ECONOMIC DEVELOPMENT AND ENVIRONMENTAL PROTECTION: AN ECOLOGICAL ECONOMICS PERSPECTIVE

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Abstract. This paper argues on both theoretical and empirical grounds that, beyond a certain point, there is an unavoidable conflict between economic development (generally taken to mean 'material economic growth') and environmental protection. Think for a moment of natural forests, grasslands, marine estuaries, salt marshes, and coral reefs; and of arable soils, aquifers, mineral deposits, petroleum, and coal. These are all forms of 'natural capital' that represent highly-ordered self-producing ecosystems or rich accumulations of energy/matter with high use potential (low entropy). Now contemplate despoiled landscapes, eroding farmlands, depleted fisheries, anthropogenic greenhouse gases, acid rain, poisonous mine tailings and toxic synthetic compounds. These all represent disordered systems or degraded forms of energy and matter with little use potential (high entropy). The main thing connecting these two states is human economic activity. Ecological economics interprets the environment-economy relationship in terms of the second law of thermodynamics. The second law sees economic activity as a dissipative process. From this perspective, the *production* of economic goods and services invariably requires the *consumption* of available energy and matter. To grow and develop, the economy necessarily 'feeds' on sources of high-quality energy/matter first produced by nature. This tends to disorder and homogenize the ecosphere, The ascendance of humankind has consistently been accompanied by an accelerating rate of ecological degradation, particularly biodiversity loss, the simplification of natural systems and pollution. In short, contemporary political rhetoric to the contrary, the prevailing growth-oriented global development paradigm is fundamentally incompatible with long-term ecological and social sustainability. Unsustainability is not a technical nor economic problem as usually conceived, but rather a state of systemic incompatibility between a economy that is a fully-contained, growing, dependent sub-system of a non-growing ecosphere. Potential solutions fly in the face of contemporary development trends and cultural values.

Keywords: carrying capacity, dissipative structure, ecological crisis, ecological deficit, ecological economics, ecological footprint, expansionism, growth model, human ecological dysfunction, human evolution, natural capital, paradigm, paradigm shift, patch disturbance, second law of thermodynamics, self-organization, steady-state, social capital, sustainability, worldview

1. Introduction: Economy and Environment in Conflict

Ten years ago, in November 1992, some 1700 of the world's leading scientists, including the majority of Nobel laureates in the sciences, issued the following warning concerning humankind-environment relationships: *We the undersigned, senior members of the world's scientific community, hereby warn all humanity of*

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what lies ahead. A great change in our stewardship of the earth and the life on it is required if vast human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated (UCS, 1992).

Since that time, and in spite of the scientists' warning, the so-called 'environmental crisis' has arguably worsened. At the dawn of the 21st Century, the sheer scale of human activity ensures that many environmental impacts are global in scope. Stratospheric ozone depletion now affects both the Southern and Northern Hemispheres; atmospheric carbon-dioxide has increased by 30% in the industrial era and is now higher than at any time in at least the past 160 000 yr; mean global temperature has reached a similar record high; the world seems to be plagued by increasingly variable climate and more frequent and violent extreme weather events; more atmospheric nitrogen is fixed and injected into terrestrial ecosystems by humans than by all natural terrestrial processes combined; up to one-half of the land on Earth has been directly transformed by human action; more than half of the planet's accessible fresh water is already being used by people; two-thirds of the world's major fisheries are fully- or over-exploited; and biodiversity losses are accelerating (Lubchenco, 1998; Tuxill, 1998; Vitousek *et al*., 1997).

The proximate causes of these numerous 'environmental' problems are often well-studied and even well-known to science – the clearing of forests and the combustion of fossil fuels, the conversion of natural ecosystems to agriculture, the excessive discharge of biophysically active chemicals, over-fishing, etc. Since the overall trend poses a threat of 'vast human misery' and the 'irretrievable (mutilation)' of our planetary home, one might reasonably expect that the global political process and policy-makers everywhere would have acted affirmatively to relieve the pressure under the rubric of 'sustainable development'. While there has, indeed, been a great increase in high-sounding rhetoric and even a flurry of environmental legislation in various countries around the world, economic growth remains the focal item on the political agenda. While economists and techno-optimists insist there is no inherent conflict between the economy and the environment, many symptoms of ecological decay are spreading unabated as the economy grows.

Just what is going on here? If ours is truly an intelligent knowledge-based society, why has the political response to a global threat been so limited and ineffective? This paper makes the case that the world continues to court disaster, in part, because industrial society misunderstands the ultimate cause of the crisis. I argue below that global ecological decline is the inevitable consequence of fundamental incompatibilities between the dominant, growth-oriented cultural paradigm and biophysical reality. Mainstream thinking and policies produce only marginal reforms when the problem demands fundamental change. The ecological crisis cannot be resolved or even fully understood from within the self-referencing perspective of expansionist thinking and neo-liberal economic theory.

The following sections contrast the prevailing expansionist perspective with an alternative framework derived from ecological economics and far-from-equilibrium thermodynamic theory. I then argue from human evolutionary history that the potential for unsustainability is inherent in human socioeconomic behaviour and show from contemporary ecological footprint studies that the human enterprise has already breached the long-term carrying capacity of Earth. Finally, I argue that while it is not difficult to conceive of possible solutions to the sustainability conundrum, to act on these flies in the face of primitive self-interest, prevailing cultural values and the dominant development trends.

2. Contrasting Paradigms[1]

Many contradictions associated with 'sustainable development' can be traced to differing fundamental beliefs and assumptions about the nature of humankind-environment relationships. These differing pre-analytic visions (paradigms, worldviews) define and delimit any significant problem to be analyzed and determine the scope, depth, and direction of our thinking about it.

Since people acquire a particular worldview simply by living, growing up, and being educated in a particular sociocultural milieu, we are often unconscious that we even have one! Thus, we are generally unaware of the subtle ways in which the prevailing paradigm shapes our understanding of, and approach to, societal problems or that there may be more viable alternative ways of thinking. Indeed, when we think that 'the universe is geocentric' was once a self-evident paradigmatic truth, it raises the unsettling possibility that much of even our present cultural worldview may consist largely of shared illusions!

Many scientists, policy analysts, and even politicians have asserted that sustainability will require a 'paradigm shift' or a 'fundamental change' in the way we do business, but few go on to describe just what needs to be shifted or the implications for the *status quo*. Certainly the policy response to date falls far short of the needed revolution. This is because most environmental reforms actually originate from within the same cultural paradigm that created the ecological crisis in the first place. Contemporary solutions address mere symptoms while ignoring the more basic cause – the prevailing 'expansionist' or 'cornucopian' paradigm itself (See Ayres (1993) for a review of a range of cornucopian to neo-Malthusian arguments.).

In short, I argue that our so-called 'environmental problems' stem from flaws in the prevailing expansionist paradigm that can be remedied only by abandoning its central premises. Instead of perpetual growth, society must strive to achieve an ecological steady-state between the human enterprise and the ecosphere. Such a 'steady-state' implies a dynamic society in which quantitative growth is replaced by qualitative social development and whose rates of resource extraction and pollution are compatible with the rates of resource production and waste assimilation by supporting ecosystems (For a more complete characterization, see Daly, 1991). In this light, sustainability poses a far more serious challenge to many of society's most basic beliefs and analytic concepts than most mainstream planners and policy makers have so far been prepared to contemplate.

3. The Expansionist Paradigm

> *Technology exists now to produce in virtually inexhaustible quantities just about all the products made by nature..'.. 'We have in our hands now... the technology to feed, clothe, and supply energy to an ever-growing population for the next seven billion years...* (Julian Simon, 1995).

As noted, the dominant paradigm of western (and increasingly global) techno-industrial culture can be characterized as the 'expansionist' or 'cornucopian' world-view. Its adherents – especially traditional economists, other technological optimists and many politicians – generally believe that humankind has achieved mastery over the natural world and, that as the global economy expands, trade and technology will be able to compensate for the depletion of natural resources and the loss of life-support services. Significantly, expansionist logic prevails at the World Bank, the International Monetary Fund, the Organization for Economic Cooperation and Development, the United Nations and within most national governments.

At bottom, even the Brundtland Commission[2] subscribed to this vision. The Commission believed that equitable sustainable development could be achieved for about twice the mid-1980s global population, assuming mid-1980s western European average material standards. This would require that the world adopt less material and energy-intensive technologies and promote more efficient regulation, greater economic integration and specialization, the continued liberalization of global markets, and an expanded role for transnational corporations. Pursuing this path, the world should anticipate a five-to ten-fold expansion in industrial activity by the time the human population stabilizes (at about 10 billion) around the middle of the 21st Century (WCED, 1987). This trajectory implies growth in gross world product in the range of 4% per year (more or less as achieved over the past 50 yr). However, the Brundtland Commission recognized that for the poorer countries of Asia, Africa, and Latin America to overcome their absolute poverty, they would have to achieve and maintain growth rates of 5 to 6%.

The economics underpinning expansionism is the neoclassical (neoliberal) market-based economics that has come to dominate geopolitics over the past 25 yr. Neoclassical models generally represent the economy as a mechanistic self-regulating and self-sustaining system. The starting point for analysis is 'the circular flow of exchange value', which is presented in economic texts as a self renewing and self-feeding process. Firms provide value embodied in goods and services (national product) to households in exchange for money. An equal value, incarnated as factors of production (e.g., labour and investment capital) flows back to firms from households in exchange for wages, salaries, dividends, etc. (national income). Households then spend their income on the next round of goods and services so the cycle repeats itself.

Neoclassical economists monitor and measure the growth of exchange value (money purchasing power) around this expanding, repetitive cycle but generally eschew consideration of the energy and material inputs required to sustain the money flow. Indeed, ecological economist Herman Daly (1991) has argued that is impossible to understand the relationship of the economy to the ecosphere in terms of the circular flow model, because the money circle is perceived as isolated and self-renewing, with no inlets or outlets connecting it to anything outside itself.

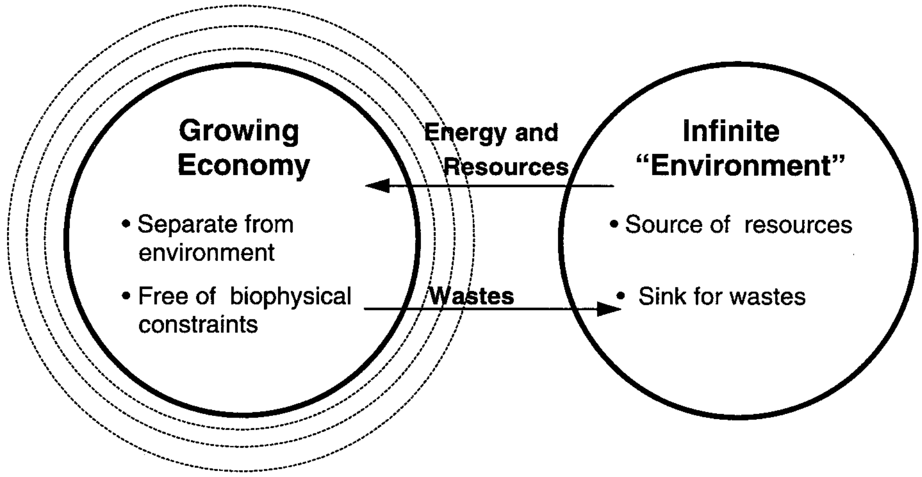
Mainstream analyses thus see people solely as economic agents devoid of ecological properties. (How often are the environmental consequences of burgeoning economic wealth analysed along with rising stock prices in the financial sections of the newpapers?). Ironically, then, as evidence mounts of a global ecological crisis, the economics running the world treats the economy as separate from, and virtually independent of, the environment (Figure 1a). Its models are not structurally capable even of anticipating the sustainability crisis.

Little wonder that to many students of economics, the productivity and growth of the economy are not seriously constrained by nature[3]. On the contrary, adherents to the expansionist school argue that the tensions caused by social inequity and environmental problems can be relieved through growth. As the economy expands, even the poor will have sufficient income to satisfy all their basic needs. ('A rising tide raises all ships'.). And, as incomes rise and hunger fades, people will place greater value on the environment and have the resources to do something about it. ('The surest way to a clean environment is to become rich'.).

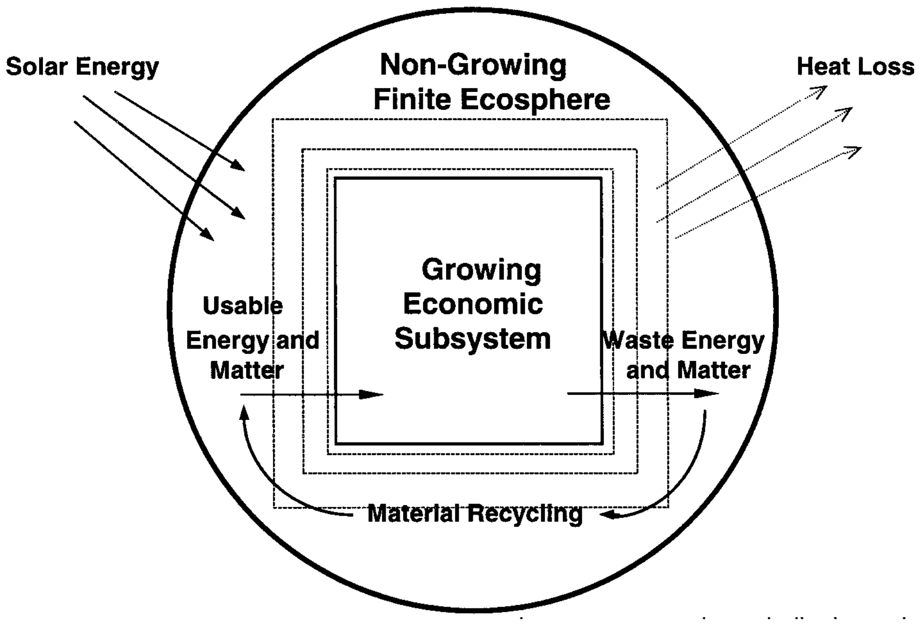
4. The Ecological Economics Worldview

> *For all its apparent mathematical sophistication, the core model of theoretical economics, that of competitive general equilibrium, is premised on an entirely faulty view of the modern world.* (Paul Ormerod, 1994).

Many ecologists, ecological economists, resource geographers, and physicists reject the expansionist paradigm absolutely. Their assessment of the human prospect flows instead from an ecological or 'steady-state' worldview. This paradigm sees the economy, not as separate from the 'environment', but rather as an inextricably integrated, completely contained, and wholly dependent growing sub-system of a non-growing ecosphere (Daly, 1992; Rees, 1995) (Figure 1b). While the economy is itself a highly-ordered, dynamic system, it is sustained by available energy/matter (exergy) 'imported' from the ecosphere and is ultimately governed by the second law of thermodynamics. In thermodynamic terms, nature is the producer and the economy the consumer – the economy requires a continuous flow of energy and material inputs from nature to sustain the production of goods and services.



(a)



(b)

Figure 1. Contrasting paradigms. (a) Expansionist (neo-classical) economics treat the economy as an open, growing, independent system lacking fundamentally important 'connectedness' to the environment. (b) Ecological economics sees the economy is an open, growing, wholly dependent subsystem of a materially-closed, non-growing, finite ecosphere.

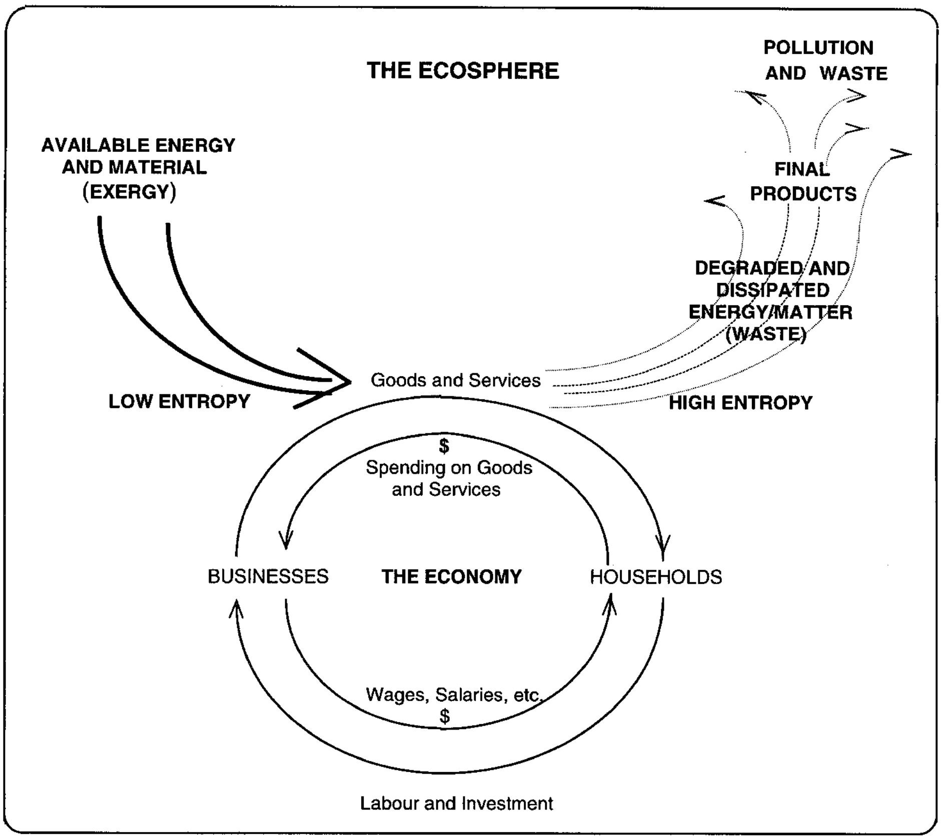


Figure 2. The linear throughput of energy/matter. The linear throughput of low-entropy energy and matter (upper part of diagram) sustains the economy and drives the circular flows of exchange value (lower part of diagram), yet is invisible to conventional economic analysis. All economic activity is 'contained' by the ecosphere, which must provide the resources and assimilate the wastes.

(Thus, there are no oil *producing* companies, only firms that extract oil from the earth where it was produced.)

It follows, that to ecological economists, the important flows in the economy are not the circular flows of money (lower part of Figure 2) but rather the unidirectional and thermodynamically irreversible flows of matter and energy from the ecosphere through the economic sub-system and back to the ecosphere in degraded form (upper part of Figure 2). It is this unidirectional throughput of resources that fuels – and constrains – the economy. Whatever the state of technology, human society remains in a state of obligate dependence on the ecosphere for both the production of useable energy/matter and for waste assimilation (in addition to many other life support services).

5. Second Law Realities

The second law of thermodynamics is fundamental to all real processes involving energy and material transformations. It is therefore fundamental to human ecological/economic processes, *yet is ignored completely by conventional neo-classical economic models*. In its simplest form, the second law states that any change in an isolated system (one that cannot exchange either energy or matter with its environment) will move the system closer to thermodynamic equilibrium. This is a state of maximum entropy in which there is a uniform distribution of energy and matter and in which nothing further can happen. Alternately, with any internal change, the 'entropy' of an isolated system increases. This means that available energy spontaneously dissipates, concentrations disperse, and gradients disappear. An isolated system thus becomes increasingly disordered in an inexorable slide toward thermodynamic equilibrium.

Early formulations of the second law referred strictly to simple isolated systems close to equilibrium. We now recognize, however, that *all* systems, whether isolated or not, near equilibrium or not, are subject to the forces of entropic decay. Thus *any* differentiated system has a natural tendency to erode, unravel, and disperse. Why, then, do not complex systems like our bodies, ecosystems, and the economy spontaneously come apart? For much of history philosophers and other analysts argued that living organisms and social organizations were exempt from the second law precisely because they do *not* spontaneously run down and dissipate. Indeed, 'from the earliest times of human thought some special non-physical or supernatural force (*vis viva*, entelechy) was claimed to be operative in the organism, and in some quarters is still claimed' (Schrödinger, 1945). Rather than 'tending toward equilibrium', biological systems, from individual fetuses to the entire ecosphere seem to gain in mass and organizational complexity over time.

Only in the past few decades has this seeming paradox been reconciled with the second law. Systems scientists now recognize that complex self-producing systems exist as loose nested hierarchies, each component system being contained by the next level up and itself comprising a chain of linked sub-systems at lower levels (see Kay and Regier, 2001). (Consider the following partial biological hierarchy: organelle, cell, organ, organism, population, ecosystem, ecosphere.) At each level in the hierarchy, the relevant sub-system maintains itself and grows by 'importing' available energy and material (exergy) from its host environment and by exporting degraded energy and material wastes (entropy) back into its host. Because living and other self-organizing systems survive by continuously degrading and dissipating available energy and matter they are called 'dissipative structures' (Prigogine, 1997).

How then does a living organism or system avoid decay? In Erwin Schrödinger's words, 'The obvious answer is: By eating, drinking, breathing and (in the case of plants) assimilating... Thus a living organism continually increases its entropy – or, as you may say, produces positive entropy – and thus tends to approach the dangerous state of maximum entropy, which is of death. It can only keep aloof from it, i.e. alive, by continually drawing from its environment negative entropy...' (Schrödinger, 1945). ('Negative entropy' or 'negentropy' is free energy available for work).

In an ecosystemic steady-state, the rates of resource imports and waste discharge by any sub-system (e.g., a species population) are maintained by negative feedback within a range that is compatible with the rates of production and assimilation by its host system. The systems hierarchy therefore retains its long-term functional integrity. However, the hierarchical relationship between sub-systems and their hosts contains the seeds of potential pathology. If a sub-system (e.g., the human enterprise) demands more than its host can produce, or discharges more waste than its host can assimilate sustainably, then the development and growth (an increase in internal order) of that sub-system will necessarily be at the expense of increasing disorder at higher levels in the systems hierarchy (see Schneider and Kay, 1994). Everyone recognizes that the uncontrolled growth of cells and tissues is the hallmark of cancer and ultimately destroys the integrity of the 'host' organism. It is less well understood that the ever-growing economy and the non-growing ecosphere exist in a similar nested hierarchical relationship. Since the economy is a dissipative structure and a dependent sub-system of the ecosphere, the former is, in effect, thermodynamically positioned to consume the latter from within (Rees, 1999).

Critics might argue that economic activity is not only dissipative in nature but that it also creates a good deal of order. This is true but misses two points: First, the creation of order by the human enterprise requires the transformation of available energy and matter extracted from the ecosphere. Since economic production involves thermodynamic processes that cannot be 100% efficient, the increased order of the human enterprise (e.g., the accumulation of manufactured capital) never fully compensates thermodynamically for the disordering of the ecosphere (through the consumption of natural income (or capital)). In short, negentropy production in the economy is always less than the negentropy drawn from the ecosphere so the entropy of the total system increases. Second, as noted, the human enterprise is a sub-system and is thus *dependent* on the continued functioning of ecosphere. Manufactured capital cannot always substitute for natural capital – to the extent that the growth of manufactured capital stocks is derived from the depletion and dissipation of natural capital stocks, economic growth destroys the material basis of its own success.

Second law analysis thus provides two basic criteria for sustainability: (a) consumption by the economy cannot persistently exceed production by its host ecosystems, and (b) waste generation by the economy cannot persistently exceed the assimilative capacity of its host ecosystems. When either condition is violated, the economy has exceeded long-term carrying capacity and is in a state of overshoot[4]. In this stage, further growth of the material economy is necessarily derived, in part, from the depletion of natural capital stocks (forests, fish stocks, hydrocarbon deposits, etc.) rather than from current natural income (sustainable bio-production). As long as this situation obtains, the economy is undermining life-support systems, eroding long-term carrying capacity, and jeopardizing its own future.

In this light, contemplate the state of our host ecosystems (e.g., forests, grasslands, coastal ecosystems, salt marshes, and coral reefs) and reserves of mineral deposits, ground-water, petroleum, natural gas and coal. These forms of ‘natural capital’ all represent highly-ordered self-producing systems or accumulations of energy/matter with great use potential (low entropy) upon which the human enterprise depends. Now think of depleted landscapes, degraded agricultural soils, collapsing fisheries, accelerating biodiversity losses, acid lakes, anthropogenic greenhouse gases, and synthetic toxicants – all these things represent disordered systems and degraded energy and matter with little use potential (high entropy). A moment’s reflection reveals that the main thing connecting these two system conditions is the human economy operating through the second law.

In summary, the ecological economics perspective sees people not only as economic agents but also as ecological agents. It emphasizes that, beyond a certain (detectable) point, continuous material economic growth must *inevitability* result in resource depletion and chronic pollution. Such trends are among the defining characteristics of the so-called ‘environmental crisis’. Most importantly, ecological analysis more correctly defines the environmental crisis as a problem of ‘human ecological dysfunction’. This distinction is not a trivial one. The former term conceptually externalizes the problem, effectively blaming it on a deficient environment which we then strive to ‘fix’. By contrast, the latter term traces the problem to its source: humans, their behavior, and their institutions (Jamieson, 1996), and suggests that it is the latter that need repair.

6. Natural ‘Patch Disturbance’: Seeds of Unsustainabilty[5]

The need for environmental protection and the call for sustainable development are inspired by obvious over-exploitation of biophysical systems. But before we can solve this problem we need a better understanding of basic human ecology. To begin, the foregoing discussion suggests that even the most ecologically sensitive humans cannot avoid perturbing any earthly habitat they occupy. This is the inevitable working of the second law of thermodynamics combined with two additional facts of human biology: humans are large animals with correspondingly inflated individual energy and material requirements; and humans are social beings who live in extended groups.

The substantial biophysical demands of even technologically ‘primitive’ people means that the productivity of most unaltered ecosystems on Earth is inadequate to support more than a small human group for very long. This simple fact precluded permanent settlement for most of human history. In pre-agricultural times, when a group of human foragers had hunted out and picked over a given area, they were forced to move on. This would enable the abandoned site to recover, perhaps to be revisited in a few years or decades. By moving among favored habitat sites – exploiting one, allowing others to recover – early humans could actually exist in an overall dynamic equilibrium with their ecosystems (albeit ranging over a large total home range). Ironically, while disparaged by technological 'man', hunting-gathering and closely related swidden (slash-and-burn) agriculture, with their long fallow periods after episodes of intensive use, may well be the most nearly sustainable lifestyles ever adopted by people (see Flannery, 1994; Kleinman *et al*., 1995, 1996). Australian Aboriginals, for example, continuously occupied their habitat for 40 000–60 000 yr (Flannery, 1994).

This is not to say that the effects of early humans on the ecosystems that sustained them were negligible. On the contrary, the recent paleoecological, anthropological, and archeological literature tells a convincing story of widespread extinctions of large mammals and birds accompanying the invasion and settlement of their habitats by human beings. As people spread over the planet in the last fifty thousand years, their first arrival seems to have been recorded virtually everywhere by the extirpation of other species (Flannery, 1994; Diamond, 1992; Ponting, 1991; Pimm, *et al*., 1995; Tuxill, 1998). In North America, South America, and Australia, about 72, 80, and 86%, respectively, of large mammal genera ultimately became extinct with the human occupation of those continents (Diamond, 1992). Pimm *et al*. (1995) estimate that with only Stone Age technology, the Polynesians exterminated more than 2000 bird species, about 15% of the world total. Thus, it was only after forcing considerable changes in ecosystem structure and dynamics that even primitive human groups equilibrated with their habitats.

The history of early 'man' emphasizes that humans are, *by nature*, a patch-disturbance species, a distinction we share with other large mammals from beavers to elephants. A patch-disturbance species is any organism that, usually by foraging, degrades a small central place greatly and disturbs a much larger area away from the central core to a lesser extent. Large animals, due to their size, longevity, and food and habitat requirements necessarily have substantial physical and systemic impacts on their host ecosystems. (This is practical biothermodynamics.)

There is, of course, a major difference between the ecology of human 'patch disturbance' and that of other species. Because of language and culture, human knowledge and technology are uniquely cumulative (although they may accumulate non-linearly). Human patch disturbance has therefore been intensifying in stages since the Paleolithic. It climbed a notch with metal tools and weapons, received a major boost with agriculture, and became the dominant force in the ecosphere with the adoption of fossil fuels and the industrial revolution. Today, human patch disturbance is evident on a continental and even global scale in the form of such persistent trends as deforestation, desertification, fisheries collapse, greenhouse gas accumulation, and accelerating biodiversity loss.

All of this is to argue that the potential for a human-induced global ecological crisis is inherent in the ecology and sociobiology of our species. We are naturally a patch disturbance species whose capacity to disrupt our earthly habitats (i.e., to exceed local carrying capacity) has been steadily augmented by technological advance and behavioural plasticity. Our superior knowledge has freed humans from much negative feedback and from competitive forces that confine other species to relatively much narrower ecological niches. Indeed, humans regularly expand into the ecological space vacated by other species that we vanquish. We moderns like to believe that technology has liberated us from dependence on nature (see Simon, 1995). However, technology arguably serves mainly to increase the scale of the 'patches' we disturb, the intensity of the disturbance, and the risk to our own survival. In short, our extraordinary evolutionary success is now a threat to continued civilization.

7. The Footprints of 'Progress'

The scale of human domination of ecosystems can readily be shown using ecological footprint analysis (Rees, 1992, 1996; Wackernagel and Rees, 1996). Ecological footprinting is a quantitative tool that converts the material demands and waste discharges of any specified population into a corresponding land/water (ecosystem) area. Thus, *the 'ecological footprint' of a specified human population is the area of land and water ecosystems required on a continuous basis to produce the resources that the population consumes, and to assimilate the wastes that the population produces, wherever on Earth the relevant land/water is located*.

Recent analyses show that average human eco-footprints start at less than a hectare *per capita* in the poorest countries like Bangladesh, reach two to three hectares *per capita* in the emerging economies like the Philippines or Brazil, range between four and seven hectares in most of the high-income developed nations of Europe, and soar to ten or more hectares *per capita* in the most energy intensive and materially profligate countries like as the United States and Canada (Wackernagel *et al*., 1999; WWF, 2000). Eco-footprint studies highlight human ecological dysfunction and the prospects for sustainability in several ways. Consider the following:

- There are only about two hectares *per capita* of ecologically productive land and water on Earth (with no allowance for the exclusive needs of millions of non-human species). Thus even moderately wealthy consumers unwittingly appropriate more than an equitable share of global ecological output (Rees, 2001, 2002; Wackernagel *et al*., 1999).
- Many high-income industrialized countries have exceeded their domestic carrying capacities several times over. These countries are running massive 'ecological deficits' with the rest of the world. They live by effectively importing carrying capacity from other countries and by discharging wastes into the global commons (the rivers, oceans, atmosphere) (Rees, 1996, 2001).

- The aggregate eco-footprint of the present world population of 6.2 billion is already 30% or more larger than Earth (Wackernagel *et al*., 1999; WWF, 2000). In short, the present human demands have already overshot the long-term carrying capacity of the planet (Rees, 2002). (Note: A population can live in overshoot for a considerable period if there are large cumulative stocks of natural capital. However, permanent erosion of essential stocks represents a loss of long-term carrying capacity.)
- Three additional Earth-like planets would be required to support just the *present* world population sustainably if everyone enjoyed Canadian material standards (Rees, 2001, 2002). (Keep in mind that the wealthiest 20% of the world's people account for 86% of private consumption.)

These data show that the world's wealthy – including even the moderately wealthy – have been able to appropriate most of the world's sustainable economic/ecological output through globalizing markets and through abuse of the global commons. They also reveal starkly the fundamental conflict between economic development based on material growth and environmental protection. The lifestyles currently enjoyed by the high-income North cannot be extended to the low-income South using prevailing technologies without the depletion of existing stocks of critical stocks of natural capital and the deterioration of vital life-support functions. Contemporary political rhetoric to the contrary, the prevailing growth-based economic 'development' paradigm is fundamentally incompatible with ecological and social sustainability (Rees, 2001, 2002).

8. Conclusions: The Geopolitics of Sustainability

This paper argues that the so-called 'environmental crisis' is really a problem of *human ecological dysfunction* with deep roots in human nature and the prevailing growth-based global development paradigm. Indeed, I have previously argued that unsustainability is an inevitable 'emergent property' of the systemic interaction between contemporary techno-industrial society and the ecosphere. The assumed mechanical structure and behaviour of the former are fundamentally incompatible with *de facto* (thermo)dynamic structure and behaviour of the latter (Rees, 2001, 2002).

Ironically, what appears to be ecological dysfunction today actually stems from humanity's extraordinary evolutionary success. The expansionist paradigm itself is arguably a cultural or ideological expression of a genetically-based human propensity to expand into all the suitable ecological space on the planet.

Whatever its origin or historical role, we are now at a point in our bio-cultural evolution where our expansionist tendency may have to be subdued. Certainly from an ecological economics perspective, achieving a harmonious relationship between the economy and the ecosphere – one that maintains the long-term integrity of both systems – depends on an absolute reduction in the total dissipative load that the economy imposes on 'the environment'. Material and energy throughput may have to be reduced by as much as 50% globally (rising to 80% or more in industrial high-income countries) (Carley and Spapens, 1998; BCSD, 1993). In this light, the greatest contribution to ecological sustainability may well come, not from environmental protection or a supply-side emphasis on improved resource management but rather from efforts to reduce demand. Policy should strive to move humanity toward a collective 'steady-state' with nature, one characterized by a much reduced throughput of energy/matter (see Daly, 1991).

Achieving an ecological/economic steady state will be no mean task for a species whose natural expansive tendencies are so strongly reinforced by its dominant cultural myth. We live in a world that, in the past quarter century, has sanctified greed and material self-interest. This is a culture that has created a multi-billion dollar advertising industry to ensure that people become – and remain – addicted to income growth and ever-rising material consumption. Contrast this climate with some of the items likely to be on the menu for ecological sustainability. The world community must work to:

(1) Reduce human populations *everywhere* including the wealthy North. After all, one Canadian or American is the material equivalent of 20 or more of the world's poorest citizens (and the US has the fastest growing population in the developed world);
(2) Reduce material consumption in the high-income countries (i.e., in at least the top quintile of the world's income-earners) both through more efficient technologies and by encouraging the adoption of simpler, less material-intensive lifestyles;
(3) Protect and rehabilitate remaining stocks of essential and natural capital including biodiversity. In a world already arguably in a state of overshoot, future development must be zero-impact development in relation to the natural world;
(4) Redirect government tax programming and expenditures from capital projects to activities that promote the development of community cohesion and social capital. People may find that investing in social capital pays higher dividends than accumulating private capital, particularly in terms of safer communities, deeper social relationships, improved population health and greater personal satisfaction;
(5) Create the reeducation programs and social safety nets that will be required to ease workers and families through the economic restructuring required for sustainability. We must shift to more sustainable economic activities and new forms of employment (e.g., from a fossil energy to a renewable energy-based economy);
(6) Improve living conditions for the chronically impoverished, particularly in developing countries, through investment in necessary public infrastructure (e.g.,

piped potable water and sewer systems) and services (public health and education). More than sufficient funding could be made available by redirecting a just a fraction of present military expenditures.

These policy directions emphasize the need both to reduce humanity's total ecological footprint and to achieve greater socioeconomic equity on a finite resource-constrained planet. They also recognize humanity's universal dependence on preserving the critical life-support functions of the ecosphere. Some of the latter services (e.g., the assimilative capacity of the oceans) are provided by the acknowledged global commons, but others flow from ecosystems that are regarded as the property of sovereign states (e.g., the global heat distribution function provided by tropical forests). Humanity's shared interest in preserving such national or privately-owned biophysical assets underscores the 'common property' quality of global life support and greatly complicates associated management issues.

Indeed, our sample of sustainability strategies illustrates that achieving sustainability is the ultimate common property/public good problem. Unfettered markets are incapable of recognizing the problem let alone providing solutions. Sustainability will therefore require an unprecedented level of both international cooperation to regulate global commerce and of government intervention in national economies. It is in our long-term mutual interest to develop new international institutions that can protect the global commons. Meanwhile, sovereign nations must commit to implement coordinated policies and programs to reduce the material flows through their economies and address the social stresses that will accompany the transition.

In this light, the prognosis is not good. For the past quarter century in particular, the world has been subjected to fierce rhetorical winds bending us in precisely the opposite direction. The international community today is committed to global a growth model that increases material consumption through liberalized trade in an expanding world market characterized by competitive relationships, individual choice, the rise of transnational corporations and private capital accumulation. The result a three-fold increase in gross global product since 1980 tainted by a grossly inequitable distribution of the benefits and costs. The rich are getting richer faster than the poor are leaving poverty behind. By 1997, the wealthiest 1% of the world's people enjoyed the same income as the poorest 57% and just 25 million rich Americans (0.4% of the world's people) had a combined income greater than that of the poorest 2 billion of the world's people (43% of the total population) (Income ratios reflect purchasing power parity (data from UNDP, 2001)). In the 1960s 'only' three dollars flowed North for every dollar flowing South; by 1998 the ratio was seven to one (Smith, 2000).

This pattern has served to consolidate political and economic power among a relatively few wealthy states and individuals who have a growing vested interest in maintaining the *status quo* and who will take any measure necessary to retain their positions of privilege. Indeed, events since the tragedy of 11 September 2001 suggest that the world is dangerously close to abandoning a collective approach to geopolitical and ecological security in favour of a fractiously primitive tribalism. It would be a tragic irony if the self-proclaimed most intelligent species on earth is unable to rise above base instinct and animal passion when confronting this greatest of challenges to its own survival.

Notes

[1] This discussion of contrasting paradigms, including Figures 1 and 2, is abstracted and revised from Rees (1995).

[2] The United Nations 'World Commission on Environment and Development' that popularized the concept of sustainable development with its 1987 report, *Our Common Future.*

[3] Remember, cornucopians argue that the resource flows from the 'environment' to the economy can be substituted by technology or sustained by increases in resource productivity. Pollution can be eliminated as a problem by measures to 'internalize the externalities'.

[4] For most of human history, our species lived in various states of 'undershoot' in which we appropriated less of nature's goods and services than might have been sustainably possible. Any state of undershoot represents a sustainable state in which more of net primary production (for example) is available to support non-human consumer organisms (see Section 6).

[5] This section extracted and revised from Rees (2000).

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