hectare/year in 1990s	Losing about 13 million hectare/year in 2000s	Primary forest area decreased overall by 300 million ha since 1990
Global materials extraction (billions of tonnes)	42 bn tonnes	60 bn tonnes (to 2005)	+ 41% (to 2005)
<ul style="list-style-type: none"> Construction materials 			+ 80% (to 2005)
<ul style="list-style-type: none"> Ores and minerals 			+ 60% (to 2005)
Fisheries		Approx 80 m tonnes	Slight decline (to 2008)
Percent that are <ul style="list-style-type: none"> Over-exploited Fully exploited Under-exploited 		33% 52% 15%	+33% +13% - 49%
Aquaculture	14 m tonnes	51 m tonnes (to 2009)	+260%
Fish consumption per capita in kg			+ 32% (by 2007)

Grazing animal herds			(to 2009)
<ul style="list-style-type: none"> • Goats • Buffaloes • Cattle • Sheep 			+45% + 23% +7% - 6%
Organic farming	110,000 km ² (1999)	> 370,000 km ² (2009)	+ 240% (in one decade)
Food Production Index	100	145	+ 45% (by 2007)
Meat consumption per capita in kg (and total)	34 kg (187 billion kg)	43 kg (2007) (283 billion kg in 2007)	+ 26% (by 2007) + 51% (2007)
POLLUTION/ECOTOXICITY			
Solid waste			
<ul style="list-style-type: none"> • Plastics production in millions of tonnes 	116 m tonnes	265 m tonnes (to 2010)	+ 130% (to 2010)
Nitrogenous fertilizers (Index)	100	Approx 135 (to 2009)	+ 35%
Ocean acidification	8.11	8.06 (to 2007)	- 0.05 (to 2007)
Consumption of ozone-depleting substances			-93% (to 2009)
LOSS OF HABITAT AND SPECIES			
Extinction risk (IUCN Red List Index) <ul style="list-style-type: none"> • Vertebrate groups 	“for those vertebrate groups where sufficient data are available, the trend is generally negative; i.e., that birds, mammals and amphibians are becoming increasingly threatened. . . . Almost one-fifth of extant vertebrate species are classified as ‘threatened’, ranging from 13% of birds to 41% of amphibians”. . . . On average, 52 species per year moved one category closer to extinction from 1980 to 2008.”		
<ul style="list-style-type: none"> • Plants 	“nearly a quarter of plant species are estimated to be threatened with extinction, and in some plant groups over 60% of species are considered threatened”		
Living Planet Index (LPI) (Indexed to 1992 = 100)	100	88 (to 2007)	-12%
<ul style="list-style-type: none"> • Tropical LPI 	100	70 (to 2007)	- 30% (to 2007)

Appendix B: The potential/current and anticipated health impacts of global ecological change

Environmental & Social Change	Type of Health Effect	Health Effects Global	Canada	General: Current state of knowledge and Concern
CATEGORY: Global geo-climatic system changes				
Mean global temperature rise up to +4°C from preindustrial era.	Negative effects >> benefits ↑ Heat deaths; ↓ cold deaths ↑ Water-, food-, and vector-borne diseases ↑ Ground level ozone → more cardio-respiratory disease ↓ food production -10%/1C ↑ Eco-refugees ++	+++++	South: ++ North: +++++	Mitigation measures available in Canada, but mitigation & adaptive actions minimal to modest. ↑ risk for: poor, indigenous, socially & geographically isolated, old, young Change is faster than anticipated
Sea level rise	↑ Death: drowning, storms, disaster ↑ Morbidity: trauma, food & water insecurity, ↑ mental distress ↑ Eco-refugees	++++	++	Approx 2.3m/1°C over next 2000y; 0.5-2m by 2100 Canada: E. Coast more affected than W. Coast Much discussion, some plans, little action Hundreds of millions affected globally by 2100. Compromised energy, sanitation, shipping facilities, civil infrastructure
Polar ice decline	Death/morbidity from consequences of snow-rain- ice- storms, flooding, damaged infrastructure and impaired emergency response Food insecurity (Arctic) Arctic Eco-refugees	+++	++++	Drops in area & volume Eventual loss of polar ice in summer Potential change in jet stream and consequent weather events Change in Arctic ecology, ecosystem function, and societal living patterns
Wider distribution of insect vectors of disease	↑ malaria, dengue, Lyme, etc.	++++ esp. tropics & semi-tropics	++	Function of altered ecosystems, vector physiology, host immunity and resilience, and effective public health and societal infrastructure. Research questions abound
Disruption of agro-ecosystems	↑ food costs, ↓ food production ↑ Hunger, malnutrition, starvation, mental distress, eco-refugees, Societal conflict likely	++++	+(+)	Global food production must double by 2050. Based on population, food production, loss, distribution. Declining resources (water, land, phosphorus, energy). Climate change worsens situation ++. Mitigation challenging.
Disruption of forest ecosystems (fire, pests, change of tree distribution)	↑ Air, water pollution ↑ Conflict ↑ Malnutrition ↑ Mental distress	++++	+++	Key carbon sink. Threats: Development: logging, agriculture (e.g. Amazon, Indonesia), urban spread; pestilence (Canada: pine beetle); climate change. Result: ↓ carbon absorption, ↓ biodiversity, poor water control,

Environmental & Social Change	Type of Health Effect	Health Effects		General: Current state of knowledge and Concern
		Global	Canada	
				temperature modulation, ↓ ecosystem function & resilience.
Ecosystem change	↑ Mental ill-health; ↓ food security; ↑ accidental injury and death; ↑ water- food-, & vector-borne disease	+++++	+++	Ecosystems key component of human well-being Ecosystem Change → Species, biodiversity loss. ↓ ecosystem resilience. Effects now often global, (e.g. land & ocean acidification, temp rise, biodiversity loss). Indigenous peoples (e.g. Inuit) perhaps more obviously affected.
Extreme hydrological events (rain, hurricane, drought, desertification)	↑ Water-borne disease; ↑ accidental injury and death; ↑ mental illness ↑ Social disruption ↓ food & water security → ↑ Malnutrition, infectious diseases, death ↑ Dust-storms → respiratory illness ↑ risk in female headed household	++++	++	Episodic, somewhat predictable and with potential for mitigation, esp. in developed countries. Requires planning, infrastructure Flooding: major concern for insurance, homeowner.. Drought longer lasting ?bigger effect Multiple areas affected globally. Educating women re sustainable practices key adaptive measure.
CATEGORY: Ozone Layer Destruction				
Increased UV radiation	↑ Skin cancer ↑ Cataracts immunosuppression	++ Mainly polar	++	Level of population based health effect uncertain Good example of international cooperation Disruption of phytoplankton system and thus disrupted food chain and potential ↓ in O ₂ generation
CATEGORY: Acid emissions (CO₂, SO_x and NO_x)				
Ocean and freshwater acidification -	↑ Food insecurity → malnutrition ↑ Ocean dead zones	++++	++	Origin: fossil fuels, N fertilizers Mitigation very difficult. Biodiversity & species loss Bottom of food chain (e.g. phytoplankton) threatened → threats to larger organisms
Land acidification	↑ Food insecurity → malnutrition ? altered food composition	++++		Origin: industry, excessive use of N fertilizer Accelerated loss of Ca ²⁺ Mg ²⁺ Biodiversity loss,
CATEGORY: Pollution and Ecotoxicity				
Outdoor air pollution: NO _x , ozone, PM	Respiratory and cardiovascular diseases	+++	+	Increasing in industrializing and urbanizing LMICs, can be severe in cities e.g. Beijing, Bangkok, Better managed but can also be severe in HICs (e.g. Paris, March 2014)
Water pollution - microbial	Gastro-intestinal disease - cholera, typhoid, E.coli, Hepatitis A, polio, etc	++++	+	Can be severe in LMICs, among both urban and rural populations, with large and fatal epidemics. Occ. Outbreaks in HIC. Likely to ↑ with

Environmental & Social Change	Type of Health Effect	Health Effects		General: Current state of knowledge and Concern
		Global	Canada	
				higher temperatures
Agricultural pollution from overuse of fertilisers, pesticides, Animal Feed lot solid waste disposal	GI illness due to Bacterial pollution from feed lot runoff Algal blooms & dead zones	+++	++	N & P overused as fertilizer → water pollution. Feed lot runoff → water pollution & bacterial contamination Biodiversity loss
Persistent Organic Pollutants (POPs) - (The UNEP 'Dirty Dozen' - PCBs, dioxins, BPA & related compounds)	May affect pregnant & nursing mothers, infants Neuro-developmental disorders Endocrine disruption Some are carcinogenic Intrauterine growth retardation)	+++	+++	Persistent, bio-accumulative, long-range transport & distribution. Affect ecosystem function, change Globally distributed; esp. in polar regions Accumulate in food chain Stockholm Convention on POP's; ? success.
Endocrine disrupting compounds (EDCs)	Altered hormonal signaling → reproductive, thyroid disorders, ?epigenetic based health effects	++ -> +++	++ -> +++	Wide variety of products: pesticides, herbicides, brominated flame retardants, industrial chemicals & commercial products. Some products banned (e.g. BPA) regulation is controversial and lethargic Degree of effect unmeasured, may be a factor in some chronic diseases (e.g. obesity, diabetes)
Radiation from human action Nuclear accident (Chernobyl, Fukushima) air, soil, and food chain contamination	Cancer, mental retardation, microcephaly, cognitive defects	++?	++?	Problematic. Fukushima current major Pacific (& global ?) threat Many nuclear power plants worldwide, all with problems of waste management/disposal.
Industrial chemicals & electronic waste products	Variable: neuro-developmental delay, congenital anomalies, reproductive disorders, cancer Clear evidence of specific health effects available for only a few substances. Most untested.	++++	+++	Pervasive in environment, may persist. Multiple interactions with other chemicals and natural products makes assessment & regulation complex and combative. Effect on ecosystems & biodiversity unclear but mainly negative. E-waste: major env. challenge. First world dumps to third world, where regulation is poor. Suspicion high; ignorance profound; industry denial massive
Heavy metals: Pb, Hg, Cu, Cd, As	Death Mental retardation Hypertension Effects now more likely due to prolonged low-level exposure	++	+	Global distribution, bioaccumulation via food chain accretion. Often in abandoned mines or industrial sites. Life cycles poorly known, risk-assessment and regulation variable. International agreements essential.
Nanoparticles	Health effects unclear. Some beneficial pharmacological uses. Can enter fetal cells: ? effects	+??	++??	Evolving: potential for human good & harm. Life cycle and biological effects not well known. May accumulate in food chain.

Environmental & Social Change	Type of Health Effect	Health Effects		General: Current state of knowledge and Concern
		Global	Canada	
				Limited safety testing (need new methods?) Regulation poor, but in process.
Microplastics (The 'plastisphere' – see Chapter 3)	Indirect: food security Consequences of chemicals in plastic - see endocrine-disrupting chemicals (EDC) and POPs	+?	+?	From deterioration of plastic products. May have chemical additives Enter food chain, esp. birds & fish. No regulation. Potential significant pollutant
CATEGORY: Resource Depletion				
Water Groundwater depletion Surface water depletion (lakes, streams, reservoirs, glaciers)	↑ Water insecurity ↑ Food & health insecurity: ↑ Malnutrition, death, dehydration, infectious diseases from poor sanitation ↑ Conflict over water	+++++	++	Major global problem, water essential for life, sanitation, food & energy. Globally 3+ billion are water insecure. ↑ demand, ↑ pollution, ↑ exploitation: ↓ supply Canada: significant potential for water scarcity on Prairies and irrigated areas in general. ↑ rates of both groundwater and surface depletion. Controversy regarding private/public ownership and management of water supplies.
Fossil fuels (FF): coal, oil, gas	Health effects mainly indirect but significant: abundant cheap energy key reason for current high levels of health. ↑ Death/morbidity secondary to hypo/hyperthermia. ↑ Conflict over FF Current FF use leads to illness from air & water pollution. FF use key driver of climate change & environmental degradation	+++++	++++	Need to ↓ FF use is key question for 21 st Century 80% of all energy used is FF based. FF main source ↑ CO ₂ → climate change. Need to restrict use or CC much worse. Alternates needed, but unavailable in sufficient supply; thus energy decline inevitable. FF major source transport, electrical energy ↓ FF → major negative economic, cultural, social effects. ↑ food insecurity, ↓ globalization Biggest problem: (a) failure to recognize need to stop use of FF, (b) develop adequate renewable sources, (c) adapt to lifestyle based on much lower energy supply. FF is finite resource, functionally gone by 2100; thus must adapt to low energy regardless. Consequences good & bad.
Phosphorus	↑ Food insecurity and consequences therefrom. P is an essential nutrient. Also food insecurity from P water pollution (mainly in fertilizer)	+++++	++++	Finite supply, can be recycled from waste streams but generally not. Depletion looms as P supply sufficient for 50-150y (controversy). Conserving, recycling, and recovering soon essential.
Ocean Fisheries	↑ Food insecurity: Malnutrition Indirect health: economic	+++++	++	Ocean fisheries approaching global collapse, secondary to overfishing, climate change, and ? pollution.

Environmental & Social Change	Type of Health Effect	Health Effects		General: Current state of knowledge and Concern
		Global	Canada	
	consequences of fisheries loss			Need for international agreements, collaboration re: conservation, fishing methods,
Topsoil, lands for agricultural use	↑ Food insecurity: Malnutrition	+++	+	Essential for most life. A finite resource. Soil Erosion is major problem Soil loss is 10-40X rate of renewal. 100 – 500 y to make 1 inch; can lose in hours
Forests	↑ Vector borne disease ↑ air pollution → ↑ respiratory disease ↓ biodiversity → fewer medicinals Loss of cooling effect	++++	++	Loss of carbon sinks ↓ biodiversity, ↓ water retention, ↑ runoff -> flooding Loss of medically valuable species
Minerals	Mainly indirect, but minerals essential for various medical products.	+++	++	↓ Minerals in soil → ↓ minerals in foods Significant gaps in global resource/use estimates Major Depletion in < 100y for: Cu, ↑ Population → ↑ Demand Extraction a function of concentration, energy, money, & waste.
Other? Rare Earths (elements)	Indirect effects: but essential for many electrical products used in hospitals.	+++	++	Problem not global reserves, but geography & politics. Rare earth poor country gets access based on economic/political agreements &/or war ('blood minerals') Vital in today's industrial economy.
CATEGORY: Loss of species, biodiversity				
Biodiversity loss & species extinction	Insect & Vector-borne Infections Potential loss of new drugs	++++	+++	Diminished ecosystem resilience, stability, productivity. Effects non-linear, may be tipping points leading to new stable state. 6 th major extinction in Earth's history; first due to human action: pervasive chemicals, pesticides, land use for agriculture, population growth
Invasive species	Exotic Infections food and water insecurity	++	++	Consequence of climate change, globalization, tourism, ecosystem change,
Crop monoculture	↑ Food insecurity: Malnutrition	+++	+++	Reflects industrial agricultural practice: high fertilizer/pesticide use. Unsustainable. Leads to biodiversity loss, ↓ ecosystem resilience.

Appendix C: Three narratives: Making sense of what is happening and what is possible

The three narratives presented here are not so much predictions of possible futures as they are stories that help us make sense of what is happening and what is possible. Thus, it is helpful to recognize how each of the scenarios presented below embodies a different cultural narrative about this time we are in and a different set of values about where we are headed, and thus how we are called to be engaged with co-creating the future. It's also important to recognize that the challenges and trends discussed earlier in this report are not hotly contested. But each scenario comes from a different place in terms of what these challenges and trends are assumed to mean, to what extent and how rapidly they develop, and thus what needs to be done about them.

The three narratives are titled 'Doing the same things', 'Doing the same things better' and 'Doing better things'.²⁶⁷ These considerations and patterns reflect the idea - from the systems-focused quality improvement approach - that 'every system is perfectly designed to achieve the results it gets'.²⁶⁸ It would appear that our present system is perfectly designed to generate economic growth and human and social development together with rising social inequity, depleted natural capital and declining ecosystem functioning, which in turn ultimately threatens future growth and development. The three narratives below help us to consider some of the different factors that may need to be in place for us to create a different system, one that is designed to generate human development that is socially just and ecologically sustainable, while creating enough material and non-material resources to ensure each person's wellbeing now and generations into the future.

Each of the three narratives was written with the voice of someone looking back from a timeframe of approximately 15 years in the future (~2028-2030). This timeframe is informed by some of the trajectories and transition points relating to the implications for population health that were introduced in previous chapters of the report. It is also informed by our understanding of existing planning cycles that public health is going to need to engage with to accommodate mitigation and adaptation. For example, municipal planning is usually undertaken in 20 year planning frames with updates every 5 years unless otherwise specified in Provincial legislation, while municipal physical infrastructure also uses a 20 -year time framework with reviews varying between 5 and 10 years; in both cases, it is worth recalling that the physical infrastructure that is created will usually be there for at least 30 years, and often 50 – 100 years, even more.

Land use is one embodiment of a community's social and cultural infrastructure whereas servicing such as transportation, water and sewer represent the physical infrastructure upon which the communities relies. In so far as the concerns described in chapters 1 through 6 are to be addressed, collaboration will be required with the professions responsible for the design of both types of infrastructure and the elected councils responsible for decision-making, if the potential to realize "what could be" is to be achieved.

267. For comparison, readers might like to look at the four scenarios used in the Institute for Alternative Future's (2014) report on alternative futures for public health in the USA in 2030 (Appendix A). Of note is the relative absence of the ecological determinants in those scenarios.

268. Generally attributed to Dr. Don Berwick, past president and CEO of the Institute for Healthcare Improvement in the USA, but also to W. Edward Demings, the quality improvement 'guru'.

Narrative 1: Business as usual: 'doing the same things'

In the early twenty-teens, governments struggled to maintain public confidence and economic growth in the midst of spreading economic malaise and growing public and private debt. Attempts to balance fiscal austerity with the cost of significant investments in 'security' infrastructure, resulted in alarming increases in social inequality, and with it growing social unrest that was seen to justify further 'security' measures. Economic woes were compounded by rising energy costs, aging infrastructure and delayed investments in infrastructure renewal, compounded by the emergence of more severe destructive extreme weather events unleashed on an aging and outdated infrastructure. In the early twenty-teens governments in the Global North redoubled their efforts to restart economic growth, reassuring populations that technological innovation would offer breakthroughs that would enable populations to continue their current ways of life, albeit with some 'belt-tightening'.

Think tanks proliferated and studies were commissioned, but the solutions offered proved difficult to implement in the context of increasingly acrimonious debate, finger-pointing, partisan politics, short-term political focus, and constrained finances. International negotiations on climate change dragged on, making incremental gains that were increasingly out of step with the growing urgency felt by scientists and many social groups. Lack of trust, growing anxiety and a scarcity mentality translated into a lack of political will at every level. Growth faltered, public confidence was shaken, and we discovered that we had lost much of our earlier capacity for meaningful public dialogue. Canada fared better than many countries, but was not immune from the worsening global economy, increasingly chaotic climate, and growing social polarization. Public health struggled valiantly to address worsening social determinants of health, drawing attention to the links between social exclusion and health, and redoubling their efforts especially in proliferating 'priority neighbourhoods' and areas hard-hit by economic and ecological change. This proved challenging, meeting growing needs while dealing with successive budget cuts and rising costs, and staff burn-out became a pressing problem with significant numbers on 'mental health leave'. Even public health 'successes' proved problematic. For example, as is the case with many health interventions, attempts to promote health and to build links between social and environmental determinants of health were taken up unevenly and in ways that exacerbated inequalities. This was seen not only in traditional public health areas like tobacco control and nutrition, but also with newer innovations such as the promotion of walkable neighbourhoods and active transportation. Despite their good intentions, such initiatives contributed to gentrification and the suburbanization of poverty, which left excluded groups with diminished access to public transit and other urban amenities as they were displaced by more affluent groups drawn to move back into the city as downtown neighbourhoods became more 'attractive', well-resourced, and valued for the proximity of amenities, 'community spirit', and socially/physically active lifestyles. Rural and remote communities were even harder hit, as they dealt with growing environmental, social and economic crises with ever-diminishing resources. Often this felt like "one step forward, two steps back".

Thus, sadly, business-as-usual represented a failure to meet emerging challenges with sufficient collaboration, innovation, foresight, political will, and integrated consideration of social and ecological determinants. The general mood among the public and many health and social service workers was that the future looked increasingly gloomy and neither governments nor the private sector were able to meet emerging challenges with anything close to the scale, speed and audacity required.

Narrative 2: Risk Management: 'doing the same things better'

Worsening economic, social, and ecological conditions in the early twenty-teens, coupled with public impatience with government inaction and finger-pointing eventually led to significant political change and an emerging social consensus on the need for concerted action to address emerging challenges. A new era of collaboration enabled long-overdue investments in public infrastructure (water/sanitation/public transit), urban renewal, and climate change adaptation measures based on the best available evidence and a renewed commitment to public participation and intersectoral collaboration. Whole-of-government approaches enabled hitherto elusive synchronicities in what different departments were doing, sparking renewed public faith in the capacities of government to respond meaningfully to emerging challenges. Policies and programs were developed for key settings (schools, workplaces, hospitals, communities) addressing sustainability and health.

Special attention was paid to the social distribution of costs and benefits, recognizing that the old neoliberal adage that “a rising tide lifts all boats” was more fiction than fact, and that progress on ecological issues would be blocked without corresponding attentiveness to social inclusion and social justice. New monitoring, regulatory, and evaluation mechanisms reflected the best of what contemporary risk management approaches had to offer. Increasingly, experience moving from policy-making to implementation enabled the wider adoption of more consultative and participatory approaches that could proactively identify and address potential sources of resistance, while building genuine consensus, shared vision, teamwork and community. Ideas of systems resilience also took hold, operationalized primarily in terms of shoring up the capacity to ‘bounce back’ from adversity. Public health played an active role, since it was well positioned to make the links between social and ecological determinants of health and issues of social exclusion and health equity. Public health professionals, energized by a broadened social mandate and social legitimacy, seized opportunities to work with professionals in other sectors as well as many actors in civil society. New alignments with emerging vibrant social movements enabled progress on multiple fronts related to cultural, political, social and policy change at the local, regional and national level.

Initially these produced favourable results, which fueled additional investments in public health and social determinants of health, legislation to address social disparities, and the reformulation of environmental policies with fuller attention to the precautionary principle and environmental justice. Social justice and environmental groups discovered common ground and worked together with a shared vision for social equity and sustainability. Despite rising energy costs, a worsening global economy, accelerated ecological decline, and worrying signs we had passed crucial climatic tipping points, many people remained hopeful, buoyed by a renewed faith in public dialogue, collaboration, and shared fate. Still, progress was slower than many people wanted, in part because the evidence base was lacking in several key areas and took time to accumulate, realignments around new values of sustainability took time to work their way through the political process into policy and practice, creating new winners and losers who mobilized to protect their interests, and phase-in periods meant that the actual implementation of change was incremental. In short, the sense of movement and collaboration was also coupled with growing frustration about the mismatch between a growing sense of urgency and the time required to phase in new regulations to appease affected parties (e.g. real and immediate reductions in carbon emissions, vehicle fuel economy requirements, the control and/or banning of key pollutants).

Narrative 3: Transition: 'doing better things'

As emerging threats (climate change, peak oil/energy insecurity, declining ecosystem functioning, rising inequalities, economic instability and their ripple effects - social unrest, energy & food shortages, etc...) became harder to ignore in the late "twenty-teens", governments were forced to abandon their commitments to "restarting economic growth at all costs". It was becoming obvious that sustained economic growth was a thing of the past, and no longer a viable option around which to build either domestic or foreign economic, social and environmental policy. The age of limits was biting hard. Core cultural narratives of "progress" and "growth" were increasingly called into question, and with it notions of "making it", and "getting ahead".

A more aggressive approach to risk management that had seemed so promising in the early twenty-teens, whose early achievements justified the huge incremental costs of setting up elaborate regulatory and enforcement mechanisms for 'driving change' through multiple systems and settings (and monitoring/evaluating impacts), proved increasingly ineffective at managing change in an increasingly unpredictable world. Further, it was becoming evident that the main function of risk management had been to 'manage' the problems arising from industrial growth society in a way that would allow it to continue, the problem being that even with significantly reduced economic growth, the more dysfunctional elements of globalized capitalism continued to wreak havoc and misery for many, especially the world's poorest, accompanied by tendencies towards the concentration of wealth and power that progressive tax reform only partially addressed. Furthermore, in a diversity of fields from agriculture to energy production to watershed and ecosystem management, risk management was increasingly recognized to have concerned itself with maximum sustainable yield, efficiency, stability/'equilibrium', and adversity to risk rather than proactive adaptation to change.

Since the 1990s those dedicated to understanding the behaviour of complex adaptive systems had been warning that traditional risk management approaches tended to lock systems into development paths that erode resilience over time and predispose systems to collapse. The collapse of the east coast cod fishery was an early example of the failure of well-developed permitting, quota, and monitoring systems to forestall ecosystem collapse, but the collapse of the west coast salmon fishery, followed by many of the world's marine fisheries despite increasingly rigorous attempts at monitoring, management, and enforcement, forced a re-evaluation of the assumptions and limitations of risk management. Risk management, it turns out, had largely concerned itself with mitigating the worst effects of the dominant social-economic system, without fundamentally calling this system into question. By the late twenty-teens it was becoming evident that deeper change was required. Many who had previously believed there was no viable alternative to late-capitalist economic globalization were forced to reconsider their stance. The significant costs incurred in creating a sophisticated risk management apparatus made this an especially difficult and bitter pill to swallow.

Increasingly resilience was redefined not as the capacity to 'bounce back' from adversity to some imagined (but increasingly dysfunctional) 'normal', but rather as the capacity to embrace (rather than resist) change and to 'bounce forward' into new ways of thinking and doing. Innovative new ways were explored for understanding the 'animate earth', sensing the changes wanting and needing to come, harnessing collective wisdom and diversity, and 'engaging emergence'. Emerging from movements and groups working on progressive alternatives to the status quo (such as ecohealth, ecovillages, Transition Towns, /

community watershed councils, bioregionalism, permaculture, degrowth and Slow Food/Money), those with capacity to identify synergies between community development, social justice and ecological harmony/renewal found themselves catapulted into the forefront of public attention, and were nearly overwhelmed by the outpouring of interest and engagement that followed, as people eagerly explored alternatives that resonated with deeper longings for connection and harmony. Interest in indigenous and Global South ways of thinking and doing grew significantly. Much was learned, although attempts at paradigm 'integration' proved challenging. Progress in addressing the results of colonization was evident in a closing of health disparities between indigenous and non-indigenous peoples after decades of deterioration.

In short, by the early 2020s, what had been seen as a marginalized world view a decade or two earlier was widely accepted: like it or not, we were already in the midst of a massive societal transition from an Industrial Growth Paradigm (a way of relating to the world based on economic growth, competition, exploitation, fear, acquisitiveness, and the impulse to control, 'manage', and impose order - enabled by 100 years of cheap fossil fuels) to a Life-Centered Paradigm where human flourishing is based on interdependence, deep respect and reverence for all life, and the capacity to listen to and work with nature and with each other.

Ultimately, and perhaps most ironically, the transition was propelled not by growing fear but by the compelling nature of the new cultural narratives and practices that enabled people to proactively and collectively build better futures together.

In this context public health work flourished in many forms. Many aspects of traditional public health work continued (school nurses, public health inspections, well baby clinics), though the work itself shifted as the new paradigm took root. Those within public health who had been leaders in interdisciplinary, bridge-building, intersectoral collaboration, and participatory governance found many new opportunities for leadership and co-creation.

The Text Box below presents an example of how the range of considerations, opportunities and tensions of Table 3 could manifest in the daily practice of a public health nurse. This example could equally be played out for other forms of public health practice, and the exercise of writing and thinking in this way may well be a consideration for future education, training and building of core competencies for public health, and other dimensions of public health research, education and practice that will be explored in Chapter 8.

Imagining the future: Every-day practice for a Public Health Nurse in 2028

A public health nurse works as part of an interdisciplinary team (community representative, political scientist, public relations officer, medical officer of health, environmental health inspector, research coordinator, nutritionist, dental hygienist, social worker, legal aid, economist, industrial liaison, data management officer etc) based in a community health centre in a rural, sub-urban or urban neighborhood set up in a store-front fashion to maximize visibility and accessibility for the community.

A typical day starts with a team conference to determine collaborative approaches to health issues identified by the community. The public health nurse may start the day with a family visit to carry out a home environmental assessment as routine part of a newborn family visit. One of the goals of the visit is to facilitate social and ecological wellness in participation with the family. On the way to the family's home the PHN continues an ongoing practice to collect relevant data about the physical neighborhood environment through an air monitor attached to her renewable energy powered scooter. As part of the home and family assessment, the PHN provides information about environmental effects of consumer products and daily practices based on the ecological footprint model to encourage ecosystem friendly practices of re-using, re-cycling and reducing. The PHN offers information about green spaces in the neighborhood, community gardens, farming co-operatives and publicly funded alternative transportation. The PHN integrates information about community day care for children as well as for the elderly, and other services provided by public and private organizations that support families.

Next, the PHN visits one of the district high-schools to meet with the nurse practitioner of the teen-health centre together with the school's principal, guidance counselor and student representatives. In addition to discussing the immunization schedule for the coming school year, the group continues to discuss a future school event about climate change and health effects for young adults.

Upon returning to the community health centre the PHN briefs the data management officer who enters the quantitative and qualitative data collected through home visits and neighborhood surveillance in a comprehensive data base, including the Genuine Progress Index and Canadian Index of Well-being to inform policy.

In the afternoon, the PHN participates on a municipal Health Equity Impact Assessment committee to discuss a draft policy for a proposed residential and commercial development adjacent to her/his district/neighborhood.

Before the end of the day the PHN participates in the design and planning work to renovate an old public housing complex built in the 1970s into a state-of-the-art, fully accessible home for single parents, with integrated employment, social, and childcare services, community garden and kitchen, integrated renewable energy source, integrated waste water system, local non-toxic building material etc....The group is finalizing a funding proposal and draft policy brief to be submitted to the Governance Board including intergovernmental ministers, community representatives and NGO coalitions.

The practice of a PHN can be related to the 6 principles [see Part 2] to guide an integrated eco-social-health & wellness approach based on a care sensitive ethic. Enabling full participation in an ecological and socially healthy way for those at the bottom of the social hierarchy requires critical analysis of social practices that create and perpetuate unhealthy living conditions in order to change practices toward eco-social-wellness. The work of a PHN is integrated across sectors, scales and policy making levels and informed by a practice rooted in communities. It is not about judging individual's decision-making as good or bad, rather it is concerned with engaging local knowledge to inform advocacy work toward healthy public policy and health equity for future populations.