# William E. Rees

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## BIOGRAPHY

William Rees received his PhD in population ecology from the University of Toronto and taught at the University of British Columbia's School of Community and Regional Planning (SCARP) from 1969 to 2011. He founded SCARP's Environment and Resource Planning concentration and from 1994 to 1999 served as director of the school.

Professor Rees's teaching and research focus on the socio-economic and ecological prerequisites for sustainable societies in an era of accelerating global ecological change. A human ecologist and ecological economist, he is best known as the originator of "ecological footprint" analysis, a sustainability assessment tool now used around the world that has helped to reopen the debate on human carrying capacity. His book, *Our Ecological Footprint* (co-authored with then PhD student Mathis Wackernagel), was published in 1996 and is now available in nine languages. Professor Rees has also authored 125 peer-reviewed academic papers and book chapters, and numerous popular articles, on humanity's (un)sustainability conundrum. His current book project asks, Is humanity inherently unsustainable? He draws parts of his answer from various disciplines.

Professor Rees is a founding member and recent past-president of the Canadian Society for Ecological Economics, and a co-founder of the One Earth Initiative. He is also a co-investigator in the Global Integrity Project, aimed at defining the ecological and political requirements for biodiversity preservation while sustaining human population health. Professor Rees's work is widely recognized. He has been invited to lecture on his research in 25 countries around the

world and in 2012 won the Kenneth E. Boulding Award in Ecological Economics, as well as the 2012 Blue Planet Prize, jointly with his former doctoral student Dr. Mathis Wackernagel. In 2006, Professor Rees was elected a fellow of the Royal Society of Canada; he was nominated a Trudeau fellow in 2007.


## ABSTRACT

Civil society is unlikely to organize spontaneously to force the necessary eco-revolution. However, if the leader of any major country or economy were to acknowledge formally that the world is on a self-destructive tack and propose a strategy to turn things around, the effect could be galvanizing. Global society may be close to a psychological tipping point at which such a dramatic call to action would "go viral," seizing the imagination of the world community. There is no reason why a Canadian prime minister should not be that leader. (Pierre Elliott Trudeau might have taken up the challenge.) Canada has nothing to lose and a future to gain by breaking from the herd in response to clear and present danger. At the very least, stepping out to facilitate negotiation of a global treaty for sustainability would serve to polish the nation's faded reputation as a significant force for economic stability, ecological integrity, and social justice.

# People and the Environment

## Introduction and Purpose

The natural world is of passionate concern to nature lovers, poets, and other romantics; "people and the environment" is a topic of almost obsessive interest to deep ecologists and environmentalists. But while many of the latter may wince at the fact, the reality is that the material relationships between people and the environment in capitalist techno-industrial societies are shaped mainly by *economic* factors.

And even if nothing else were involved, this would be problematic. Economic models often assume people to be self-interested utility maximizers with fixed preferences and insatiable material demands—certainly not romantic or even the type of character one would wish to invite to dinner! *Homo economicus* as described would wreak havoc in any environment, at any scale, from dinner table to entire planet. Nevertheless, discovering how to serve that insatiable demand as efficiently as possible is one of the principal goals that economists set for their discipline.

Not surprisingly, the economists' description of *H. economicus* is often criticized as a shallow, unidimensional caricature of real people (i.e., your friends and mine). Be that as it may, there is little doubt that human material demands, insatiable or not, are seriously

degrading whole ecosystems and compromising vital life-support functions upon which we all depend. No one has captured the flavour of contemporary people–environment relationships better than award-winning Canadian environmental journalist and author Andrew Nikiforuk:

> Let's face it: *Homo economicus* is one hell of an over-achiever. He has invaded more than three-quarters of the globe's surface and monopolized nearly half of all plant life to help make dinner. He has netted most of the ocean's fish and will soon eat his way through the world's last great apes. For good measure, he has fouled most of the world's rivers. And his gluttonous appetites have started a wave of extinctions that could trigger the demise of 25 percent of the world's creatures within 50 years. The more godlike he becomes the less godly *Homo economicus* behaves. (Nikiforuk, 2006)

In this light, the major goal of this paper is to highlight the need to seriously revisit the conceptual, scientific, and cultural foundations of modern society's economic relationships with its environment (is there really any such thing?). The daily cascade of bad news—record temperatures, unprecedented flooding and drought, acidifying oceans and sea-level rise, peak oil and accelerating biodiversity loss, and so on—is proof enough for reasonable people that humanity's current mode of engagement with the natural world is dangerously maladaptive. Ecological health and long-term sustainability require that we stimulate a very public *reconstruction* of the material relationships between people and the rest of nature, one that better reflects emerging ecological reality, both nationally and globally.

## The Environment as Social Construct

> *An object seen in isolation from the Whole is not the real thing.*
> *—Masanobu Fukuoka (1978)*

Not all Canadians' interactions with nature are material relationships, but even on the psychological level, most of us seem to have

an increasingly ambiguous and distant relationship to the natural environment. True, nature—often wild nature—figures prominently in our cultural self-image, in everything from folk music to fine art. The Group of Seven's iconic portrayals of the Arctic and north woods are burned into the national mind and resonate as truth to more adventurous Canadians everywhere. Authors as disparate as Pierre Burton, Mordecai Richler, Farley Mowat, and Margaret Atwood have set their histories and fantasies in natural settings that range from the romantically pristine to the fatally dystopic. Roch Carrier's poignant portrayals of life in rural Quebec trigger nostalgia in both official languages. But belying the myth of Canadians as a nature-loving, outdoorsy people is a different reality: Canada's population is among the most heavily urbanized peoples in the world population, and if we visit the wilderness—or even the rural countryside—at all, it is likely to be in a well-appointed SUV. For most of our citizens most of the time, the environment has become remote, cold, and even vaguely foreboding. (How else could we tolerate the wholesale ecological destruction associated with such economic activities as clearcut logging, ocean bottom trawling, and oil-sands strip-mining?) And it seems that the inclination to engage intimately with nature is fading with each passing generation. Even visits to the relatively safe havens of our national parks and nature reserves are in steepening decline.

These facts and trends are, in part, the result of an important but largely subconscious human cognitive process. People acquire their perceptions and understanding of both society and the environment (of everything, in fact) simply by growing up in a particular cultural milieu. By being immersed in and repeatedly exposed to contemporary beliefs, values, assumptions, and behavioural norms, most individuals acquire the ancient myths and contemporary narratives (read world views, paradigms and ideologies) that characterize their native "tribe." Indeed, cognitive neuroscientists tell us that oft-repeated

experiences, teachings, and thought patterns help to shape the developing brain—they literally acquire a physical presence in our synaptic circuitry (Wexler, 2006). Members of every culture thus acquire a socially constructed cognitive model of what constitutes normal humankind–nature relationships, and it is this construct that determines how individuals and society "act out" in the real world (see Berger and Luckmann, 1966).

As noted at the outset, contemporary society's "acting out" in nature is increasingly problematic. The world community is facing an unprecedented global ecological crisis. Anthropogenic greenhouse gases (GHGs) are accumulating in the atmosphere and resultant climate change is a fact; floating Arctic sea ice is disappearing; 75 percent of the world's fish stocks are overexploited; ocean dead (anoxic) zones are spreading and the seas are acidifying; deserts are expanding; tropical deforestation wreaks havoc with biodiversity; half the land area of Earth has been appropriated for human purposes; soil degradation and rising energy costs threaten future food production; water scarcity is an urgent and growing problem for millions of people, particularly in densely populated poor countries—the list goes on. While each of these problems is serious in itself, all are merely symptoms of a greater systemic malaise—*gross human ecological dysfunction*. None can be solved without addressing the general syndrome producing them all. In effect, *H. sapiens* has become a rogue species that seems not to acknowledge its dependence on the natural world and whose increasingly global consumption-oriented way of life is destroying the functional integrity of that natural world (the only habitat *H. sapiens* is ever likely to know).

One source of human ecological roguishness is industrial capitalist society's social construction of man-in-nature—our contemporary model grossly misrepresents biophysical reality. To begin, the citizens of most modern nations, including Canada, learn to perceive the environment as separate from the human enterprise, as a distant "other" that serves primarily as a resource trove and physical

backdrop for human affairs. This cognitive alienation of humans from nature has deep cultural roots traceable at least to ancient Greece; its modern expression flowered during the Enlightenment with the articulation of what we now know as Cartesian dualism; and it has only recently found its most ebullient (and environmentally violent) expression in the ongoing scientific/industrial revolution. Bottom line? By the time a typical denizen of the modern world becomes an active citizen, he or she has been preprogrammed with a nearly unassailable, socially constructed psychological barrier that distances him or her from the natural world.

At its simplest level, this cognitive separation fosters a dangerous illusion. If humanity is safely "in here" and the environment is at some distance "out there," then perhaps so-called environmental problems are not really all that critical—what happens to the other will not necessarily turn around to bite us when we are not looking. Consistent with this perception, the ethical foundation for human relationships with the environment in industrial societies is *utilitarian, anthropocentric*, and *instrumentalist*. It is utilitarian in that other species matter only to the extent that people value them, anthropocentric in that humans are assigning the values, and instrumental in that all of nature is regarded as a resource trove that exists strictly for human satisfaction (Randall, 1988). Certainly there is nothing about the distant other that might constrain human ambitions, including perpetual growth.

It does not help that urbanization and technology serve to reinforce the illusion. Many urban sophisticates, spellbound by the latest electronic gadgetry and surrounded by concrete see the wired (and wireless) city as their natural habitat, and it is a habitat far removed spatially and psychologically from the wilderness. So complete is this alienation that, despite the cascade of human-caused environmental bad news, most people today do not perceive of themselves as ecological agents. Indeed, we seem somewhat embarrassed by basic facts of our own biology—we may concede that *H. sapiens*

is an animal, but in the collective modern mind, humans not only differ from, but are clearly superior to, all other species. Many people still take offence at the evolutionary *fact* that humans and the other great apes descended from a common ancestor.

### *Human exceptionalism: alive and well in the 21st century*

Such human exceptionalism, along with ordinary anthropocentrism, permeates the Canadian identity. Consider the Law Reform Commission of Canada's 1985 report, *Crimes Against the Environment*. The commission argued that the Criminal Code should be reformed to prohibit acts that "seriously compromise a fundamental societal value and right, that of a safe environment or the right to a reasonable level of environmental quality." At the same time, the 1985 report emphasized "that the scope of a Criminal Code offence against the environment should not extend to protecting the environment for its own sake, apart from human values and interests." The commissioners thus remained wedded to the existing humanistic framing of the Criminal Code, which while defending persons and property, "does not, in any explicit manner, prohibit offences against the natural environment itself" (LRCC, 1985).

In responding to this report, Canadian "deep ecologist" Stan Rowe went straight to the core of the issue, regretting that the commission's findings reflected the entrenched anthropocentrism of society and thus missed an opportunity for deeper reform. According to Rowe, *Crimes Against the Environment* took "environment to be exactly what its etymology suggests: the context and surroundings of things of greater importance—namely people." As he had on other occasions, Rowe noted that, to the popular mind (and thus to the commission), "environment is peripheral." The very word "is its own pejorative" meekly setting itself aside from the thing of real interest at the centre (Rowe, 1989). (Rowe wondered whether "the environment" was even a useful concept.)

## The Ethereal Economy

Most of our mainstream academic disciplines also reflect the cognitive gulf between people and nature. This is true even of ecology and economics—the two domains of knowledge that one might expect to have the most to offer in resolving the evolving sustainability crisis. Historically, academic ecologists have studied mainly non-human species and ecosystems, ignoring *H. sapiens*; meanwhile, economists focus exclusively on the material demands of humans, either ignoring the environment altogether or considering the collateral damage caused by economic activity to be mere unfortunate "externalities." Bottom line? Neither discipline has a solid grip on the whole; neither yet operates from a pre-analytic vision of the human enterprise as an inseparable, integral component of the ecosphere.

This is no trivial perceptual lapse. The *ecosphere* is in dire peril, but it is the *economy* that remains the primary focus of, or provides the context for, almost all policy initiatives by governments everywhere. Economists are therefore the first to be consulted by policy-makers (not to mention the media) on most issues relevant to national well-being, including ecological threats at both the local and global scales.

Again, the systemic problem is that mainstream economics embodies the prevailing cultural paradigm. The discipline is utilitarian and anthropocentric to its core and, true to the Cartesian divide, its models treat the human enterprise as if suspended in space, aloof from the environment. The traditional starting point for neoliberal economic analysis is the circular flow of exchange value, typically portrayed in standard texts as "a pendulum movement between production and consumption within a completely closed system" (Georgescu-Roegen, 1971). Value embodied in goods and services flows from firms to households in exchange for spending by households (national product). A supposedly equal value, represented by factors of production (labour, knowledge, finance capital),

flows back to firms from households in exchange for wages, rents, dividend, and so on (national income). Some academic economists have described this stripped-down economy as a form of perpetual motion machine that generates a "flow of output that is circular, self-renewing, self-feeding" (Heilbroner and Thurow, 1981). Indeed, the circular flows model makes no reference whatever to the energy and resources required to produce the goods and to generate the income flows that the model does represent. Thus, in economists' minds "the circular flow is an isolated, self-renewing system with no inlets or outlets, no possible point of contact with anything outside itself" (Daly, 1991, 196). As ecological economist Herman Daly graphically observes, considering the economic process as a circular flow without considering the unidirectional throughput of energy and matter is akin to studying physiology in terms of the circulatory system with no reference to the digestive tract. One might as well ask engineering students to fathom how a car can run on its own exhaust or biology students to accept that an organism can metabolize its own excretia (Daly, 1991, 197).

The emergence of major ecological problems in the 1960s forced economists to adapt their thinking and at least acknowledge the existence of something outside the economy. Figure 1 shows the still-prevailing vision of the economy–environment relationship from the perspective of mainstream *environmental* economics. Note that there are still two separate systems. And while the economy may draw on the environmental other for resources, this is not really a critical relationship—economists generally argue that, abetted by free-market incentives, human ingenuity will find technological substitutes for any product of nature that humans may deplete. Similarly, we can solve problems arising from pollution (the overflowing of environmental waste sinks) by "internalizing the externalities"—putting a market price on waste sink functions. (Consider contemporary efforts around the world to put an effective price on carbon emissions.)

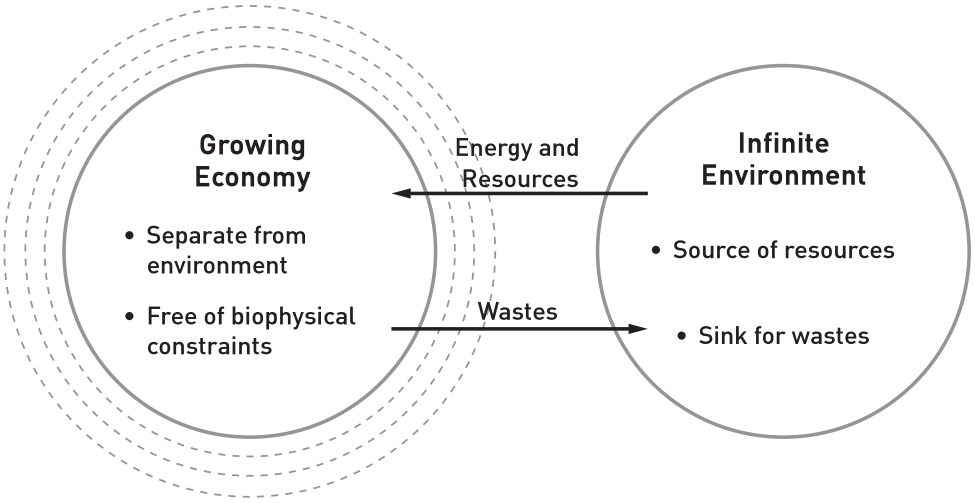


**Figure 1.** Growth-based neoliberal economics treats the economy as a separate, open, growing, quasi-independent system lacking any important connectedness to an inanimate environment.

Consistent with this perspective, some economists persist in their attempts to unshackle the economy from its annoying ties to the environment. Using abstract money-based models, they suggest that the human enterprise is actually "dematerializing," that economic activities are "decoupling" from the natural world. The critical implication is that the human enterprise should be able to continue growing and consuming, unaffected by resource depletion or changes in the state of the ecosphere.

In effect, then, mainstream economic theory dissolves ecological constraints—or takes the environment to be limitless—thus freeing the economy for perpetual growth. Little wonder that politicians and policy-makers rarely hesitate to trade off ecological concerns for economic gain (with a generally willing populace cheering from the bleachers). Economic growth has thus become the strongest plank in the policy platforms of most governments in Canada and around the world for at least the last half century (see Victor, 2008).

## Beyond Perceptual Lapses: Environment and Social Justice

Trading off the environment for economic gain does not mean there are no ecological costs, only that the latter are deemed to be less than the benefits. However, there is an ethical problem. While the benefits of economic growth accrue mainly to the rich and powerful, the burden of resource depletion, land degradation, and pollution falls mostly on the weak and poor. A growing body of research reveals that economically disadvantaged (low-income) communities suffer more consequences of ecological decline than do wealthier communities (e.g., Agyeman et al., 2009; Buzzelli, 2008). Poor people everywhere are losing their livelihoods and lives because of floods, drought and desertification, toxic spills and dump sites, hydroelectric projects, strip mines, radiation exposure, clearcut logging, soil erosion, and other forms of "economic" landscape abuse. Negative impacts fall particularly heavily on the urban poor in the burgeoning cities of low-income countries, but also on economically marginal groups and racial minorities in high-income countries. In effect, we are seeing the emergence, both globally and nationally, of *eco*-apartheid, the segregation of the people along ecological gradients, with the poor and racial minorities suffering the worst environments and consequences.

Even Canada suffers the syndrome. Does anyone doubt that people living in impoverished urban neighbourhoods (such as the Downtown Eastside in Vancouver or St-Henri in Montreal) and many First Nations reserves endure some of the most degraded and degrading physical and social environments in the nation? Native people in the north, already suffering from the industrial contamination of their traditional country foods (courtesy of climate patterns that carry industrial and agricultural wastes pole-ward from all over the world) confront the immediate impacts of climate change: the melting of sea ice and permafrost. Physical and mental health statistics tally the human costs. Meanwhile, wealthy Canadians enjoy the

best-manicured of urban neighbourhoods (increasingly in the form of gated communities) and often spend part of each year in second homes in the most nearly pristine natural habitats on Earth.

Indeed, income is the obvious critical independent variable (figure 2). The wealthiest 20 percent of the human family account for 76.5 percent of private consumption, while the poorest 20 percent get by on 1.5 percent (Shah, 2010). Thus, the rich can buy their way to ecological safety while the poor, particularly women and racial minorities living in wasted habitats, suffer the health, aesthetic, and spiritual impacts of polluted soil, air, and water. An estimated 22,000 children die each *day* from poverty-related causes. Consider that, in 2000, more than 600 million of the urban poor lived without sanitary sewers and 450 million do not have safe drinking water.

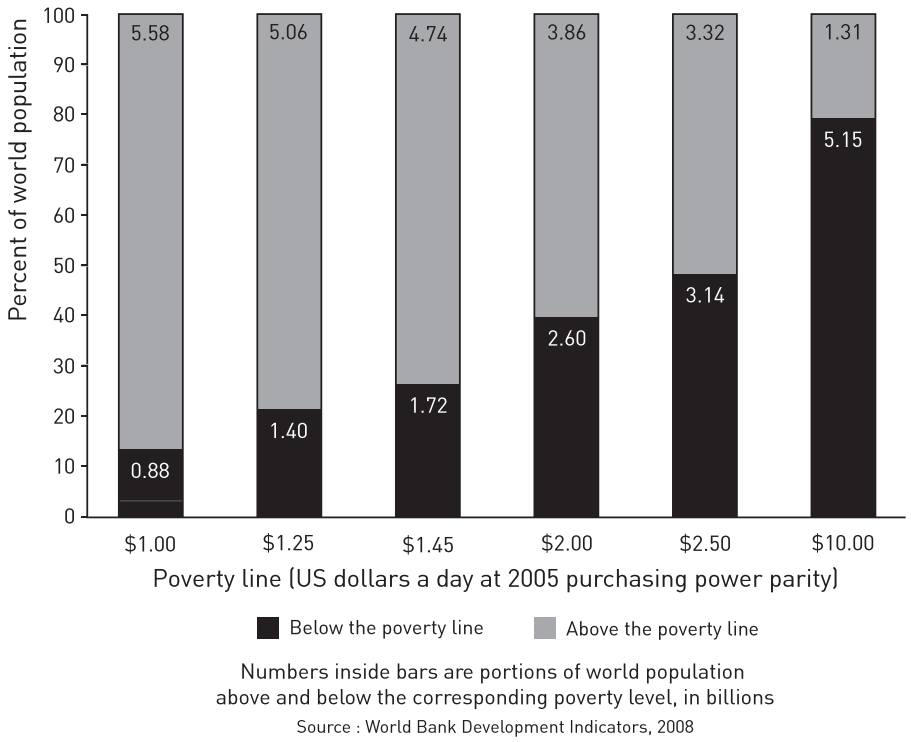


**Figure 2.** Percentage and numbers of the world's people living at different poverty levels. Nearly half of the human family (over 3 billion people) live on less than $2.50 per day and nearly 1 billion survive on less than $1.00 per day.

Even today, some 1.1 billion people in developing countries have inadequate access to water, and 2.6 billion lack basic sanitation. Not surprisingly, millions die every year from environmentally borne diseases, including 1.8 million children from diarrhea alone (UNCHS, 2001; Shah, 2010).

Both ecological degradation and moral imperatives urge society to look beyond sheer material growth for ways to relieve poverty, reduce social inequity, and reverse ecological apartheid. Progressive tax regimes designed explicitly to redistribute income constitute one possible solution, but there is little enthusiasm for redistributive policies in today's conservative political climate. Indeed, despite an already egregious income distribution (figure 2), 80 percent of the world's population live in countries where the income gap is widening (Shah, 2010) (including in the United States and Canada where regressive tax *breaks* are channelling additional income to the already wealthy). Canadians' growing environmental concerns have obviously not generated adequate political pressure to confront environmental injustice (Buzzelli, 2008), either domestically or internationally. One indication is that Canada's contribution to international development assistance is stagnant—at only 0.3 percent of gross national income (GNI)—or falling, despite our having committed to 0.7 percent in 1970. It seems that concern for environmental justice in Canada is largely confined to a few nongovernmental organizations (the United States is a worse offender, with official development aid at only 0.2% percent of GNI [OECD, 2010, cited in Shah, 2011]).

As noted, the proximate reason for such generally poor moral performance is the inequitable distribution of benefits and costs. The winners, those most able to force serious reform (and who can afford it) have no direct—that is, economic—incentive to act, and the losers, those most in need of reform, are economically and politically powerless. This situation is unlikely to change peacefully in the near future—the rich–poor income gap is increasing between

and within many nations with the spread and entrenchment of neo-conservative values.[1] As a result, eco-apartheid is almost certain to worsen with the threat of climate change and incipient resource shortages. Of particular concern is the fact that urban populations, particularly in poorer developing countries, are projected to explode by an additional 2.9 billion in the next four decades (UN, 2009).[2] This means that in the coming 40 years, the world's cities are expected to add more people with all their "furniture" than had accumulated on Earth in the entire history of *H. sapiens* up until 1957!

## Biophysical Reality: The Human Enterprise as "Dissipative Structure"

> *You may say, if you wish, that all "reality" is a social construction, but you cannot deny that some constructions are "truer" than others. They are not "truer" because they are privileged, they [become] privileged because they are "truer."*
> *—Neil Postman (1999, 76)*

Any effort to articulate a truer alternative construct of humankind–environment relationships must include a sound understanding of the biophysical laws underlying those relationships. The fact is that, technological illusions aside, human beings are subject to the laws of nature. One of the most fruitful ways to conceptually reconnect people to the ecosphere is through contemporary interpretations of "far-from-equilibrium" thermodynamics. The starting point for this approach is the second law of thermodynamics, the entropy law.

In its simplest form, the second law states that any spontaneous change in an isolated system—a system that can exchange neither energy nor material with its environment—increases the system's

1. The shift to the political right has been accompanied by reduced social cohesion—the erosion of community, a diminished sense of mutual responsibility, and increasing ecological injustice.

2. Most urban inmigrants will settle in the expanding barrios, *favelas,* and slums of low-income cities.

entropy. This is a technical way of stating that things naturally tend to wear out and run down. With each successive change, an isolated system loses potential—it becomes more randomly structured, energy dissipates, concentrations disperse, gradients disappear. Eventually, the system reaches thermodynamic equilibrium, a state of maximum entropy in which no point is distinguishable from any other and nothing further can happen.

Of course, many complex real-world systems—from new-born infants, through cities, to the entire ecosphere—are neither isolated nor sliding toward equilibrium. The ecosphere, for example, is a highly ordered self-organizing system of mind-boggling complexity, multi-layered structure, and steep gradients represented by millions of distinct species, complex functional dynamics, and accumulating biomass. Over geological time, its internal diversity, structural/functional complexity, and energy/material flows have generally increased—that is, the ecosphere has been moving ever *further* from the equilibrium state. Indeed, this phenomenon may well be the measure of life. As Prigogine (1997) asserts, "distance from equilibrium becomes an essential parameter in describing nature, much like temperature [is] in [standard] equilibrium thermodynamics."

Since living systems *gain* in structural mass and functional complexity over time, scientists and philosophers long thought they were exempt from the second law. This is not the case—all systems are subject to the same processes of entropic decay. (There are no known violations of the second law.) The paradox dissolves only when we recognize that all living systems, from cellular organelles to entire ecosystems and the ecosphere, are *open* systems that freely exchange energy and matter with their host environments.

Most critically, systems biologists have begun to emphasize that living systems exist in overlapping nested hierarchies in which each component subsystem ("holon") is contained by the next level up and itself comprises a complex of linked subsystems at lower levels. (Think of Russian nesting dolls). This organizational form

is the basis for self-organizing holarchic open (SOHO) systems theory (see Kay and Regier, 2002). Within the hierarchy, each subsystem (or holon) grows and develops using energy and material (negentropy) extracted from its environment—its host system—one level up. It processes some of this energy/matter internally to produce and maintain its own structure/function and exports the resultant degraded energy and material wastes (entropy) back into its environment. In short, all living organisms produce and maintain their *local* organization as far-from-equilibrium systems at the expense of increased *global* entropy, particularly the entropy of their immediate host systems (Schneider and Kay, 1994, 1995). Because all self-organizing systems survive by continuously degrading and dissipating available energy and matter they are called "dissipative structures" (Prigogine, 1997). Table 1 compares pristine with fully humanized ecosystems.[3]

SOHO thermodynamics obviously has profound implications for our understanding of the concept of humans in nature. Like the ecosphere, the human economy—indeed, the entire human enterprise—is a self-organizing, far-from-equilibrium, dissipative structure. However, the human enterprise is also an open, growing, dependent *sub*system of the materially closed, non-growing, finite ecosphere. Thus, while the ecosphere evolves and maintains

3. Renegade economist Nicholas Georgescu-Roegen (1971a, 1971b) was among the first to understand the implications of the second law for the human economy. Since all economic activity must draw low entropy resources out of nature and dump useless high entropy waste back in, he reasoned first that "in a finite space there can be only a finite amount of low entropy and, second, that low entropy continuously and irrevocably dwindles away." He further speculated that since modern humans are unlikely to practise restraint in their use of resources, nature and human nature may combine to ensure that "the destiny of man is to have a short but fiery, exciting, and extravagant life" (Georgescu-Roegen, 1975). This view naturally remains controversial with opponents relying on resource substitutions and human technological ingenuity to defeat such second-law pessimism.

itself by "feeding" on an extraterrestrial source of energy and by continuously recycling matter, the human subsystem grows and maintains itself by feeding on its supportive ecosystems and ejecting its wastes back into them. In effect, the increasingly consumption

| ECOSYSTEMS WITHOUT HUMANS | HUMANIZED ECOSYSTEMS |
|---|---|
| Such systems grow and evolve by assimilating, degrading, and dissipating high-grade solar energy through photosynthesis and evapo-transpiration. | Such systems are dedicated to economic processes involving the extraction, processing, and consumptive degradation of fossil energy and other material resources that have accumulated in the ecosphere, including biomass and non-human species. |
| Anabolic processes (bio-production) exceed catabolic processes (respiration and dissipation). | Catabolism (destructive dissipation) exceeds anabolism (production of goods, services, and manufactured capital). |
| Available energy and matter (biomass and other resource gradients) accumulate, species proliferate, ecosystems differentiate, and complexity increases. | Human populations and artifacts accumulate, but resource stocks are depleted and dissipated; biodiversity declines; ecosystems unravel and simplify. |
| Waste heat dissipates off-Earth; material resources are fully recycled; while the complexity of ecosystems increases, the entropy of the solar system and the universe increases. | Waste heat dissipates off-Earth; material wastes (often toxic) accumulate in the ecosphere; the human enterprise expands and complexifies at the expense of the structural and functional integrity of the ecosystem; the entropy of the ecosphere (and ultimately the universe) increases. |

**Table 1.** A second-law comparison of human-less and humanized ecosystems

-based human enterprise is thermodynamically positioned to consume and dissipate the ecosphere from the inside out (Rees, 1999). (It is no stretch to recognize that humanity is currently living as a parasite on Earth—a parasite is an organism that gains its vitality at the expense of the vitality of its host.) Figure 3 illustrates this economy-inside-ecosphere relationship as perceived by ecological economists. The latter argue that the most important flows in the economy are not the circular flows of money values but rather the one-way, irreversible flows of energy and material.

Let's pause to ponder the socio-economic implications of this relationship. To reiterate, SOHO theory and far-from-equilibrium thermodynamics dictate that the human subsystem can grow and maintain its internal order (negentropy) *only* by degrading the ecosphere and increasing global entropy. The production of *anything*—an e-mail message, our own bodies, an ocean liner—requires the extraction from nature of vastly more useful energy and material

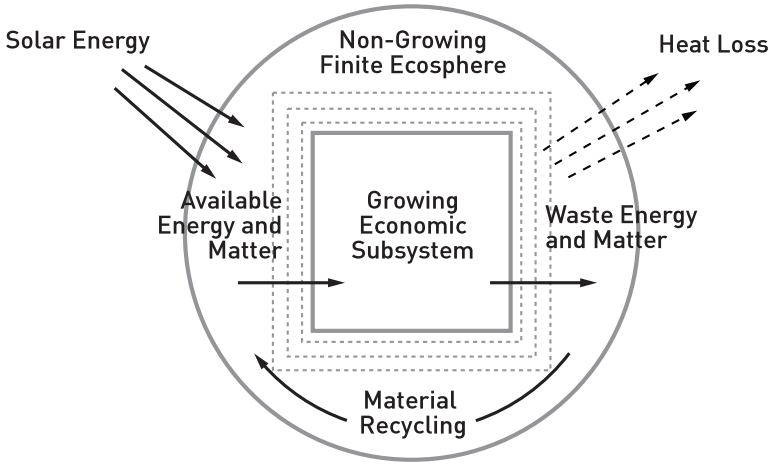


**Figure 3.** Steady state or "ecological" economics sees the human enterprise as an open, fully contained dependent subsystem of the living but non-growing ecosphere. This hierarchical relationship imposes strict limits on growth and the scale of the human enterprise.

than are embodied in the product, and the ejection back into nature of a quantity of useless (and often toxic) waste equivalent to the total amount of resources originally extracted.

These are irreversible processes. The energy consumed is almost immediately permanently radiated off the planet and, while the material may remain in the system, much of it is chemically transformed and widely dispersed into the air, soil, and water. Recapturing such dissipated material is economically impossible. Even recycling or reusing consolidated wastes (such as aluminum cans and glass bottles) invariably requires the consumption/dissipation of additional energy. Bottom line: *Any* so-called productive activity that raises the human system ever further from equilibrium is actually mostly a consumptive process that simultaneously degrades the ecosphere.

All of which means that, contrary to popular belief and political fantasy, *there is an inevitable and unavoidable conflict between continuous material economic growth and the maintenance of ecosystems integrity*. Indeed, every so-called environmental problem from fisheries collapses and deforestation (overexploitation) to marine dead zones and GHG accumulation (excess waste pollution), can be explained by reference to second-law relationships. Most importantly, there is no escape from the grip of the second law. As physicist Sir Arthur Eddington famously observed:

> [Thermodynamics]…holds the supreme position among the laws of nature…If your theory is found to be against the Second Law of Thermodynamics, I can give you no hope; there is nothing for it but to collapse in deepest humiliation. (Eddington, 1929)

## The Increasing Human Load on Earth

I have made the case that contemporary growth-oriented techno-industrial society has become dangerously parasitic on its supportive ecosystems. Humans are fuelling their current consumption and growth, in part, by depleting in mere decades stocks of so-called natural capital—fish stocks, soils, forests, groundwater, fossil fuels,

and so on—that required thousands or millions of years to accumulate in the ecosphere.

Since people live in the moment and take their own times to be "normal", few are conscious of how recently and rapidly humans have come to dominate the planet. The human population had begun to edge up from about half a billion in 1600 but took over 200 years to reach its first billion sometime in the first half of the 19th century. However, it was during that century, when fossil fuels began to energize the human enterprise, that the modern human explosion got under way. The population increased over six-fold in the subsequent less than 200 years up to 2000 (and will reach 6.9 billion in 2011). So spectacular was this acceleration "that roughly 90% of the increase in human numbers since the beginning of time has occurred since 1650, in fewer than 350 years" (Cohen, 1995).

The increase in resource consumption and pollution is even more dramatic. In the 20th century alone, a 16-fold increase in energy use powered a 40-fold increase in industrial output, a 35-fold increase in fish catches, and a 9-fold increase in water use (mostly in agriculture to support burgeoning human numbers). Of course, the entropic burden on ecosystems increased apace—carbon dioxide ($CO_2$) emissions increased by a factor of 17; sulphur dioxide emissions by a factor of 10 and myriad other contaminants infected the air, soil, and water all over the planet. By the end of the century, the scale of human activities had approached the scale of natural processes—industrial activities were fixing more atmospheric nitrogen and injecting it into terrestrial ecosystems than were all natural terrestrial processes combined; humans had directly transformed half of the land area of Earth; people were using more than half of the planet's accessible fresh water (data from Vitousek et al., 1997; Lubchenco, 1998; McNeill, 2000). Perhaps most significantly, *H. sapiens* was directly or indirectly appropriating at least 40 percent of the products of terrestrial photosynthesis for human use (Haberl, 1997; Vitousek et al., 1986), resulting in the accelerated competitive

displacement of other species from their ecological niches. (Biomass appropriated to grow the human enterprise is irreversibly unavailable to consumer organisms.)

## H. sapiens, *the Ultimate Predator?*

Consider the impact on fish stocks, just one of humanity's critical bioresources. By the end of the 20th century a mere 50 years of high-tech industrial fishing had reduced the large predatory fish biomass of the world's oceans to about 10 percent of pre-industrial levels (Christensen et al., 2003; Myers and Worm, 2003). In some cases, stocks have been reduced to less than 1 percent of historic norms. Pressure on stocks increased through this period despite steadily diminishing returns to fishing effort, the collapse of major fisheries, and the warnings of fisheries scientists that catches were unsustainable. As early as 1993, Ludwig, Walters, and Hilborn (1993) concluded a review of modern bioresource management with the observation that while "there is considerable variation in detail, there is remarkable consistency in the history of resource exploitation: resources are inevitably overexploited, often to the point of collapse or extinction."

Such alarming data stimulated Fowler and Hobbs (2003) to consider whether *H. sapiens* is "ecologically normal," that is, do humans fall within the normal range of natural variation observed among ecologically similar species for a variety of relevant measures? The researchers found that humans rarely showed normal tendencies for the variables tested. For example, in terms of population size, energy use, $CO_2$ emissions, biomass consumption, and geographical range, humans differ from 95 ecologically similar species by orders of magnitude. It seems that humanity is an "outlier" species in many of the ways that we exploit the goods and services of nature (figure 4). The fact that human consumption of biomass was almost two orders of magnitude (100 times) greater than the upper 95 percent confidence limits for the range of species assessed in itself goes a long way toward explaining fisheries collapses and related biodiversity losses.

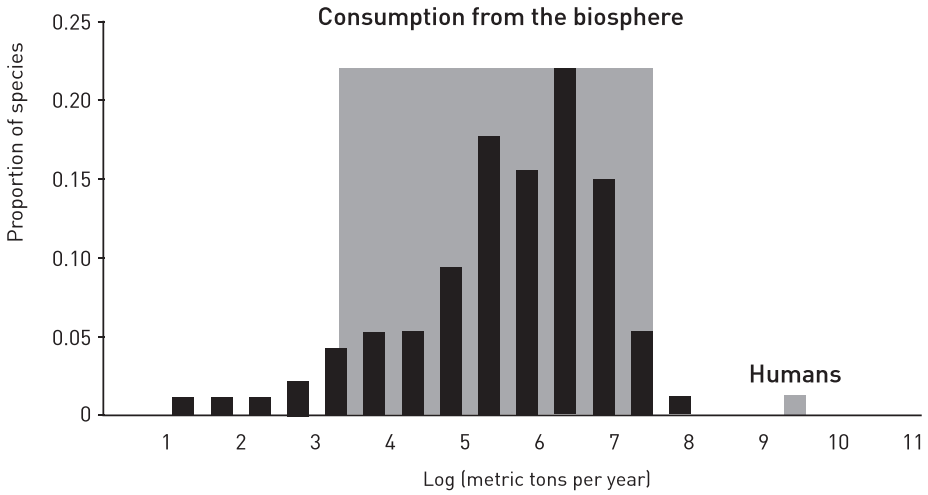


**Figure 4**. Human ingestion of biomass from ecosystems (black bars) in comparison with 95 other ecologically similar mammals. The 95 percent confidence limits among non-humans species are indicated by the left and right margins of the large pale-shaded rectangle (from Fowler and Hobbs, 2003).

Fowlers and Hobbs' analysis support the notion that *H. sapiens* may well be "the most voraciously successful predatory and herbivorous vertebrate ever to walk the earth" (Rees, 2008). People are more indebted to more ecosystems than ever (as is necessary to feed and otherwise provision our expanding population and insatiable "industrial metabolism"). Contrary to economic analyses, the economy is not significantly dematerializing; humanity is not decoupling from nature. On the contrary, in the aggregate, human economic activities have become the major biological and geological force changing the face of the Earth.

## Success as Prelude to Failure

It is no small irony that this increasingly dysfunctional relationship is actually testament to humanity's remarkable evolutionary success. The contributing factors are both biological and cultural. Consider that *H. sapiens* shares certain critical innate behavioural predispositions with all other species. In particular, unless or until constrained by negative feedback (e.g., disease, starvation, other critical resource

shortages) humans will expand into any accessible habitat and tend to use all available resources (in the case of humans, availability is determined by our steadily evolving technology).[4] Such tendencies are actually essential for individual and therefore species survival in the Darwinian struggle for existence.

But humans have proved superior to other advanced species in the evolutionary game. Our capacity for language—particularly written language—and our unmatched technological prowess have given us a significant leg up in the competition. Recorded knowledge is cumulative, so people have been getting continuously better both at suppressing negative feedback and at exploiting their ecosystems for thousands of years. (The pace of cultural evolution vastly exceeds that of biological evolution.) As a result, we have the greatest geographic range of any advanced vertebrate species and a history of depleting resource stocks in serial fashion wherever on Earth we find ourselves (Ponting, 1991).

The problem is that, while we have already breached safe biophysical limits to growth, contemporary humans continue to be driven by Cro-Magnon's expansionist instincts. And it doesn't help that our contemporary socially constructed perpetual growth ethic *reinforces* humanity's innate expansionism. Nurture augments nature. Industrial societies thus show little constraint in their exploitation of the environment. In effect, environmental behaviours that once conferred a selective advantage on individuals have become hazardous to the species in the rapidly changing world created by the unrelenting expression of those same traits.

4. If this is difficult to accept, consider the recent history of petroleum exploitation in some of the most remote and dangerous environments on Earth (including deepwater Gulf of Mexico and Canada's oil sands). Or, on a more personal level, think of the credit card. This is an invention that enables people to consume resources that they don't have after they have consumed their way through the income that they do. Household indebtedness in Canada is now equivalent to 160 percent of annual family income.

Fowler and Hobbs (2003) were moved to ask, Is humanity sustainable? Warren Hern argues that at present it is not. He likens our species to a kind of planetary disease—the sum of human activities over time "exhibits all four major characteristics of a malignant process: rapid uncontrolled growth; invasion and destruction of adjacent tissues (ecosystems, in this case); metastasis (colonization and urbanization, in this case); and dedifferentiation (loss of distinctiveness in individual components)" (Hern, 1997). It seems that humanity's evolutionary success is literally killing us.

The good news is that, despite this apparent pathology, there is nothing *inherently* unsustainable about life in the SOHO hierarchy. Indeed, until recently, net primary production by producer species (mostly green plants) has been more than adequate to sustain the world's entire complement of consumer organisms, including humans. From this perspective, far-from-equilibrium thermodynamic theory provides a simple double-barrelled criterion for sustainability: the human enterprise must not persistently consume more bioresources than nature produces nor generate more waste than nature can assimilate (taking into account a generous allowance for the thousands of other consumer species with whom we share the planet).

## The Human Ecological Footprint

Consistent with the foregoing, the first questions of human ecology should be How much of Earth's biocapacity is required to sustain any specified human population? and How does this compare with available supplies? We can produce approximate answers to these questions using ecological footprint analysis (EFA). EFA is a quantitative tool I have developed with my students, particularly Dr. Mathis Wackernagel, specifically to reopen the debate on human carrying capacity and to assess the sustainability of the human enterprise (Rees and Wackernagel, 1994; Wackernagel and Rees, 1996; WWF, 2008, 2010, 2012; Rees, 2006, 2013).

EFA starts from a series of inarguable premises:

- Conscious of it or not, *H.sapiens* is an integral and fully dependent component of supportive ecosystems and the ecosphere.
- Most human impacts on ecosystems are associated with energy and material extraction and waste disposal (i.e., economic activities).
- We can convert many of these energy and material flows to corresponding productive or assimilative ecosystems areas.
- There is a finite area of productive land and water ecosystems on Earth.

As previously detailed, all human populations extract a continuous supply of material resources and waste assimilation services from their supportive ecosystems to sustain themselves and grow. Therefore the ecological footprint of any specified population is formally defined as:

> The aggregate area of land and water ecosystems required, on a continuous basis, to produce the bioresources that the population consumes, and to assimilate (some of) the wastes that the population produces, wherever on Earth the relevant land/water may be located. (Rees, 2006)

The size of a population's eco-footprint depends on four factors: the population size, its average material standard of living, the average productivity of land/water ecosystems, and the efficiency of resource harvesting, processing, and use. Regardless of the relative importance of these factors and how they interact, *every population has an ecological footprint* and the productive land and water captured by EFA represents much of the natural capital (productive natural resource base) required to meet that population's consumptive demands.[5]

5. EFA is not intended to represent all human impacts, only those material demands that can readily be converted to a corresponding ecosystem area. Toxic wastes, for which there is no assimilative capacity, are not represented; similarly, such impacts as stratospheric ozone depletion are excluded

Eco-footprints are based on final demand for goods and services. The first step in population EFA is to estimate the total annualized consumption of all significant categories of commodities and consumer goods consumed by that population. It is possible to obtain domestic production and trade data from national statistical offices and other sources such as the Food and Agriculture Organization and United Nations statistical publications. When possible, all consumption estimates are trade-corrected. Thus a population's consumption of wheat is estimated as follows:

$$\text{domestic consumption}_{\text{wheat}} = \text{domestic production}_{\text{wheat}} + \text{imports}_{\text{wheat}} - \text{exports}_{\text{wheat}}$$

EFA builds on material flows analysis by adding the additional step of converting the material inputs and output into a corresponding area of productive and assimilative ecosystems. The total national eco-footprint is the sum of contributions from all individual commodities plus the area of carbon sink lands. Per capita eco-footprints are estimated simply by dividing national footprint estimates by total population.[6] To facilitate comparison among nations, all domestic eco-footprint estimates are converted into hectares of global average productivity. It is important to recognize that population eco-footprints constitute *mutually exclusive* appropriations of productive capacity. The biocapacity used by one population is not available for use by another. *All human populations are therefore competing for the available biocapacity of Earth.*

Note also that ecological footprints can be interpreted in terms of thermodynamic theory. I have described the human enterprise

because they cannot be converted into a corresponding ecosystem area. We also err on the side of caution whenever data are sparse or conflicting. For all these reasons, EFA generates a conservative estimate of total human load.

6. A major strength of EFA is that it connects people and their lifestyles to their impacts on nature using two indicators everyone can readily understand—consumption (everyone is a consumer) and productive land.

as a dissipative structure whose metabolic activities irreversibly dissipate useful energy and material (negentropy) and increase global entropy. It follows that, since the production of renewable resources is driven by solar energy, a population's ecological footprint is the ecosystem area required, on a continuous basis, to regenerate photosynthetically the energy and biomass equivalent of the negentropy being consumed by that population. A given rate of consumption is theoretically sustainable as long as there is a corresponding, adequate exclusive area of productive ecosystems (biocapacity) available to supply the demand.

## The Comparative Eco-Footprints of Nations

Because consumption depends on income, per capita eco-footprints are strongly correlated with gross domestic product (GDP) per capita. Figure 5 shows the average per capita eco-footprints for a cross-section of countries. The citizens of rich countries like the United States and Canada need an average of 4 to 10 global hectares (gha) (10 to 25 acres) to support their consumer lifestyles. (Canada's per capita eco-footprint is greater than 7 gha.) Meanwhile, the chronically impoverished get by on less than 0.5 hectare (1 acre) (WWF, 2008).

Unlike abstract monetary measures (such as per capita GDP) that have no theoretical limits, eco-footprints estimate land and water areas that can be compared to finite available supplies. Significantly, EFA shows that many (mostly rich) countries have eco-footprints several times larger than the area of their domestic productive land- and waterscapes. The Netherlands, for example uses four times as much productive ecosystem area as is contained within its own borders; Japan's eco-footprint is *eight* times greater than the country's domestic biocapacity.

Even when they have fiscal surpluses, all such countries are running ecological deficits with the rest of the world. This means that their populations survive mostly on biocapacity (both productive

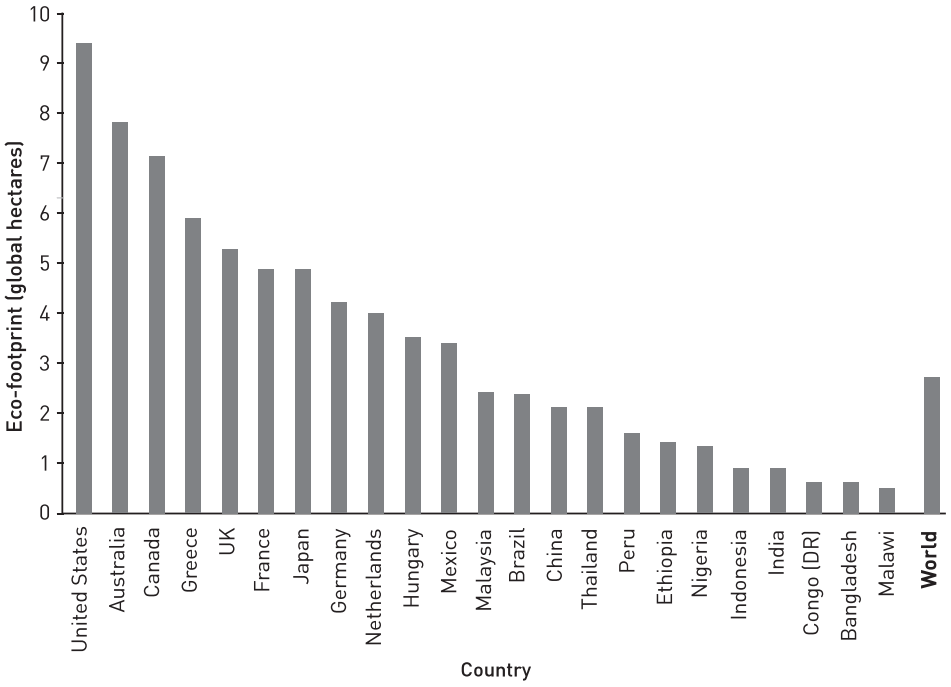


**Figure 5.** Per capita ecological footprints of selected countries (2005 data from WWF, 2008).

and assimilative capacity) appropriated from poorer countries, a few large relatively low-density countries such as Canada, and the global commons. Globalization and trade have enabled deficit regions and countries to degrade their own natural capital and expand far beyond their domestic carrying capacities with (short-term) impunity.[7] The problem is that such long-distance exploitation accelerates the degradation and pollution of the foreign ecosystems upon which the importing populations now depend, and this risks the long-term sustainability of both trading partners. In today's trade-oriented world, our eco-footprints are increasingly wandering all over the planet but, by separating production from consumption, globalization blinds consumers to the fact that their survival may depend

7. Trade in biocapacity is just one of the many ways in which modern humans have undermined the negative feedback—food and other resource scarcity, in this case—that would otherwise keep regional populations and economic growth in check.

on the sustainable management of land- and waterscapes half a world away. Globalization has enabled an increasingly unsustainable entanglement of nations in which the world's moneyed elites gain market access to remaining pockets of productive natural capital at the expense of the poor (Kissinger and Rees, 2009).

### *Eco-footprints, global equity, and social justice*

All of which brings us back to environmental (in)justice and eco-apartheid. EFA clearly highlights the gross economic inequity among the world's peoples. By 2007, North Americans were enjoying an average eco-footprint of about 8 gha. Meanwhile, the average citizen of Earth had an eco-footprint of 2.7 gha, and there are only 1.8 gha of bio-productive land and water per person on the planet (WWF, 2010, 2012). These data underscore the fact that the world is well into a state of unequal "overshoot"—even with half the population still in poverty the human enterprise is using about 50 percent more bio-production and waste sink capacity annually than the ecosphere can regenerate. The world community is living, in part, by depleting natural capital and degrading ecosystems essential for survival—the very definition of unsustainability.[8]

The biophysical data also draw out a sobering socio-economic reality. Extending the wealthy lifestyles of North Americans or Europeans to all the world's poor is wishful thinking on the part of growth economists. To raise just the present global population to Canadian material standards using existing technologies would require the biocapacity of about 4.1 Earth-like planets. Since appropriate miracle technologies are not yet available, and we are unlikely to acquire the services of even one more Earth, we will probably have to do with the one we have. Perhaps we should get used to it!

8. One does not need EFA to confirm this. Accumulating GHGs, climate change, fisheries collapses, and so on, are all symptoms of general overshoot.

What might getting used to it mean in moral and practical terms? First, we must recognize that environmental justice must be an integral goal of any sustainability strategy. EFA shows that, on a per capita basis, Canadians are major players on the world's ecological stage. Indeed, *Canada's per capita demand on global biocapacity is 2.5 times that of the average Earthly citizen and almost 4 times our equitable Earth-share*. Meanwhile, the poorest of the poor consume only a quarter of their fair entitlement.

These data show that, on a per capita basis, depletion and pollution traceable to consumption by Canadians has generated more ecological damage than consumption by almost any other peoples. Arguably, therefore, Canadians are disproportionately accountable for global change and any human-induced eco-violence currently being visited on disadvantaged people (e.g., from the drought, floods, and rising food prices resulting from anthropogenic climate change).

This is not to say that Canadians should be condemned and shamed for harming others merely by their pursuit of the good life. Certainly it could be argued that our failing to date is due to innocent ignorance of the consequence of past actions. However, once the fact of anthropogenic global change and its violent impact on others has been established and raised to consciousness, would Canada not be guilty of at least moral negligence in failing to act on that knowledge? As I have argued elsewhere (Rees and Westra, 2003), if this really is a global village, the world community should be working vigorously, in the name of environmental justice, to establish legal grounds for transnational negligent actions.

Canadian common law provides useful guidance on the principles in play. A negligence action may be launched in Canada in the event of environmental damage to one party by another. The plaintiff must establish five key elements of the tort—legal duty, breach of the standard of care, cause in fact, proximate cause, and damage to the plaintiff. Environmental negligence actions focus on compensation for loss caused by unreasonable conduct that

damages legally protected interests. Unreasonable conduct means doing something that a prudent or reasonable person would not do, or failing to do something that a reasonable person would do. Note that fault may be found even in the case of *unintended* harm if it stems from *unreasonable* conduct.

The Criminal Code (section 219) is even clearer that lack of intent to harm is no defence if the damage results from conscious acts performed in careless disregard for others: "Everyone is criminally negligent who (a) in doing anything, or (b) in omitting to do anything that it is his duty to do, shows wanton or reckless disregard for the lives or safety of other persons" (where "duty" means a duty imposed by law). Significantly, section 222(5)(b) states that "a person commits homicide when, directly or indirectly, by any means, he causes the death of a human being, by being negligent."

Obviously, Canadian law does not apply in the international arena and, because international law doesn't even acknowledge the offence, it cannot create or enforce a legal duty to act. However, the main point here is that there is no prima facie reason why the behavioural standards imposed by international law should not be as rigorous as those required by domestic law.

The Intergovernmental Panel on Climate Change has established with greater than 90 percent certainty that GHG emissions from human activities have caused most of the observed increase in globally averaged temperatures since the mid 20th century and that climate change is capable of causing catastrophic damage. In these circumstances, the failure or refusal of major $CO_2$ emitters to reduce their emissions arguably breaches a reasonable standard of care. Thus, if human-induced climate change is already causing property damage and death, are not Canada, the United States, and other countries with among the highest per capita $CO_2$ emissions on the planet morally, if not legally, guilty of "wanton or reckless disregard for the lives or safety of other persons"?

On a more general level, if humanity is indeed confined to this one Earth and we are in a state of overshoot, ethics and social justice compel the world community to come together to negotiate the means by which to achieve a more equitable redistribution of global biocapacity (sometimes referred to as ecological or environmental space). On what grounds should Canadians be permitted to continue appropriating four times their equitable share? Why should impoverished people in the poorest countries be restricted to only a quarter of their entitlement? Any equity-oriented global accord for sustainability would almost certainly require that Canadians and other rich peoples significantly reduce their appropriations from the ecosphere in order to create the ecological space required for justifiable growth in the developing world.

This *really* "inconvenient truth" has actually been known for some time. As early as 1993, a report of the World Business Council on Sustainable Development (WBCSD) found that "Industrialised world reductions in material throughput, energy use, and environmental degradation of over 90% will be required by 2040 to meet the needs of a growing world population fairly within the planet's ecological means" (WBCSD, 1993). Even our more conservative eco-footprint results show that, to achieve equitable sustainability, Canadians would have to reduce their ecological footprints by about 75 percent (from seven gha to our "fair Earth-share" of 1.8 gha). Other rich countries would have to contract theirs in proportion.

These numbers are consistent with the 80 percent plus reductions in GHG emissions from rich countries required by mid-century if the world is to avoid catastrophic climate change. From this perspective, the 2009 Copenhagen and the 2010 Cancun climate conferences can be judged only as abject failures. Neither the world community at large nor any individual nation has even hinted at its preparedness to implement GHG emissions reduction policies that would meet the stabilization targets demanded by climate science.

On the contrary. The United Nations' Rio+20 Earth Summit (the biggest UN conference on the economy and the environment ever) ended in June 2012 with a vapid statement, *The Future We Want*, that was little more than a bland renewal of commitment to sustainable development and endless reassurances of international dedication to previously failed initiatives. *The Future We Want* commits no national government to anything and essentially equates "sustainable development" to "sustained economic growth" (see UN, 2012). The inimitable environmental journalist George Monbiot accused governments of concentrating "not on defending the living Earth from destruction, but on defending the machine that is destroying it." According to Monbiot, Rio+20 was "perhaps, the greatest failure of collective leadership since the first world war" (Monbiot, 2012).

It is a testament to the power of addiction to growth that our best science and even the threats of overshoot, climate meltdown, resource shortages, and geopolitical chaos are insufficient to induce the world's nations seriously to consider restructuring their economies in the service of sustainability (i.e., long-term survival).[9]

9. Consider Canada's economic and energy development policies in light of the above arguments. The present Conservative government ignores the warnings of the world's best science, holds (alleged) market efficiency and material growth above all other values, and defines international relationships mainly in terms of economic ties. Indeed, the national interest is assumed to coincide with ecologically bankrupt neoliberal economic ideals; international capital and competitive global markets should determine how national assets should be allocated. Thus, even as climate extremes ravage the world —climate change is perhaps our most global example of market failure—the government declares that markets will drive the development of Canada's oil-sands, markets will determine which pipelines are built, markets will decide who gets the oil, and markets seem set to override rising ecological and social concerns. (Environmental impact procedures have been simplified, the Fisheries Act diluted, and other regulations abandoned, presumably to facilitate oil-sands and pipeline development.) Certainly, too, there has been no consideration of the ethical implications of the country becoming a major exporter of climate change, given the ecological violence the latter is already visiting (mostly) on the world's poorest citizens.

## Rewriting Our Cultural Narrative

If we are ever to overcome this addiction, we will have to draw on certain human qualities that, if not unique, we exhibit to a far greater degree than any other earthly species. Five such qualities are particularly relevant to sustainability:

1. High intelligence and the capacity for logical thought
2. The ability to plan ahead, to affect how the future unfolds
3. The capacity for moral judgment, to distinguish right from wrong
4. The ability to feel compassion both for other people and other species
5. A predisposition to cooperate

If exploited effectively, these critical attributes should enable global society to override both expansionist instincts and the ill-considered economic models that support them. In the best of all possible worlds, the global community would therefore organize in ways that demonstrated each of these attributes in full flight.

For example, assume that the world's nations could agree to apply their collective intelligence to the goal of cooperating in consciously rewriting their shared global development narrative. The world needs an unprecedented "International Protocol for Mutual Sustainability". The motivating principle is simple: if civilization is to survive without resource wars and ecological devastation, the human community must learn to live more equitably within the means of nature. This in turn requires recognition that (a) no country can become sustainable on its own—sustainability is a collective problem that demands collective solutions [10]; (b) perhaps for the first time in history, individual and national interests are converging with humanity's collective interests—everyone and all nations are in the same frail boat; and (c) we can no longer implement economic

10. Even if Canada (or any other individual nation) were exemplary in its ecological behaviour, it would be dragged down by the global impacts generated by other countries staying the present course.

policy without ecological and social policy. In short, we must be prepared simultaneously to contemplate the end of material growth, the redistribution of economic and natural wealth, and the design of a "steady-state" economy based, in part, on the principles of ecological economics. The latter recognizes that the economy is a fully contained dependent subsystem of the ecosphere severely constrained by far-from-equilibrium thermodynamics and related biophysical law (see figure 3).

We might start the process by organizing to generate several inspiring alternative scenarios for comparison with the grim future that is unfolding under the status quo. (For an example of a global scenarios-building exercise, see Raskin et al., 2002). Finally, we also need to devise new global forums in which to publicize and debate the relative merits of feasible alternatives as widely as possible. People will take ownership of scenarios that ensure positive improvements in their security and well-being, even if substantial changes to their way of life are required.

Consider the upside of just one such radical change. Any progressive sustainability scenario must address the fundamental injustice associated with today's global economic disparity. Fortunately, this turns out to be a win-win proposition. Wilkinson and Pickett (2009) show that a widening income gap (more than poverty itself) is associated with declining population health and civil unrest, and even increases competitive consumption. Stability and sustainability are associated with greater equity. Logic therefore dictates that even powerful nations should be willing accept the need for greater equity—it is in their long-term self-interest to do so (and compassion for others should facilitate people's acceptance of any short-term pain).

Of course, a moment's reflection reveals that nothing remotely resembling the planning process described above is playing out on the real world's stage (and certainly not in Canada—see note 9). The threat to global civilization is real and increasing, yet the cascade

of hard evidence accumulating in academic journals goes largely unheeded. When the data do occasionally get out, the hopeful flash of popular interest quickly fades. Entrenched beliefs and values, hopes and fears (to say nothing of powerful interests with a major stake in the status quo) generally triumph over reason in the policy arena. Ironically, society cannot seem to exercise those special intellectual qualities that make people truly human in circumstances where primitive instincts and base emotions are aroused (Rees, 2010).[11] This is truly disheartening. Diamond (2005) shows that only those distressed societies able to abandon deeply entrenched but ultimately destructive core values, and commit to long-term planning, are able to pull back from the brink of collapse.

## *A role for Canada*

This conundrum presents Canada with an unprecedented opportunity to demonstrate real leadership in the global quest for sustainability. This nation was previously in the front ranks on environmental issues. For example, in October 1988, Canada hosted the Toronto Conference on the Changing Atmosphere, the first major international meeting bringing governments and scientists together to discuss action on climate change.[12] Since then, the country has become something of a environmental pariah: Canadian mining and petroleum companies have been implicated in various local ecological disasters in different countries around the world; neither

11. The role of instinct- and emotion-based behaviours in human affairs is as evident in economics as it is in human ecology. Building on Keynes's idea that that people do not always act rationally in their economic pursuits but are often under the spell of "animal spirits" (e.g., hope, suspicion, greed, fear, jealousy), Akerlof and Shiller (2009) have recently elevated animal spirits to a central role in their new theory of how the world economy *really* works.

12. This conference established the so-called Toronto target for emissions reductions (industrialized countries pledged voluntarily to cut $CO_2$ emissions by 20 percent by the year 2005), the first of such targets to fall in the face of economic priorities and the growth imperative.

Liberal nor Conservative governments have taken the economically difficult measures necessary to meet Canada's obligations under the Kyoto climate protocol; Canada has been vilified as one of the principal game-spoilers at recent international climate change conferences in Copenhagen (2009) and Cancun (2010)—the country was labelled "the dirty old man of the climate world" by *The Guardian* during the Copenhagen meetings (Adam and Randerson, 2009)—and at Rio+20. Most recently, by declaring synthetic petroleum from the Alberta oil sands to be "ethical oil," Canada's prime minister and environment minister are promoting development of one of the world's least efficient—it takes the equivalent of a barrel of oil to produce three to four barrels of oil-sands crude—and most polluting hydrocarbon deposits, all in the name of economic growth.[13]

There couldn't be a better time for Canada to re-establish its moral reputation and ecological credibility. Millions of people worldwide are waiting for true political leadership on the ecological crisis. Civil society is unlikely to organize spontaneously to force the necessary eco-revolution until the crisis is irreversible, but the effect could be galvanizing if the leader of any major country or economy acknowledged pre-emptively, publically, and formally that the world is on a self-destructive tack and proposed a strategy to turn things around. We may even be close to a psychological tipping point at which such a dramatic call to action would go viral, seizing the imagination of the world community.

There is no reason why a Canadian prime minister should not be that leader. (Pierre Elliott Trudeau might have taken up the challenge.) Let us invite the world to a special forum on the future of the human species on Earth, a forum to set in motion the process needed to articulate the aforementioned International Protocol for

13. Ironically, current energy policy forces much of the eastern part of the nation to live on unethical oil imported from Organization of the Petroleum Exporting Countries.

Mutual Sustainability. Again, the goal of this initiative would be nothing less than to rewrite our increasingly global cultural narrative in conformity with biophysical laws and social justice.

In many respects, this should not be a difficult task. Intelligent, well-informed citizens should be able to appreciate that in already rich countries further income growth produces no additional improvements in either population health or subjective well-being.[14] Indeed, ecological economist Herman Daly argues that the world may well have entered a new era of *un*economic growth—growth that generates more costs than benefits at the margin. This is *growth that makes us poorer rather than richer* (Daly, 1999, 2012). Certainly incomes in wealthy countries are often three or four times higher than necessary for optimal returns—further material growth merely degrades the environment and appropriates ecological space needed for justifiable growth in the developing world.[15]

Meanwhile, the rationale and guiding principles of steady state (ecological) economics have long been in the public domain (e.g., Daly, 1991), and a fully compatible handbook for redesigning humankind–nature relationships is being promoted in the form of *The Earth Charter*. The real novelty resides in the leader of a middle power having the courage to break through the cognitive shell of denial, admit that the world is in ecological crisis, and argue that the

14. For example, the Canadian economy has grown by 130 percent since 1976 and GDP per capita is 70 percent higher. Nevertheless, there has been no change in the percentage of people in poverty or unemployed, and the absolute numbers of both have increased (Victor, 2008). Meanwhile, subjective well-being is constant or declining.

15. Economists and others who argue that the end of economic growth would be disastrous have an obligation to refute such arguments. Which is more ruinous (and foolish), learning to live more equitably in a steady-state economy within the means of nature, or ignoring the data and tempting climate/ecological implosion by clinging to a growth model that wrecks the environment while providing no net economic benefits?

receding hope for solutions can be realized only through unprecedented international cooperation for the common good.

The era of growth-based, resource-depleting, ecosystem-destroying competitive international relations will come to an end in coming years or decades either because humans will it to or because global change and geopolitical chaos brings the whole system down. So far, however, the world has been content to sleepwalk into the future. Philosopher John Ralston Saul put it this way:

> We have all by our actions or lack of them—in particular over the last quarter-century [now 40 years]—agreed to deny reality… If we are unable to identify reality and therefore unable to act upon what we see, then we are not simply childish but have reduced ourselves to figures of fun—ridiculous figures of our unconscious. (Saul, 1995)

In this light, Canada has nothing to lose and a future to gain by breaking from the herd in response to clear and present danger. At the least, stepping out to facilitate negotiation of a new humankind-to-environment relationship would serve to polish the nation's faded reputation among those who care as a force for global ecological integrity, economic stability, and social justice. At best, it might catalyze the triumph of collective reason over tribal instinct, thus enabling yet another chapter in humanity's evolutionary story.

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