From Overshoot to Contraction: The Path to a Sustainable Steady State

by

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1. Introduction and premises

There can no longer be any serious debate of the fact that the human enterprise is on an unsustainable tack and that 'solutions' to date have had only marginal effects, some decidedly counterproductive. The reasons for this are complex, but a solid case can be made that the world community is hopelessly mired in a self-referencing paradigmatic trap. The twin myths of continuous technological progress and endless economic growth have mesmerized global society. Our laptops, i-Pads and SUVs blind us to emerging biophysical and social reality. Ecological decline accelerates; poverty stubbornly persists, yet the world is in a state of collective denial about both the causes of the crisis and changes to our way of being in the world necessary for survival.

This paper starts from two premises consistent with the forgoing. First, the world community must wake up to the fact that the proximal cause of human-induced global ecological change, including climate change, is excess energy/material consumption and waste production, i.e., the scale of the material economy is *already* excessive relative to the ecological capacities of the ecosphere. Second, the distal or root cause resides in a perverse alliance between certain socially-constructed economic norms and innate elements of human economic behaviour.

It follows that technological wizardry alone offers no solution to the (un)sustainability crisis. While new technologies can help to address the material aspects of the crisis, any lasting solution will flow *mainly* from a conscious rewriting of our cultural narrative. The time has come to promote individual and collective behaviours that reflect ecological reality and to suppress propensities that have become maladaptive.

2. Nature, Nurture and the Environmental Crisis

The global environmental crisis is arguably unsolvable without attention to basic facts of human evolutionary biology. Indeed, the case can be made that humanity's contemporary ecological predicament is a near-inevitable 'emergent property' of our species' ecological and reproductive behaviour (Rees 2009, 2010).

Several factors align in support of this assertion. First, ecologists classify *H. sapiens* as a 'heterotroph'. This is a fancy way of saying people are consumers by nature. We are totally

dependent on other organisms and material resources extracted from ecosystems for our very existence. In strictly biophysical terms, *humans don't produce anything*. Our houses, toys, electronic paraphernalia, factories, machines—even our bodies—are made from something else *first produced by nature*. At best, humans are secondary producers that convert nature's products into ourselves and our cultural artefacts.[1] Most significantly, the quantities so 'produced' embody only a fraction of the energy and material resources consumed and dissipated in the process (see Part '4' below).

Second, reproductive biologists know humans to be 'K'-strategists. That is, *H. sapiens* is a relatively large, long-lived, slowly reproducing species with extended parental care and low infant mortality. Consequently, human populations generally grow until they press up against the carrying capacity ('K') of their local habitats. (This was Thomas Malthus' great insight.) Humanity's 'K'-oriented reproductive strategy is particularly relevant in modern times because of two related innate qualities that *H sapiens* shares with all other species. Unless or until constrained by negative feedback (starvation, resource shortages, disease, etc.) humans will: a) occupy and fill all accessible habitats and; b) tend to use up all available resources (and, with humans, "available" is increasingly defined by technology).

The thoughtful observer might recognize with alarm that humans' innate expansionist tendencies are currently being *reinforced* by a global, growth-oriented cultural/economic narrative that sanctifies greed, encourages instant gratification and confers social status based on material acquisition. Indeed, problems emerge precisely because *H. sapiens* is more successful than any other advanced species in exercising the combined forces of nature and nurture (culture). Most importantly, technology has—at least temporarily—suspended the negative feedback that historically held our populations in check and simultaneously extended humanity's reach for resources. As a result, the human population is exploding; we have invaded all the habitable—and not a few uninhabitable—ecosystems on Earth (we enjoy the widest geographic range of any vertebrate species); and are we are literally scraping the bottom of the resource barrel all over the planet. (For example, we can now extract petroleum from kilometers beneath the ocean floor which is already kilometers below the surface of the sea.)

With such observations in mind Fowler and Hobbs (2003) asked whether *H. sapiens* is "ecologically normal". They found that our species is, in fact, an extreme outlier—in terms of energy use (and therefore carbon-dioxide emissions), biomass consumption, and other ecologically significant indicators, human demands on their ecosystems dwarf those of 95 ecologically similar species by ten to a hundredfold! Such data indicate that humans have become, directly or indirectly, the dominant macro-consumers in all major terrestrial and aquatic

[1] Contrast this with green plants. Plants are primary producers or 'autotrophs'. They produce themselves and all the accumulated energy-rich organic matter on earth from simple dissipated compounds (water, carbon dioxide and trace nutrients) using off-planet solar energy. Unlike people, plants produce (photosynthesize) much more biomass than they consume. Indeed, their surplus production supports consumption by all the hetertrophs, including humans, on Earth.

ecosystems on the planet.[2] In fact, our species may well be the most voraciously successful predatory and herbivorous vertebrate ever to walk the Earth (Rees 2009, 2010).

3. Ecological Overshoot and Social Inequality

The qualities responsible for *H. sapiens*' remarkable evolutionary success clearly have the potential to become dangerously maladaptive on a finite planet. Indeed, since the mid- to late 20th Century, humanity has existed in state of global ecological 'overshoot' (Catton 1984). People are using even renewable resources faster than ecosystems can produce them and global waste sinks are full to overflowing.[3]

One telling indicator is that *H. sapiens*' aggregate ecological footprint (EF) now exceeds available bio-capacity by about 50 percent.[4] This means that it currently takes about 1.5 years for the ecosphere to regenerate the renewable resources people use, and to assimilate the carbon their economies emit, each year (WWF 1012). It also implies that the continued growth and maintenance of the human enterprise is partially at the expense of depleting self-producing natural capital and polluting life support systems (Rockström, *et al.* 2009; Rees 2013). The climate is changing, the oceans are acidifying, fresh waters are toxifying, the seas are over-fished, soils are eroding, deserts are expanding, tropical forests are shrinking, biodiversity is declining. And, for the first time since the beginning of the industrial revolution, the world economy is facing *non*-renewable resource shortages. By 2008, 63 of the 89 non-renewable resources that sustain modern industrial economies had become globally scarce as revealed by diminishing returns to exploration and dramatically rising prices (Clugson 2012). As human demands exceed safe planetary boundaries (Rockström, *et al.* 2009), evolutionary success becomes ecological dysfunction.

There is an attendant social problem. The litany of ecological damage and resource scarcity to date is largely the result of production and consumption to satisfy just the wealthiest 20% of the world's population. This privileged elite consumes almost three-fourths of almost everything. As poet-philosopher Gary Snyder has observed, it is people "…who make unimaginably large sums of money, people impeccably groomed, excellently educated at the best universities—male and female alike—[who orchestrate] the investment and legislation that ruin the world" (Snyder, 1009, p,119). And, we might add, who have constructed and propagate a lifestyle that is literally consuming the ecosphere. By contrast, the chronically impoverished leave almost no footprint.

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[2] It is no small irony that economists claim the human enterprise is "dematerializing" or "decoupling" from nature. Only the economists' models (based on monetary analysis) are decoupled from nature; humanity certainly is not.

[3] Even climate change is a waste accumulation problem—carbon dioxide is, by weight, the dominant waste emission of industrial economies (WRI 2000).

[4] A population's eco-footprint (EF) is the area of productive land and water ecosystems required, on a continuous basis, to produce the renewable resources that population consumes and to assimilate its carbon wastes (Wackernagel and Rees 1996; Rees 1996, 2013). Because of globalization and trade, most populations' EFs are scattered all over the planet. Many consumers are unaware that they have exceeded local carrying capacity and are living on biocapacity 'imported' from distant elsewheres.

This is relevant because the prevailing global development 'plan' is to grow our way out of poverty and into sustainability. Such efforts are doomed. The world community has yet to acknowledge that on a planet already in overshoot, there is no possibility of raising even the *present* world population to, say, Western European material standards with known technologies. To do so would require the biocapacity of two more Earth-like planets; to achieve North American levels of resource consumption and waste emission for everyone would command at least three additional Earths (see WWF 2012)—and we would still have to accommodate the additional two billion people expected by 2050 (see Box 1).

Box 1: Inequality and Sustainability (2007 data)

At purchasing-power-parity exchange rates, the most economically privileged quintile of the human family (1.4 billion people) enjoys more than 70% percent of global income [i.e., consumption] while the poorest 20% survive on a paltry 2%. (At market exchange rates, the ratio of richest to poorest income quintile becomes 83:1). Such gross inequality is also reflected in peoples' comparative ecological footprints. The wealthy fifth of humanity enjoy average EFs ranging upward from four global average hectares (gha). (North Americans have seven gha/capita eco-footprints.) The poorest of the world's poor survive on less than half a hectare. (Note that there are only about 1.8 gha of productive ecosystems *per capita* on Earth. This represents each person's 'fair Earthshare'.) If consumption by the wealthy 20% has already pushed the world into overshoot, even the arithmetically challenged should see immediately why attempting to grow our way out of poverty is ecologically naïve and potentially disastrous for everyone.

That said, poverty itself remains a barrier to sustainability. The poorest 20% of humanity survive on $1.25 per person per day and a full 40% of the world's people on less than $2.00 daily. If this is not sufficient to underscore the world's egregious inequality, consider that the wealthiest 61 million individuals —just 1% of the population—enjoy the same income as the poorest 3.5 billion (or 56 percent of the human population) [Ortiz and Cummins 2011; Shah 2013]). Social justice demands that poverty and gross inequity be addressed. The question—one the world has thus far feared to face—is how to achieve a just sustainability without relying on universal growth.

4. The Fallacy of Efficiency

The mainstream 'solution' to this conundrum is globalization, other improvements in economic efficiency and enhanced factor productivity (essentially producing more from less). But this market-based business-as-usual (BAU) panacea both discounts the effects of increased connectivity and ignores recent history of the rebound effect. Consider that the most recent half century represents the epitome of efficiency-oriented economic restructuring (as capital has

pursued cheaper labour and resources) accompanied by unprecedented gains in material productivity. Yet the world has witnessed an equally unprecedented explosion in the consumption of just about everything (e.g., half the fossil fuel ever burned has been consumed in just the past 35 years) (see Steffen *et al*. 2007). Meanwhile, the material effect of globalization has been to expose the world's remaining pockets of abundant resources to growing numbers of increasingly expectant consumers. In short, globalization and economic restructuring extend the formal economy spatially while enhanced efficiency lowers prices and increases wages. As more people with more money chase cheaper goods and services, demand rises, the world economy expands and we witness surging energy/material consumption and waste production. Bottom line: without accompanying measures to prevent rebound, sustainability policies based on economic and resource efficiency are ecologically counter-productive.

They are also thermodynamically naïve. Remember, *H. sapiens* is a consumer species; the human enterprise primarily a consuming machine. However, the economy is also an open, growing, dependent sub-system of a materially closed, non-growing finite ecosphere (Daly 1992). While the ecosphere evolves and maintains itself by 'feeding' on an extra-terrestrial source of energy, the sun, and by continuously recycling matter, the human sub-system can produce, grow and maintain itself only by 'feeding' on and polluting its host system, the ecosphere. Moreover, the second law of thermodynamics dictates that humans must consume vastly more energy and material to produce themselves and their artifacts than is embodied in the final products. Thus, in thermodynamic terms, the human enterprise is potentially dangerously parasitic—it can grow and maintain its internal order (negentropy) *only* by gradually 'disordering' the ecosphere and increasing global entropy (a fancy term for degradation, dissipation and pollution) (see Schneider and Kay 1994, 1995). Beyond a certain point, the human enterprise must *inevitably* destroy the productive capacity and life-support functions upon which it depends (Rees 2010, 2012).[5] And the evidence is that we are perilously close to (or have already breached) just such a tipping-point-of-no-return (Barnosky 2012).

5. The Great Reckoning: Contraction toward a Steady-State

If the modern world is addicted to material growth and profligate consumption, and the habit is taking us down, what can be done to salvage civilization?

As any recovering addict knows, the first step is to acknowledge the addiction and its causes. We must accept the still radical notion that the high-energy, material-intensive growth-based lifestyle of wealthy societies has run its course. At present, world leaders are in denial, steadfastly ignoring the world's best science precisely to avoid this conclusion. The growth-based *status quo* prevails. But if the science is correct (is there any reason to doubt it?) efforts to grow our way to

[5] Nicholas Georgescu-Roegen (1971) was the first to argue the central role that the second law of thermodynamics should play in shaping economic theory. Regrettably mainstream growth economists have avoided G-R's foundational concept of a "perpetually eroding economy" like a bad odour to this day, perhaps because it gives the lie to such neo-liberal economic mainstays as perpetual growth (now disguised as 'green growth' or 'sustainable growth'), infinite substitutability, and zero waste (see Czech 2013, p. 140).

salvation virtually guarantee our descent to perdition instead. Even the World Bank has acknowledged the folly of business-as-usual (BAU). "The science is unequivocal that humans are the cause of global warming", that "we are on a path to a 4°C (7.2°F) warmer world", that this would have "devastating impacts on agriculture, water resources, ecosystems, and human health", and that that "*bold, … immediate global action is needed to slow the growth in greenhouse gas emissions this decade*". Bottom line? Four degrees of warming "must be avoided" (World Bank, 2013 [emphasis added]; 2012). Various other analyses suggest that a BAU future leads not only to climate chaos and ecological decay, but also to geopolitical turmoil and resource wars (some would argue that this phase has already started).

The second step is for the world community to accept that the (un)sustainability conundrum is not amenable to technological solutions alone. As noted, we have a century of evidence that, in the prevailing 'growth-at-all-costs' cultural context, improved resource productivity and new 'lean' technologies, don't induce conservation but rather generate increased energy and material demand. Considering that sustainability requires as much as a 50% absolute reduction in resource consumption and pollution globally, this is as counterproductive as it is counterintuitive.

Potentially even more dangerous are various suggestions to 'geo-engineer' a solution, particularly to climate change. Some such schemes would put the entire planet at risk of an uncontrolled experiment gone wrong. (In effect, we've already 'been there, done that' with climate change itself.) Moreover, if the real goal of geo-engineering is to preserve the *status quo*, the effect of 'fixing' climate change would be to perpetuate material growth, the proximal cause of all our other ecological problems.[6]

A third step is to recognize that (un)sustainability is a collective problem that requires collective solutions (Rees 2012b). No person or country can be sustainable on his/its own in a world that persists on staying the BAU course. Mutual survival requires that today's world of combative political and economic one-upmanship give way to a world of unprecedented cooperation and mutualism at all spatial scales. In particular, living sustainably on a finite planet requires that the world community acknowledge every person's right to a more or less equivalent share of the necessities of life. Satisfying this condition will make it difficult to achieve sustainability without some form of income and wealth redistribution. Is it morally unacceptable that frivolous and unnecessary consumption by the rich deprive the poor of basic necessities even as it undermines global life-support? A just sustainability will require that people share available biocapacity and material resources, even jobs.

The situation is complicated by the simultaneous need for a 50% *reduction* in total material throughput. And this implies even steeper cuts in high-income countries. As early as 1993 the World Business Council on Sustainable Development reported that: "Industrialised world reductions in material throughput, energy use, and environmental degradation of over 90% will

[6] Climate change is obviously problematic in itself, but is merely one of many symptoms of human ecological dysfunction.

be required by 2040 to meet the needs of a growing world population fairly within the planet's ecological means" (BCSD 1993, p.10). Consistent with this finding, recent climate science reveals that to keep global warming to a mere 2 C°, developed nations must commit to an 80%-90% reduction in carbon emissions by mid-century. Indeed, Anderson & Bows (2008) argue that if the world hopes to avoid a catastrophic 4 C° increase in mean global temperature, industrial nations must begin to decarbonize at the "draconian" rate of 6% per year which would likely require a "planned economic recession".

Eco-footprint analysis arrives at similar conclusions. For sustainability with justice, wealthy 'consumers' must reduce their ecological footprints to open up the ecological space (biocapacity) needed for justifiable material growth in the developing world. For the average North American this implies an eco-footprint contraction of 75% from seven global average hectares to an equitable Earth-share of 1.8 gha (Rees 2010, 2013). Fortunately, technologies are available which, in combination with policies to prevent the rebound effect,[7] could theoretically achieve most of the needed material reductions without reducing quality of life (Weizsäcker, *et al*. 2009). Indeed, careful planning could improve well-being for everyone. Wilkinson & Pickett (2009) show unequivocally that, once basic needs are satisfied, population health and well-being are no longer associated with income and that greater equality is better for everyone.

A forth major requirement for sustainability follows immediately from the above. The world must transition from today's 'growth-at-all-costs' economy toward a smaller more equitable steady-state economy that can satisfy the needs of the entire human family continuously within the means of nature. On a finite planet, the logic for 'steady-state' thinking is impeccable. Ecological stability requires a more or less constant annual rate of energy and material consumption and waste discharge compatible with the productive and assimilative capacities of the ecosphere. This, in turn, implies a paradigmatic shift in economic policy from its emphasis on efficiency and quantitative growth (getting bigger) toward equity and qualitative development (getting better). Fortunately, we have a template for the necessary reconstruction—the scientific rationale, political philosophy and structural elements of steady-state economics have already been articulated in detail (Daly 1980, 1991,1992; Dietz & O'Neill 2012; Czech 2013).

It is worth underscoring that while a steady-state economy may not be growing, it is anything but static. Dynamic change will prevail as new technologies emerge and sunset industries disappear. Innovation will be more necessary, and necessarily more creative, than ever. (Remember, we have to supply everyone's needs with 50% less fossil energy and material.)

[7] Full-cost pricing measures are essential in this regard. This will require government intervention in the economy to correct for gross market failures such as climate change. Specific instruments include resource depletion taxes; carbon taxes and other pollution charges; and cap, auction and trading schemes applied to both resources and waste discharges.

It should not have to be emphasized that an essential fifth dimension of global sustainability and the steady-state is a global population plan.[8] The world community must devise effective cultural replacements for the natural constraints once imposed on human numbers. Indeed, given ecological overshoot, we need strategies for long-term population *contraction*. This is necessary both to ease pressures on the ecosphere and to increase available ecological space *per capita.* Long-term prospects for everyone will be enhanced if the human population is maintained at a level that provides more than material sufficiency for everyone, safely within global carrying capacity.

6. Epilogue: Social Engineering for Survival

It should be evident from the forgoing that achieving global sustainability depends more on social (re)engineering than on technology. In short, the world's peoples must engage in the *purposeful creation and promotion at all levels of a new cultural narrative* explicitly oriented to: a) overriding humanity's innate expansionist tendencies and chronic myopia (our innate preference for the here and now) and; b) inverting the core values and behavioural elements of the prevailing global cultural narrative. For example, it is time to resurrect people's capacity for community, mutualism and cooperation and subdue excessive individualism, greed and competition.

Those who recoil at the notion of deliberate social engineering should be reminded that the 'social construction of reality' (or at least our shared *perceptions* of reality) is an undisputed fact (see Berger and Luckmann 1966). On one level, therefore, people cannot *not* be socially engineered. All political ideologies, religious doctrines, and disciplinary paradigms are 'social constructs that people acquire simply by maturing in a particular social context(s).

Social constructs are more-or-less abstract products of the human mind that may or may not have a counterpart in the real world (the concept of 'gravity' does; 'civil rights' does not). Most constructs are an uneasy amalgam of beliefs, values, facts and assumptions that may nevertheless have enormous power to motivate behaviour. Each construct is first birthed in language and only gradually acquires legitimacy through repetition/imitation, consensual agreement (or unconscious adoption) and social practice.

Seen through this lens, neo-liberal (expansionist) economics, the values of consumer society and the ethics of the 'me generation' are all social constructs consistent with our overarching—and similarly socially constructed—global cultural narrative of continuous progress and perpetual material growth. Given the pervasive and persistent influence of mass media, public relations and advertising (i.e., soft propaganda) in support of this narrative, recent generations of *H. sapiens*, at least in the industrial capitalist world, are arguably the most socially-engineered generations of people ever to walk the earth (so successfully so, that most people remain unaware of their 'training').

[8] Here, too, the world is in denial. Nothing of the kind is on the horizon; population regulation remains a taboo subject.

The important point to remember is that all social constructs are mere abstractions or *models* that should be tested or validated against any aspect of reality the model purports to represent. For example, an economic paradigm that does not adequately reflect the structure and behaviour of real-world eco-systems with which the economy interacts, or which misrepresents the complexities of human social behaviour, is ultimately doomed to failure. From this perspective, the global ecological crisis, chronic income gap and increasing social unrest provide clear evidence that growth-based neo-liberal economic theory consists of deeply flawed constructs.

In these circumstances, should not a truly intelligent species retract and reconstruct the offending model? How can we learn from the failures of the present paradigm to inform the construction of an alternative that performs better in the real natural and social worlds? Progress comes from constant refinement of paradigmatic constructs so that they better conform to reality. Instead, the modern world seems obstinately determined to force biophysical and social reality to conform to demonstrably faulty models. This is a dead-end strategy.

Bottom line: Humans cannot live without social constructs but not all constructs are created equal. Some are positively destructive. The most successful social constructs will be those best adapted to real world conditions; long-term survival depends on economic paradigms and cultural norms that are compatible with both biophysical and human nature.

Fortunately, learning processes that have been used for ill can also be used for good. A world interested in long-term sustainability would invest in a crash program—let's call it 'Survival 2100' (Rees 2012b)—of global education for mutual survival (social re-engineering for 21st Century realities). This program would employ the enormous communicative powers of the internet and mass media in the unprecedented task of intentionally re-writing the world's dominant cultural narrative. The mission is nothing less than designing a world economic system that meets the basic needs of everyone without destroying the biophysical basis of human existence.

Steady-state economics and a socio-cultural narrative that builds on the human propensity for community, cooperation and long-term survival are clearly more adaptive constructs for a finite-world-in-overshoot than are growthist economics and short-term competitive individualism. The world is at a crossroads where the basic choices are to: 1) accept the evidence and get on with constructing a more ecologically resilient and equitable steady-state world or; 2) maintain the dogged pursuit of the growth-oriented, systems-destabilizing *status quo.* So far the steady-state alternative has no takers among the world's political and economic elites and most ordinary citizens have never heard of the steady-state or are disbelievers in global change—not least because of the recent emergence, particularly in North America, of powerful right-wing organizations dedicated to constructing a wall of denial and misinformation. The question is, how long can society persist under this opaque umbrella of self-delusion if our basic science is correct?

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