The foundations for an ecological economy: an overview

Beyond Uneconomic Growth, Vol. 2

A Festschrift in honor of Herman Daly

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PREFACE

(FORTHCOMING)

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1. The foundations for an ecological economy: an overview

Joshua C. Farley

1.1 INTRODUCTION

This book began as a single-volume Festschrift to honor the work of Herman Daly, one of the pioneers of ecological economics. Unfortunately, the destiny of too many Festschrifts is to sit on the shelf unread, and we believe that among all economists, Daly's ideas are the most important to disseminate and apply. Furthermore, given the significance of Daly's contributions and the numerous scholars he has influenced, a single volume would be inadequate. We have therefore chosen to publish two volumes in different formats: one volume available in print or as an ebook with Edward Elgar Publishing and the other an online, open-access ebook downloadable at http://www.uvm.edu/~jfarley/BUG.

Daly came of age as an economist during the 1960s, a time of increasing alarm over the ecological impacts of economic growth, population growth and global inequality. Mainstream economists as a whole were largely complacent about these issues, trusting in technology and substitution to address resource limits (Barnett and Morse, 1963; Simpson et al., 2005) and in markets to distribute wealth in proportion to an individual's role in creating it (Clark, 1908). Continuous economic growth would provide the resources to protect the environment and eliminate poverty and incentives to have fewer children, stabilizing the global population (see Daly, 1977 for a detailed discussion).

Daly, in contrast, had the crucial insight that the human economy is a subsystem sustained and contained by a delicately balanced global ecosphere, which in turn is fueled by finite flows of solar energy. As the economy expands, it transforms more ecosystem structure into economic products and generates greater flows of waste, both of which reduce the capacity of ecosystems to generate life sustaining ecosystem services and other amenities. He realized that ever-increasing material consumption must have devastating impacts on natural systems and the non-market benefits they generate and was therefore neither socially desirable nor biophysically possible. Economic analysis must begin with the recognition that the economy is wholly dependent on the finite global ecosystem. Furthermore, given finite resources, their just distribution within and between generations is an unavoidable focus of economic analysis. As early as the late 1960s, he began calling for a steady state, no-growth economy with a more equal distribution of wealth and income (Daly, 1968, 1973). For a brief period in the 1960s and 1970s, it almost seemed that Daly's view might win out on the policy level. The United States and other developing nations passed major legislation to protect the environment and to improve the distribution of wealth.

Unfortunately, since then global environmental problems have grown significantly worse, income inequality has skyrocketed and the global population pushes toward ten billion. In the world's richest country, the United States, the poverty rate has actually increased. Paradoxically, despite a doubling in per capita income since the 1960s, there seems to be a growing belief that we can no longer afford to tackle environmental problems and inequality.

Herman has nonetheless continued to dedicate his professional life to creating the transdisciplinary field of ecological economics that seeks to balance what is biophysically possible with what is socially, ethically and psychologically desirable. We believe that the best tribute to Herman is to help advance this agenda before it is too late. The goal of these books is therefore to build on Herman's work to propose sustainable, just and efficient solutions to society's most pressing ecological and economic problems. The goal of this chapter is to briefly describe the problems we face, explain why the current economic system is failing to address them and suggest how Daly's work is capable of transforming our complex ecological economic system. The chapter concludes with a brief introduction to the remaining chapters in this book and its companion volume, all contributed by scholars and activists working toward the creation of a sustainable and desirable economy.

1.2 ENVIRONMENTAL PROBLEMS AND THE ANTHROPOCENE

Geologists divide geologic time into epochs, which correspond to dramatic changes in biophysical events on our planet. Our current official epoch, the Holocene, has been characterized by an unusually stable climate that has provided conditions conducive to the development of agriculture. Agriculture in turn allowed the population density, accumulation of surplus production and division of labor that were essential to developing civilization.

Human society is profoundly influenced by environmental conditions. *Homo sapiens* first appeared about 200 000 years ago during a period of dramatic climate instability that persisted for the first 95 percent of human history. In spite of climate instability, small bands of humans characterized by remarkably similar stone-age technologies and highly egalitarian political and economic systems nonetheless managed to spread across the planet. When the Holocene arrived around 11 700 years ago, many of these spatially separated groups responded to a newly stable climate in remarkably similar ways. For example, although the North American populations were completely isolated from the old world, when the Europeans 'discovered' the major American civilizations in the sixteenth century, they found large cities, agricultural systems and hierarchical political, economic and religious institutions that were instantly recognizable, though none of these institutions had evolved in the many millennia preceding the Holocene (Richerson et al., 2001).

Humanity is again facing dramatic environmental changes, but this time as a result of our own actions. Though climate change is the most widely discussed, biodiversity loss, nitrogen and phosphorous cycles, ocean acidification, land use change, freshwater use, ozone depletion, chemical pollution and atmospheric aerosol loading also threaten unacceptable environmental change that may be incompatible with continued human development or even survival (Rockstrom et al., 2009). In fact, the human influence on the environment is now so profound that many scientists argue that we have entered a new geologic epoch, the Anthropocene: human impacts on the environment are now on the scale of geological forces (Crutzen, 2002). There is considerable debate over when the Anthropocene actually began, but one powerful contender is the start of the industrial revolution, when the vast power of fossil fuels (and their immense waste emissions) was first unleashed. Not coincidentally, the origins of both the modern market economy and the theory describing it both date to this same era. There is little debate that a Great Acceleration in human activities and their environmental impacts began around 1950. Among other radical changes, the human population and species extinctions doubled in only 50 years, fossil fuel use and water use more than tripled, fertilizer use increased five fold and the size of the economy (as measured by gross domestic product (GDP)) increased 15 fold (Steffen et al., 2011).

The impacts of the Anthropocene on human development may be at least as profound as those of the Holocene, but with potentially devastating consequences. Humans like all species, depend on well-functioning ecosystems for their survival, and human civilization almost certainly depends on agriculture. Unfortunately, agriculture may be the greatest single threat to global ecosystems (Brown, 2012; Godfray et al., 2010;

Tilman et al., 2011). Our global economy also depends on fossil fuels, which provide 86 percent of our energy supply, and fossil fuel emissions vie with agriculture as the dominant threat to global ecosystems. Critical economic and ecological thresholds are in direct conflict. Society must thread a narrow path between ecological and economic collapse.

Growing inequality only exacerbates the problems of ecological degradation. The Great Acceleration initially coincided with the Great Compression: a period during which wages, incomes and the distribution of wealth became dramatically more equal, largely as a result of government policies influenced by the Great Depression and Keynesian economics. Economic inequality in the United States reached a minimum during the early 1970s, but has since increased nationally and globally to record levels in what is known as the Great Divergence (Alvaredo et al., 2013; Piketty and Saez, 2006).

A brief look at our most important economic sector – agriculture – can help illustrate the severity of the challenges we currently face. Most economists would agree that there are rising marginal costs to economic production, and diminishing marginal benefits. The goal of economists is generally to maximize net benefits, which occur when marginal costs (which translate into a supply curve in market economics) are equal to marginal benefits (the demand curve).

The supply curve should include not only the marginal costs of labor, capital and material inputs, but also those of ecological degradation. Recent studies suggest that agricultural impacts already threaten or exceed ecological thresholds (Foley et al., 2011; IPCC, 2013; Millennium Ecosystem Assessment, 2005; Reid et al., 2010; Rockstrom et al., 2009; Steffen et al., 2011) beyond which the marginal costs of continued activity become immeasurably high. Thresholds represent the limits of marginal analysis: a marginal change in supply leads to non-marginal change in costs. To paraphrase Herman Daly, at a threshold, one marginal step takes us over the precipice (Daly, 1977). It's reasonable to assume that the supply curve for conventional agriculture becomes increasingly vertical as it approaches one of these thresholds.[1]

The demand curve is determined by marginal benefits. Humans confront a physiological threshold when they fail to consume enough food to survive, at which point the physiological demand curve for food becomes vertical. Once we have met our basic survival needs, the marginal benefits from food fall dramatically. Arguably, for the one billion malnourished people on the planet who may suffer retarded development, high mortality rates and so on, the marginal benefits from additional nutrition are immeasurably high already.

The demand curve described here is quite different from market

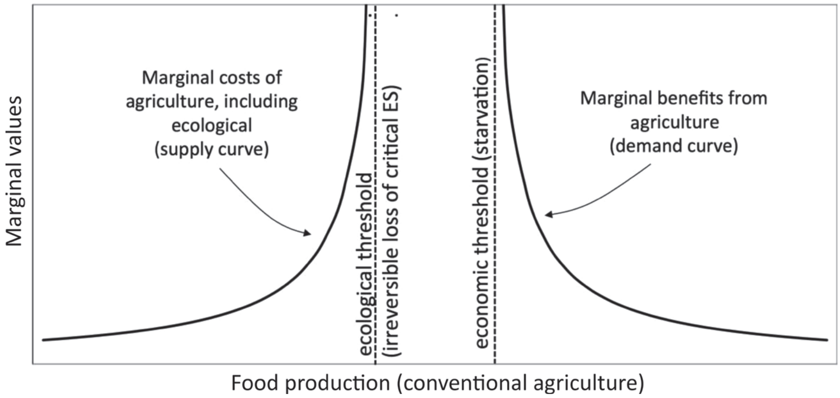

Figure 1.1 *Conceptual supply and demand curves for food production that account for ecological costs and the preferences of the poor, assuming current technologies and economic institutions*

demand, which weights preferences by purchasing power. Global agriculture produces enough to feed the world, but an unequal distribution of purchasing power results in a highly unequal distribution of food. During the food crisis of 2007–08, when drought, increased ethanol production and speculation led the price of staple grains to double, the richest countries with the highest levels of per capita food consumption saw negligible change in demand or in the percentage of food being thrown away. Poor countries, in contrast, saw a significant increase in malnutrition, social disruption and political turmoil. When income is highly unequal, markets may allocate essential resources to those who gain the least marginal benefit (Farley et al., 2015).

Figure 1.1 depicts supply and demand curves based on these assumptions concerning marginal costs and benefits. With current production practices, economic institutions and human populations, the supply and demand curves do not intersect, and we are forced to choose between unacceptably high ecological or social costs. Ecological catastrophe of course will also lead to unacceptable social costs. We require agricultural systems that reduce ecological impacts while producing adequate food, as well as a much better distribution of the food we do produce. We require economic institutions that incentivize those agricultural systems and distribute food more equitably.

This economic (but non-market) analysis of supply and demand for food systems applies to the supply and demand of other essential resources and to the economy as a whole. For example, greenhouse gas emissions currently exceed absorption capacity, threatening runaway climate change in the future. If we immediately reduced emissions to sustainable levels, the resulting economic disruption could prove catastrophic. Aggregate economic activity already exceeds ecological thresholds, while in our current system failure to keep growing leads to unemployment, poverty and misery. We need a new economic system capable of addressing these ecological and physiological thresholds before the former become irreversible and catastrophic, and the latter result in social or economic collapse. Herman Daly's economic theories can help create this system.

1.3 THE RESPONSE OF MAINSTREAM ECONOMICS[2]

While some mainstream economists are responding to the dual challenges of the Great Acceleration and the Great Divergence, the evolution of the discipline as a whole has likely exacerbated these trends. The Great Acceleration began around the time that mainstream economics became obsessed with economic growth. Prior to 1947, the phrase 'economic growth' appeared just once in all the economic journal articles indexed in Econlit, while in the decade of the 1950s it appeared 178 times, and has shown exponential increase since then.

Concerns over biophysical constraints to growth surfaced in the 1940s and 1950s (The President's Materials Policy Commission, 1952), but among economists and policy makers, largely gave way in the 1960s to faith in technological progress and endless substitutability (Barnett and Morse, 1963; Milliman, 1962; Spengler, 1961). The advent of earth day, petroleum price shocks and the publication of numerous environmental critiques of growth in the early 1970s reignited concerns over biophysical constraints. Economists initially reacted to these concerns with condescension and hostility, referring, for example, to *Limits to Growth* (Meadows et al., 1972) as 'such a brazen, impudent piece of nonsense that nobody could possibly take it seriously' (Beckerman, 1972, p. 327); one of the 'doomsday models' that are 'bad science and therefore bad guides to public policy' (Solow, 1973, p. 43); 'an empty and misleading work . . . less than pseudoscience and little more than polemic fiction' (Passell et al., 1972, p. 1); and an example of crying wolf (Kaysen, 1972; all cited in Yissar, 2013). In spite of these vicious criticisms, economists began responding to concerns over resource depletion in sufficient numbers to form the sub-discipline of natural resource economics, which focused on the optimal use of raw materials and fossil fuels, considered obligations to future generations and integrated natural resources into economic growth models. Nonetheless, most economists continued to assume that capital, labor and technology were near perfect substitutes for natural resources (Dasgupta and Heal, 1979; Hartwick, 1977; Nordhaus et al., 1973; Solow, 1974a, 1974b, 1997; Stiglitz, 1974, 1997), rather than complements to resources, as Daly and others argued (Daly, 1997). Resource scarcity would not limit growth.

Economists also began to consider environmental amenities (aka ecosystem services) and pollution (Ayres and Kneese, 1969; Krutilla, 1967; Smith and Krutilla, 1979) – common property whose values are often ignored by market decisions – giving rise to the sub-discipline of environmental economics. Environmental economists generally accepted limitless substitution for natural resources, though not necessarily for benefits provided by unique ecosystems. However, the general conclusion is that if appropriate policies such as environmental taxes, cap and trade systems, and economic incentives for providing or protecting ecosystem services internalize these failures into market prices, growth can continue unabated (Simpson et al., 2005).

The emergence of natural resource and environmental economics is certainly promising, and these sub-disciplines favor some of the same policies as ecological economics. Nonetheless, the reaction of mainstream economics to the Great Acceleration falls short for two reasons. One problem lies within these sub-disciplines, which continue to view the planetary ecosystem as the part and the economy as the whole, as epitomized by the definition of environmental problems as externalities that can be internalized into economic decisions. Efficient allocation is assumed to generate sustainable outcomes, and just distribution is rarely addressed. Endless economic growth remains the goal. Ecological economists, in contrast, believe that the nature of the economy as a physical subsystem of a finite planet makes continuous exponential growth impossible. Irreducible uncertainty concerning ecological impacts means that future costs are unknowable. Ecological sustainability and just distribution must take precedence over efficient allocation. Other important differences between these neoclassical sub-disciplines and ecological economics are nicely summarized elsewhere (Daly, 2007; van den Bergh, 2001), and therefore need not be reviewed here.

The second major problem is that natural resource and environmental economics have had little impact on mainstream economics as a whole. One prominent economist states that '[n]ature did not appear much in twentieth century economics, and it doesn't do so in current economic modelling. When asked, economists acknowledge nature's existence, but most deny that she is worth much' (Dasgupta, 2008, p. 1). Another argues that while 'there is a branch of growth theory that includes environmental and resource variables . . . this has not affected the core of growth theory and associated policy debate. Moreover, most growth models with resources exclude realistic constraints on the substitution possibilities between energy and capital' (Ayres et al., 2013, p. 80). In short, natural resource, environmental and ecological economics all 'remain somewhat isolated from the main body of contemporary economics, especially as the discipline is presented in textbooks and journals' (Dasgupta, 2008, p. 2).

The Great Divergence in turn coincides with the period during which standard economics largely abandoned any concern over the distribution of wealth. Previously, many economists recognized that diminishing marginal utility implied that a more equal distribution of wealth increased total utility, all else equal (for example, Marshall, 1890). In the 1970s, however, mainstream economics solidified its position that since it was impossible to compare utility between individuals, economists should focus on the supposedly value neutral goal of satisfying subjective preferences (for example, Stigler and Becker, 1977), typically failing to explicitly acknowledge that markets weight preferences by purchasing power. Essential needs were treated the same as 'tastes.' The result was the use of 'wealth rather than happiness as the criterion for an efficient allocation of resources' (Posner, 1985, p. 88). Redistribution may reduce incentives to accumulate wealth, and equality and efficiency are in conflict (Okun, 1975). It is not unusual for conventional economists to acknowledge that '[w]e live in a world of staggering and unprecedented income inequality' but to then assert that '[o]f the tendencies that are harmful to sound economics, the most seductive and . . . the most poisonous, is to focus on questions of distribution' (Lucas and Robert, 2004). From this perspective, it was perfectly efficient and utility-maximizing for those consuming the least amount of food to reduce consumption by the most during the 2007–08 food crisis, since they were 'unwilling' to pay as much for food as the rich.

In recent years it has become increasingly common for influential economists to acknowledge that growing inequality is a serious problem (for example, Piketty, 2014; Piketty and Saez, 2006; Stiglitz, 2014, see also Paul Krugman's weekly column in the *New York Times*). However, within the mainstream the importance of distribution is obscured by the economist's obsession with efficiency, as economists define it. Few if any mainstream economists question the efficiency of market allocation, regardless of income distribution or the essential nature of a particular resource. Few if any challenge the assumption that allocating resources according to preferences weighted by purchasing is optimal, or ask if the world's poor would offer a different definition of optimality.

Mainstream economists therefore have an entirely different interpretation of supply and demand than was presented in Figure 1.1. If belief in technological progress and the capacity for substitution is virtually unlimited, marginal costs will never become immeasurably large. For example, the influential Stern review on the economics of climate change (Stern, 2006) assumes that even if we do nothing to mitigate climate change, continued economic growth ensures that future generations will be better off than the present. Marginal benefits for food cannot become immeasurably high because the destitute essentially drop off the demand curve when the price of staple grains exceeds their capacity to pay.

In distinct contrast, Herman Daly and his supporters argue that economic theory must acknowledge that the economy is entirely dependent on the raw materials, energy flows and ecosystem services that nature provides. Furthermore, we cannot solve ecological problems without simultaneously pursuing a just distribution of wealth and resources: in a world of pronounced income inequality, addressing the conflict between food production and ecosystem services by internalizing the costs of ecological degradation into market prices would result in severe hardships for the poor, and at most mild inconvenience for the rich. The decision to prioritize the preferences of the rich and the current generation is purely normative. We urgently require an economic system that prioritizes ecological sustainability, just distribution and obligations to future generations while acknowledging the profound uncertainty inherent to complex systems. Herman Daly and the scientists in these volumes are actively working to develop economic theories that support this transition. They recognize that climate change, resource depletion, population growth, the unjust distribution of resources and the current financial crisis are all interrelated components of a single complex system. We turn now to the challenge of changing complex systems.

1.4 EFFECTING CHANGE IN COMPLEX SYSTEMS

After decades of study using computer models and empirical evidence, Donella Meadows came up with a series of leverage points that are particularly effective at changing complex systems (Meadows, 2009). By conscious design or intuition, Daly's work concentrates on three of the most powerful of these levers: changing the paradigm; changing the goals; and changing the rules.

A paradigm is the worldview underlying the theory and methods of a field or discipline. Herman has changed the conventional economic paradigms concerning biophysical possibility and human behavior. In regards to biophysical possibility, Daly rejects analysis of the economic system as the whole, capable of expansion without limit, and the ecosystem as a part that supplies useful raw materials and services. Instead, Daly argues that economic analysis must begin with the recognition that the economic system is sustained and contained by the finite global ecosystem, which supplies all raw materials required for economic production, absorbs all resulting waste flows and provides irreplaceable ecosystem services essential to our survival (Daly, 1973, 1991). Energy is an essential input into all economic production. We have finite stocks of terrestrial energy sources, finite flows of solar energy, and useful energy is always lost in the economic process. The raw materials that the economy transforms into economic goods and services alternatively serve as the structural building blocks of ecosystems. Arranged in particular configurations, these materials create ecosystem funds capable of transforming solar energy into a flux of ecosystem services essential to the survival of humans and all other species (Malghan, 2011). Resource extraction and waste emissions significantly alter these configurations, threatening the essential and non-substitutable services they generate, including the reproduction of renewable resources. Continuous *physical* growth of the economy is therefore impossible within a larger, non-growing, biophysical system (Daly, 1996).

Daly has also challenged the ruling paradigm concerning human behavior. Conventional economists model people as perfectly rational, self-interested and insatiable individuals who gain utility only from consumption, not from interaction with others, except as that contributes to consumption. Daly, in contrast, rightfully insists that we are persons-in-community who define ourselves more by our relationships and associations with other individuals and groups than by the stuff we own. If you take away these relationships, there is little left of the individual (Daly and Cobb, 1994). Within mainstream economics, the sub-discipline of behavioral economics also challenges conventional assumptions of human behavior, but so far has had little impact on the discipline's core assumptions as presented in introductory textbooks. In fact, simply studying economics makes people more likely to conform to conventional assumptions (Cipriani et al., 2009; Kirchgässner, 2005).

Daly argues that acknowledgement of biophysical limits and our nature as persons in community forces us to change the goals of economic activity. Conventional economists prioritize efficient allocation, defined as any allocation in which it is impossible to make one person better off without making someone else worse off, and claim that free markets achieve this goal. Efficient allocation boils down to the maximization of monetary value subject to the initial distribution of wealth and resources, hence economists pursue the dynamic goal of ever-increasing GDP.[3] Daly offers instead three alternative economic goals: ecological sustainability; just distribution; and efficient allocation (Daly, 1992). Humanity depends for its survival on the life support functions of the planetary ecosystem. If we show any moral concern for future generations, and the current generation as a whole is not destitute, ecological sustainability is essential. The goal of sustainability limits the total amount of resources any single generation can consume, in which case we must ensure available resources are justly distributed. Daly redefines efficiency as attaining the greatest level of human welfare from a sustainable flow of throughput (Daly, 1996). Markets can contribute to the efficient allocation of resources, but fail to address sustainability or justice, which take priority over efficiency. GDP fails to accurately measure human welfare, and must be replaced with an indicator that accounts for the costs as well as the benefits of economic activity. Along with John and Clifford Cobb, Daly pioneered the index of sustainable economic welfare (ISEW), which does exactly this (Daly and Cobb, 1994). While GDP continues to grow, in most countries the ISEW peaked decades ago (Lawn, 2003).

Finally, Daly calls for new rules for the economy. Conventional economists prioritize rules that promote the functioning of competitive free markets and the price mechanism. Daly, in contrast, argues that 'ecological and ethical decisions are price determining, not price determined' (Daly, 1986, p. 321). We must have rules that ensure sustainable scale and just distribution before we can trust in market allocation via the price mechanism. For example, one possible rule for achieving sustainable scale would be to set quantitative limits on throughput from outside the market economy, and let these limits determine prices. One possible rule for achieving just distribution would be to allot everyone an equal share of resources created by society or nature as a whole. Market allocation will only be efficient once these first two rules are satisfied (Daly, 2007).

It's certainly worth noting that conventional economists are often supportive of cap and trade systems, which are one application of Daly's rules. Daly also shares with conventional economists support for policies such as green taxes. The major difference is that conventional economists focus on the Pareto efficiency of these rules in maximizing monetary value, which they generally treat as necessary and sufficient. Daly, in contrast, focuses on the rules' effectiveness in achieving a just, steady state economy, defined as an economy in which flows of throughput are non-increasing, equitably distributed and within the biophysical carrying capacity of the planet (Daly, 1973, 1991).

We must either achieve a steady state economy through conscious choice or nature's feedback loops will force it upon us, perhaps catastrophically. Until we change the economic paradigm concerning what is biophysically possible, society will not recognize the need for a steady state economy. Until we change our goals concerning what is socially, psychologically and morally desirable, society will view a steady state as an unacceptable sacrifice. Until we make our economic institutions more just, sustainable and efficient, a steady state economy is not possible. Daly has laid the groundwork. It is the task of Daly's intellectual and moral heirs to move us forward.

1.5 ORGANIZATION OF THE BOOK

The remaining chapters in these volumes provide not only an overview of Herman's foundational work in ecological economics, but also showcase continuing efforts to build a new economic system that is value driven, science based and solutions oriented. The volumes are divided into six parts, including an introduction and conclusions. The middle sections parallel the leverage points for changing complex systems described above: 'Changing the paradigm,' 'Changing the goals' and 'Changing the rules,' with an additional section on the 'Steady state economy.' There is some overlap between the parts. In the remainder of this overview, we will use *chapter* to refer to the Edward Elgar edition and *article* to the online volume.

The second chapter in the Introduction section is by Daly's long-time collaborator and World Bank colleague, Robert Goodland (see the eulogy in the Preface). Goodland provides a superb overview of Herman's lifetime contribution to economics, divided between a brief but excellent synthesis of his theoretical contributions and specific solutions to global problems ranging from ecological degradation to financial instability. The chapter concludes with a reference list with particular emphasis on Daly's earlier works. A chapter by Daly's long-time collaborator, Robert Costanza, describes their efforts over the past 35 years to build a sustainable and desirable future. The online companion volume adds to this an interview with Herman Daly edited by Deepak Malghan.

Part II on 'Changing the paradigm: what is biophysically possible, and how do humans behave?' begins with an online article in by David Batker, one of Daly's former students and the Executive Director of Earth Economics, a non-governmental organization (NGO) dedicated to developing ecological economic solutions to pressing societal problems. David's article places Daly's theoretical work in the context of previous revolutions in economics, explaining how new paradigms generate new goals, new institutions to achieve them and new ways to measure their success. The article also explains how Earth Economics has applied this theory to help solve real-life problems. Chapter 4 by Jonathan Harris, a Senior Research Associate and Director of the Theory and Education Program at Tufts University's Global Development and Environment Institute, presents the biophysical evidence supporting the paradigm that the economic system is sustained and contained by our finite global ecosystem. He concludes that market forces will not solve the challenges this presents, and calls for an activist macroeconomics that simultaneously achieves both justice and sustainability. Chapter 5 is by Arild Vatn, an institutional economist at the Norwegian University of Life Sciences and former President of the European Society for Ecological Economics. His chapter addresses limits, both those imposed by the biological and physical constraints of our finite planet and those imposed by society. He also addresses social constructions of no-limits, essentially the beliefs that finite resources place no limits on consumption, and that there is no limit to the human desire to consume. This provides a nice segue to Chapters 6 and 7, which focus on human behavior. Conventional economists have traditionally assumed that people are rational and primarily motivated by self-interest. Chapter 6 is by John Gowdy, an ecological economist at Renssalaer Polytechnic Institute and former President of the International Society for Ecological Economics. Gowdy's chapter explores how behavioral economics, evolutionary psychology and neuroscience have changed our understanding of human behavior, with profound implications for conventional economic models and public policy. He concludes that different economic institutions can stimulate or inhibit humanity's innate propensity for the cooperative behavior required to manage biophysical constraints, and that markets may inhibit such behavior. The concluding chapter in Part II (reprinted as an article in the online edition) is by William Rees, Professor emeritus of City and Regional Planning at the University of British Columbia, developer of ecological footprint analysis and winner of the Blue Planet Prize. Rees applies insights from the evolutionary biology of human cognition to understand why conventional economists and policies makers have largely rejected Daly's worldview of the economy as sustained and contained by a finite global ecosystem. He concludes that new information and rational argument rarely undermine deeply held convictions. Getting people to accept the dramatic changes needed to confront ecological overshoot will require 'a world program of social re-engineering. . .to assert humanity's collective intelligence and reason over people's predisposition to defend the status quo.'

Part III on 'Changing the goals: what is socially, psychologically and ethically desirable?' explores the goals of sustainable scale, just distribution and efficient allocation. Chapter 8 by Philip Lawn, Professor of Ecological Economics at Flinders University, Australia, explains the importance of these goals and the order in which they should be addressed. Arguing that distribution becomes increasingly important on a full planet and has too often been neglected in theory and practice, he proposes several policies for achieving an equitable distribution of resources within and between nations. An article by Gary Flomenhoft, former lecturer and research associate at the University of Vermont now doing his doctoral work at the University of Queenland, Australia, also focuses on just distribution. Gary explains how the adoption of Pareto efficiency as the central goal of conventional economics led the discipline to largely ignore problems with distribution, and documents how inequality has exploded in recent years. He then suggests a number of policies for addressing both inequality and poverty. Chapter 9 by Salah El Serafy, a former senior economist and colleague of Herman Daly and Robert Goodland at the World Bank, focuses on measuring real income, defined as the maximum amount one can consume over some time period and still be as well off at the end as at the beginning. He explores the implications of this definition for national income accounts, capital stocks (including natural capital), the steady state economy and the purpose of economic activity. An article by Mathis Wackernagel, co-developer with Rees of the ecological footprint, co-recipient of the Blue Planet Prize and Director of the Global Ecological Footprint Network, provides a brief overview of the organization's annual report, which was dedicated to Herman Daly. The report adopts sustainability and justice as fundamental goals: the global footprint currently exceeds global productive capacity, which is unsustainable, and many nations currently exceed their national productive capacity, imposing ecological costs on others, which is unjust.

Part IV turns to 'Changing the rules: institutions for a sustainable and desirable future.' Chapter 10 by Clifford Cobb, co-developer of the Index of Sustainable Economic Welfare and the Genuine Progress Indicator, focuses on shifting taxes from earned to unearned income, particularly that generated by land and other natural resources, as a policy that simultaneously promotes a more just, efficient and sustainable allocation of resources. An article by Lester Brown, founder of World Watch, founder and President of the Earth Policy Insitute and world-renowned environmental analyst, focuses on shifting subsidies from taxes onto activities that harm the environment. The bumper sticker summaries of these two chapters are 'tax what we take, not what we make' and 'tax bads, not goods.' Chapter 11 by John Cobb, co-author with Herman Daly of *For the Common Good*, global authority on Whiteheadian Process Thought and theologian at Claremont University, focuses on the monetary system. Specifically, Cobb shows that modern monetary systems based on interest bearing debt demand never-ending economic growth to avoid financial collapse, which is impossible on a finite planet. He proposes instead a 100 percent fractional reserve system and decentralization of the monetary system, both fundamental changes in one of the economy's most important institutions. An article by Sabine O'Hara, current President of the International Society for Ecological Economics and Dean of the College of Agriculture, Urban Sustainability & Environmental Sciences at the University of the District of Columbia, concludes the section with an article on production in the context of the biophysical and social processes required to sustain it. She explains why a theory of economic production must expand its boundaries to account for these contextual processes, and offers a policy agenda for ensuring their maintenance.

Part V turns to one specific institution that is a prerequisite for avoiding ecological collapse: 'The steady state economy.' This section is similar in both the online and Edward Elgar editions, but the chapters in the latter have been significantly updated. Peter Victor, Professor at York University and recent recipient of the Boulding Award, initiates Part V with a detailed history of the steady state economy in economic thought, followed by a brief overview of his simulation models that show how such an economy could plausibly be achieved in both the United States and Canada. Joan Martinez Alier, Professor at the Autonomous University of Barcelona and founding member and former President of the ISEE addresses the need for degrowth en route to a steady state economy. For degrowth to be socially sustainable, the richest economies will have to shrink enough that the poorest countries can still expand without exceeding environmental constraints. After discussing degrowth in the context of the financial crisis, oil prices, carbon dioxide (CO_2) emissions and social and political movements from the south, he concludes that we can only transition to a steady state economy if we change our economic goals to emphasize a good life (buen vivir) rather than materialistic consumption as measured by GDP. The online version was written shortly after the ongoing 2007–08 financial crisis, while the book chapter updates this to 2014. Brian Czech, founder and President of the Center for the Advancement of a Steady State Economy (www.Steadystate.org), Professor of Ecological Economics at Virginia Tech and wildlife biologist, concludes this section by tackling the politics of a steady state economy. He describes several problems that impede political support for the steady state, and argues that one important step to overcoming the obstacles is to document widespread support for such an economy by leading academic societies. He describes his own increasingly successful efforts to generate and document such support.

After identifying the leverage points for changing complex systems, Meadows adds that the most powerful lever is to transcend the paradigm, never allowing ourselves to become too bound to a particular preanalytic vision. It is therefore fitting that both volumes conclude with a chapter by Peter Brown, Professor at McGill University, that presents ecological economics as only a partial step on the path to a sustainable and desirable future. To complete its journey, ecological economics must adopt a new system of ethics that extends moral standing to life as a whole, explicitly recognizing that humans are simply one subset of citizens in the grander ecological community.

Together, these volumes explain the origins of some of the most serious threats currently faced by human society, and offer concrete suggestions for solving them. We hope the economic theory presented here can help transform the economic system.

NOTES

1. It's important to note that both flow thresholds and stock thresholds exist. Using the example of greenhouse gases (GHGs), we exceed a threshold when the stock of GHGs results in an unacceptable degree of climate change, for example, one that causes positive feedback loops of rising methane emissions or falling albedo. We exceed a flow threshold when the emission of GHGs exceeds the capacity of ecosystems to absorb them and they accumulate into an ever-growing stock. Unfortunately, it may be impossible to accurately predict precisely where a threshold lies. Furthermore, given the frequent time lags between cause and effect in complex ecosystems, we may not suffer the impacts of crossing a threshold until decades into the future.
2. Conventional or mainstream economics in this chapter refers to neoclassical economics, or more specifically to the belief that the goal of economic activity at any point in time is the satisfaction of subjective individual preferences, which in a market economy leads to an equilibrium that balances supply with demand across all goods and services in an economy and maximizes economic surplus, typically measured in monetary terms. People are generally considered insatiable, so the goal over time is continuous economic growth. However, the worldview that the economy is the whole and the ecosystem the part permeates many heterodox schools of economic thought as well.
3. A growing number of economists recognize that GDP is a poor measure of economic welfare (Stiglitz et al., 2009; van den Bergh, 2009), which only makes mainstream economics' continued obsession with the metric more puzzling.

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1. An Interview with Herman Daly

Deepak Malghan

Deepak Malghan (DM) spoke (a lot of it over email) to Herman Daly (HD) about his oeuvre and his hopes for the future of ecological economics. The conversation below is mostly a verbatim record except for minor editing to avoid unnecessary repetition.

DM: *Herman, one of the biggest achievements of ecological economics has undoubtedly been the advocacy of an "embedded economy" -- an economy that is contained within the larger ecosystem (and less frequently in the larger society). You have played a preeminent role in articulating this vision. Do you think ecological economists have developed a deep ethical critique of 'disembeddedness' that goes beyond merely utilitarian "disembedded economies lead to ecological or social crises"? More specifically, is it necessary to develop a deeper normative critique of the disembedded economy ontology? What would be the main elements of such a critique?*

HD: I think "embeddedness" is mainly a question of how the world really is—ontology—rather than how it should be—ethics. The economy really is a subsystem of the ecosystem, and our failure to realize this in economic theory is a failure of perception. Our unwillingness to face the problems of distribution, arising from the limits to growth that prevent "growing our way out of poverty", may be due to ethical panic at the prospect of having to share. This panic may result in denial—a refusal to see things as they are because it threatens us with problems to which we have no happy answer. So ethical questions are likely involved in the denial of what is real. But there is a deep ontological, indeed religious, question—Is man a creature subject to the basic limits of the creation of which he is a part, or a potentially unlimited creator engaged in remaking the world in his own image? The religion of scientism has led too many to believe the latter.

DM: *Having brought up ontology in the context of embedded economies, let me follow up with something you have written about in some detail. Aristotle looked at ontological questions by looking at material, formal, efficient, and final causes. How would you critique the disembeded circular-flow ontology at each of these four levels.*

HD: Mainly I see a correspondence between Aristotle's four causes and the ends-means spectrum. Ultimate Means is low-entropy matter-energy, the Ultimate End is the "final" final cause. Intermediate Means corresponds to efficient cause, and Intermediate Ends more or less to formal cause. Ultimate means eventually is converted into irrevocable waste, the final physical product of the economy. The final cause that redeems the economy from being an idiot machine for creating waste is a non-physical final cause—the enjoyment of life. The big question is how to use Ultimate Means efficiently in the service of the Ultimate End? This is too big a question to answer directly, but I recently saw an index that in effect calculates the ratio of penultimate proxies for these two ultimates. The ultimate end is approximated by "happy life years"—objective life expectancy weighted by a subjective measure of self-evaluated happiness. This measure is divided by the ecological footprint of the country based on carbon only. How long and happily citizens live divided by how heavily they use ultimate means is not a bad measure of efficiency in the largest sense. All numerical indexes have their limits, but this one at least attempts to measure the right things. (see New Economics Foundation, "Happy Planet Index").

The circular flow vision is only good for analyzing exchange, and what is flowing in a circle is not matter or energy or even utility, but abstract exchange value, untethered to the real world by either inflows or outflows of matter-energy. Interpreted physically the circular flow model is a perpetual motion machine, as Georgescu-Roegen pointed out. Therefore it is highly misleading as a guide to studying relations of the economy to the ecosystem—a classic case of Whitehead's Fallacy of Misplaced Concreteness. The circular flow model does have legitimate uses in studying exchange and in national income and product accounting.

DM: *I will get back to the dreaded T-word [Teleology] later in this interview but given that we are discussing ontological problems with dis-embedded economies, I want to stick to Aristotle for the moment. How important is the Aristotelian final cause for your ontological conception of the economy? Can a final cause be articulated without reference to any teleological visions?*

HD: My previous answer is relevant here. I think articulation of a final cause does imply some teleological vision, although in economics we can go a very long way with the goal of maintenance and enjoyment of life. The Benthamite "greatest good for the greatest number" contains one too many "greatests"—an impossible double maximization. I think it should be sufficient per capita good for the greatest cumulative number over time. That builds in sustainability while recognizing that the present has the right to consume resources sufficient for a good (not extravagant or luxurious) life.

DM: *A more personal question. Please talk a bit about your own intellectual evolution with particular reference to the preanalytic vision for ecological economics. When were the first 'seeds of doubt' sown in your mind about the neo-classical vision for economics? Who were the major influences? Will you pick any one book/paper that most influenced you in your early career?*

HD: I think the two economists who most opened my mind as an undergraduate were John Kenneth Galbraith and Kenneth Boulding. I clearly remember being excited by Galbraith's critique of the consumer society, "The Affluent Society", and of the economic theory supporting consumption as the be-all. Also I remember reading Boulding's article "Income or Welfare?" in the basement of the Rice University library and thinking at the time that his simple recognition that stocks of wealth both provide services of utility and require production flows as a cost of maintenance had profound and revolutionary implications for economics. Another lucky break for me as an undergraduate was that my first course in economics was not Principles of Economics but History of Economic Thought. That meant that I read Smith, Ricardo, Mill, etc. without already "knowing that they were wrong" about one thing or another.

DM: *Continuing, a more specific question: would you consider your essay, "Economics as life science", published in the Journal of Political Economy as your point of departure from neoclassical economics?*

HD: At that time, 1968, I saw that article as more within neoclassical economics than as a departure. Its intent was to push from within towards making economics rely more on biological analogies and less on mechanical analogies—something that Alfred Marshal had advocated but without attempting himself. The use I made in that article of Leontief's input –output model was a departure from neoclassical economics, but not a radical one. I remember that then editor of the JPE, Robert Mundell, sent me the referee's comment from Frank Knight. It said "I do not think that it would at all disgrace the JPE to publish this". I was later told that was about as favorable a comment as one could expect from Knight. In subsequent years

I found the JPE editorial policy to be much more ideologically narrow and protective of the Chicago school of thought.

DM: *You have commented extensively on the analytical and philosophical problems with the conception of homo economicus. One possible solution lies in recognizing that individuals behave as utility maximizers (through appropriate rank ordering of subjective preferences) in the market place, but are more concerned with "ends" rather than mere subjective preferences in non-market settings. This requires economics to recognize "market" and "society" (or community as you have used in For the Common Good) as distinct ontological categories. Economists would of course argue that market has increasingly subsumed society, and ergo, homo economicus is a good abstraction to study the society and communities. Is this neoclassical ontology that describes the relationship between market and society an accurate description of extant reality? Your thoughts?*

HD: The problem with homo economicus is that she is an atomistic individual connected to other things only by external relations. John Cobb and I proposed instead "person-in-community" whose very identity is constituted by internal relations to others in the community. I can only define myself by reference to these relations in community. I am: son of…, husband of…, father of…, friend of…, citizen of..., member of…,etc. Shorn of all these relations there is not much left of "me". I am defined by these relations and therefore they are internal to my identity as a self-conscious, willing being, not just external connections between some abstract, atomistic, independent "me" and other people or things. Similarly, my relation to the environment is not just external. I am literally constituted by what I take in from the environment. My connection to air is not just external, it is an internal relation manifested in my lungs—I <u>am</u> an air-breather, just as I <u>am</u> the brother of…. This is an ontological statement about how the world is, how people are, not a wish about how they should be. Homo economicus is a wish about how people would have to be for neoclassical economics to work! Person-in-community means that my welfare depends much more on the quality of all the relationships that define me than on my external relations to the things I buy or consume. The idea that the welfare of a community or commonwealth can even be approximated by summing up the annual consumption based individual utilities of atomistic individuals related only externally through an exchange nexus is quite absurd and the source of much bad policy and misery. The concept of community is both inclusive and exclusive. The relationships by which we are defined as persons-in-community do not include all possible relations with all people all over the globe, except in a very abstract and tenuous way. World community is viewed as a federation of national communities, a community of communities, not as an immediate community in which persons have direct membership.

DM: *How did you come to collaborate with John Cobb on the For the Common Good, arguably your best known work (at least in the larger market place outside the academy)? What specific influence has this collaboration had on your articulation of the preanalytic vision for ecological economics?*

HD: John Cobb's son, Clifford, read something I wrote and passed it on to his Dad, and that led John to invite me to a conference he was hosting on "Limits to Growth" at Claremont. A friendship developed, and later he suggested that we co-author a book looking at economics from a Whiteheadian and environmental perspective. He had done something similar with biologist Charles Birch in a book "The Liberation of Life". The preanalytic vision was already in place, but our collaboration helped to work out many implications and specific critiques of economic policy, particularly the critique of free trade. Also the Appendix developing the Index of Sustainable Economic Welfare was mainly based on work by John and Clifford, with me as a friendly critic.

DM: *Finally a question on how you came to borrow Schumpeter's term, prenalytic vision: why did you use this as a rough synonym for "ontological conception?"*

HD: At first I used Kuhn's term "paradigm"because I had been influenced by his book, "The Structure of Scientific Revolutions". I thought it applied very well to the situation in economics. Later, upon looking up something in Schumpeter I came across a paragraph that developed the same idea as Kuhn, but used the very apt term "pre-analytic vision" which I thought was much more descriptive than "paradigm"—and Schumpeter was a famous economist! So I adopted Schumpeter's term. Probably Kuhn was unaware of Schumpeter's short discussion of the same basic idea.

DM: *I would now like to revisit your oeuvre. Let me start with your "steady state book". What was the initial reaction to your Toward A Steady-State Economy (1973)? Twenty years later, in your introduction (with Townsend, Valuing the Earth), you recollect that your 1973 book "explored the changing interpretations of the usefulness of the prescription of continued economic growth as a panacea for problems originating in underdevelopment and maldistribution of wealth."*

How would you evaluate the impact of your first book today, more than thirty-five years after it was first published?

HD: The idea was to bring together in one place the thinking of a number of people that lent support to the idea of a steady state economy—Georgescu-Roegen, Boulding, Schumacher, Donella Meadows, Garrett Hardin, Paul Ehrlich, and others. My contributions to the volume tried to develop the concept a bit more, starting from these authors. I think the book had some influence, but certainly was not a best-seller.

DM: *In particular, you observed in 1993 that your 1973 book "originated as a signal of an emerging paradigm shift in economics". Thirty-five years on, how far do you think the economics profession has progressed?*

HD: Not very much. Although ecological economics is a big step forward it is still largely ignored by the mainstream.

DM: *How and when did you start using "steady state" instead of the "stationary state" you used in the first years of the 1970s?*

HD: I first used the term stationary state, following the classical economists, especially Mill. But since many arguments were based on physical science where the term steady state was commonly used to denote a dynamic equilibrium, I thought that might be clearer and have a more modern resonance, especially since modern economists didn't study the history of economic thought any more!

DM: *When did you start working on the Steady State Economy? Can you trace the story of Steady State Economy from, say, your publication of On Economics as Life Science?*

HD: SSE grew out of the debates and discussions that TSSE got me involved in, both with students and colleagues. It was an effort to unify, clarify, and tighten the case for a SSE, which required a critique of standard growth economics.

DM: *How did the academy react to your 'drifting' away from mainstream economics very early in your academic career?*

HD: There was more tolerance then than now, and my drift away was gradual. I did enough standard work to easily get tenure and promotions, but finally the distance became so large that conflict became inevitable, and took on a sharper edge as the economics profession turned toward right-wing market fundamentalism.

DM: *Your Steady State Economics book was subtitled "The Political Economy of Bio-physical Equilibrium and Moral Growth". Do you get a sense that the first part of your thesis, "bio-physical equilibrium" has gained wider currency than the "moral growth" part, especially within ecological economics?*

HD: Yes, for sure. There are a lot of objective scientific arguments concerning biophysical equilibrium, ultimate means, etc. Moral growth involves a better appreciation and perception of good and bad, better and worse, and is generally less definite, but not for that reason less necessary. Both economists and ecologists are hung-up on the belief that they should be "value free".

DM: Steady State Economics *has a chapter on "Institutions for a Steady State Economy" where you talk about practical strategies for achieving the steady state economy. Will you revise some of the prescriptions from 1977 in 2008? Social choice theory has made tremendous strides in the last thirty years – are some of those insights relevant in updating your recommendations? Your recommendations thirty years ago stressed the importance of a "coordinated effort" across different sectors of the economy. Surely the social tolerance for government regulation has undergone a sea change in these intervening years. No serious student of biophysical sustainability will suggest leaving sustainability to the market. However, would you want to recalibrate the relative roles for market and government regulation? On a specific note, would you still recommend Boulding's Birth License as necessary to achieving the steady state economy? Thanks to rising incomes, and participation of women in the workforce, birth rates have been falling everywhere (not just in the OECD nations). Population is perhaps still a relevant ecological issue in some parts of the world but do you think per capita consumption is more important today?*

HD: The three institutions were: maximum and minimum limits to the range of income inequality; depletion quota auctions, ; and Boulding's birth license scheme. Income distribution has become more unequal. There is support for minimum incomes, but none for a maximum. I still think that will eventually prove necessary. The depletion quota auction is another name for the cap-auction–trade systems that have come into being already. The Boulding transferable birth license plan is a cap and trade system for limiting births. I think it was the first cap and trade system of any kind to be suggested. No one takes it seriously because population control itself is not taken seriously at the present time. It seems to have fallen under the stricture of "political correctness"—too great an interference with the personal sphere of human reproduction. Yet the politically correct seem to have little difficulty with Nobel Laureate sperm banks, buying and selling ova, and renting wombs for gestation—the latter giving a new meaning to "cheap labor". Also confidence in the "demographic transition" has moved population control to the side. But the demographic transition depends on economic growth, and as that slackens the transition may work in reverse. In sum I think the three institutions I suggested still make a lot of sense, and could well gain political favor in future circumstances.

DM: *Let me get back to the "moral growth" part of your Steady State bargain. Apart from all the utilitarian 'environmental protection' arguments for limiting throughput (and thereby achieving a steady state economy), what would be your three most important ethical arguments for sufficiency? In your later works, you have argued that the logic of sufficiency should precede the logic of efficiency. There are both empirical, and more fundamental first-principle arguments that support your conclusion. Which ones have you found more persuasive in getting people interested in the steady state economy?*

HD: Sufficiency for all should take precedence over luxury for some and insufficiency for others. No one has a right to luxuries while others lack necessities. The position can be stated in utilitarian-efficiency terms if one accepts the law of diminishing marginal utility of income, and the democratic principle that everyone's utility counts equally. On these premises the sum of utility is a maximum when income is equally distributed. As Joan Robinson said these egalitarian implications were sterilized by moving to the notion of Pareto optimality, based on the presumed impossibility of interpersonal comparisons of utility. Somewhat related to this I have argued that "frugality first" gives us "efficiency second" as a consequence, but efficiency first simply makes frugality less necessary—the Jevons or rebound effect. Frugality and sufficiency may not be the same thing, but they are closely related.

DM: *Presumably you want the steady state to correspond with the socially and politically determined optimal scale. Arguably, optimal scale as a benchmark scale can only be defined in terms of a goal for a steady state economy. Has it been a strategic choice not to point to the connection between steady state economy and optimal scale?*

HD: Perhaps. One early argument against talking about a steady state economy was that it was a waste of time until you could specify the optimal scale at which to remain constant. My reply was that knowing the optimum scale without first knowing how to manage a steady state economy would merely allow us to recognize and wave goodbye to the optimum as we grew past it. First learn to live in a steady state, break the addiction to growth. Then seek the optimal scale, which may well be below, rather than above, the present scale.

DM: *One of the most important considerations in defining steady state is the temporal dimension. You have mostly articulated steady state as an economy with constant material and energy throughput. The key question is: for how long, and in what form? Let me be more specific. No steady-state can be sustained for ever – that much is obvious. If one were to ask a technical question it becomes – 'sustain' for how many generations? The size of the steady state throughput determines the answer. This is a deep moral, ethical, religious question. What was your thinking in 1977? Has it changed in the last thirty years?*

HD: Georgescu-Roegen said that mankind's long run economic problem is to maximize the cumulative number of lives over time lived at a level of per capita resource consumption sufficient for a good life. We seem to have chosen instead to maximize the present per capita resource consumption seeking a luxurious life for a "sufficient number" of people, usually taken as the elite of the present generation and possibly the next. This is an ethical choice—a balancing of many good lives versus fewer luxurious lives. The biblical answer is "neither poverty nor riches", but sufficiency. Neither alternative involves forever, for which the model must be death and resurrection—a New Creation.

DM: *Let me now come to the other aspect of the temporal question. A complex system can be dynamically evolving rather than being in a strict steady state, and still be remarkably stable. Some would even argue that if biophysical resilience is the criteria for evaluating economy-ecosystem interactions, economic throughput cannot strictly be at steady state but should be allowed to vary within some narrow band, or perhaps even oscillate around a mean value. However the key idea continues to be the fact that there cannot be an infinite secular growth of throughput. How would your practical prescriptions change if one were to use this expanded definition that is strictly speaking not 'steady-state'?*

HD: Well on average over a longer time period it would still be oscillation around a steady state. Resilience is a tricky notion. Ecologists can't even estimate sustainable yields, so I am not eager to see the less well defined notion of "resilience" take the place of the already hard to specify "sustainability". The subtext seems to be don't worry about exploiting beyond sustainable yield if the system is resilient—but oh yes, it may be brittle too, and we really don't know which.

DM: *I believe Georgescu-Roegen's objected to your articulation of the steady state economy primarily because of differences on how to account for the temporal dimension when talking about a steady state economy. Over cosmic time no economy, in any kind of steady state is 'sustainable' – one of his objections to the steady state conception. Why do you think somebody who made fundamental contributions to the understanding of the temporal dimension in economics (through his distinction between stocks and funds) had trouble seeing the central point that you were making in* Steady State Economics*?*

HD: I don't know. Georgescu-Roegen objected to the steady state model when I used it, but not when Schumpeter used it, when the Classical Economists used it, or when demographers used it, or when he used it. He is right that a steady state does not last forever. Also he is right that entropic degradation of the resource base forces qualitative change in the technologies required for maintaining a constant population and capital stock, so in that sense a steady state develops but does not grow. I thought that had all been said clearly enough, but Georgescu-Roegen frequently surprised me in both his ideas and personal behavior.

DM: *How did you come to use* Ecological Economics *as label for the body of work that was emerging in the late 1980s?*

HD: Bob Costanza and I started the journal and society while colleagues at LSU in 1987. We needed a name and chose "ecological economics" over "economic ecology" and "bioeconomics". It seemed more descriptive than the alternatives. We liked the common first syllable, Greek for "household" applied both to the human and natural households and their proper joint management. We adopted economics as the noun since that is what we thought needed to be changed, specifically to be influenced by ecology.

DM: *To me ecological economics is different from environmental economics because of the inversion of the 'ecosystem is a sub-sector of the macroeconomy' ontology in standard economics. Evidently this is not quite how the academy or the larger public perceives ecological economics. I have a hard time telling people that*

I do not do neoclassical environmental economics. How did so much of environmental economics find its way into ecological economics? For example, why would folks at Beijer want to call their enterprise "ecological economics"?

HD: Neoclassical environmental and resource economics do not see the economy as a subsystem, consequently have no concept of scale of the economy relative to the ecosystem, nor of the metabolic throughput by which the economy lives off the ecosystem, nor of the entropic nature of the throughput and its myriad consequences. Concepts from standard economics such as externalities, rents, user cost, etc., remain useful so they are used by ecological economists and provide some common ground. The Beijer Institute was in my view initially a bridge that attempted to bring the best of ecological economics and standard economics together. It turned out however, that in practice that seemed to mean emphasizing neoclassical economics and forgetting the issues of scale, entropy, throughput and distribution. They did give emphasis to property rights and systems analysis. But it was and is a conservative, elite, top-down institution run by the Swedish Royal Academy of Sciences. Why they chose to adopt the term ecological economics is anyone's guess. Perhaps they thought it was just a nice new name for what they were already doing. Perhaps they wanted to preempt a competing movement they saw as threatening. I was on the first board of directors of the Beijer Institute, but after several years I realized that they were faithfully neoclassical, and I resigned.

DM: *One of the primary precepts to emerge from ecological economics is that there are 'limits to economic growth'. In recent years you have adapted Jevons to articulate the difference between "economic" and "uneconomic" growth. Is this utilitarian framework that you have adapted merely a pedagogical strategy, or do you believe it indeed accurately captures the essence of ecological economics. More specifically, what is the process that will determine the point of inflection in practice – the point where growth goes from being "economic" to being "uneconomic"? Can a* laissez-faire *market process determine the point of inflection in theory, if not in practice? If the market can indeed (even if only in theory) determine the end of "economic growth", then the most important practical prescription of ecological economics is reduced to the familiar "get your prices right" argument. Is your "Jevonian Limits to Growth" consistent with your articulation of optimal scale for the macroeconomy where the optimal scale is socially and politically determined rather than 'discovered' in a* laissez-faire *market process?*

HD: The Jevonian utility analysis is to demonstrate the conceptual existence of uneconomic growth (beyond optimum scale) in language and logic familiar to economists. What institutions will be capable of recognizing and leading us to that optimal scale (and avoid uneconomic growth) is a separate question. Getting prices right helps with efficient allocation. But a different scale just results in a different set of efficient prices for that scale, just as a different distribution also results in a different efficient allocation. A sustainable scale and a just distribution both must be socially and politically determined and imposed as constraints on the market, which can only then determine proper allocative prices. Sustainable scale and fair distribution cannot be discovered by the market. They have to be politically imposed on the market. Only then will efficient allocation really be worth pursuing.

DM: *One of the most prominent areas of research within ecological economics has been the monetary valuation of ecosystem services. Beyond the fact that this research explicitly recognizes the existence of ecosystem services, it quickly morphs into standard neoclassical 'externalities' problem. Do you see this as a problem? Specifically, does it dilute the core precepts of ecological economics?*

HD: I think it is more operational to internalize sustainability by setting sustainable quantity limits, and then let the market calculate the proper rationing price. If we try to calculate the price first on the basis of willingness to pay or accept, or even replacement costs, we are saying implicitly "you can have as much as you want as long as you pay this price". We can always have more by growing more is the message, and limits fade away. A higher price for the good in question slows its rate of use, but the income from the higher price can be used to increase consumption. The price internalization approach is good for efficient allocation, but the Jevons effect or rebound makes it insufficient for limiting scale.

DM: *Let me press on with my previous question for a bit. Is biophysical sustainability, as the term literally implies, an objectively determinable parameter (something that exercises like the ecological footprint attempt to do)? If sustainability is an objective parameter, who should determine the criteria that will be used to define biophysical sustainability? Technical experts? Market? Society?*

HD: Yes, biophysical sustainability is an objective concept, although dialectical rather than analytic—as objective as "money" in my opinion. Since it is an objective concept we would expect that there would be general agreement among informed people, subject to the dialectical nature of the concept. The market—exchange and production driven by utility and profit maximization—would have no way to incorporate the value of sustainable scale, or of just distribution either.

DM: *Pushing on, if different individuals in a society have different conceptions of what constitutes sustainability, how should (and, can) a society aggregate these differing conceptions into a shared societal goal? I ask this question especially in the context of your critique of the utilitarian notions of sustainability. I think most ecological economists would agree with you that the standard Brundtland inspired utilitarian definition of sustainability cannot be operationalized in practice. It can at best serve as a (not so useful) heuristic. However, one of the big challenges for ecological economics is to articulate the institutional pathways through which an alternative biophysical definition of sustainability can be operationalized.*

HD: The first part of this question seems to be premised on a contrary answer to the previous question. I do not see aggregation of differing conceptions, but rather discussion and persuasion elucidating the objective goal. The cap-auction-trade system seems to me the paradigm institutionalization for a policy that serves scale then distribution, then allocation.

DM: *One of the fundamental achievements of modern science is model-building – the most parsimonious description model of the universe (or some part of it) that can explain (and predict) phenomenon of interest. While rightly criticizing neoclassical economics for producing abstract models that are too parsimonious to accurately capture the many non-linearities involved in economy-ecosystem interactions, ecological economists have had to sacrifice parsimony in their own attempts to model economy-ecosystem interactions. Do you believe there is real theoretical (and not just pedagogical) value in complex dynamic modeling framework that has become a cottage industry within ecological economics?*

HD: Complex models are useful as calculating devices that can keep track of many interdependencies. But from a policy perspective they can also be stifling—you can't do anything until you understand everything! For example, complex climate models are full of uncertainties, but it is fairly certain that we cannot continue to put more and more greenhouse gases into the atmosphere without eventually paying an unacceptable price. That is clear from first principles known for a century (Svante Ahrrenius). And that is enough to guide first policy steps. Mid-course corrections to initial policies are always required as we get feedback from the real system. I would rather act on first principles followed by corrective feedback from the real system itself than wait for a realistic model of reality in all its complexity.

DM: *Let me ask a more pointed question about current dynamic modeling trends currently in vogue within ecological economics. Some of the models have hundreds of variables and many of these variables are calibrated using what are at best ad hoc strategies. My guess is that Georgescu-Roegen would not be very amused with these models. For him it would represent a futile attempt – even a pretension of being able describe a nonlinear phenomenon in cardinal terms when only an ordinal description is possible. Would you agree with GR? If you do agree, what should be the role for complex dynamic models beyond being a pedagogical apparatus?*

HD: I suppose it does involve projecting ordinal phenomena on to a cardinal grid, but I have not thought much about that aspect.

DM: *For all the problems that ecological economists have identified with neoclassical economics, the neoclassical enterprise has done remarkably well when it comes to internal consistency. The inherent interdisciplinary nature of ecological economics notwithstanding, what do you think will form the key ingredients of a future project to develop ecological economics into a coherent internally consistent enterprise?*

HD: Probably a breakdown of current global capitalism, provoked by destruction of the supporting ecosystem. The crisis would destroy the legitimacy of standard growth economics. By analogy Keynesian economics would have gotten nowhere without the great depression. Internal consistency is good, but correspondence with external facts is better.

DM: *Any modern intellectual enterprise needs the services of both philosophers and technicians (I am not using this term in any disparaging sense). What do you see as the most promising areas in ecological economics where philosophers and technicians can begin talking to each other?*

HD: I see the ends-means spectrum as a map for collaboration.

DM: *You have suggested that ecological economics is not about reinventing the wheel and you would like to see chunks of neoclassical economics integrated into the future of ecological economics. Can you sketch out the main contours of a program to integrate neoclassical economics with ecological economics? Do you see your textbook (with J. Farley) as representative of this endeavor?*

HD: Yes, I do see the textbook with Josh Farley as a step in that direction.

DM: *A more specific follow up question: is utilitarian ethics compatible with ecological economics? Neoclassical economics is essentially an extension of utilitarianism. Is it even possible to integrate so much of ecological economics that is clearly not utilitarian with neoclassical economics?*

HD: We need to substitute person-in-community for homo economicus, and recognize the entire ends-means spectrum. Utilitarian concepts like marginal utility, supply and demand, consumer surplus, seem to me useful without claiming that utilitarianism has all the answers.

DM: *Finally, what are your predictions for the evolutionary trajectory of ecological economics? What are the three most important things that you would like to see more in ecological economics?*

HD: A stronger normative emphasis on distribution—, intra-generational, inter-generational and inter-species distribution of places in the sun. More emphasis on the entropic throughput of resources as our ultimate means, and on complementarity between capital funds and resource flows in production. More emphasis on scale and distribution relative to allocation. More focus on policy with a consequent affirmation of non-determinism and non-nihilism as necessary philosophical presuppositions of policy to counter the fecklessness of scientific materialism underlying so much of biology, including ecology.

DM: *I guess the last one was not 'final'. Ecological economics has often been described as the science of sustainability. You have written about this elsewhere – the need to distinguish between hope and optimism. Let me end this part by asking you what are your hopes for the sustainability discourse, and how optimistic you are about your hopes?*

HD: Experience with sustainability in the World Bank did not feed my optimism, but I am hopeful nevertheless. Sustainability means longevity—more people over time enjoying a sufficient consumption for a good life. Nothing is forever in the present Creation—both science and Christianity agree on that. Christianity and some other religions hope for a New Creation free from death and decay. Science is not in the business of hope, although scientism peddles a cheap substitute. I share the Christian hope, but also accept the scientific description of the present creation and its subjugation to entropy and finitude. Georgescu-Roegen criticized sustainability and the steady-state economy as advocacy of eternal life rather than of longevity. Maybe some people confused the two, but it is a confusion easily corrected. As creatures of the present creation we must do the best we can with what we have, even while we hope for the New Creation as an eschatological faith. In the past "doing the best we can" seems to have meant a larger and larger population consuming more and more stuff. Now we see that too many people alive at one time and consuming a lot per capita reduces the carrying capacity of the earth and means fewer people and/or lower consumption per capita in the future, and a lower cumulative total. If our ethical understanding of the value of longevity ("sustainability") is to "maximize" cumulative lives ever lived at a per capita consumption level sufficient for a good life, then we must limit the load we presently place on the Earth—fewer people, lower per capita resource consumption, and more equitable distribution. None of this the world wants to hear. But it is strange that some of us hear it. Unless we think we are somehow unique we must expect that others will eventually hear it just as we have.

2. The emergence of ecological economics in theory and practice

David Batker

2.1 INTRODUCTION

The most important advances in economic theories and systems have all involved the development of new economic paradigms that generate solutions for the most pressing economic problems of the day. Adam Smith developed the core theories of microeconomics to explain demand and supply, markets and the emerging industrial economy. Smith's theories explained economics at the scale of firms and markets. John Maynard Keynes pioneered the field of macroeconomics in an effort to understand output, employment, money supply, aggregate demand and the economic cycles that induced The Great Depression. He generated a coherent economic paradigm at the scale of the nation. History's greatest economists have appeared during times of transformation or crisis, when old theories no longer provided adequate descriptions of a changing reality. The great economists were able to transcend the work of their peers to catalyze new economic paradigms capable of explaining these changes, and in the process fundamentally transformed our understanding of the economic system. New paradigms emerge not only from an improved understanding of how our economic system works, but also from new economic goals; they entail new measures of our success in achieving those goals, new funding mechanisms, policies, and new institutions for putting them into practice. Most important, the greatest economists have created practical paradigms capable of generating solutions to humanity's most burning current problems, thus shaping society, even if the solutions are not fully adopted during their lifetimes.

Today's most burning current problems, ranging from environmental crises to the grave shortcomings of our financial and monetary systems, cannot be adequately explained or solved by the mainstream micro and macroeconomic theories that currently dominate both academia and government. Herman Daly's efforts to understand and solve these problems gave rise to the field of ecological economics, which offers a new theoretical framework for economics. Ecological economics completely inverts the dominant paradigm of an economic system unconstrained by biophysical limits and capable of infinite growth, building instead on the laws of physics and ecology to put the economy in its proper place as a subsystem of the finite global ecosystem. Ecological economics has replaced the goal of ever increasing growth with the triple goals of sustainability, justice and qualitative improvements to human welfare. Daly helped develop the Index of Sustainable Economic Welfare to measure our success, and has proposed policies and mechanisms necessary to achieve a steady state economy, a fundamentally new economic institution. However, as was the case for other great economists, the rest of the world is only now, 50 years into Herman's career, beginning to recognize the critical importance of his contributions.

This chapter takes an activist's perspective, and has two objectives. First, it describes in broad terms the evolution of economic theory from micro to macro to "whole earth" ecological economics with a particular focus on Herman Daly, whose pioneering contributions ensure his place in the history of economic thought like Smith and Keynes before him. From an activist's perspective, it is not the subtleties of micro and macroeconomics that are most important, but rather how they are interpreted and applied by policy makers and citizens. The second objective of this chapter is therefore to explain how ecological economic principles can help solve pressing societal programs, using concrete examples of projects done by the non-governmental organization Earth Economics. To an activist, the nuances of ecological economic theory are important, yet it is the pragmatic outcomes that contribute directly to sustainability, justice and quality of life that matter most.

2.2 THE EVOLUTION OF ECONOMIC SYSTEMS AND THEORY: FROM THE PART TO THE WHOLE

Since the dawn of agriculture, economic systems have been in a continuous state of co-evolution, adapting to technological, environmental and social changes while at the same time changing technology, the environment and society in a recursive process. Change in hunter-gatherer society was glacially slow, literally at the pace of natural climate change, perhaps with periods of more rapid change corresponding to new technologies that appeared every few thousand years. With the advent of agriculture, the larger populations it could sustain wrought tremendous changes in social structure, the rate of technological advance, and the rate of environmental change. Those economies that evolved the best adaptations to these changes spread more rapidly than those that did not. The unleashing of fossil fuels during the industrial revolution dramatically increased the rate of change, leading to the emergence of the modern market economy. For the first time, human activities had global impacts on the scale of geological forces. The complexity of the system increased as well, contributing to bubbles and busts such as the great depression. Economic theory and practice has always adapted to past changes, and must continue to do so. When changes are profound, the change to theory and practice must be as well. Such profound changes are commonly referred to as paradigm shifts. The following sections briefly examine the evolution of two previous paradigm shifts as a prelude to explaining why another—the shift to ecological economics—is essential.

2.2.1 Adam Smith and Microeconomics

Adam Smith was born into momentous times. The explosion of scientific and technical knowledge and the unleashing of vast stores of coal for energy were joining together to fuel an industrial revolution capable of transforming human economies and many of the earth's natural systems, increasing the physical production of goods and services as never previously imagined. Monopolies, guilds and the King's unmitigated power to grant commercial empires to cronies were slowly giving way to new economic forces. Adam Smith was able to develop and disseminate a coherent theory of capitalist markets, in which freedom of entry into markets and competition could not only allocate raw materials towards the products that maximized their value, but also lead to ever greater production (Smith 1776). His work sped the transition process to this new economic system at a time when increased availability of basic market goods could profoundly improve quality of life.

Smith's vision of liberty, production, and efficiency in a primarily capitalist economy provided a paradigm shift away from rigid and potentially stifling economic order, to one capable of harnessing the energies and technologies at its disposal. His most widely recognized insight was that the self-interested activities of individual economic actors would lead to the greatest good for society, as if guided by an "invisible hand". Markets could therefore be viewed as self-regulating, with little need for government intervention. Smith not only recast economics, but his work provided a path for partially eating away at the social hierarchy of his time, providing greater economic opportunity and mobility to a greater swath of the population. Yet Smith's world was not one devoid of regulation, indeed his came in the form of sympathy and ethics as discussed in Moral Sentiments (Smith 1859). Moral philosophy and economic motivations were not divorced in Smith's economic vision.

Though Smith himself was a classical economist, he is widely seen as the father of modern neoclassical microeconomics, which by the end of the 19th Century had transformed economics into the "scientific" (i.e. mathematical) study of markets, firms, and households. Though Smith explicitly saw an important role for human empathy and government intervention to make markets better serve the needs of all, he was widely interpreted as a prophet of an unbridled market free from government constraints or moral behavior. Smith was focused on the motivation of individuals, on how factories and firms worked, markets, and households, yet even microeconomics shifted away from Smith's moral view to a positivist perspective. In spite of his microeconomics insights, however, for Smith, economics at the scale of the nation was largely an empty set.

2.2.2 John Maynard Keynes and Macroeconomics

The Great Depression had a long gestation period. Factors contributing to the depression included falling agricultural prices and rural incomes after WWI, rising unemployment, greater job and income insecurity, a lack of modern monetary policy, and the growing gap between rich and poor. The dramatic collapse of a barely regulated stock market in 1929 was another symptom of trouble. This led to a massive banking crisis, foreclosures, deflation, shrinking production, business bankruptcies and massive unemployment. Suddenly, the economy could no longer employ unused machinery and unemployed labor to meet unmet human needs. Despite hunger and tremendous suffering, the overwhelming policy advice from mainstream economists of the early 1930s was to do nothing. This advice was based on economic theory that neither required nor provided any measures of unemployment, inflation, or production. Deep faith in a self-regulating economy led the leading economists of the day to assume that, as surely as winter turns to spring, the "business cycle" would return prosperity, even as an economic ice age delivered year-round winter.

Those not fixated by free market ideology however recognized that the dominant economic paradigm of the 19th Century was incomplete, incorrect and incapable of solving the most challenging economic problems of the Great Depression. Most notable among these economists was John Maynard Keynes, another of history's great economists who helped catalyze an economic paradigm shift. Keynes' accomplishment was to create an economic framework at the national scale capable of dealing with the vexing and urgent economic problems of the Great Depression (Keynes 1936).

Keynes new economic framework came to be known as macroeconomics.

Macroeconomics was driven by a new set of goals, including full employment, maintaining aggregate demand, managing inflation, limiting working hours, setting a minimum livable wage and providing secure income for the elderly. These new goals had to be supported by a new set of economic measures at the national scale, including unemployment, GDP, inflation, money supply and more. They also required new policies including fiscal stimulus and unemployment insurance, and new national-scale institutions such as a re-vamped Securities and

Exchange Commission, new banking regulations, the Labor Department and Social Security.

Keynes, his macroeconomist contemporaries, and critically, President Franklin Delano Roosevelt were not interested in re-building a nineteenth century economy. Macroeconomics and the experimental policies of the New Deal were intended to fundamentally restructure the Nation's economy, to build a completely different and better 20th Century economy.

The Keynesian policies of the New Deal only fully succeeded with the enormous deficit spending driven by World War II, and only became basic tools of government policy in the 1950s and 60s, years characterized by middle class prosperity. Though Keynesian principles fell out of favor during the 1970s under the influence of Milton Friedman and later Thatcher and Reagan, in many ways virtually every nation in the world, communist, socialist, capitalist or hybrid, is still guided by macroeconomic goals, measures and policies. Macroeconomics is still seen by many as "modern" economics.

The Depression and the emergence of macroeconomics were part of a turning point in human history. Twentieth century national industrial economies were built on technological advancement, and fueled by a shift from coal to oil and natural gas —millions of years of stockpiled sunlight available as highly concentrated, portable liquid energy. Macroeconomic theory led to an increasing focus on economic growth, which was considered necessary to maintain full employment with stable prices. Cheap and abundant petroleum proved capable of fueling growth at unprecedented rates, while New Deal policies succeeded in distributing benefits more equitably than ever before. However, economic growth gradually came to be seen as an end in itself, with greater importance than reducing unemployment or poverty. When macroeconomics first emerged, the global economy still appeared fairly small relative to most resource stocks and planetary systems, and limits to growth were not so obvious. This is no longer the case.

2.2.3 Herman Daly and Earth Economics

The economic and ecological crises we face today are more daunting than the Great Depression. For example, the green house gasses generated by economic activity are profoundly changing the earth's atmosphere. Climate change will span not years or decades, but centuries or millennia (IPCC 2013). Paradoxically, another threat is that the global industrial economy is running out of oil (Heinberg and Lerch 2010). Renewable resources are also being depleted far faster than they can regenerate. The human population may already exceed the planet's carrying capacity, and is predicted to grow by another two billion. An unsustainable use of resources is accompanied by increasingly unjust and inefficient distribution. While many people in the world today over-consume to a point of making themselves obese and sick, clearly reducing their quality of life, a billion others lack the most basic necessities of adequate food, clean drinking water, clothing, shelter, basic education and opportunity. While arguably far less severe than our ecological crises, our recurring financial crises regularly plunge additional hundreds of millions of people into poverty.

Unfortunately, most economists lack adequate training in the natural sciences. They fail to acknowledge the role of global ecosystems in sustaining all economies, and hence are wholly incapable of tackling these 21st Century problems. Microeconomics focuses on relative scarcity and the role of prices is to balance the supply of market goods with the preferences of individuals living today weighted by their purchasing power. Macroeconomics studies the economy at the national scale and strives for unlimited growth. Both essentially ignore the central problem confronting humanity today, which is the physical relationship between limited, fragile natural systems and the scale of the built economy that depends on those systems to generate resource inputs and absorb waste outputs. As a result, without an understanding of physical scale limitations, conventional microeconomics, macroeconomics, trade economics and international economics are incomplete, incorrect and incapable of solving our current crises.

Fortunately, many economists have provided important insights into separate components our current crises. Malthus (1798) recognized the physical limits to exponential growth. John Stewart Mill (1909) foresaw the need for a steady state economy. Soddy (1935) pointed out the incongruity between a monetary system based on interest bearing debt that obeys the abstract mathematical laws of exponential growth, and real economic assets whose growth is constrained by physical laws. Kenneth Boulding (1966) introduced the concept of a spaceship earth. Nicholas Georgescu-Roegen (1971) forcefully promoted the idea that economies are physical systems subject to the laws of physics, such as first and second laws of thermodynamics (a radical idea in economics). Culbertson (1985) identified flaws in modern trade theory, pointing out that we are in a world of absolute advantage, not comparative advantage.

However, it took the efforts of Herman Daly and the other pioneers of ecological economics to draw these different strands together into a coherent theoretical framework capable of responding to these historic crises. Ecological economics integrates economics into a transdisciplinary framework that transcends previous economic paradigms. Like macroeconomics before it, ecological economics transforms the very framework and scale of economics. An economy must be properly scaled within the physical systems that sustain and contain it. A city resides within one or few watersheds, the global economy within the troposphere (albeit largely protected from UV radiation by the stratosphere's ozone layer, and fueled by the sun). A finite planet cannot sustain 200 national economies dedicated to limitless physical growth. According to the International Monetary

Fund, the global economy is experiencing "slow growth" (Talley 2014), which would be much slower still if the environmental and social costs of that growth were subtracted. We are not faced with a choice between an economy of unlimited physical growth or a steady state economy. The former is physically impossible. We have a choice between economic collapse or a steady state economy.

A finite scale to the economy forces society to pay attention to distribution: excessive consumption by the rich deprives future generations and the poor of basic needs. Solutions to our current crises require a global perspective with a solid grounding of economics in science and ethics: we must adopt a new set of goals including the proper scale of the economy relative to the natural systems upon which every economy and all people depend. Daly has therefore proposed new economic goals, measures, policies and institutions designed to prevent the economy from exceeding the physical boundaries imposed by a finite planet and to ensure the just distribution of wealth and resources within those boundaries.

A new paradigm that views the economy as the part and the ecosystem as the whole, requires a new set of economic goals: sustainable scale, just distribution, and efficient allocation (Daly 1992). Perhaps the recognition of scale—the size of the economy relative to the ecosystem that sustains and contains it— is Daly's most significant contribution. Recognition of scale radically changes economic analysis. For example, conventional economists have diagnosed the origins of our current financial crisis as inadequate liquidity. Daly in contrast correctly diagnoses the problem as too much liquidity leading to the accumulation of paper and electronic money, pension funds, stocks and bonds, interest and debt, bundled mortgages and derivatives, which are nothing more than ephemeral promised wealth. The production of real stuff to which every dollar (well-earned or ill-gotten) ultimately lays claim simply cannot keep pace. One option is to devalue the ephemeral claims to wealth while trying to minimize the impacts of the resulting economic disruption on the poor. A second, futile option is to try and continually increase the supply of physical stuff in response to excess liquidity and ever-burgeoning demand for credit, which must inevitably lead to climate chaos, resource depletion, peak oil, and an increasing toxic environment. These are the economic challenges of the 21st Century. Instead of striving to increase physical economic growth, societies must respect physical scale at every level of ecological economic aggregation, from neighborhood to nation to planet or suffer the fate of past societies that have collapsed after failing to do so (Diamond 2005). For the first time in human history, however, we threaten to exceed sustainable scale at the global level. We had microeconomics and macroeconomics, but prior to Daly, there was no global-scale economics, no Earth Economics.

Daly has also developed new economic measures to support a 21st Century economic paradigm. His Index of Sustainable Economic Welfare (ISEW), developed together with John and Clifford Cobb, improves the tremendously flawed GDP to provide a more accurate measure of welfare (Daly and Cobb 1994). Daly's work has directly inspired efforts to develop other measures and tools, such as the ecological footprint, full-cost accounting, life-cycle analysis, ecosystem service analysis (identification, valuation, mapping and modeling), and perhaps most critically the integration of geographic information systems (GIS) and economic analysis. These tools are needed to emerge from the dark ages of macroeconomic theory that fails to recognize that the economic system is an embedded part of global and local ecosystems. Currently, macroeconomic theory fails to perceive climate change, resource depletion and other ecological and resource crises as economic problems. Economists of the 1930s had no theory for the importance of employment in the economy and no measures of it. They were left with the grossly negligent "do nothing" policy. Today, because economics is so deficient in measuring the costs of climate change and so adept at devaluing future generations, "it costs too much" remains the predominant economic argument against addressing climate change (Mendelsohn 2006; Tol and Yohe 2006; Nordhaus 2007).

Daly has suggested numerous new economic policies designed to create a sustainable, just and efficient economy. He has not shied away from tough problems or tough audiences. Herman suggested to OPEC, at their invitation, a structure for including the costs of carbon emissions into oil prices at the wellhead. Herman has even tackled the politically sensitive topic of population control, daring to suggest that we must purposefully limit births (Daly 2007). While these ideas are controversial, they are also correct. For example, the US state of Louisiana with a population of 4.6 million (2014) and an area of 52,000 square miles is composed of the Mississippi River delta and has a slightly smaller land area than the deltaic country of Bangladesh at 57,000 square miles with a population roughly 36 times larger. If Louisiana housed 166 million people, could it feed itself? What would be the impact on wages or quality of life? What will happen to both Louisiana and Bangladesh as the agricultural deltas upon which they reside continue to subside into salt water; as sea level rises; and as storms become more powerful? Population, over-consumption and excessive waste emissions are central issues in the economics of the 21st century, but are largely ignored by both micro and macroeconomics.

Today, humanity is at a crossroads and can no longer rely on myopic economic theories and institutions. Daly's vision of a sustainable and just economy coupled with his capacity to weave together the most brilliant insights of 20th century economists and ecologists with his own original thoughts provides a new 21st Century economic paradigm capable of helping solve the world's most pressing problems. Ecological economics must eventually be adopted by universities. This does not displace conventional micro and macroeconomic theory, but rather provides the broader context in which these incomplete disciplines can be understood. When that happens, Daly will assume his rightful place in the pantheon of great economists along with Adam Smith and John Maynard Keynes.

2.3 EARTH ECONOMICS IN PRACTICE

While a paradigm shift within academia and among policy makers is important, meaningful applications of ecological economics need not await this change from within. Daly's work has spurred the efforts of activists, academics outside of mainstream economics, and civil society to change both economic theory and practice. The remainder of this chapter chronicles the efforts of one NGO, Earth Economics, to transform Daly's theories into solutions to pressing societal problems.

The Mississippi Delta, Ecological Processes, Scale and Economics

The scale of the solution must be at the scale of the problem. North America's largest river basin and delta provide a vivid example.

The Mississippi Delta lost over 1.2 million acres of land since the 1930s (CPRA 2007). In some areas, the coastline has retreated by as much as 30 miles (CPRA 2012). The lower Mississippi River is constricted by levees, flushing billions of tons of valuable sediment and trillions of gallons of valuable freshwater into deep water off the edge of the continental shelf, and cutting the river off from the delta. In addition, oil drilling from canals allowed salt water to move into freshwater areas and has killed vast tracts of fresh and brackish marshlands as well as contributing to subsidence in some areas. Hurricanes Katrina and Rita struck in 2005 shocking the nation and world, killing over 1,400 people, and inflicting over $200 billion in public and private damages (USGAO, 2006). The record Mississippi River Flood of 2011 damaged cities, farms and factories along the river and its tributaries, costing the Federal Emergency Management Agency a fortune in flood insurance damage claims while the 2012 Mississippi Basin drought left farmers with withered crops, costing the US Department of Agriculture a fortune in crop insurance. Both floods and droughts temporarily halted shipping on the Mississippi River, compounding these losses.

When a delta falls apart, the economy and people it houses cannot stand aloof. The State of Louisiana is now undertaking the largest, and unquestionably most well-funded deltaic restoration effort in world history. The current effort, detailed in "Louisiana's Comprehensive Master Plan for a Sustainable Coast" sets out a $50 billion coastal restoration effort (CPRA 2012). Though not stating it explicitly, the plan is based on ecological economic assumptions. Economies need nature. Louisiana's coastal economy is housed within the Mississippi Delta and Chenier Plain. Without a healthy Mississippi Delta and Chenier Plain, the wetlands, economy, and population of the area will shrink.

This is not only an issue for the 2.2 million people who live in coastal Louisiana. The scale of both the problem and hence necessary solutions is larger. The Mississippi River Basin comprises 3.2 million km2, about 40 percent of the continental US. Over 28 % of the nation's oil and gas is piped through the Mississippi Delta. The Ports of South Louisiana, New Orleans, and Baton Rouge are ranked 1, 5 and 10 as the largest ports in the US by tonnage (USDOT 2014). As sea level rises, the slope at the mouth and delta of the Mississippi River is reduced, affecting flooding throughout the river's main stem and major tributaries. The Mississippi River Delta, the basin, farming, flood control policy, sediment, and drought are all a closely connected yet jumbled ecological-economic system (Day et al. 2014).

Is restoration possible? The short answer is yes: a two-year study has shown that while all deltas are in flux, losing and gaining land as sediment and river channels shift, sedimentation and wetland plant growth can outpace sea level rise (Day et al. 2014). An orderly decommissioning of dams on the Missouri and western Mississippi Basin would release sediment needed to achieve this goal in Louisiana. To mitigate future flooding, appropriate management techniques could store more floodwaters on agricultural lands and wetlands. This could be achieved through a funding mechanism that rewards farmers for storing water and conserving wetlands. This not only reduces flooding, but recharges groundwater and retains moisture on farms in case of drought. In addition, Improvements, such as no-till planting, cover crops, better tillage timing, stream buffers and other policies, would also reduce the scale of on farms fertilizer usage and costs, while reducing nitrate flows into rivers (Salomon and Sundberg 2012). Applied in the highest fertilizer use areas of the Mississippi River Basin, these policies could also improve the Gulf of Mexico water quality. Shrinking the nitrogen leaching into the Mississippi River on a large scale would reduce the hypoxic marine dead zone in the Gulf of Mexico, and presumably increase fishery production.

Is restoration worth it? Not if nature counts for nothing. A $50 billion investment is a lot to invest in a delta. However, if the Mississippi Delta were treated as a typical capital asset, a 2010 study by Earth Economics showed that "Mississippi River Delta ecosystems provide at least $12-47 billion in benefits to people every year. If this natural capital were treated as an economic asset, the delta's minimum asset value would be $330 billion to $1.3 trillion (3.5% discount rate)" (Batker et al. 2010). Maintaining and enhancing a $1 trillion asset, upon which far more built assets are based, is likely worth a good investment. This valuation is based on only 11 of 21 identified categories of economic value provided by marine waters, wetlands, swamps, agricultural lands and forests. The goods and ecosystem services valued in the study included "hurricane and flood protection, water supply, water quality, recreation and fisheries. The Mississippi River Delta is a vast natural asset, a basis for national employment and economic productivity. It was built by literally gaining ground: building land with sediment, fresh water and the energy of the Mississippi River."

These values are for a capital asset—the delta— in a state of collapse. Restoration both avoids the costs associated with a delta continuing to disintegrate, and provides benefits with areas of wetland and barrier island expansion. Aggressive restoration could provide as much as $62 billion in annual increased benefits over the current path of continued collapse.

It's worth noting that Herman Daly spent decades teaching at Louisiana State University and influenced a generation of academics, government officials and citizens. The International Society for Ecological Economics was founded in Baton Rouge, Louisiana. Though many are ignorant of Daly's influence, others who now advise the world's largest restoration project and recognize "emerging megatrends" at the landscape level such as Dr. John Day, recognize Daly's leadership (Day et al. 2013). A delta is a fertile place, even for ideas once considered to be weeds.

2.3.1 Improving disaster economics: FEMA adds Nature into benefit/cost analysis

Benefits provided by nature are frequently referred to as ecosystem services. One of many services that coastal wetlands and barrier islands to people is the reduction of storm surges that accompany hurricanes. The science and economics behind these "ecosystem services" is becoming more widely understood. For example, after Hurricane Rita, students from Louisiana State University marked out the debris line, which measures the maximum extent of the hurricane storm surge. Where unimpeded by wetlands, the storm surge did vast damage. Where wetlands and barrier islands stood in the path of the storm surge, the storm surge was greatly reduced, and did less damage. That reduction in damage can be measured and monetized, providing an estimate of the dollar value of damage mitigation provided by wetlands and barrier islands. Human made services like those provided by a levee have always been accounted for. In contrast, benefits of ecosystem services such as disturbance regulation and water provision are not sold in markets, do not show up on asset sheets, and until recently were largely ignored in economic analysis.

Incorporating the value of natural systems, including riparian areas, green space and floodplains, can have profound impacts on policy. Prior to 2013, such values were typically ignored in disaster risk reduction economics. In the post-Katrina years, under new leadership and with staff given the mandate to improve analysis and results, the Federal Emergency Management Agency embarked on a process to better achieve the mission of the agency to "build, sustain, and improve our capability to prepare for , protect against, respond to, recover from and mitigate all hazards." One approach FEMA has adopted is to systemically include dollar values for riparian areas and open space in all FEMA decisions concerning mitigation for flood and hurricane damage. Flood and hurricane damage accounts for about 80% of FEMA mitigation expenditures.

One of FEMA's roles is to provide financial assistance to people, businesses and agencies affected by natural disasters. The monetary value of damages to every house, business, road, water filtration plant, barn or structure is entered into FEMA's disaster benefit/cost (BCA) tool to calculate the amount of mitigation funding and the most appropriate action to avoid future damages. One of the most critical is whether to repair or rebuild the structure in place, or to move structures and people out of the floodplain. Relocation is nearly universally more costly than rebuilding or raising structures. The past FEMA BCA Tool (V4.8) did not account for the fact that buying out landowners in a floodplain and returning the land to a more natural state reduces the flood risk to other properties by expanding flood storage or conveyance, at the same time that it improves water quality, wildlife habitat, recreation opportunities, in addition to other economic benefits. Without counting the benefits of land returned to the floodplain, the economic bias was to rebuild in the same location even if residents wanted to move out of harm's way. This omission historically contributed to rebuilding in disaster-prone areas, repetitive flooding, increased costs to homeowners, businesses, cities, counties, states and the National Flood Insurance Program (NFIP). The NFIP was $24 billion in debt in 2013, with FEMA and congress approving higher flood insurance rates (GAO 2013).

In 2012, Earth Economics provided FEMA with estimates of the monetary values of 37 ecosystem services for inclusion in the FEMA BCA Tool (V5.0). The values were reviewed by an expert panel as well as FEMA staff and management with a subset approved in June 2013. This landmark policy is the first systemic application of ecosystem service valuation in economic analysis for a US Federal Agency (FEMA 2013b). And everyone is happy.

The values were tested by applying them to past flood events. Had this valuation process been adopted prior to those evens, it would have led to decisions that reduced repetitive damage and disaster expenditures. FEMA's top policy committee agreed not only to incorporate ecosystem service values into future decisions, but also retroactively adopted these values for use in Hurricane Sandy mitigation, allowing more people who wanted to move out of areas most threatened with potential repeat damage to do so.

Moving quickly to purchase flooded properties is critical. Subsequently, FEMA ran a test case of 33,000 flooded houses and showed an average of a 300% return on investment for relocation of any house valued at $275,000 or less. FEMA adopted a second policy for approval of house removal for any house below $275,000 without the need to conduct a BCA (FEMA 2013a). These policies opened the door for the Agency to consider a third critical policy, adopted in

December 2013 in which sea level rise, and the increased risk and associated costs of flooding and hurricane damage would is included in the BCA flood and hurricane mitigation tool (FEMA 2013c). These actions unquestionably save money for both taxpayers and people affected by disasters, and are lead policies that implement climate change adaptation by removing structures from repetitive flooding areas.

2.3.2 Watershed Investment District

One of the hallmarks of the 20th century was the creation of the single purpose tax district. If flooding is a problem, create a tax district to build levees and solve it. For storm water, create storm water districts and pipe water into the river (which contributes to higher peak floodwaters). Water utilities, waste water utilities, port districts, park districts, shellfish districts, conservation districts, school, fire, police, emergency, even subsidence districts have been created. And the list goes far beyond these. Washington State in the US gained statehood in 1889 at the height of the Populist Movement. Rather than concentrate power at the state, county, or city level, the state promoted a multitude of independent tax districts. Though many of the problems these taxing districts are intended to address are environmental in nature, such as stormwater, the district boundaries have often been drawn without the consideration of environmental boundaries. Tax districts at the scale of the watershed would be particularly appropriate in many cases. Washington State has watershed scale institutions, the Water Resource Inventory Areas, but they have no taxation authority.

The Duwamish/Green River watershed, also known as Water Resource Inventory Area #9 (WRIA 9), includes 16 cities from Black Diamond to Seattle. Contained within that 556 square miles watershed are about 150 separate local tax districts. In addition, federal agencies working within the watershed include the US Army Corps of Engineers, FEMA, EPA, US Forest Service, US Fish and Wildlife, Social Security and 140 other federal agencies (present in most all other US watersheds as well).

Though perhaps extreme, Washington State typifies a problem. There were once 16 storm water districts busy building pipes to get water out of the city and into the river, while a local flood district, cities, King County and the US Army Corps have been experiencing higher peak flood flows and levee damage. This can be called infrastructure conflict, where some infrastructure destroys or impairs the functioning of other infrastructure. That’s expensive. At the same time, both the storm water systems and levees have damaged salmon and reduced water infiltration to recharge groundwater.

Ecological economics can be applied to help solve such problems. Scales of governance – towns, cities, provinces, and nations— map political boundaries, but rarely coincide with ecological boundaries, such as a watershed marked out by the physical features of mountain ridges. The boundaries of economic systems are affected by both political and ecological boundaries, but rarely defined by either. Adopting a systems approach, ecological economics recognizes that effectively managing natural assets requires matching governance scales to economic and ecological boundaries. River basins, watersheds, and sub-watersheds are often suitable scales for managing benefits such as water purification, storm water regulation, flood risk reduction, waste water processing and ecological restoration. Unfortunately such boundaries are too often ignored.

In 2011, WRIA #9 representing King County, 16 cities and other agencies and jurisdictions worked with Earth Economics to draft legislation, now under legislative study, to create a watershed investment district to rationalize water related investment at the watershed scale.

The Watershed Investment District is designed to coordinate water-related investments and fund both built and natural capital investments. All watersheds are different, physically and politically. Thus the structure of the watershed investment district must be highly flexible. The district as currently laid out in draft legislation would allow jurisdictions to coordinate existing district investments in water, and where rational and supported, merge existing tax districts. The remit would include a few or all of the following: storm water, drinking water, waste water treatment, river nutrient and water temperature levels, flood risk management, salmon habitat restoration, forestry and rural landowner education. Earth Economics' role is to create the framework, identify points of contention and opportunities and be available as an "expert" resource for policy makers and citizens.

Though Earth Economics does not conduct any lobbying for this project, it has created a list of 10 Reasons Why a Watershed Investment District (WID) is a Good Idea:

1) Facilitates Watershed Scale Built and Natural Capital Investments
2) Rationalizes Tax Districts
3) Allows for More Efficient Infrastructure Spending
4) Provides Sustainable Funding Mechanisms
5) Improves Growth Management and Planning
6) Creates New Opportunities for Public Discourse
7) Develops Green Infrastructure as a Critical Part of the Green Economy
8) Appeals to all Political Perspectives
9) Recognizes Solutions must be at the Scale of Problems
10) Empowers Local Decision-Making
11) Paves the Way to a 21st Century Economy

In addition, in the case of the Duwamish/Green River, the participants in the 2011 WRIA 9 process identified 25 funding mechanisms to facilitate salmonid recovery and restoration as well as to provide other services. The first of these funding mechanisms identified was approved without the full creation of a Watershed Investment District. The King County Flood Control District approved a $1.2 million in funding to WRIA 9 for salmon habitat restoration (King County Flood Control District 2013). For example, with the watershed approach, over $75 million in overlap between flood risk reduction and salmon restoration projects have been identified, dominated by levee set-backs which allow for greater flood storage and conveyance as well as salmon habitat.

By examining a full watershed as a productive asset, and examining all of the water-related infrastructure, governance is more effective. Infrastructure conflict is better avoided and money is saved. Flood districts can both provide better flood risk reduction services and provide co-benefits, such as salmon, groundwater recharge and recreation. Setting levees back, for example, restores floodplains, provides room for salmon, provides greater flood risk reduction with lower costs and longer levee lifetimes (with a wider floodway, floodwaters lose power when spread out. In addition, the vision of greater efficiency, saving money, reducing disaster impacts, and providing services more effectively can unite the often-contentious leaders from the cities and other jurisdictions from conservative Black Diamond to liberal Seattle.

2.4 CONCLUSION

The most influential economists, such as Adam Smith, John Maynard Keynes and Herman Daly provide practical solutions to the most pressing economic problems of their times. Herman Daly's most important theoretical contribution to economics was to establish the central importance of relationship between the scale of the economy and the scale of the natural systems that contain and provide for the economy. This contribution makes it obvious that effective policies must account for scale, and must be driven by the goals of sustainable scale, just distribution and efficient allocation. Also, considering the value of natural assets as economic assets facilitates synchronizing the scale of the solution to the scale of the problem, as in the case of the Mississippi River Delta restoration. Wise policy, based on both science and economics can save the taxpayers a great deal of money. Finally, the creation of new institutions that can better implement solutions at the watershed scale is needed. The Watershed Investment District is just such a potential institution.

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7. Denying Herman Daly: why conventional economists will not embrace the Daly vision

William E. Rees

7.1 INTRODUCTION: THE ILLUSION OF REALITY

This chapter contrasts key elements of the dominant neoliberal free market brand of economics with Herman Daly's steady-state ecological economics and provides a partial explanation of why the world prefers the former to the latter. To those who rigorously compare the two visions, there is little question that the Daly brand is more rational and better grounded in reality. Yet in half a century it has gained little traction in the minds of the public and policy makers alike.

This is no mere academic dispute. If pervasive influence is the measure, traditional neoliberal economists may well be the most universally acclaimed of performers on the global economic stage. Nevertheless, my starting premise is that for all the seeming elegance of their analyses, neoliberal economists are little better than master illusionists. The audience will therefore be excused for feeling betrayed – or merely silly – if the stage is left empty when the magician's mist of abstract equations has finally dissipated on the evening air.

Neoliberal economists should take no special offence at having their sleight-of-hand exposed. Technically speaking, all economists – even Herman Daly – are illusionists. In fact, everyone is. We can't help it. Humans necessarily conceive in metaphor and think from conceptual frames that may actually have little basis in reality. This is worth thinking about because metaphors, myths and models largely determine how individuals and whole cultures interact with each other and the rest of the material world. Indeed, my second premise is that the fate of civilization may well hinge on the content of contemporary conceptual models, particularly the economic models that give force and direction to both national and global development policy.

Some people may find the assertion that society is illusion-driven difficult to accept. Hard-headed practical people in particular will claim that their thoughts, politics and actions spring from 'real-world' experience; no mystical musings or whimsical abstractions interfere with *their* judgment. The problem with this is that humans actually have little truly direct experience of even physical reality. The best we can say is that we base our actions on seasoned perceptions – and seasoned perceptions, like all perceptions, are only elaborate models.

'But wait,' you protest, 'surely we experience the physical world directly through our five senses. Vision, hearing, touch, taste and smell have evolved precisely to enable us to navigate safely through the material world!'

On one level this is true and, by all the evidence, the process has worked fairly well. But consider for a moment what is involved with just our power of sight and, by inference, our other senses.

7.1.1 The Anatomy of Primary Illusion

Humans are visual animals with a well-developed optical system; vision is perhaps the most highly evolved of our senses. If you and I were sitting opposite each other at a well-lit table we would no doubt agree that each could 'see' the other (assuming, of course, that we are normally 'sighted'). Indeed, if encouraged, either could come up with a vividly elaborate verbal description of the other's physical being. (Add the interpretive freedom due artistic license and we might have the basis for an interesting party game!)

But would we actually be describing each other, the 'real (physical) thing'?

In fact, we would not. 'Seeing' does not provide the observer direct access to anything! We don't see objects per se, we detect light reflected off those objects, and this light contains only a tiny quantum of the total information about the object that might be revealed if we had sensory access to the entire electromagnetic spectrum. [1]

Fortunately, evolution has provided us with a very sophisticated instrument with which to extract that quantum of information. The human eye is a complex organ 'designed' to project a sharply focused image of perceived objects onto a light-sensitive tissue at the back of the eye called the retina. Thus, we can claim to experience reality at least indirectly as represented by tiny images-in-light dancing on the backs of our eyeballs.

But even this is not quite true. Our brains cannot decode light per se no matter how well focused and exquisitely detailed the retinal image (which, by the way, is upside down). The retina must first encode the image into electrical impulses, the only form of 'data' that the brain can understand. The optic nerve then conveys the impulses to various parts of the brain for processing and interpretation and only when the signal finally (but seemingly instantaneously) arrives at the primary visual cortex do we actually experience 'seeing.' (That said, just how the brain assembles the continuous cascade of optical data into a coherently comprehensive virtually real-time moving picture remains largely a mystery!)

What this technical romp reveals is that even our most vividly 'real' visual pictures are, in fact, nothing more (or less) than neural reconstructions of initially scanty data that are subsequently filtered by the mechanical eyeball and undergo at least two energy conversions in the retina before being fed to an unknown number of neuro-interpretive processes (all at what loss or tainting of information?) before finally emerging as sensory 'experience.'[2] In short, the sensory images that we use to regulate our interaction with the rest of the biophysical world (generally quite successfully) are mere feeble abstractions – and we often submit even these to subjective interpretation based on our previous education, socialization and personality. Bottom line? Humans routinely operate from sensory illusions that are woefully incomplete and distorted shadows of corresponding physical reality. Sometimes the imperfections and omissions are hazardous to life. We cannot see the camouflaged predator, taste the toxins in our food or sense the high-energy radiation that eventually gives us cancer.

All of which poses an interesting question: If the brain's reconstructions of the physical world are such partial representations, how much more ethereal and potentially dangerous are concepts, myths and models that are entirely socially constructed or that have few real-world touchstones? This is no trivial matter: a glance at the headlines reveals that religious dogma, political ideology, disciplinary paradigms (including economic paradigms) and all manner of cultural norms are more important determinants of how people behave as social beings than is their sensory experience.

7.2 SECONDARY ILLUSION AND DUELING PARADIGMS

> All thinking about the world involves a degree of abstraction. Economics has taken this principle further than any other social science. (Wolf, 2010)

> Existing economics is a theoretical system which floats in the air and which bears little relation to what actually happens in the real world. (Coase, 1997)

Which brings us back to economics. Economics used to be concerned with what people did with and on 'the land' to acquire the material basis of their own existence. The eighteenth-century 'physiocrats' believed that land, particularly agricultural land, was the source of national wealth and valued agricultural labor as the means to extract it. Physiocracy, sometimes called the first body of organized economic thought, was also the last body of traditional economic thought to be so conceptually wedded to biophysical reality.

The divorce is virtually complete when it comes to the neoliberal market economics that dominates global development thinking today. 'Something strange happened to economics about a century ago. In moving from classical to neo-classical economics . . . economists expunged land – or natural resources' from their theorizing (Wolf, 2010). Land and resources were quietly dropped from mainstream production functions as capital (including finance capital) and knowledge came to be perceived as the principal sources of wealth and drivers of growth.[3]

This abstraction could be maintained historically: (1) because the undervaluation of nature relative to other factors of production (no one pays the earth for the resources we extract) means that in 'advanced' economies land and resources per se often contribute only marginally to gross domestic product (GDP) and (2) technology has succeeded until recently both in keeping the costs of extracting raw materials low and finding substitutes for some resources that have become scarce (for example, coal substituted for wood as the primary fuel of the industrial revolution; fish-farms increasingly substitute for wild fish stocks; fertilizer substitutes for depleted soil in industrial agriculture). Bottom line? Most contemporary economic models still float free from biophysical reality, blind to the energy and material flows essential for human existence and to the 'natural capital' stocks that produce them (Box 7.1).

7.2.1 The Economy as Self-fueling Machine

This blindness is the target for one of Herman Daly's most pointed challenges to mainstream thinking. Consider that mother of all conventional economic models, the 'circular flow of exchange value' (Daly, 1991a, p. 195). Economic textbooks typically feature a standard circular diagram of the economic process as 'a pendulum movement between production and consumption within a completely closed system' (Georgescu-Roegen, 1993, p. 75). Value embodied in goods and services flows from firms to households in exchange for spending by households (national product). A supposedly equal value, reincarnated in factors of production (labor knowledge, finance capital), flows back to firms from households in exchange for wages, rents, dividend and so on (national income).

Mainstream texts sometimes suggest that this stripped-down economy operates as a perpetual motion machine, generating a 'flow of output that is circular, self-renewing, self-feeding' (Heilbroner and Thurow, 1981, p. 127). From this perspective, economic growth is a spontaneous autocatalytic

BOX 7.1 THE CONSTANT CAPITAL STOCKS CRITERION FOR SUSTAINABILITY

Much contemporary discussion of 'sustainability' hinges on the concept of 'Hicksian income' after the British economist, Sir John Hicks. Hicks defined true income as the maximum level of consumption that an individual (or nation) can consume over a given time period while leaving wealth-producing capital intact (Hicks, 1946). In other words, living on true income means 'living on the interest' – not tempting poverty by depleting capital assets.

Hicksian income so defined is at the heart of the so-called 'constant capital stocks criterion for sustainability.' As might be expected, there are two competing versions (Victor, 1991). The dominant version reflects neoliberal economists' dismissal of the unique contributions of resources (particularly self-producing natural capital) to the economy and human well-being (Pearce and Atkinson, 1993; Victor et al., 1995). This so-called 'weak' version of the constant capital stocks criterion can be stated as follows: 'An economy is sustainable if the aggregate value per capita of its stocks of manufactured and natural capital (or the money-income derived from those aggregate stocks) remains constant or grows from one accounting period to the next.'

This definition obviously assumes the commensurability and substitutability of different forms of capital. As long as the aggregate market *value* of different forms of capital remains unchanged (or increases), society is deemed to be sustainable. It horrifies ecologists to observe that the weak sustainability criterion assumes all is well provided if the rising market value (that is, increasing scarcity value) of natural capital (or the income derived therefrom) increases to compensate for the depletion of the physical stocks.

Ecological economists therefore subscribe to an alternative 'strong' version of the constant capital stocks criterion as follows: 'An economy is sustainable if its physical stocks of both manufactured capital and natural capital per capita are held constant or grow in separate accounts from one accounting period to the next.'

By this definition, manufactured and natural capital are not commensurable and substitution is at best imperfect. Money valuation does not enter the picture. (Money is itself an abstraction.) Herman Daly has championed the idea that in many circumstances, manufactured capital and natural capital are complements not substitutes – more fish boats do not compensate for the collapse of the fish stock (for example, Daly, 1991a, chapter 13; Daly, 1994). Indeed, a moment's reflection reveals that some form of natural capital is a *prerequisite* for all forms of manufactured capital and their functioning.

Why does this dispute matter? Because self-producing 'natural capital' maintains the life-support functions of the ecosphere, the risks associated with its depletion are unacceptable and there may be no possibility for technological substitution. Meanwhile, the prevailing system of costs, prices and market incentives fails absolutely to reflect ecological scarcity or help determine appropriate levels of natural capital stocks. Even some fairly mainstream environmental economists have therefore observed that '*conserving what there is* could be a sound risk-averse strategy' (Pearce et al., 1990, p. 7, emphasis added).

process. All the more miraculous because the circular flows model makes no reference whatever to the energy and resources to which value is added to produce the goods and to generate the income flows that the model does represent, nor to the waste outflows the system generates: 'the circle flow is an isolated, self-renewing system with no inlets or outlets, no possible point of contact with anything outside itself' (Daly, 1991a, p. 196). Starting from self-generating flows and armed with bracing confidence in both market efficiency and human ingenuity, many mainstream economists face the challenges of global change with unabashed optimism.

7.2.2 The Economy as Super-organism

> In the later stages of economics, when we are approaching nearly to the conditions of life, biological analogies are to be preferred to mechanical (Marshall, 1925, p. 14).

If neoliberal economics casts the economy as lifeless machine, Daly's critique portrays it as living organism. He argues that studying the economic process in terms of self-generating circular flows without considering unidirectional throughput 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 excreta' (Daly, 1991a, p. 197) (Box 7.2).

Daly's living system metaphor compares 'the basic within-skin life process of metabolism (anabolism and catabolism) with the outside-skin process of economics (production and consumption)' (Daly, 1968 [1980]). The value added by the metabolic process is the maintenance of life; the value added by the economic process is the maintenance and also the enjoyment of life. But in either case, 'the only *material* output is *waste*' (Daly, 1968 [1980], p. 251, emphases in original).[4]

Some readers might protest this last assertion. Is not the entire purpose and major output of the economy to produce useful (and sometimes not so useful) goods and services? So it would seem, but this is a limited, static view. It does not recognize that usable energy can make only a single pass through the economy. With useful work extracted, 100 percent of the degraded infrared residue radiates off the planet. As for material, only a fraction of the energy and material resources that enter the economy is actually converted to marketable products, and once these are consumed or worn out, the embodied material also joins the waste stream. Even with some recycling (which uses additional energy and at least some 'fresh' material), the *entire* stream of energy and resource inputs ultimately returns to 'the environment' as degraded waste.[5] Thus, from a purely

BOX 7.2 INTELLECTUAL RESCUE

Discovering Herman Daly's vision of the economy as living organism helped salvage my academic career. In the 1970s, not long after my arrival at the University of British Columbia (UBC) (as a card-carrying ecologist in a policy-oriented planning school) I had an occasion to present some early research ideas to an assembly of senior colleagues from across the campus. I was young, nervous and naïve, and had been struggling to adapt concepts from bio-ecology to land use planning in ways that my students (mostly geographers and economists) could understand. I opted to present a crude model of the human carrying capacity of the Vancouver region (the Lower Mainland of British Columbia) pointing out that the region was already living well beyond its biophysical limits.

After my presentation (which was received politely enough) I was invited to lunch by a senior colleague who just happened to be a prominent resource economist. Very gently, with the greatest of professional respect and courtesy, he advised me that should I persist in pursuing research on human carrying capacity, my academic career would likely be a Hobbesian 'nasty, brutish, and short.' He argued that economists had effectively negated all such neo-Malthusian thinking. Why should the population or economy of a given region or country be constrained by local shortages of anything? Any region could simply trade services or surpluses of resource 'a' for needed supplies of resource 'b,' thus freeing itself (and presumably its trading partners) from local limits to growth. And, in any event, technology could substitute for nature. He ended by suggesting that I bone up on trade theory, the power of the marketplace, the emerging service economy and technology's role in increasing 'factor productivity.'

My economist friend had delivered his verdict with intimidating assurance and conviction. These were new ideas for me. My formal training had not stretched far beyond the disciplinary boundaries of biology; I had never had so much as an introductory course in economics. I left the lunch deflated, discouraged and depressed, tail lodged firmly between my legs.

But there was something incomplete about my colleague's prescription. The farm-boy and ecologist in me could not conceive of a *Homo sapiens* so detached from nature. This question became the worm in the apple of my mind, gnawing away beneath the surface struggling to emerge. Even so, an embarrassing length of time passed (given the simplicity of the insight) before I had my 'eureka' experience. Part of the problem was with the standard definition of carrying capacity as 'the average maximum population of a given species that can occupy a particular habitat without permanently impairing the productive capacity of that habitat.' Since humans engage in trade and are capable of increasing resource productivity, local limits apparently dissolve and economists could indeed argue that 'carrying capacity' had no useful meaning applied to humans.

But what happens if we invert the carrying capacity ratio? Rather than asking what population can be supported in a given area, the relevant – and answerable – question becomes how much ecosystem area is needed to support a given population on a continuous basis, *wherever on earth the land and water is located and whatever the technological sophistication of the population*. This simple shift in perspective re-established people's direct connection to 'the land.' It also led to my conceiving 'ecological footprint analysis' (EFA) as a tool to estimate the ecosystem area effectively appropriated by any specified population to produce the resources it consumes and to assimilate its wastes. Human carrying capacity was firmly back on the agenda.

But what really restored my confidence in studying *H. sapiens* as an ecologically significant species was encountering Herman Daly's insistence that the economy is indeed embedded in nature and that the economic process is subject to natural law, particularly the second law of thermodynamics. (A population's eco-footprint can also be defined as the photosynthetic surface required, on a continuous basis, to regenerate the biomass equivalent of the negentropy being consumed and dissipated by that population.) EFA has subsequently shown that most high-income consumer societies are running ecological deficits relative to domestic biocapacity and therefore living, in part, on imports. It also suggests that there is insufficient capacity elsewhere in the world to cover these deficits (only a few countries have surplus biocapacity). Trade has enabled the world as a whole to go into overshoot and, despite humanity's technological wizardry, the per capita eco-footprint is still expanding. As Herman Daly has long suggested, the human enterprise now grows by drawing down natural capital and the latter has become the scarce factor of production. This reality imposes formidable limits to growth.

'outside-the-economy' biophysical perspective, economic activity is clearly much more a consumptive process than it is a productive process.

7.2.3 Dissipating the Planet

This by no means exhausts the metaphor of the economy as superorganism. Seeing the economy as a generator of degraded energy and material cues us that, like all biological entities, the economy is subject to physical laws, particularly the second law of thermodynamics.

The second law is fundamental to all processes of energy and material transformation and is thus arguably the ultimate regulator of both biological and industrial metabolism. While the implications of this fact have been deemed irrelevant by neoliberal economists, Herman Daly (following his mentor Nicolas Georgescu-Roegen) has for decades led a small band of insurgents struggling to have the second law reflected in conventional analyses.

In its simplest form, the second law states that every spontaneous change in an isolated system increases the 'entropy' of the system (an isolated system that cannot exchange energy or matter with its environment). In general, this means that the system becomes increasingly 'random' – energy dissipates, material concentrations disperse, gradients disappear. In short, with time, isolated systems become increasingly degraded in an inexorable, irreversible descent toward thermodynamic equilibrium. This is a state of maximum entropy in which nothing else can happen.

In recent decades, science has recognized that the workings of the entropy law apply also to open, far-from-equilibrium systems. *Any* complex differentiated system tends to unravel and run down. Despite all reasonable attempts at maintenance, every shiny new car eventually becomes worn out. And this is invariably a one-way trip – no rusted-out shell has ever spontaneously reacquired its show-room splendor.

Readers may be quick to point out the many apparent exceptions. A newly conceived fetus, an early succession ecosystem, the world's great cities, indeed, the entire human enterprise all prove that, rather than sink toward equilibrium, *living* systems actually gain in mass and complexity over time. How such systems subvert the second law long puzzled philosophers and scientists. Physicist Erwin Schrödinger resolved the conundrum only in 1945: 'The obvious answer is: By eating, drinking, breathing and (in the case of plants) assimilating . . .' Like any other system, 'a living organism continually increases its entropy – [that is, produces positive entropy] and thus tends to approach the dangerous state of maximum entropy . . . of death. It can only keep aloof from it, i.e. alive, by continually drawing from its environment negative entropy . . .' (Schrödinger, 1944 [1967], p. 70). ('Negative entropy' or 'negentropy' is free energy available for work.) In other words, organisms thrive by exchanging high-entropy outputs (waste) for low-entropy inputs (resources). However, second law inefficiencies also dictate that the organism's gain in negentropy is only a fraction of the increase in global entropy. As Daly asserts, this statement 'would hold verbatim as a physical description of the economic process' (Daly, 1968 [1980], p. 253).

The near-homology of living systems and the economy has acquired a sharper edge in recent years with the development of self-organizing holarchic open (SOHO) systems theory. Systems scientists have recognized that self-producing systems exist as loose overlapping hierarchical structures where each component subsystem ('holon') is contained by the next level up and itself comprises a chain of linked subsystems at lower levels (Kay and Regier, 2000). (Consider that an individual organism is part of a community embedded in an ecosystem, and itself comprises a descending hierarchy of subsystems from organs to cells.) The critical point is that at every level in the hierarchy, the relevant holon can develop and maintain itself *only* by using available energy and material (negentropy) extracted from its 'host' system one level up and by exporting degraded energy and material wastes (entropy) back into that host.[6] In effect, all thermodynamically open self-producing subsystems thrive – maintain themselves far-from-equilibrium – at the *expense* of their hosts (see Kay and Regier, 2000; Schneider and Kay, 1994a, 1994b, 1995).[7]

The highest earth-bound level in the SOHO hierarchy is the ecosphere, the macro-holon that comprises all subsidiary biomes, ecosystems and species. It follows that the structural and functional integrity of the ecosphere can be maintained only if the productivity and resilience of constituent ecosystems is sufficient to support indefinitely the development and maintenance of lower level holons (for example, all consumer organisms, the economy) and to assimilate/dissipate the ecosystems' aggregate entropic output.

Normally within ecosystems, the rates of resource imports and waste discharge by any subsystem (for example, a species population) fluctuate in the short term but are maintained by negative feedback within a range that is compatible with the overall rates of production and assimilation by the host ecosystem. Each lower holon therefore normally exists in a more or less 'steady-state' relationship with its host so the entire systems hierarchy retains its long-term structural and functional integrity. However, the hierarchical relationship among subsystems and their hosts contains the seeds of potential pathology (Rees, 2003). If any subsystem demands more than its host can produce, or discharges more waste than its host can assimilate, then further growth of that subsystem will necessarily deplete, degrade and dissipate higher levels in the systems hierarchy.

Now it is undeniable that the economy (which is really the material manifestation of human ecology) is an earthly entity, and therefore a subsystem of the ecosphere (actually, a subsystem of multiple ecosystems). But the two holons differ in one critical respect. The ecosphere evolves and maintains itself in far-from-equilibrium steady state by assimilating and dissipating radiant energy from the sun, that is, an extra-planetary source of negentropy (and, effectively, the next highest level in the thermodynamic hierarchy). The economy, however, can grow and maintain itself only by extracting and degrading resources extracted from ecosystems. As noted, an unavoidable consequence of the second law is that when any given subsystem expands and complexifies (that is, rises further from equilibrium) its gain in negentropy is always less than the increase in global entropy.[8] It follows that, beyond a certain point, the expansion of the human enterprise *necessitates* the entropic depletion and dissipation of its host ecosystems (Table 7.1). Fisheries collapses, landscape degradation, soil erosion, tropical forest deforestation, biodiversity loss and so on are all symptoms of over-consumption by humans; marine dead zones, accelerated eutrophication, ocean acidification, ozone depletion, the toxic contamination of food webs, greenhouse gas accumulations (climate change) and so on are all symptoms of waste sinks filled to overflowing. SOHO systems framing clearly reveals today's perpetual growth economy to be an entropic black hole, thermodynamically positioned to consume and dissipate the ecosphere from within (Rees, 1999).

Table 7.1 A 'second law' comparison of human-less and human-dominated ecosystems

Ecosystems without humans	Human-dominated econo-ecosystems
Evolve and develop by assimilating, degrading and dissipating available solar energy (exergy) using photosynthesis and evapotranspiration.	Grow and develop by extracting, degrading and dissipating energy-rich 'resource stocks' that have accumulated in the ecosphere, including other species, entire ecosystems and fossil hydrocarbons.
Anabolic processes (production of biomass) marginally exceed catabolic processes (degradation and dissipation).	Catabolism (consumption and dissipation of energy and material resources) exceeds anabolism (the production of humans and their artifacts).
Biomass accumulation dominates; species proliferate, complexity increases; stocks of available energy and matter (resource gradients) accumulate.	Humans and their artifacts accumulate; ecosystems are simplified or eliminated, biodiversity declines; resource stocks are depleted and dissipated.
Materials recycle through ecosystems (biogeochemical 'nutrient' recycling); waste heat dissipates off-earth; the entropy of the universe increases.	Material wastes (economic throughput), often novel and toxic, accumulate in the ecosphere; waste heat dissipates off-earth; functional integrity of ecosystems is lost; the entropy of the ecosphere (ultimately the universe) increases.

7.2.4 The Problem of Scale and the Steady State

As Herman Daly has long recognized, the first corollary of any thermodynamic model of the economic process is the need to limit the scale (energy and material throughput) of the economic enterprise within the capacity of supporting ecosystems (for example, several chapters in Daly, 1991a; Daly and Farley, 2004). In theory, an economy has achieved its optimal scale or size at the point where the (diminishing) marginal benefits of material growth just equal the (rising) marginal costs – including the (currently unaccounted) costs of depleted natural capital, capital substitution and pollution. At this point the total net benefits of economic growth to date (total benefits minus total costs) is at a maximum and, as Daly originally noted – and is frequently moved to remind us – any further growth actually makes us 'poorer than richer' (for example, Daly, 1999). If intelligence and logic were the principal determinants of economic policy, the primary goal would be to ensure that growth slows as we reach the optimal scale and that the economy does not exceed this optimal size.

There is a problem, however – several actually. The facts that our measures of benefits are flawed (for example, GDP puts plus signs on both negative and positive entries), that we can neither identify nor monetize many of the costs (for example, who knows the present value of some future climate change cost of which we are as yet unaware but which may already have been triggered by historic and present actions?) and that changing circumstances constantly shift the exact 'location' of the optimal point, means that we could not actually perform a valid benefit/cost analysis of economic growth even if society were inclined to do so. But this in no way invalidates the basic point. There are real ecological and economic limits to sustainable global energy and material throughput. Politicians, heady from addiction to economic growth, should find it sobering that no mainstream economists can state with certainty that society is still below the optimal point and that numerous ecological economic indicators and biophysical studies suggest we may have long exceeded it (for example, Rockström et al., 2009; WWF, 2008).

The second corollary of economy-as-thermodynamic-process is that sustainability implies a steady-state economy. Our own bodies are steady-state systems in which the daily inflows of energy and matter are, on average, quantitatively equivalent to the outflows. (Of course, the *quality* is diminished by the extraction of negentropy from the inputs.) Thus, if 'we view capital as material extensions of the body, and we accept the fact that there are limits to the total number of human bodies supportable, then by the same logic we should recognize that the stock of extensions of human bodies is also limited and thus be led naturally to a steady-state perspective on the economy' (Daly, 1991a, p. 32).

The essential lesson is that after an initial phase of growth, all healthy living systems become steady-state systems, any propensity for further expansion constrained by negative feedback (for example, incipient resource scarcity, disease). The ecosphere as a whole is in approximate steady state limited by the constant solar flux and the geographically variable availability of water and nutrients. It follows that the economic subsystem, rapidly becoming the dominant subsystem of the ecosphere, must increasingly conform to the operational dynamics of the ecosphere *if it is to survive*. The operational dynamics of the ecosphere exemplify a dynamic steady state.

Which is not to be confused with a static state. The economy needn't cease developing, it must merely stop growing. With luck and good management it could hover indefinitely in the vicinity of its 'optimal scale' while steadily improving human well-being. There are no limits on the capacity of human ingenuity to better quality of life, only on the quantity of throughput available to do it. And even within that constraint, new firms and even whole industrial sectors could both develop *and* grow even as their thermodynamic equivalents in obsolete or 'sunset' industries are phased out. Because it draws so many logical threads together, Herman Daly's pioneering development and persistent advocacy of the steady-state economy is perhaps his greatest overall contribution.

7.2.5 The Quest for the 'Truer' Economy

> 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 are privileged because they are 'truer.' (Postman, 1999, p. 76)

We have described two competing 'social constructions' or conceptual models of the workings of the economic process. The dominant neoliberal paradigm treats the economy as an independent entity, an open growing system whose productive cycle is virtually unconstrained by any biophysical reality outside itself. By contrast, ecological economists see the economy as an open, growing but also fully contained and dependent subsystem of the finite, non-growing and materially closed earth ecosystem (Daly, 1990 [1991]). This latter framing also recognizes that the bio-metabolism of the ecosphere and the industrial metabolism of the economy are both governed by inviolable biophysical laws. In the context of sustainability, the important question is which of these conceptual models provides a 'truer' representation of biophysical reality.

Who can dispute that in today's world the economy interacts with and seriously affects the productivity and behavior of ecosystems? Nevertheless, the mainstream economic models used to govern/regulate national economies and international development remain insensitive to the structure and function of the ecosystems upon which the economy draws, and of the time- and space-dependent processes that characterize ecosystem behavior. Indeed, the simple, reversible, mechanistic behavior of the economy implicit in mainstream models and derivative analytic tools (for example, benefit/cost analysis) is quite inconsistent with the complexity, irreversibility, lags, thresholds and positive feedback dynamics of the complex energy, information and ecosystems with which the economy interacts in the real world (Christensen, 1991). Even more remarkably, the modeled behavior is inconsistent with that of the real economies the models supposedly represent (as was clearly revealed, yet again, by the financial collapse of 2008). On all these grounds, a reasonable person would be justified in dismissing mainstream sustainability analyses as fatally illusory from an ecological perspective. The structural and relational assumptions framing the dominant economic models behind global development today disqualify them from generating useful insights into humanity's relationship with nature.

Contrast this with the relative structural integrity of the Dalyesque vision and the insights accessible to it. Seeing the economy as a growing dependent subsystem of the non-growing ecosphere enables one to surmise from the outset that at some point – even after accounting for human ingenuity – the economy will eventually be hobbled by scarcity and begin to suffocate in its own detritus. And what if the economy and the ecosphere really are far-from-equilibrium dissipative structures and the former is nested within the latter? This allows the equally rational conjecture that the ever-growing economy must inevitably degrade and dissipate the ecosphere in the manner of a malicious parasite. Virtually every so-called 'environmental' problem today, from collapsing fisheries and biodiversity loss, through peak oil and potential food shortages to contaminated food webs, accumulating greenhouse gases, climate change and ozone depletion is predictable or explicable from Daly's 'contained system' framing of the economic process.

Finally, ecological economics recognizes that complex systems – social systems, ecosystems and economic systems – are characterized by nonlinear (discontinuous) behavior, particularly lags and thresholds. The latter represent 'tipping points' – if key variables of the system are pushed beyond these (by, for example, overexploitation) the entire system may 'flip,' potentially irreversibly, into a new stability domain where conditions are hostile to human purposes. (The collapse of the North Atlantic cod stocks in 1992 serves as a memorably tragic example – and warning.) Indeed, complex systems may have multiple possible equilibria or stable regimes whose existence is unknowable before the fact. These qualities together speak to the need to carefully monitor resource exploitation for any sign that the system is being over-stressed and to limit the overall scale of the human enterprise within cautiously safe limits.

Given present circumstances and global trends, Daly's organismic/thermodynamic model of the human enterprise is clearly less reassuring than the mainstream perspective. Nevertheless, one suspects that if ordinary people were given an opportunity to dissect and assess these two conceptual 'constructions,' most would judge Daly's version on the evidence as being a 'truer' representation of economy-environment relationships. Daly's construction is therefore the one that should be 'privileged' in the economic policy arena.

7.3 'THAT'S NOT THE RIGHT WAY TO LOOK AT IT'

Despite the growing cascade of data supporting this conclusion many practicing economists still do not agree. Their resistance has a cumulative history. Consider just one well-known example (Daly, 2008). The first draft of the World Bank's 1992 *World Development Report* (which focused on sustainable development) contained a diagram called 'the relation of the economy to the environment.' All it showed was a rectangle labeled 'economy' with an in-bound arrow labeled 'inputs' and an exit arrow labeled 'outputs.'

As senior economist in the Bank's environment department, it fell on Herman Daly to critique the draft. Daly observed that this drawing should be revised to include 'the environment.' As matters stood, the economy was exchanging inputs and outputs with nowhere. Always helpful, Daly suggested that the next version of the diagram show the economy as contained within a circle labeled 'ecosystem.' This would make clear that the economy was a subsystem, that the input arrow represented resources extracted from the ecosystem and that the output arrow represented waste returning to it as pollution. Daly suggested that this would stimulate fundamental questions, such as how large the economy could grow before it overwhelmed the total system.

The second draft of the report duly showed the original figure enclosed in a large unlabeled rectangle but this prompted Daly to complain that, incompletely labeled, the diagram changed nothing. The third draft omitted the diagram altogether. The Bank apparently recognized that something was wrong with that diagram but preferred to omit it rather than deal with the inconvenient questions it raised.

Sometime later Daly had an opportunity to question Lawrence Summers, Chief Economist at the World Bank (under whom the report was being written) about the same issue. Did the Chief Economist consider the question of the size of the economy relative to the total ecosystem to be an important one? Did he think economists should be asking the question: What is the optimal scale of the economy relative to the ecosphere? Summers' reply was 'immediate and definite: '*that's not the right way to look at it*' (quoted in Daly, 1996, p. 6, emphasis added). Apparently, 'The idea that economic growth should be constrained by the environment was too much for the World Bank in 1992, and still is today' (Daly, 2008, p. 46).

Other rogue economists have advanced similar critiques of modern growth fetishism. According to Julie A. Nelson, economists show 'dogged allegiance to a narrow set of epistemological ideals, methodological framing and substantive assumptions' in their application of endogenous growth theory (EGT) (Nelson, 2005, p. 9). EGT explores the role of technological innovation and other sources in GDP growth, but 'no matter how tortured the logic, [the explanations] lead back to a source in economic fundamentals.' Apparently, the word 'endogenous' is a signal that the model is closed off from historical developments or other considerations that might undermine its validity. Evidence that violate its assumptions is set aside. 'And in line with the vast majority of economic theorizing about growth, the ecological implications of a ceaseless expansion of production are totally ignored' (Nelson, 2005, p. 9).

Mainstream economists are not doing much better in formally acknowledging the potentially devastating impacts of complexity theory on prevailing economic dogma. This makes economists and finance managers culpable in the 2008 collapse of the global finance system (Ormerod, 2010). The latest attempt to explain business cycles and 'booms and busts' from the 'rational agents using rational expectations' view of the world goes by the term 'dynamic stochastic general equilibrium' (DSGE) models. DSGE models contain all the key microeconomic assumptions of orthodox economic theory. Acting under the illusory fog thrown up by this framing, 'the authorities' assumed, falsely, that brokers and agents had used the 'correct' model in setting prices, that is, that the massive volumes of loans and debts being traded in the market had been 'priced rationally and hence optimally.' Had this been the case, and institution 'A' defaulted on a loan:

> sufficient provision via the optimal pricing of the loan [would have] been made to cover the loss arising from any such default. There was no need to tie up capital unnecessarily in liquid assets when it could be lent out at a profit. Across a portfolio of many such loans, the default of a single loan simply could not cause a problem. (Ormerod, 2010, p. 14)

The real economy, however, is a complex system that behaves little like a DSGE model whether or not its assumptions have been satisfied. Complex systems theory, specifically network theory, 'tells us that in an interconnected system, the same initial shock can, if we could replay history many times, lead to dramatically different outcomes.' Uncertainty is large and essentially irreducible. It may be that most of the time, 'shocks are contained and do not spread very far through the system. But in principle a shock of identical size can trigger a cascade of global proportions.' Unfortunately, as noted in other contexts, is that 'The economics profession in particular has become very insular and hostile to scientific work outside its own field.' Accordingly, 'economists are largely ignorant of the large amount of work carried out on cascades in interconnected systems by a whole range of disciplines over the past decades such as control engineers, computer scientists, physicists, and mathematicians.' Result? 'In the brave new world of DSGE, the possibility of a systemic collapse, of a cascade of defaults across the system, was never envisaged at all' (all quotes from Ormerod, 2010, pp. 14–15).

James K. Galbraith extends his critique of modern economics to include even the domain that it *does* purport to encompass. He argues that the empirical evidence 'flatly contradicts' the five leading ideas of modern economics and interprets this disconnect from the real world as evidence that 'modern economics . . . seems to be, mainly, about *itself*' (Galbraith, 2000, p. 1, emphasis in original). He goes on: 'But self-absorption and consistent policy error are just two of the endemic problems of the leading American economists. The deeper problem is the nearly complete collapse of the prevailing economic theory . . . It is a collapse so complete, so pervasive, that the profession can only deny it by refusing to discuss theoretical questions in the first place' (Galbraith, 2000, p. 4).

7.4 THE TRIUMPH OF ILLUSION

How can we explain this seeming abandonment of reason, the widespread hiding of heads in the sand? Humans pride themselves on being the best evidence that the universe is coming to self-awareness and intelligence. We claim to be a science- or at least a knowledge-based society. Why is it, then, that in so many domains, modern humans seem to act out of habit, ignore contrary data and happily embrace illusory fantasies?

Such illogical behavior could be part of a contemporary cultural trend. More than a half-century ago (at about the time economic growth began to push its way to prominence on the policy agenda) German philosopher Martin Heidegger observed that 'man today is *in flight from thinking*' (Heidegger, 1955 [2003], p. 89, emphasis in original). By 'thinking' Heidegger did not mean the day-to-day calculative thought processes at which technological society actually excels. Rather, he believed that modern society was 'in flight' from the deeper kind of critical, questioning or, in his terms, 'meditative' thinking, the tool of the philosophers and ordinarily contemplative people alike. Such generalized thoughtlessness (as reflected in the quality of the evening news?) is characterized by our failure to ponder, to observe, to question and even to show awareness of what is actually taking place around us and within us. From Heidegger's perspective, contemporary society is thus allowing to 'lie fallow' one of our great and most uniquely human abilities. With intellectual blinkers on, the world is being swept away in the techno-material tide, guided, if at all, by careless whims and sheep-like adherence to prevailing myth and ideology.

On the other hand, perhaps nothing has changed. Heidegger may merely be observing most people for what they are. And it seems people have always been lazy thinkers, preferring skillful illusionists to realists in politics as in art. Consider French behavioral psychologist Gustave Le Bon's observation in his 1895 classic study of 'group-think':

> The masses have never thirsted after truth. They turn aside from evidence that is not to their taste, preferring to deify error, if error seduce[s] them. Whoever can supply them with illusions is easily their master; whoever attempts to destroy their illusions is always their victim. (Le Bon, 1895 [2001])

Le Bon's observation is no mere curiosity. The 'deification of error' and resultant behavioral inertia (or deviance) at the top can determine the fates of nations. Pulitzer Prize winning American historian, Barbara Tuchman, details the tragic effects of self-delusion on entire societies through millennia in her 1984 classic, *The March of Folly*. According to Tuchman, 'folly' involves 'the pursuit of policy contrary to the self-interest of the constituency or state involved.' To qualify as true folly a particular course of action must be pursued even though a 'feasible alternative course of action [is] available.' In addition, the action or policy must generally be 'that of a group' (not merely an individual leader) and 'persist beyond any one political lifetime' (Tuchman, 1984, p. 5). So defined, political folly or 'wooden-headedness':

> plays a remarkably large role in government. It consists in assessing a situation in terms of preconceived fixed notions [for example, ideology] while ignoring any contrary signs. It is acting according to wish while not allowing oneself to be deflected by the facts. (Tuchman, 1984, p. 7)

My point? Le Bon and Tuchman are describing seemingly universal perceptual blocks and behavioral intransigence – even in the face of imminent danger – that are exhibited by people who have developed deeply entrenched systems of belief that have long shaped and directed their lives. (More on this to follow.)

Let's return to the present context but assume that the global community is *not* perceptually handicapped, that is, we are able to act decisively in a spirit of collective engagement and high intelligence in the face of global ecological change. This means that national and global policies for sustainability would have to be consistent with the scientific evidence that ecosystems and the climate system are in stress, including the fact that the human enterprise is currently in a state of overshoot (drawing down even self-producing natural capital and filling critical waste sinks to overflowing). The world would also have to recognize: (1) that the economy is a dependent subsystem of the ecosphere subject to thermodynamic laws, that is, for the economy to grow and maintain itself 'far-from-equilibrium, it necessarily 'feeds' on its supportive ecosystems and uses them as waste dumps and (2) there are limits to the regenerative and assimilative capacity of ecosystems. Corollary: for sustainability, there must be caps on aggregate energy and material flows and thus constraints on the scale of the material economy so that it operates safely within the means of nature. Let's also assume that as good global citizens, we express our compassion for others – basic equity considerations require formal recognition that today's levels of gross material disparity are intolerable.

In these circumstances, rich countries would accept that it is their responsibility to initiate programs to *shrink* their national economies toward a globally viable energy and material steady state (à la Herman Daly). North Americans, for example, would have to reduce their ecological footprints by about 80 percent, from around 9 global average hectares (gha) per capita to our 'fair Earth-share' of 2 gha (Rees, 2006; WWF, 2008). Such contraction at the top is necessary to make room for needed growth in the developing world given that earth is a finite planet already in overshoot (Rees, 2008; Victor, 2008). These may seem to be unreasonable demands and impossible goals, but analysis shows that we actually have the technology to enable a 75–80 percent reduction in energy and (some) material consumption (von Weizsäcker et al., 2009) while improving quality of life in both rich and poor countries. (Remember that people in wealthy countries were actually happier on average with less than half of today's average per capita income.) In any case, as Daly and other analysts have shown, aggregate global growth itself has already likely become uneconomic and self-defeating.

The most politically plausible alternatives to such a 'steady-state with redistribution' strategy are the status quo or some technologically engineered variant. But if our best science is correct, the increasingly likely outcome of these alternatives is ecosystemic collapse, resource wars and geopolitical chaos. This dismal outcome underscores that it is actually in everyone's long-term interest to give up on continuous material growth and learn to share the earth's existing bounty. For what may be the first time in human history, *individual and national self-interest has converged with humanity's collective interests* (Rees, 2008).

Of course, as matters stand, 'steady state with redistribution' is off the table.[9] Instead, the dismal alternative is in play. Far from considering a planned economic contraction, all national government and mainstream international organizations (for example, the United Nations and the World Bank) subscribe to a mythic vision of unlimited global expansion inspired by neoliberal economics, fueled by globalization and expanded trade, and inflated by overweening confidence in efficiency gains and technological hubris. Popular support is assured by the single most successful program of social engineering in history, the purposeful global promulgation of consumer culture. A multi-billion dollar 'public relations' and advertising sector has converted virtually whole nations of potentially engaged citizens into passive consumers.[10] Little wonder that the concept of 'contraction' does not resonate in society's collective consciousness – it is not the narrative people have been conditioned to hear. In effect, we live from a socially constructed materialistic world model sustained by the smoke, mirrors and pixie dust sent aloft by professional illusionists of all stripes, prominent among whom are growthist economists.

To be fair, growth-based economics has been remarkably successful in improving the material well-being of a significant minority of the human population in what started out as an 'ecologically empty' world (Daly, 1991b). This provides superficial support for the prevailing mode of thinking. Why spoil what could be a luxury cruise for all if human ingenuity promises to maneuver the ship around any shoals thrown up in what is now an 'ecologically full' world? Privileged elites with the greatest personal stake in the status quo thus sit at the Captain's Table and insist we stay our course through the fog of illusion; middle-class passengers, even those nervous about the voyage, seem willing to sacrifice uncertain but major long-term gain (that is, global survival) to avoid the certain but minor short-term pain of having to adapt their lifestyles; and the folks in steerage have little choice but to go along for the ride, clinging hopefully to the expansionist myth as to a life-raft in effective denial of their lived reality.

7.5 EXPOSING THE ROOTS OF DENIAL

> No one is immune to it; in some respects it is the foundation of our lives. Magical thinking is a universal affliction. We see what we want to see, deny what we don't. (Monbiot, 2010)

How can we explain this behavioral conundrum? What motivates the perversely illogical politics described by Le Bon, Tuchman and others? Whenever people possess knowledge that should be powerfully motivating or profess a strong commitment to some belief or social ethic yet persistently ignore or violate it, there is a good possibility that some innate predisposition is unconsciously directing their actions (Pinker, 2002). This section argues that not only do illusory social constructions confound human intelligence, but that genetically determined 'biological drives . . . can [also] be pernicious to rational decision-making . . . by creating an overriding bias against objective facts . . .' (Damasio, 1994, p. 192).

Understanding the innate predispositions that affect individual and group behavior requires reference to the evolutionary biology of cognition. The latter involves both the evolved structure (nature) and the experiential development (nurture) of the human brain. First, consider that the human brain is a complex organ with a long and complex evolutionary history. Indeed, MacLean (1990) argued that the organization of the human brain roughly recapitulates three broadly overlapping phases of vertebrate evolution. Successive anatomical developments were added to and integrated with pre-existing structures, thus retaining original functions while enhancing the organism's overall fitness. In effect, the human brain has three quasi-independent subsystems each having distinct functions, memory, 'intelligence' and limitations:

1. The reptilian brain (the brainstem and cerebellum) is the seat of sensory perception and related coordinated movement; autonomic functions associated with the body's physical survival (for example, circulation and breathing); instinctive social behavior (for example, pertaining to territoriality, social stature, mating and dominance). It also executes the fight or flight response and controls other mainly hard-wired instinctive behaviors.
2. The limbic (or paleo-mammalian) system is the primary locus of emotions (for example, happiness, sorrow, pleasure, pain) and related behavioral responses (for example, sexual behavior, play, emotional bonding, separation calls, fighting, fleeing). It is also the location of affective (emotion-charged) memories and the source of value judgments and informed intuition.
3. The neo-cortex (neo-mammalian or 'rational brain') is the most recent (and least experienced) addition, but occupies over two thirds of the human brain by volume. It is the seat of consciousness and the locus of abstract thought, reason, logic and forward planning; it controls voluntary movement and actions.

Of course, the normal healthy brain acts as an integrated whole – the three sub-brains are inextricably interconnected, each continuously influencing the others. The emergent behavior and overall personality of the individual is therefore generally a seamless melding of thoughts, emotions and instincts. However, since awareness springs largely from the neo-cortex the individual may not be conscious that she or he is also under the influence of neural and chemical (hormonal) stimuli originating in other parts of the brain.

This interplay of motivations is of more than passing interest. It implies that *H. sapiens* is inherently a conflicted species. In some circumstances, emotional/instinctive predispositions (for example, overt aggression, passionate hatred, abject fear, sensual desire) originating beneath consciousness may well override reason and when this happens the individual may not be aware that a 'lower' part of the brain has seized control. Sometimes we crave the emotional boost that comes from being certain even when we are dead wrong (Burton, 2008)! Even if our actions are guided *mainly* by emotions, we often lie to ourselves (rationalize) that we are being entirely reasonable. Everyone is aware of situations in which *endogenous* factors generate irreconcilable tensions between our rational minds and our emotional/instinctive control centers. The 'circumstances' can range from trivial to life-changing. What dieter has not found himself or herself unable to resist that third helping from the all-you-can-eat buffet? The statistics on marital infidelity are witness enough to the frequency with which people's conscious will and professed morality yield to raw sex drive and emotions when the opportunity arises. Whether reason or emotion/instinct wins out in a particular case depends on myriad factors including previous experience (for example, socialization, education and religious training) and the native personality of the individual. The main point is that whether or not one is conscious of what is going on, 'There are indeed potions in our own bodies and brains capable of forcing on us behaviors that we may or may not be able to suppress by strong resolution' (Damasio, 1994, p. 121).

Irresolvable conflict may also develop between the individual's sense of stability and *exogenous* factors. In these circumstances the universal human predisposition to lie may come into play. People are often not psychologically equipped to bear the burden of reality. Confronted by an overwhelming problem with no satisfying solution at hand, the natural human reaction is to paper it over, to lie about it to ourselves and to others. In some situations lies are psychologically necessary 'because without them many deplorable acts would become impossibilities' (Jensen, 2000, p. 2). (The same would apply to stupid or irrational acts.) Psychologist Dorothy Rowe suggests that 'Lying gives us the temporary delusion that our personal and social worlds are intact, . . . above all, that we are not likely to overwhelmed by the uncertainty inherent in living in a world we can never truly know' (Rowe, 2010, p. 29).

Perhaps the most complex and consequential form of self-deception is deep systemic denial by whole subgroups within society. Consider the well-funded and highly organized climate denial movement or continuing over-the-top resistance to the fact of evolution on the part of the religious right[11] (see MacKenzie, 2010). Systemic denial generally emerges in situations where an individual's or group's core beliefs and values are under siege. It is clearly reflected in such phenomena as unyielding loyalty to the established order of things in the face of overwhelming contrary data (for example, economists' continued defense of growth-based economics) or in situations where there is clear acknowledgment of 'a dire problem yet no volition to address it' (Pratarelli and Aragon, 2008) (for example, the failure of the November 2009 Copenhagen climate change conference).

This form of denial actually has a physical basis and involves yet another layer of nature/nurture interaction. Recent studies in human cognition show that in the course of individual development, repeated sensory experiences and continuous exposure to fixed cultural norms (for example, religious doctrines, political ideologies and disciplinary paradigms) literally help to shape the brain's synaptic circuitry in quasi-fixed patterns that reflect and embed those experiences. In short, *H. sapiens* has evolved in such a way that the brain is pre-adapted *to record for playback* critical beliefs and behavioral norms shared by members of the individual's group. (The automatic inscription in juvenile brains of tribal/cultural norms that have proved successful to date would presumably be highly adaptive in a relatively static biophysical environment.) The critical point in the present context is that once a synaptic circuit has formed, people tend to seek out *compatible* beliefs and experiences to reinforce the associated cultural pre-sets and, 'when faced with information that does not agree with their [preformed] internal structures, they deny, discredit, reinterpret or forget that information' (Wexler, 2006, p. 180).

Cognitive neurobiology thus provides a multi-layered bio-social basis for understanding individual behavioral intransigence and wider cultural inertia in the context of accelerating global change. Once a person's synaptic pathways are well entrenched and adapted to particular circumstances it is difficult for that individual to accept subsequent changes in their socio-cultural or biophysical environments. Even when one accepts that 'reprogramming' is necessary, the process can be lengthy and unpredictable. Re-establishing cognitive consonance between people's programmed perceptions and new environmental realities thus requires that all parties engage wilfully in the restructuring of their own neural pathways and psychological states (Wexler, 2006).

In these circumstances, achieving sustainability may require that global society engage in a world program of social re-engineering. There may be no other way to assert humanity's collective intelligence and reason over people's predisposition to defend the status quo. Certainly creating a global mind-set receptive to planned dramatic change is the only way to implement anything like the 'steady-state with redistribution' strategy for sustainability outlined earlier. [12]

As part of the above we will certainly have to discard many of the 'pre-analytic visions' associated with the political ideologies, religious doctrines and academic paradigms that are helping to create the (un)sustainability crisis. Consider the dominant conception of the economy as an open, growing, self-producing system floating free from the biophysical world. This vision is so fundamentally at odds with Herman Daly's more realistic vision of the economy as an open, growing but fully contained and totally dependent subsystem of the non-growing ecosphere, that no reconciliation is possible. However, fully consistent with denial, or perhaps the subconscious need for familiar certainty, mainstream economists have generally tended 'to deny, discredit, reinterpret or forget' the Daly alternative rather than accept the collapse of their fundamental models. Given the pace of global change, Max Planck's interpretation of the general problem is particularly sobering:

> a new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it. (Planck, 1949, p. 33)

(Of course, even this won't turn the trick if the universities keep churning out thought-clones of Lawrence Summers rather than Herman Daly think-alikes.)

7.6 EPILOGUE: HERMAN DALY AND CULTURAL EVOLUTION

I started out by arguing that humans have no choice but to live according to socially constructed models of reality and that, in the unconscious construction of these abstractions, we tend to be seduced by 'magical thinking.' I have also argued that this is not necessarily a hopeless situation – society could choose to engage in the *conscious* rewriting of its core cultural narratives. Certainly we need a new deliberately structured model of the economy that recognizes both humanity's de facto ecological niche as a consumptive 'dissipative structure' and people's complex relationships in community.

We already consciously create physical and abstract models in many domains of human activity from architecture to zoology. Invariably, the purpose is to simplify certain aspects of reality while retaining the essential character and behavior of the entity being modeled. We hope that understanding how carefully constructed models behave when we manipulate key variables or parameters will provide reliable insights into how the real world might behave under similar circumstances. This is why good experimental science proceeds cautiously, continuously testing its assumptions and hypotheses against the real world. When a hypothesis fails, scientists restructure the model accordingly, each time hoping to nudge the model's behavior closer to that of the reality it purportedly represents.[13]

It is worth noting too that bio-evolution proceeds in precisely this 'trial and error' fashion. In effect, every genetic mutation represents an experimental 'hypothesis' about the relevant organism's environment. Mutations that increase an individual's survivability or 'fitness' are retained and accumulate in its offspring, that is, in future 'models' of the organism. Failed hypotheses are 'selected out' and eventually disappear from the population.

Shouldn't society apply this understanding of both the creative role of models and the evolutionary process to the great economic experiment presently playing out in the material world? As we test the neoliberal economy against external reality, we are performing an uncontrolled and potentially dangerous experiment in human evolution. However, as the results come in we are showing little willingness to adapt the model to its 'environment.'

This is particularly disappointing. The fact that human evolution is more driven by cultural than by biological factors gives us a potential advantage over other species. It is common knowledge that 'genes' are the basis of biological evolution. Genes are heritable bits of genetic information that interact with 'the environment' to determine the physical and behavioral phenotype (the 'appearance') of the individual. Less familiar is the concept of 'memes.' Memes are heritable units of cultural information – persistent myths, economic models or working technologies – that influence the 'phenotype' of the society of concern (Dawkins, 1976). Memes are thus the basis of cultural evolution; they have a leg-up over genes in that memes can spread rapidly among living individuals in the *same* generation or population. This means that human evolution, particularly the cultural component, is potentially much faster than biological evolution.

But only potentially. Memes, like genes, are subject to natural selection. If a previously successful meme or meme complex (for example, growthist economics) becomes maladaptive under changing environmental circumstances it may be eliminated by that environment. Thus, while memetic evolution is theoretically faster than the genetic variety, it may not always be fast enough. Whole cultures that refused to abandon maladaptive meme complexes – core values and beliefs – have foundered and collapsed (see Diamond, 2005).

With this in mind, a truly rational society would quickly adopt Herman Daly's steady-state economics on the evidence that neoliberal economics is about to be 'selected out' and that the Daly brand provides a better map of contemporary biophysical reality. Simply put, steady-state economics offers humanity superior fitness and greater survival value.

While we're at it, we might consider improving the social dimensions of economic life. In addition to logical intelligence, humans also have unmatched capacity for empathy (with both other people and species), to exercise moral judgment and to use all of these traits in planning for their future. Neoliberal economics ignores most dimensions of human intelligence, eschews moral and ethical considerations and dismisses long-term planning. Once again, by contrast, Herman Daly's political economy displays all these qualities in abundance (see Daly and Cobb, 1994) and all are necessary if global civilization is to achieve an equitably sustainable 'steady-state' relationship with the ecosphere.

Wake up world! It would be a tragic irony if modern *H. sapiens*, that self-proclaimed pinnacle of self-conscious intelligence and earthly evolution, were to be unceremoniously ejected by the ecosphere because of a lingering, maladaptive propensity for political and economic folly based on self-deception and 'magical thinking.'

NOTES

1. There is a vast amount of electromagnetic energy out there that is not accessible to our senses but is as 'real' as what we can detect. For example, the signals of virtually every radio and television program being broadcast for hundreds of kilometers around and every cell-phone conversation in the vicinity are passing through your body unsensed right now. (Fortunately, one can only suppose.)
2. See Regal (1990) for a detailed description of how 'reality is always being tampered with by our nervous systems' and how 'the construction of internal [that is, 'subjective'] reality is a continual process in the human brain' (to which Regal refers as 'The Illusion Organ').
3. This will seems odd to non-economists, because most people still participate in 'the economy' to acquire the material basis of their own existence.
4. This perspective has spawned the entire subdiscipline of 'industrial metabolism' stimulated largely by the work of another renegade economist (and physicist) Robert U. Ayres (see Ayres and Simonis, 1994; Ayres and Warr, 2009).
5. The quantities can be prodigious. By the late 1990s, material waste output ranged from 11 metric tons per person per year in Japan to 25 metric tons per person per year in the United States. When so-called 'hidden flows' were included – flows resulting from economic activity but which do not actually enter the production process, such as soil erosion, mining overburden and earth moved during construction – total annual waste material output increased to 21 metric tons per person in Japan and 86 metric tons per person in the United States (WRI, 2000). That's 86 000 kilograms (198 598 lbs) every year for every man, woman and child in the latter country!
6. Because self-producing systems maintain themselves 'far-from-equilibrium' by degrading and dispersing imported energy and matter, they are called 'dissipative structures.' Prigogine suggested that distance from equilibrium would become as essential a variable in thermodynamic descriptions of nature as temperature is in classical equilibrium thermodynamics (Prigogine, 1997, chapter 2).
7. In some cases, host systems can thrive without (some of) their subsystems – the ecosphere would persist in the absence of humans, for example. In others, the subsystems and 'hosts' exist in a state of mutual dependence – think of the relationship between the nervous system and the entire body.

8. Even photosynthesis converts only about 2 percent of available solar energy ('exergy') into biomass (negentropy); the rest is dissipated into space as low-grade infrared (heat) radiation, mostly through evapotranspiration. The negentropy gain by the ecosphere is trivial compared to the entropy gain of the universe.
9. And is likely to remain so. What military or economic superpower has ever voluntarily relinquished its privileged position in the geopolitical hierarchy? For that matter, even most ordinary citizens as presently 'programmed' would see such a plan as a threat to their survival and respond accordingly.
10. To this extent, Heidegger was right – the corporate sector has exploited both humans' natural tendency to intellectual laziness and their hidden wants and fears to sideline meditative thinking from the public domain.
11. Many levels of motivation are at play. For big oil and coal, for example, it may seem rational in the economic short term to turn the public against effective carbon emissions reduction policies, but if the climate science is correct this strategy of denial is against everyone's longer-term interests.
12. Those who recoil at the thought of social engineering for the common good should keep in mind that the present generation has already been socially engineered for the corporate good. The alternative is to wait until widespread disaster knocks large numbers of people off their comfortable cognitive perches. This will also force them to reconstruct their internal 'realities' (perceptions) but in much less agreeable ways.
13. It has been argued that economist do the opposite, asking the real world to conform to their models!

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3. The Triumph of Pareto: How Dominant Economics Distorts Reality and Perpetrates Hidden Values, and What We Can Do to Fix It

Gary Flomenhoft

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3.1 INTRODUCTION

Neo-classical economics (NCE), or mainstream economics, is touted as a positive, "value-free" science. Economic efficiency is defined by the criteria of Pareto optimality as if it were a perfectly objective, value free measure of efficiency. When looked at in depth we find that Pareto optimality is highly charged with underlying normative values, assumptions, and implications. In part one of this article I will explore the underlying meaning of Pareto Optimality (aka efficiency), and conclude it is actually a normative criteria masquerading as "value-free". Part two explores the philosophies of Vilfredo Pareto, shows that they are entirely consistent with his principle of optimality, demonstrates and their relationship to recent economic conditions, and concludes that his views and values have triumphed. Finally in part three I will propose some solutions. Of particular relevance to Daly's work are the growth imperative and inequalities that result from using Pareto optimality as a measure of efficiency. Daly has long advocated for consideration of fair distribution in his work as one of the key principles of ecological economics, contrary to most of the economics profession, which has abandoned fairness in favor of growth.

3.1.1 Pillars of Neo-classical welfare economics

The three pillars of neo-classical welfare economics are Homo-economicus—self-interested, utility maximizing, rational economic man; Perfect competition— independent actions of firms, no market power, constant returns to scale, perfect information, no uncertainty; and Pareto Optimality or Potential-Pareto Optimality (also know as the Kaldor-Hicks criteria). Behavioral science has convincingly refuted the premise of economic man (e.g. Tversky and Kahneman 1981; Gintis 2000; Kahneman and Tversky 2000; Ariely 2008; Thaler and Sunstein 2008), while the recent Nobel prize to Joseph Stiglitz for asymmetrical information demonstrated the rarity of perfect competition. Though neoclassical economists have largely abandoned the assumptions of economic man and perfect competition in their empirical research, "the profession is just beginning to come to grips with the policy implications of abandoning Pareto optimality" (Gowdy and Erickson 2005).

Pareto optimality is still the fundamental goal of neo-classical welfare economics. It says that a state in which no one can be made better off without making someone else worse off is Pareto optimal or efficient. However, Pareto optimality offers no guidance when confronted with a policy that lifts a million people out of dire poverty but imposes a minor loss on a single millionaire. Any policy alternative that makes anyone worse off in their own estimation, even while other people are made better off in their own estimation, are "Pareto incomparable." Since they fail the Pareto efficiency criteria they are by implication undesirable. Economics claims to be a "value-free", objective science. If this is the case, then widely used principles of economics such as Pareto Optimality should stand up to scrutiny as being value-free.

3.1.2 Pareto Optimality in the view of economics

Mainstream economists refer to Pareto optimality as Pareto efficiency, or simply efficiency. No one is opposed to efficiency. If markets guarantee efficiency, then by implication they must be good: If we can make at least one person better off with no sacrifice, then shouldn't we do so? Mainstream economists obsess on the importance of diminishing marginal utility in the context of individual choice. However, they virtually ignore the implications of diminishing marginal utility in the context of income redistribution, and exalt Pareto optimality as the single criterion for economic desirability. Mainstream economists admit that there are an infinite number of possible Pareto efficient outcomes, with a different one for every possible distribution of wealth and income. How do we choose between them? Daly has argued that sustainability and distribution take priority over any measure of efficiency and therefore a Pareto efficient outcome will only be desirable if it results from sustainable levels of throughput and a just distribution of wealth and resources (Daly 1992).

Efficiency in any technical field is normally defined by the ratio of output to input. Why choose Pareto optimality as the measure of efficiency? Pareto efficiency seems trivial compared to other measures of efficiency such as GDP per unit of energy, value of output per unit of labor (labor productivity), well being per unit of throughput, Genuine progress indicator (GPI) per unit of ecological footprint, and so on.

3.1 PROBLEMS WITH PARETO OPTIMALITY

There are several serious problems with the use of Pareto Optimality as the central goal of economics. One of the primary implications of "Pareto Optimality" is that it accepts the current distribution of wealth as a given. . If any income distribution can lead to an 'optimal' outcome, there is no need to be concerned about just distribution. Mainstream economists generally make no distinction between earned or unearned income, and when they do, it is typically to recommend lower taxes on the latter, a policy that has been adopted in the USA. Mainstream economists rarely question the legitimacy of the source of wealth. Fairness or origin of the current distribution is a problem left to politicians and society. It is not considered a legitimate question for economics. As Steven Hackett points out, "Slavery was widely seen in the North as being unethical from a deontological perspective, but a policy alternative of ending slavery would make slave owners worse off than under the status quo, and thus would have failed the Pareto efficiency criterion." (Hackett 2001: 26)

While Pareto developed his theory of Optimality, he also described the idea of "indifference curves" in conjunction with Edgeworth, which captures each person's preferences for different combinations of various goods. It established the idea of ordinal rather than cardinal welfare, and eliminated comparisons of utility between people. According to Pareto and current neo-classical orthodoxy, each person can only decide how well off they are "in their own estimation." This avoids any consideration of justice in the current social conditions. In the words of Daly, "The extreme individualism of economics insists that people are so qualitatively different in their hermetical isolation one from another that it makes no sense to say that a leg amputation hurts Smith more than a pin prick hurts Jones." (Daly and Farley 2010: 306)

Economics was originally based on classical utilitarianism, which followed the philosophy of "the greatest good for the greatest number", and thus was very concerned with issues of distribution. Maximizing the total utility of society was the goal, and it was well understood that extra income provided more utility for a poor person than for a rich one. Following Pareto, this was abandoned in favor of ordinal measures of welfare. Interpersonal comparisons of utility are still generally considered outside the bounds of neo-classical welfare economics.

Utility curves of an individual assume diminishing marginal utility: the more of something a person has, the less utility an additional unit provides. Figure 3.1 below depicts the difference in utility from receiving $100 for a person with $1000 compared to the same person with $0. Is it really so far-fetched to believe that two human beings might have similar utility curves, especially when satisfying basic physiological needs? If this curve represented two people, rather than one person at different times, then the wealthier person obviously gets less utility from $100 than the poorer person. Economists can only accept Pareto efficiency as a central goal of economics by largely rejecting the notion of diminishing marginal utility. Therefore Pareto Optimality is self-contradictory.

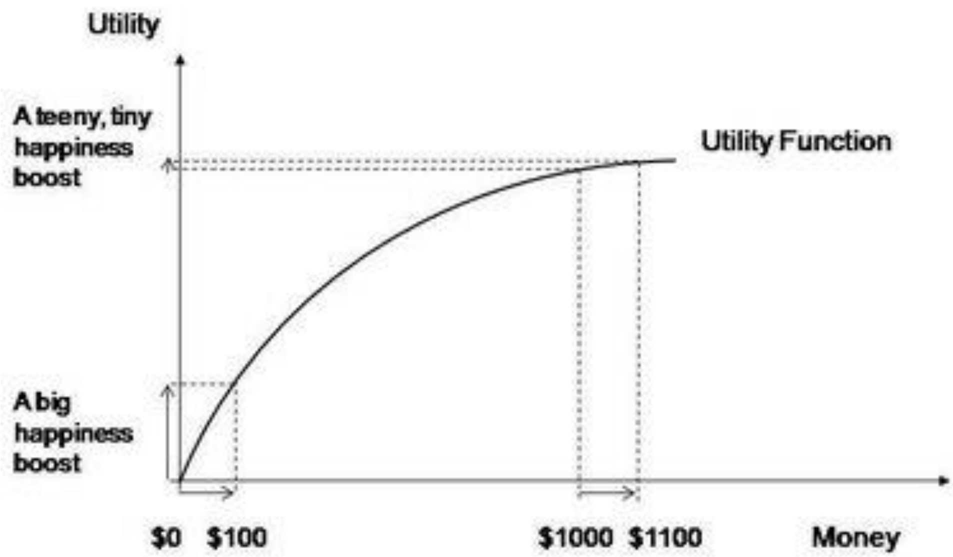

Figure 3.1 Interpersonal comparison of Utility[1]

One of the primary implications of Pareto optimality is that economists cannot pass judgment on the desirability of different distributions of wealth and income. "Potential Pareto optimality" relaxes this criterion by declaring one option superior to another if the winners could potentially compensate the losers through transfer payments, even if no compensation actually takes place (Kaldor-Hicks criteria). Actual compensation is left to society to take care of and is out of the realm of economics.

Economists' obsession with Pareto optimality has led them to virtually ignore the welfare implications of redistribution. If redistribution of the pie is considered off-limits, then the only option left for improving welfare is a bigger pie, typically measured by higher GDP. Also, since the measure of welfare is entirely subjective, how could one determine who feels better or worse? It's much safer to assume that a rising tide lifts all boats, and don't worry about the people with no boats. It is universally believed that we can grow our way out of poverty. Does reality support the myth? Prior to 1967 the poverty rate appeared to decline as GDP increased. However, as shown in Figure 3.2, since 1968 there has been no relationship between long term GDP growth and poverty alleviation as is commonly believed.

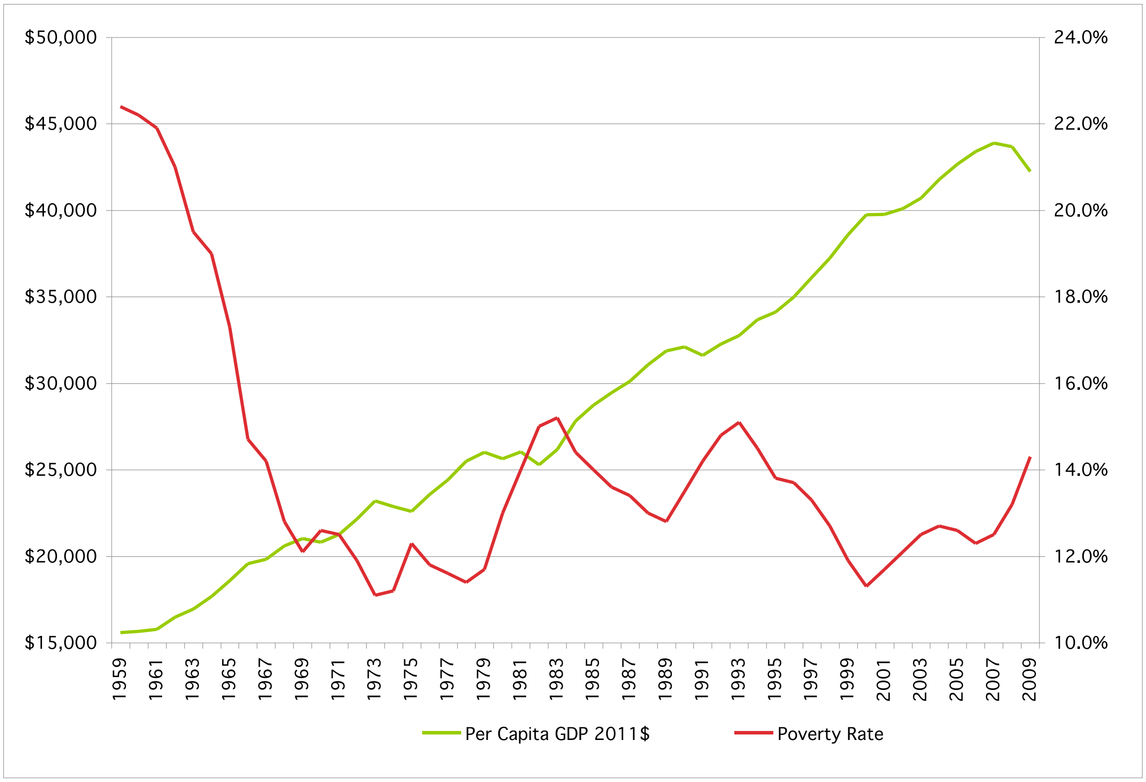

Figure 3.2 Poverty Rate vs. GDP (US Census Bureau 2012)

Even if growth did contribute to poverty alleviation it is questionable if it is a viable option any longer due to the limits of planetary growth. It would require an estimated 4.5 planets to extend current levels of US consumption of resources and emission of pollutants to all 7 billion people on the earth (Ewing et al. 2010) .

3.2 PARETO OPTIMALITY IN THE CONTEXT OF SOCIAL CONDITIONS AND PARETO'S OTHER PHILOSOPHIES

In order to understand the genesis of Pareto's principle of optimality it is important to realize that this principle did not emerge whole cloth in isolation, but was a reflection of his deeply social Darwinist views. The overwhelming dominance of neoclassical market economics in modern society, particular in the US, therefore affected other attitudes and policies in our society, and getting economists to accept Pareto optimality paved the way for the triumph of Pareto's ethical values. In adopting Pareto Optimality, economists unleashed a hidden principle driving society toward ever-increasing inequality. Since the official end of the recession caused by the financial crisis, the top 1% of income earners captured 95% of the income gains and now earn over 20% of the total income, with the top 10% receiving over 50% of total income. (Pikkety and Saez, 2006).

This section of the paper therefore examines Pareto's moral philosophy, and assess the extent to which it is reflected in the American econonomy. In 1916 Pareto wrote what he considered his greatest work, Mind and Society. In this work he elaborated his sociological theory of the "Circulation of the Elites." Persons of superior ability actively seek to confirm and aggrandize their social position. The best-equipped members of the lower classes rise to challenge the position of the upper-class elites. This theory best captures Pareto's social Darwinist beliefs, and also corresponds with recent economic history.

The period of 1980-2008 was one of the longest sustained periods of economic growth in US history. It included a period of neo-liberal supremacy after the demise of the Soviet Union. A huge increase in economic and social inequality also occurred during this time. A combination of factors led to this result. Because of the demise of the communist system, the promoters of capitalism now had "proof" that their system was better and celebrated the "End of History" with the emergence of free market democracies as supposedly the best possible system (Fukuyama 1989) . Free from a countervailing adversary, neo-classical economists, in conjunction with neo-liberal business and political interests, were given free reign to promote their agenda in advocating free-trade, globalization, structural adjustment, corporate downsizing, elimination of the social safety net, destruction of unions, privatization, etc. How did it work out? Pareto's other principles offer a lens through which to evaluate the results of the neo-classical economic (neo-liberal political) resurgence from 1980 to present.

3.2.1 Pareto On Social Class

> "…no social class can for long hold its property or its power if it does not have the strength and vigor necessary to defend them. In the long run only power determines the social forms; the great error of the 19th century will be to have forgotten this principle" (Pareto 1906: 361, cited in Gaffney and Harrison 1994).

Pareto was certainly a supporter of class warfare, the right of elites to control property, and the primacy of power over other social considerations such as justice or equality that are espoused by democratic societies. Let's examine the evidence of income and wealth distribution by economic class, to see if it is consistent with this principle. The first factor we can observe since the 1980's is the concentration of US wealth held by the top 1% of the population. It reached 40.1% in 1997, its greatest level since just before the stock market crash of 1929, when it reached 44.2%. Concentration dropped slightly due to the dot.com crash around 2000, but trended upward to 34.6% until the financial crisis of 2008. After the crash the trend continued up to 35.4% in 2010 (Figure 3.3). This was due in large part to stock market gains going mainly to the wealthy, but also correlated with increasing

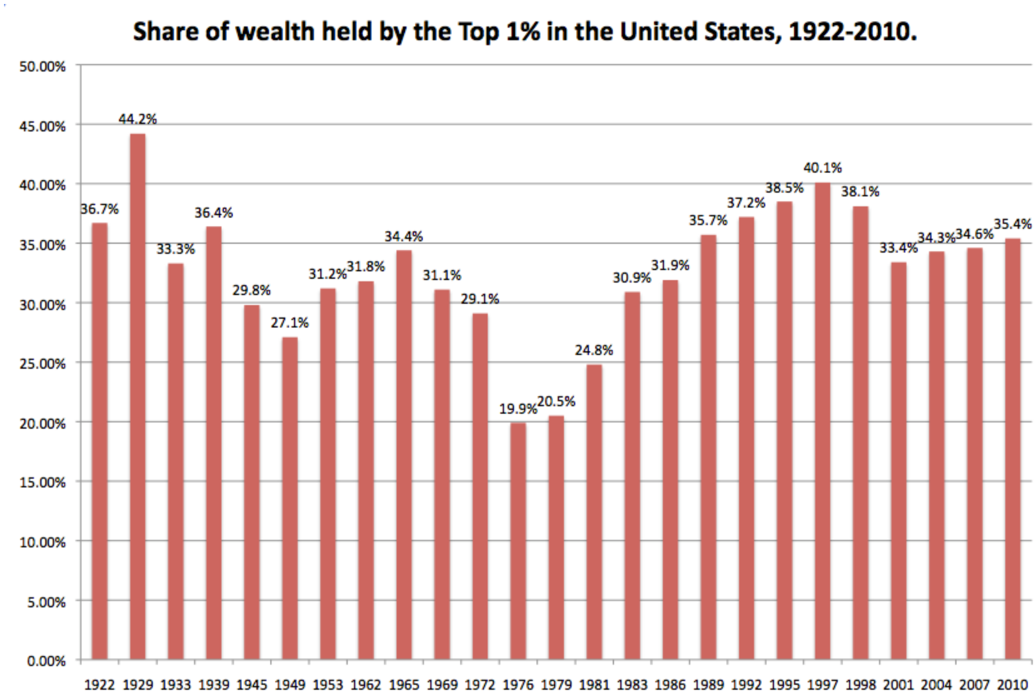

Figure 3.3 Top 1% Share of Household Wealth (Wolff 2001, 20010, 2012)

disparities in income and benefits, tax reductions, and other factors . Certainly, control over approximately 40% of all wealth would appear to give the top 1% the strength to defend its property and power.

In terms of income we see a similar story. The top 10% of society was able to exceed 50% of the total income share in 2012 (Figure 3.4).

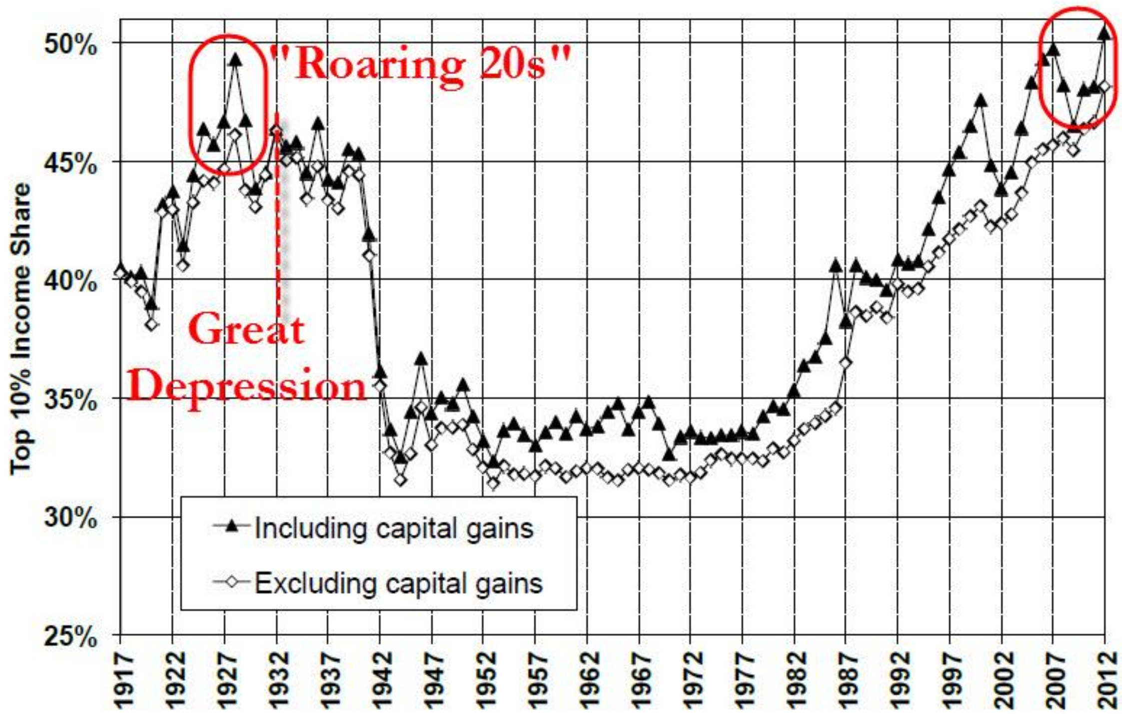

Figure 3.4 Top Decile Income Share 1917-2012 (Piketty and Saez 2006; Saez 2013). For more information on trends in the distribution of wealth and income, see Atkinson et al. (2011); Alvaredo et al. (2013).

Pareto further claimed that "the dominant class A has an alpha part with still enough strength and energy to defend its share of authority; and a beta part made up of degenerated individuals, with feeble intelligence and will, humanitarians, as is said today…Objectively, the struggle consists solely in the B-alpha trying to take the place of the A-alpha; everything else is subordinate and incidental." (Pareto 1927: 91, cited in Gaffney and Harrison 1994).

Pareto explicitly describes a patriarchal battle for dominance as the existing and desirable state of society. While admiring the elite, Pareto also somewhat admired the self-seeking B-alphas, leaders of the lower classes who seek to overthrow the upper classes. Pareto's "Circulation of the Elites", to anyone who has studied primate behavior, is nothing but a description of the dominance hierarchy of chimpanzee society. Alpha males (A-alphas) rule, and are constantly challenged by beta males (B-alphas) for dominance. Despite the wide variety of primate and human societies throughout evolutionary history, including matriarchal and matrilineal societies, and egalitarian neolithic and tribal societies, Pareto holds Chimpanzee society up as the human ideal. Even among apes, chimpanzees are more aggressive and hierarchical compared to others such as Bonobos or Orangutans. Is chimpanzee society what we aspire to as human beings?

3.2.2 Distribution of Wealth 1947-2013

Additional evidence on income distribution reveals that the "Circulation of the Elites" is consistent with recent history. While real family income grew fairly equally across the board from 1947-1979 (Figure 3.5), in the period from 1982-2006 inequality vastly increased (Figure 3.6). The gains increased with increasing income, and those at the top increased their already much higher income by sixteen times as much as those at the bottom. This is considered Pareto "efficient" since no one received less income. Yet do we consider this outcome desirable? It appears to be exactly what Pareto had in mind. In household net worth, the situation was even worse. People at the top got better off, while people at the bottom got much worse off, therefore failing the Pareto efficiency criterion (Figure 3.7). During these

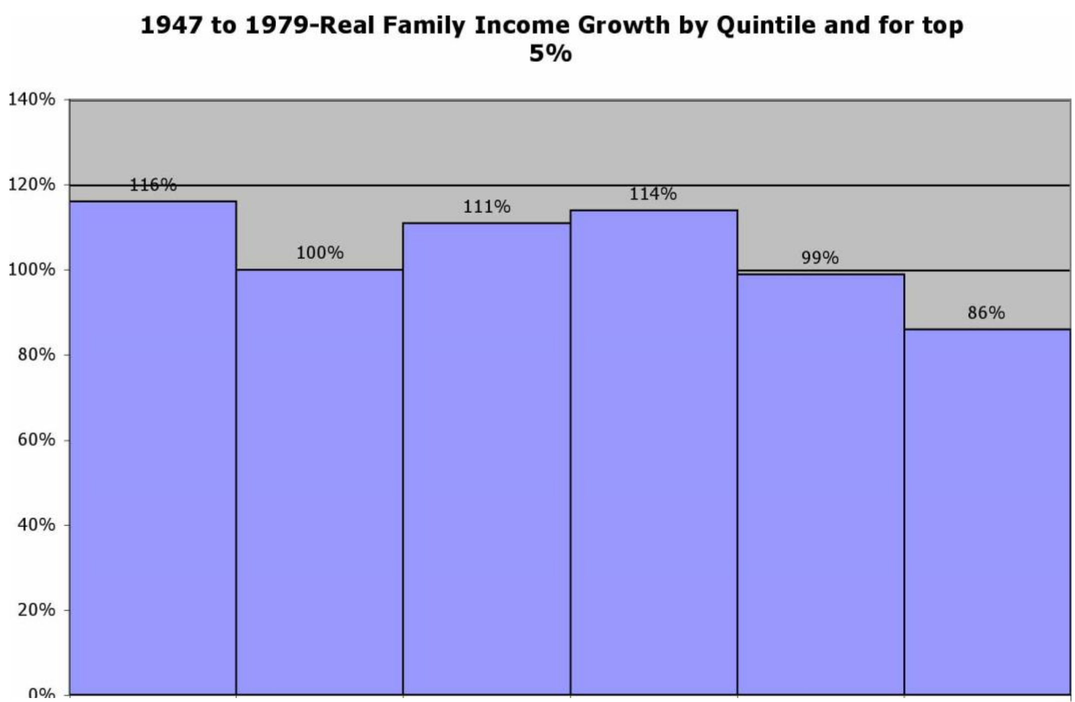

Figure 3.5 1947-1979 Real Family Income Growth (Collins 2000)

years we heard much about "irrational exuberance", and little or nothing from economists about wealth or income inequality. We certainly heard nothing about the decline in household net worth of the bottom 40% of society as a violation of Pareto efficiency. Evidence suggests economic growth in recent decades has made the rich richer and poor poorer. If Pareto efficiency is our sole criterion for judgment, we cannot say whether such growth is good or bad, while the Kaldor-Hicks criterion of potential Pareto efficiency says that aggregate growth is good no matter how unequal the distribution. .

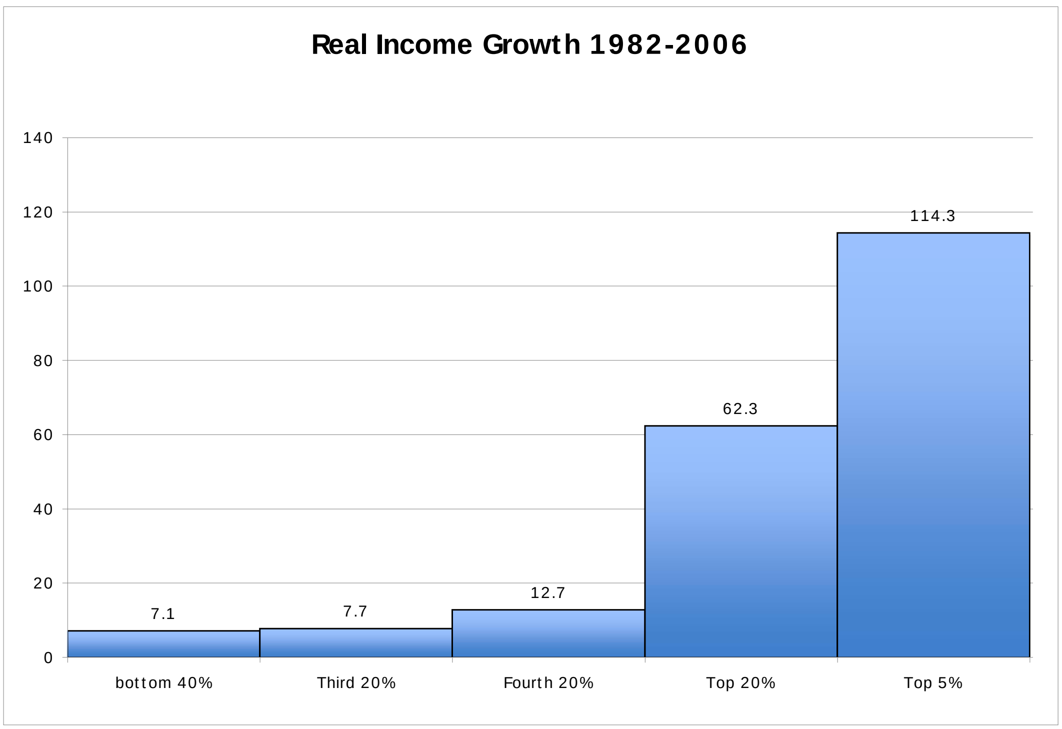

Figure 3.6 1982-2006 Real Household Income Growth (Wolff 2010)

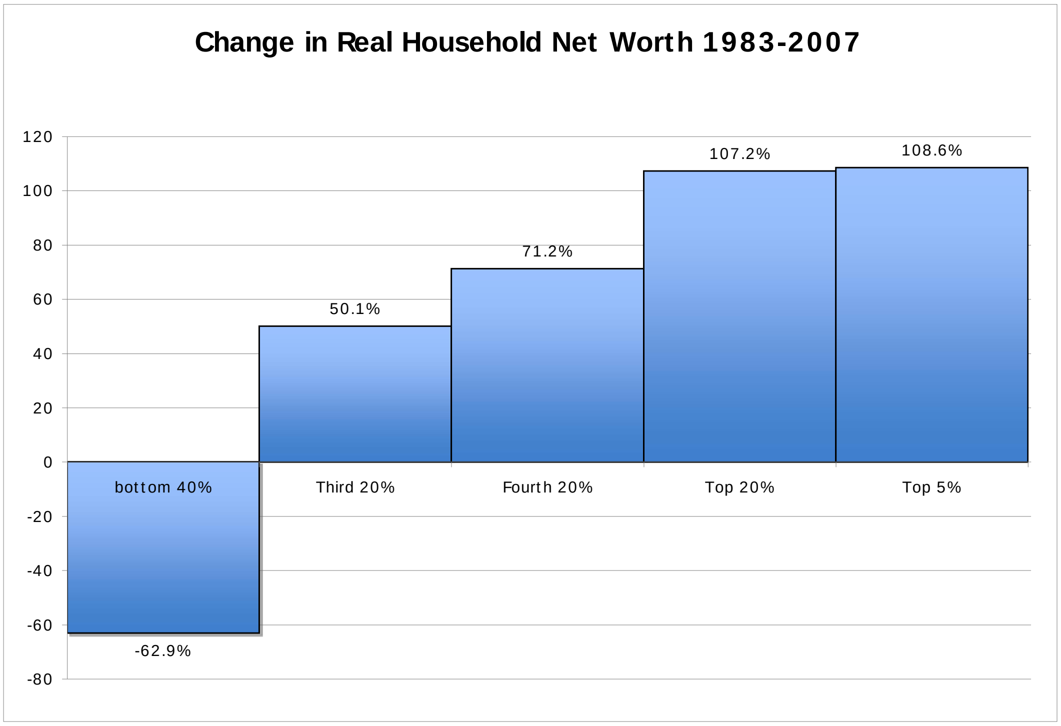

Figure 3.7 Change in Average Household Net Worth (Wolff 2010)

3.2.3 Pareto on Genetic Selection

> "The struggle to appropriate the goods of others may be favorable to (genetic) selection" (Pareto 1906: 341).

CEO pay reflects this principle as corporate management in the US drastically increased its share of corporate income from 1980-present. We have heard the justification from Wall Street that CEOs are the "Job creators", and that "they need high salaries to recruit good people", and that CEO pay reflects performance. But this is all very self-serving as CEOs received huge bonuses even while their companies stock prices were dropping drastically in 2008, or going bankrupt. From 1980 to 2000 the ratio of CEO pay to the average worker increased from 42:1 to 411:1 (Figure 3.8). .Though the ratio of CEO to worker pay in the US dropped to 209:1 in 2009 as seen in figure 3.8, it has since rebounded to 354:1 according to the AFL-CIO (2013). Many other countries such as Germany and Japan are also experiencing dramatic increases in the ratio of CEO to worker pay, but starting from a much more equal base (Khazan 2013) .

Labor productivity increased 33% during this same period of time (Figure 3.9). According to neo-classical economic doctrine, wages always rise in proportion to labor productivity. From 1972 onward, there was basically no corresponding increase in wages. Real wages remained virtually unchanged or fell even lower.

Much of Pareto's writing suggests that he would exalt the CEOs position and be contemptuous of the passive masses who accepted this condition. Several important factors led to the stagnation of real wages in the US:

1) The decline in unionization from 35% in 1948 to 14% in 1999.
2) The export of jobs due to globalization and a "race to the bottom" for wages (Daly and Goodland 1994). (Free-trade zones, NAFTA, WTO, etc.)
3) Increased temporary and contract workers with no benefits
4) Layoffs resulting from corporate downsizing and mergers.
5) The loss of manufacturing jobs

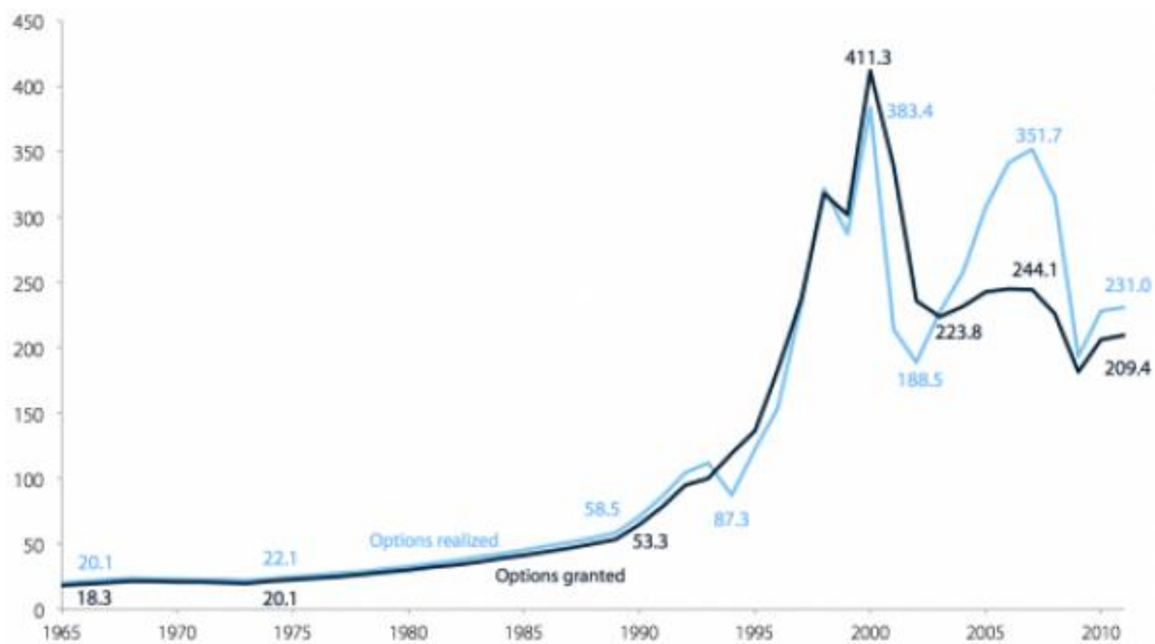

Figure 3.8 Ratio of US CEO pay to Average Worker (Misheland and Sabadish 2012)

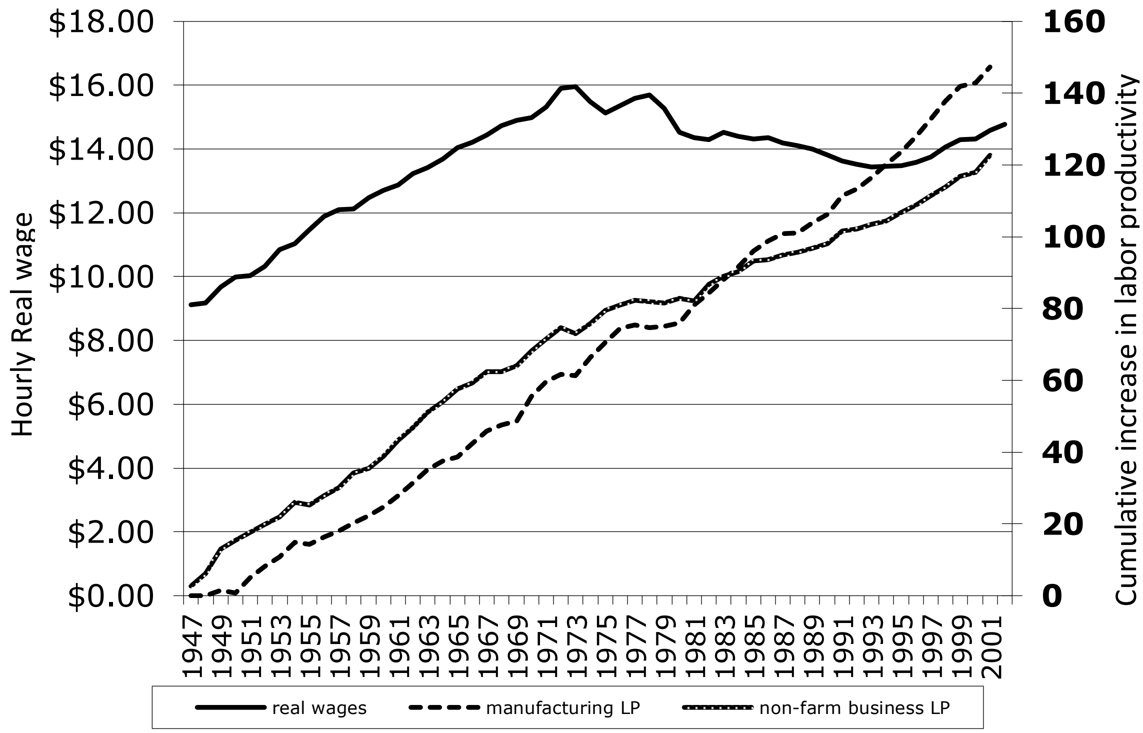

Figure 3.9 Hourly Real Wages and labor productivity (Heintz and Folbre 2000)

3.4 Pareto on Suffrage

> "When suffrage has been given to all men, including madmen and criminals, when it has been extended to women, and if you like, to children, it will have to stop. One cannot go any lower, unless the suffrage is extended to animals" (Pareto 1906: 100, cited in Gaffney and Harrison 1994).

Aside from being a social Darwinist, Pareto was also a misogynist. Is it surprising that economic statistics show that women suffer the most from economic deprivation in a culture where economists follow Pareto's principles? Women, children, and single parent families are most often the victims of hunger. In 2001, 60% of adults seeking food assistance were women, and more than 40% of the total were children (Gazette Community News, 2001). Poverty has risen since 2001. In 2010, 58.7% of single mothers with children under 6 were poor, and 34.2% of all women headed households were poor (Table 3.1). Pareto's goal of disenfranchising women and children has been achieved.

Table 3.1 Poverty Among Families and Children. (Source: US Census Bureau 2012)

2010	all families	children <18	Children <6
all families	13.2%	21.5%	25.4%
married couple	7.6%	11.6%	13.3%
male householder, no wife	17.3%	28.1%	32.2%
female householder, no husband	34.2%	46.9%	58.7%

3.2.4 Pareto on Equality

> "Equality before the law is a dogma for many people…it is not at all evident a priori that such equality is advantageous to society;…the contrary appears more probable." (Pareto 1906: 95, cited in Gaffney and Harrison, 1994).

Pareto belief that inequality is good for society seems to be shared by neo-classical economists. Mainstream economics over the last several decades have espoused the belief that inequality is necessary because it provides incentives for economic growth. Furthermore, inequality is the natural state of society and that to oppose it would be against natural law. On that basis they have opposed policies such as increasing the minimum wage, and ignored the fact that lower income people have a higher propensity to spend and hence to stimulate economic activity. Therefore, economists have fostered a tolerance for the extreme disparities in wealth that we see today. There has been extensive recent experience with inequality as it has rapidly increased over the last several decades. So we can evaluate the results empirically to test Pareto's theory that inequality is good for society.

The Gini coefficient is a commonly used measure of income inequality. While declining slightly prior to 1968 in the US, it has been rising dramatically since then (Figure 3.10).

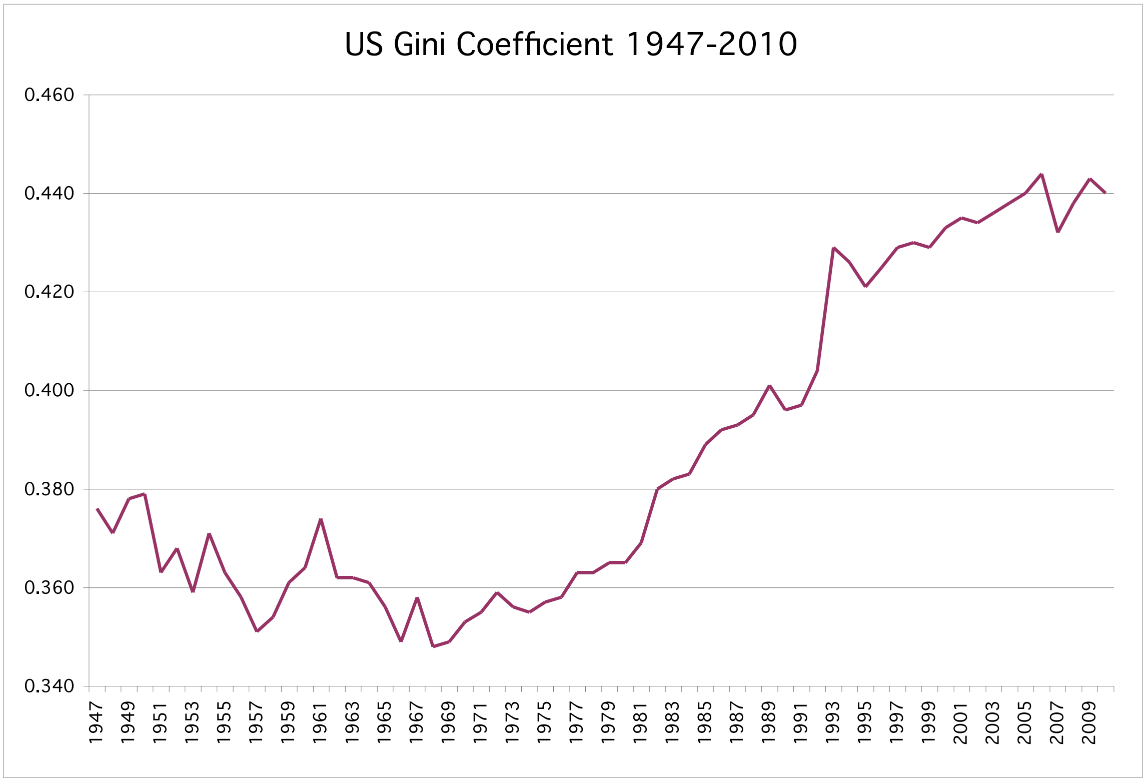

Figure 3.10 US Gini coefficient (US Census Bureau 2011)

3.2.5 Is inequality good for society?

The notion that inequality is good for society, although espoused by neo-classical economists and neo-liberal (US conservative) politicians following Pareto, has been utterly refuted most recently by the book "The Spirit Level". Authors Wilkinson and Pickett (2009), found that numerous indicators of health and social problems, including trust, mental illness, life expectancy, infant mortality, obesity, children's educational performance, teenage births, homicides, imprisonment rates, and social mobility are all made worse by inequality, as depicted in figure 3.11. They found this correlation to hold both between countries and between the 50 US states. Furthermore, the greater the degree of inequality, the worse the outcome as shown in the following charts. Surprisingly, health and social problems show a weak inverse correlation to average income among similar countries, but strong positive correlation with inequality, as depicted in figure 3.12.

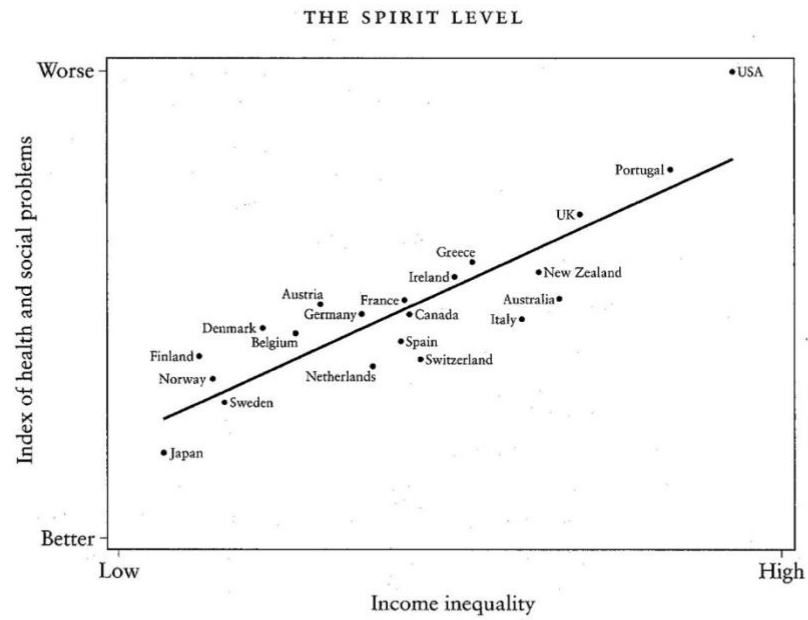

Figure 3.11 Health and social problems are closely related to inequality among rich countries (Wilkinson and Pickett 2009)

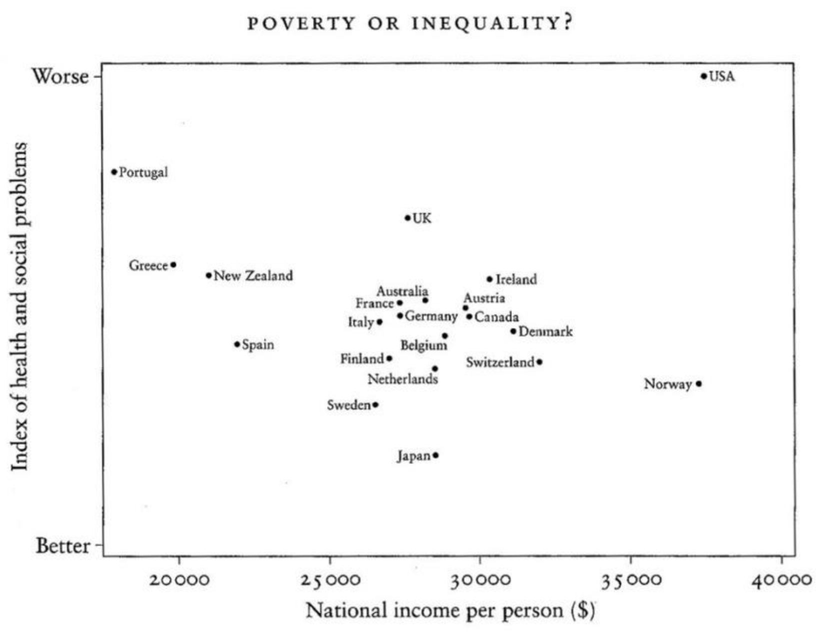

Figure 3.12 Health and social problems are only weakly relaed to national average income among rich countries (Wilkinson and Pickett 2009)

3.2.6 The Triumph of Pareto, economic growth, and welfare

In the last 30 years we have seen the implementation of Pareto's values through laissez-faire, free-market capitalism as promoted by neo-classical economists and neo-liberal advocates. We have seen a huge transfer of wealth and income from the lower income groups to the upper income groups. The greatest poverty is among single women and children. Nonetheless, there seems to be a growing belief that redistribution of any kind is considered morally repugnant. Remember, Pareto considered humanitarians who want to share wealth equitably to be "degenerated individuals". The economy grew, but inequality grew much greater. It is truly the triumph of Pareto.

The response of mainstream economists to this growing inequality has been to call for yet more growth to reduce poverty and inequality. As this article illustrates, economic growth and poverty reduction, in the US at least, are completely unrelated. Furthermore, it is debatable that growth in material throughput is sustainable for much longer. The most effective way to increase the total utility of society is to provide for the material needs of those with the greatest marginal utility from increases in income, namely those at the bottom of the economic scale. How to go about this is an essential question.

3.3 POLICIES TO ADDRESS POVERTY AND INEQUALITY

Given the political difficulty of a Robin Hood tax-the-rich and redistribute scheme, perhaps the best way accomplish to reduce poverty and inequality is through the sharing of rent from the commons . Many policy recommendations have been made to address poverty that do not necessarily require additional economic growth. They include higher and more progressive taxation, eliminating the cap on payroll taxes, negative income tax or basic income, refundable care-giver tax credit, affordable housing, universal health care, income deductible rent, and so on. Many recommendations addressing inequality are based on a Robin Hood approach, transferring wealth from the rich to the poor. Debates usually deteriorate into unproductive and divisive arguments between supporters of redistribution and opponents. Advocates seek to remedy the injustice of the current inequality of wealth, while opponents consider it unfair to confiscate and redistribute what they consider private wealth, and consider it a deterrent to initiative and productivity.

3.3.1 Addressing Inequality

A better approach to inequality would be to make a distinction between those assets that are created by private effort and those which are inherently common property, namely those assets produced neither by individual labor nor by capital. Every person shares a common inheritance of natural and cultural assets. These assets contribute actual or potential dividends to everyone on Earth. Justice requires that contributions to welfare from natural capital and the shared cultural heritage of humankind should be equitably distributed among all, while the value added to these assets by individual or collective effort (labor or capital) should belong to the individuals who contributed that value. Daly has repeatedly argued that taxing low entropy matter and energy inputs to the economy is preferable to taxing value added by labor and capital (Daly 2007). Actual and potential dividends can be computed on a per capita basis for ecosystem services, human and social services, and rent on natural and social assets. For the purposes of redressing inequality I will focus on rent from natural common assets.

3.3.2 Equity from Common Assets

Many resources cannot be assigned individual property rights and are inherently public, such as climate stability and the ozone layer. It is however possible for individuals to destroy them. A number of other resources created by nature can be privately owned, but were traditionally shared by communities, often with explicit rules or norms that limited the amount of resource that any individual could use. Examples include grazing rights, fishing rights, and the right to collect firewood from public lands. The enclosure movement, beginning in England in the 17th century, converted many of these common property rights into private rights (Bollier 2002). Mainstream economists frequently claim that common property resources are poorly managed, resulting in overuse and a 'tragedy of the commons', and therefore should be privatized, though abundant evidence shows that common property institutions can sustainably manage such resources for millennia. Lack of property rights is the problem, not common property rights (Bromley 1992; Ostrom 2002). New technologies frequently create whole new types of resources, such as the electromagnetic broadcast spectrum, , aircraft landing rights, orbital satellite slots, the Internet and other products of government research, and genetic information. New institutions can also establish ownership rights to previously unowned resources, such as cap and trade permits for emissions of pollutants such as sulfur dioxide, NOx, or CO2. Both new resources and newly created property rights raise the important question of to whom these resources should belong. Following the advice of mainstream economists, most of these resources have been turned over to society's wealthiest individuals and corporations, even though when public enforcement of private property rights is very expensive. A more just alternative would be to retain rental values on these assets, as well as charges for harm done to them, as citizen equity.

3.3.3 Equity from Natural Capital

UN Resolution 1803 (XVII) of 14 December, 1962/ Declaration of Permanent Sovereignty over Natural Resources states: "Violation of the rights of peoples and nations to sovereignty over their natural wealth and resources is contrary to the spirit and principles of the Charter of the UN, and hinders the development of international co-operation and the maintenance of peace."

Another View:
"The meek shall inherit the earth... Except for the mineral rights." J. Paul Getty

An existing model of citizen equity in natural capital, combined with weak sustainability currently exists in the US state of Alaska. Oil resources in Alaska belong to the people of the state. The severance tax rate on oil is 12.25%-15% of extraction value depending on the age of the oil field, and 10% on natural gas. Royalties paid by oil companies drilling in Alaska are partly used for state revenue, but a large portion is placed in a permanent fund (APF), which is invested for the benefit of the citizens of Alaska.

Without depleting the capital fund, interest is paid as an annual dividend to every resident of Alaska who has lived in the state for more than one year. Payments have averaged over $1000 per year in recent years (Table 3.2). This illustrates the transformation of natural capital into a sustainable stream of financial capital. As state oil resources are used up, the citizens of Alaska will still have a large and growing capital fund earning interest for them. This will continue indefinitely as long as the fund is managed well, and the state government is prevented from spending the fund.

The APF is one of the few cases in the world where property rights to natural capital have in essence been equally distributed among all citizens. Governments usually retain rights to these resources, and revenues are used for general government expenditures, or quite often end up in the bank accounts of government officials, especially in authoritarian regimes. Under the Bush administration oil companies in the Gulf of Mexico were given a waiver on paying royalties to the government (Andrews 2006). These tax breaks were upheld in Congress as of April 4, 2012. By establishing citizen equity to common assets and natural capital, these benefits will accrue to the population at large, rather than to government officials and their associates, or to corporate owners. What does the Alaska Oil dividend have to do with equity? It turns out that Alaska has the lowest Gini ratio of any state in the US at .40217 (2000 census figure).

Table 3.2 Permanent Fund Dividend 1982-2009

1982	$1,000.00
1983	$386.15
1984	$331.29
1985	$404.00
1986	$556.26
1987	$708.19
1988	$826.93
1989	$873.16
1990	$952.63
1991	$931.34
1992	$915.84
1993	$949.46
1994	$983.90
1995	$990.30
1996	$1,130.68
1997	$1,296.54
1998	$1,540.88
1999	$1,769.84
2000	$1,963.86
2001	$1,850.28
2002	$1,540.76
2003	$1,107.56
2004	$919.84
2005	$845.76
2006	$1,106.96
2007	$1,654.00
2008	$2,069.00
2009	$1,305.00

3.4 CONCLUSION

Pareto Optimality is consistent with Pareto's other writings that are explicitly social Darwinist, advocating "survival of the fittest" in the human economy. Use of this principle in neo-classical economics and calling it "value-free" is inconsistent with reality if not deceitful. It contributes to inequality in society and the constant call for economic growth. Ecological economists such as Herman Daly are correct in questioning Pareto Optimality as a measure of efficiency. “Efficiency” could just as legitimately be measured by reductions in the Gini coefficient, which all else equal would be likely to increase the welfare produced per unit of output.

Redressing the vast inequities in wealth created by the Triumph of Pareto does not require a transfer of hard earned wealth from the rich to the poor. A better way would be to distribute common assets, which do not involve confiscating anyone’s rightfully earned property. Distributing dividends universally from natural and social assets such as minerals, land, and the electromagnetic spectrum might be relatively trivial to those at the top of the income scale. To those at the bottom who receive much greater marginal utility from small increases in income, these dividends could make a significant difference. The reduction in inequality that results, as demonstrated by Alaska, could reduce the perceived need for economic growth. It might also achieve the common good for the many as advocated by Daly, rather than the private good for a few as advocated by neo-classical economists following Pareto.

NOTES

1. http://nicoleandmaggie.files.wordpress.com/2011/10/figure2.jpg

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4. What happens when an infinite-growth economy runs into a finite planet?

Mathis Wackernagel

The essence of Herman Daly's contribution to the science of sustainability is his recognition of physical constraints to economic activities. More accurately than his mentor, economist Nicholas Georgescu-Roegen, Herman Daly argued that it is not the planet's non-renewable resource stocks that are limiting the human economy. Rather, Herman Daly identified correctly, it is the renewable capacity of the biosphere that determines the sustainable size to which an economy can grow. Living within the regenerative budget of our planet would allow humanity to thrive forever (or at least until the human genome morphs into something else, which is likely to happen long before the sun runs out of fuel). In essence, Herman Daly's view correctly departs from Georcescu-Roegen, who incorrectly concluded that humanity is subject to an unwinnable race with entropy as non-renewable stocks get inevitably depleted.

Herman Daly's insight of size limitation, or nature's renewable budget, is at the core of his argumentation and the foundation of Ecological Economics. It frames his proposition of putting the physical scale (or the physical size constraints of an economy imposed by planetary boundaries) at the center of public policy. "The closer the economy approaches the scale of the whole Earth, the more it will have to conform to the physical behavior mode of the Earth," he explains, contrasting the mainstream economic view that scale is largely irrelevant for economic considerations (Daly 2008). Since humanity has already exceeded the scale of the whole world, and is now operating in overshoot (IPCC 2007; Rockström et al. 2009; Global Footprint Network, varia), there is now physical evidence that reaching scale constraints is not just a theoretical possibility but that this constraint is becoming the limiting factor for the human economy. Evidence that the human economy has reached scale constraints has significant implications, since traditional macro-economic theory "becomes an absurdity if its scale is structurally required to grow beyond the biophysical limits of the Earth" (Daly 2008).

Given the absence of this recognition in traditional economic theory, scale has become the core principle of Ecological Economics, an attempt to reconcile economic theory with physical reality.

Inspired by this emerging field of economics informed by thermodynamics, and in support of Herman Daly's premise, Bill Rees and I started to develop the Ecological Footprint in 1990. We attempted to quantify the scale of the human economy compared to the biosphere. We focused on the research question, "How much biocapacity—that is, how much of the biosphere's biologically productive land and sea area—does a population have compared to how much biocapacity it uses to support itself?"

Human and non-human life competes for space – the planet's surface – which provides all the ecosystem services on which life depends. Using space as the accounting unit for both demand on and supply of "biosphere" seemed therefore a logical starting point. Since then, we have developed this approach into a more sophisticated accounting methodology that allows us to track economies' resource metabolisms in the context of the planet's capacity to renew resources and to neutralize waste emissions. Now, we can measure supply versus demand – the two sides of accounting needed for determining the scale of the human economy compared to the planet which hosts the economy.

In 2003, Susan Burns and I founded Global Footprint Network (GFN) with the goal to provide the Ecological Footprint as a robust tool to national governments so they can assess the scale of their economies. So far, more than 12 countries have reviewed our assessments, and none have fundamentally contested the results. A French government study independently reproduced our time series for France within 1 to 3 percentage points. Still, some governments did not like the implications and therefore recommended not to use the Footprint in their public policy – but others have started to incorporate the Footprint in their official measurement efforts. Many of the studies are listed on our website, and can be viewed at www.footprintnetwork.org/reviews.

In 2011, we decided to dedicate our annual report to Herman Daly and his fundamental contributions to Ecological Economics. Hence the report's title: 'What happens when an infinite-growth economy runs into a finite planet?' (GFN 2011). We also included his famous graph distinguishing the "empty world" from the "full world" (GFN 2011: 48–49). And we added an economic interpretation. We explained that an empty world—or what Global Footprint Network calls a "factory world"—allows for unlimited production of goods. In such a world, supply is limited by demand. If there is demand for twice as many widgets, twice as many will be produced. In contrast, in a full world, the economic rules are changing: In a full world, Global Footprint Network argues, the economy becomes a "global auction."

More specifically, if we assume that we are in a world of resource limitations (as indicated by growing global overshoot), with all countries wanting more and more from Earth's limited resource stock, then the world we are in can be likened to a global auction of finite goods. In such an auction, what matters is not absolute ability to pay, but the relative ability compared to all other bidding powers.

For most people, relative income has decreased. For instance, the average Italian, Swiss and American are now earning 30–40 percent less of the global income pie than they did 40 years ago. Yet, those countries' biocapacity deficit (or their demand in excess of what they have available domestically) has increased. If we truly are in an auction world, then this would mean that as countries' dependence on foreign ecosystems is increasing, their ability to bid for resources is weakening.

It points to a structural weakening of economies. In a world of plentiful resources—the "empty world"— declining relative income would not have affected economies. But in a world of ecological overshoot, a country's success depends on its ability to compete for access to limited ecological resources and services. And ability to compete will be increasingly determined by relative income.

Overshoot, we believe, not only produces carbon accumulation in the atmosphere, forest loss and depleted groundwater stocks, but is also becoming a driver behind financial debt crises. This is why we provocatively answer our report's title with "debt boils over." As you will see, the answer is unpacked more in the back of the report, and even more on our website (GFN 2011). Each of our answers is supported by a brief discussion and references.

Global Footprint Network's 2011 Annual Report (GFN 2011) is a modest thank you to one of our living giants and inspirational sources. Herman Daly's genius lies in his ability to drive discussions back to core principles with clarity and a sense of ease, his eloquent and accessible language, and his profound compassion and patience. We are grateful for being able to build on his solid foundation.

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5. Restructuring taxes to create an honest market

Lester R. Brown

Eds. Note: This Chapter was originally published on Encyclopedia of Earth, (EoE) but is no longer available there. It appears that EoE is no longer functioning.

The market is in many ways an incredible institution. It allocates resources with an efficiency that no central planning body can match and it easily balances supply and demand. The market has some fundamental weaknesses, however. It does not incorporate into prices the indirect costs of producing goods. It does not value nature's services properly. And it does not respect the sustainable yield thresholds of natural systems. It also favors the near term over the long term, showing little concern for future generations.

As economic decision-makers—whether consumers, corporate planners, government policymakers, or investment bankers—we all depend on the market for information to guide us. In order for markets to work and economic actors to make sound decisions, the markets must give us good information, including the full cost of the products we buy. But the market is giving us bad information, and as a result we are making bad decisions—so bad that they are threatening civilization.

The roots of our current dilemma lie in the enormous growth of the human enterprise over the last century. Since 1900, the world economy has expanded 20-fold and world population has increased fourfold. Although there were places in 1900 where local demand exceeded the capacity of natural systems, this was not a global issue. There was some deforestation, but over-pumping of water was virtually unheard of, overfishing was rare, and carbon emissions were so low that there was no serious effect on climate. The indirect costs of these early excesses were negligible.

Now with the economy as large as it is, the indirect costs of burning coal—the costs of air pollution, acid rain, devastated ecosystems, and climate change—can exceed the direct costs, those of mining the coal and transporting it to the power plant. As a result of neglecting to account for these indirect costs, the market is undervaluing many goods and services, creating economic distortions.

One of the best examples of this massive market failure can be seen in the United States, where the gasoline pump price in mid-2007 was $3 per gallon. But this price reflects only the cost of discovering the oil, pumping it to the surface, refining it into gasoline, and delivering the gas to service stations. It overlooks the costs of climate change as well as the costs of tax subsidies to the oil industry (such as the oil depletion allowance), the burgeoning military costs of protecting access to oil in the politically unstable Middle East, and the health care costs for treating respiratory illnesses from breathing polluted air.

Based on a study by the International Center for Technology Assessment, these costs now total nearly $12 per gallon ($3.17 per liter) of gasoline burned in the United States. If these were added to the $3 cost of the gasoline itself, motorists would pay $15 a gallon for gas at the pump. These are real costs. Someone bears them. If not us, our children. In reality, burning gasoline is very costly, but the market tells us it is cheap, thus grossly distorting the structure of the economy. The challenge facing governments is to restructure tax systems by systematically incorporating indirect costs as a tax to make sure the price of products reflects their full costs to society and by offsetting this with a reduction in income taxes.

Another market distortion became abundantly clear in the summer of 1998 when China's Yangtze River valley, home to nearly 400 million people, was wracked by some of the worst flooding in history. The resulting damages of $30 billion exceeded the value of the country's annual rice harvest.

After several weeks of flooding, the government in Beijing announced a ban on tree cutting in the Yangtze River basin. It justified this by noting that trees standing are worth three times as much as trees cut: the flood control services provided by forests were far more valuable than the lumber in the trees. In effect, the market price was off by a factor of three.

We know from our analysis of global warming, from the accelerating deterioration of the economy's ecological supports, and from our projections of future resource use in China that the western economic model—the fossil-fuel-based, automobile-centered, throwaway economy—will not last much longer. We need to build a new economy, one that will be powered by renewable sources of energy, that will have a diversified transport system, and that will reuse and recycle everything.

This situation has occasional parallels in the commercial world. In the late 1990s Enron, a Texas-based energy trading corporation, may have appeared on the cover of more business magazines than any other U.S. company. It was spectacularly successful. The darling of Wall Street, it was the seventh most valuable corporation in the United States in early 2001. Unfortunately, when independent auditors began looking closely at Enron in late 2001 they discovered that the company had been leaving certain costs off the books. When these were included, Enron was worthless. Its stock, which had traded as high as $90 a share, was suddenly trading for pennies a share. Enron was bankrupt. The collapse was complete. It no longer exists.

We are doing today exactly what Enron did. We are leaving costs off the books, but on a far larger scale. We focus on key economic indicators like economic growth and the increase in international trade and investment, and the situation looks good. But if we incorporate all the indirect costs that the market omits when setting prices, a very different picture emerges. If we persist in leaving these costs off the books, we will face the same fate as Enron.

As we have seen, a corporate accounting system that left costs off the books drove Enron, one of the largest U.S. corporations, into bankruptcy. Unfortunately, our global economic accounting system that also leaves costs off the books has potentially far more serious consequences.

The key to building a global economy that can sustain economic progress is the creation of an honest market, one that tells the ecological truth. To create an honest market, we need to restructure the tax system by reducing taxes on work and raising them on various environmentally destructive activities to incorporate indirect costs into the market price.

If we can get the market to tell the truth, then we can avoid being blindsided by a faulty accounting system that leads to bankruptcy. As Øystein Dahle, former Vice President of Exxon for Norway and the North Sea, has observed: "Socialism collapsed because it did not allow the market to tell the economic truth. Capitalism may collapse because it does not allow the market to tell the ecological truth."

The need for tax shifting—lowering income taxes while raising levies on environmentally destructive activities—has been widely endorsed by economists. For example, a tax on coal that incorporated the increased health care costs associated with mining it and breathing polluted air, the costs of damage from acid rain, and the costs of climate disruption would encourage investment in clean renewable sources of energy such as wind or solar. A market that is permitted to ignore the indirect costs in pricing goods and services is irrational, wasteful, and, in the end, self-destructive.

Some 2,500 economists, including eight Nobel Prize winners in economics, have endorsed the concept of tax shifts. Harvard economics professor N. Gregory Mankiw wrote in Fortune magazine: "Cutting income taxes while increasing gasoline taxes would lead to more rapid economic growth, less traffic congestion, safer roads, and reduced risk of global warming—all without jeopardizing long-term fiscal solvency. This may be the closest thing to a free lunch that economics has to offer."

The first step in creating an honest market is to calculate indirect costs. Perhaps the best model for this is a U.S. government study on the costs to society of smoking cigarettes that was undertaken by the Centers for Disease Control and Prevention (CDC). In 2006 the CDC calculated the cost to society of smoking cigarettes, including both the cost of treating smoking-related illnesses and the lost worker productivity from these illnesses, at $10.47 per pack.

This calculation provides a framework for raising taxes on cigarettes. In Chicago, smokers now pay $3.66 per pack in state and local cigarette taxes. New York City is not far behind at $3 per pack. At the state level, New Jersey—which has boosted the tax in four of the last five years to a total of $2.58—has the highest tax. Since a 10-percent price rise typically reduces smoking by 4 percent, the health benefits of tax increases are substantial.

Tax restructuring can also be used to create an honest pricing system for ecological services. For example, forest ecologists can estimate the values of services that trees provide, such as flood control and carbon sequestration. Once these are determined, they can be incorporated into the price of trees as a stumpage tax. Anyone wishing to cut a tree would have to pay a tax equal to the value of the services provided by that tree. The market for lumber would then be based on ecologically honest prices, prices that would reduce tree cutting and encourage wood reuse and paper recycling.

When Nicholas Stern, former chief economist at the World Bank, released his ground-breaking study in late 2006 on the future costs of climate change, he talked about a massive market failure. He was referring to the failure of the market to incorporate the climate change costs of burning fossil fuels. The costs, he said, would be measured in the trillions of dollars. The difference between the market prices for fossil fuels and the prices that also incorporate their environmental costs to society are huge.

The most efficient means of restructuring the energy economy to stabilize atmospheric CO2 levels is a carbon tax. Paid by the primary producers—the oil or coal companies—it would permeate the entire fossil fuel energy economy. The tax on coal would be almost double that on natural gas simply because coal has a much higher carbon content. As noted in Chapter 11 of Plan B 3.0: Mobilizing to Save Civilization (W.W. Norton & Co., NY: Brown 2008), we propose a worldwide carbon tax of $240 per ton to be phased in at the rate of $20 per year between 2008 and 2020. Once a schedule for phasing in the carbon tax and reducing the tax on income is in place, the new prices can be used by all economic decision-makers to make more intelligent decisions.

Gasoline's indirect costs of $12 per gallon provide a reference point for raising taxes to where the price reflects the environmental truth. Gasoline taxes in Italy, France, Germany, and the United Kingdom averaging $4.40 per gallon are almost halfway there. The average U.S. gas tax of 47¢ per gallon, scarcely one tenth that in Europe, helps explain why more gasoline is used in the United States than in the next 20 countries combined.

Phasing in a gasoline tax of 40¢ per gallon per year for the next 12 years, for a total rise of $4.80 a gallon, and offsetting it with a reduction in income taxes would raise the U.S. gas tax to the $4–5 per gallon prevailing today in Europe and Japan. This will still fall short of the $12 of indirect costs currently associated with burning a gallon of gasoline, but combined with the rising price of gasoline itself it should be enough to encourage people to use improved public transport and motorists to buy the plug-in hybrid cars that have recently entered the market.

These carbon and gasoline taxes may seem high, but there is at least one dramatic precedent. In November 1998 the U.S. tobacco industry agreed to reimburse state governments $251 billion for the Medicare costs of treating smoking-related illnesses—nearly $1,000 for every person in the United States. This landmark agreement was, in effect, a retroactive tax on cigarettes smoked in the past, one designed to cover indirect costs. To pay this enormous bill, companies raised cigarette prices, bringing them closer to their true costs and further discouraging smoking.

A carbon tax of $240 per ton of carbon by 2020 may seem steep, but it is not. If gasoline taxes in Europe, which were designed to generate revenue and to discourage excessive dependence on imported oil, were thought of as a carbon tax, the $4.40 per gallon would translate into a carbon tax of $1,815 per ton. This is a staggering number, one that goes far beyond any carbon emission tax or cap-and-trade carbon-price proposals to date. It suggests that the official discussions of carbon prices in the range of $15 to $50 a ton are clearly on the modest end of the possible range of prices. The high gasoline taxes in Europe have contributed to an oil-efficient economy and to far greater investment in high-quality public transportation over the decades, making it less vulnerable to supply disruptions.

Tax shifting is not new in Europe. A four-year plan adopted in Germany in 1999 systematically shifted taxes from labor to energy. By 2003, this plan had reduced annual CO2 emissions by 20 million tons and helped to create approximately 250,000 additional jobs. It had also accelerated growth in the renewable energy sector, creating some 64,000 jobs by 2006 in the wind industry alone, a number that was projected to rise to 103,000 by 2010.

Between 2001 and 2006, Sweden shifted an estimated $2 billion of taxes from income to environmentally destructive activities. Much of this shift of $500 or so per household was levied on road transport, including hikes in vehicle and fuel taxes. Electricity is also picking up part of the shift. Environmental tax shifting is becoming commonplace in Europe, where France, Italy, Norway, Spain, and the United Kingdom are also using this policy instrument. In Europe and the United States, polls indicate that at least 70 percent of voters support environmental tax reform once it is explained to them.

Environmental taxes are now being used for several purposes. As noted earlier, landfill taxes adopted by either national or local governments are becoming more common. A number of cities are now taxing cars that enter the city. Others are simply imposing a tax on automobile ownership. In Denmark, the tax on the purchase of a new car exceeds the price of the car itself. A new car that sells for $25,000 costs the buyer more than $50,000. Other governments are moving in this direction. New York Times reporter Howard French writes that Shanghai, which is being suffocated by automobiles, "has raised the fees for car registrations every year since 2000, doubling over that time to about $4,600 per vehicle—more than twice the city's per capita income" (French 2005).

Cap-and-trade systems using tradable permits are sometimes an alternative to environmental tax restructuring. The principal difference between them is that with permits, governments set the amount of a given activity that is allowed, such as the harvest from a fishery, and let the market set the price of the permits as they are auctioned off. With environmental taxes, in contrast, the price of the environmentally destructive activity is incorporated in the tax rate, and the market determines the amount of the activity that will occur at that price. Both economic instruments can be used to discourage environmentally irresponsible behavior.

The use of cap-and-trade systems with marketable permits has been effective at the national level, ranging from restricting the catch in an Australian fishery to reducing sulfur emissions in the United States. For example, the government of Australia, concerned about lobster overharvesting, estimated the sustainable yield of lobsters and then issued catch permits totaling that amount. Fishers could then bid for these permits. In effect, the government decided how many lobsters could be taken each year and let the market decide what the permits were worth. Since the permit trading system was adopted in 1986, the fishery has stabilized and appears to be operating on a sustainable basis.

Although tradable permits are popular in the business community, permits are administratively more complicated and not as well understood as taxes. Edwin Clark, former senior economist with the White House Council on Environmental Quality, observes that tradable permits "require establishing complex regulatory frameworks, defining the permits, establishing the rules for trades, and preventing people from acting without permits." In contrast to restructuring taxes, something with which there is wide familiarity, tradable permits are a concept not widely understood by the public, making it more difficult to generate broad public support.

Each year the world's taxpayers provide an estimated $700 billion of subsidies for environmentally destructive activities, such as fossil fuel burning, over-pumping aquifers, clear-cutting forests, and overfishing. An Earth Council study, Subsidizing Unsustainable Development, observes that "there is something unbelievable about the world spending hundreds of billions of dollars annually to subsidize its own destruction." (de Moor and Calamai 1997)

Iran provides a classic example of extreme subsidies when it prices oil for internal use at one tenth the world price, strongly encouraging car ownership and gas consumption. If its $37-billion annual subsidy were phased out, the World Bank reports that Iran's carbon emissions would drop by a staggering 49 percent. This move would also strengthen the economy by freeing up public revenues for investment in the country's economic development. Iran is not alone. The Bank reports that removing energy subsidies would reduce carbon emissions in India by 14 percent, in Indonesia by 11 percent, in Russia by 17 percent, and in Venezuela by 26 percent. Carbon emissions could be cut in scores of countries by simply eliminating fossil fuel subsidies.

Some countries are already doing this. Belgium, France, and Japan have phased out all subsidies for coal. Germany reduced its coal subsidy from $2.8 billion in 1989 to $1.4 billion in 2002, meanwhile lowering its coal use by 38 percent. It plans to phase out this support entirely by 2018. As oil prices have climbed, a number of countries have greatly reduced or eliminated subsidies that held fuel prices well below world market prices because of the heavy fiscal cost. Among these are China, Indonesia, and Nigeria.

A study by the U.K. Green Party, Aviation's Economic Downside (Whitelegg et al. 2003), describes the extent of subsidies to the U.K. airline industry. The giveaway begins with $18 billion in tax breaks, including a total exemption from the federal tax. External or indirect costs that are not paid, such as treating illness from breathing the air polluted by planes, the costs of climate change, and so forth, add nearly $7.5 billion to the tab. The subsidy in the United Kingdom totals $426 per resident. This is also an inherently regressive tax policy simply because a part of the U.K. population cannot afford to fly, yet they help subsidize this high-cost travel for their more affluent compatriots.

While some leading industrial countries have been reducing subsidies to fossil fuels—notably coal, the most climate-disrupting of all fuels—the United States has increased its support for the fossil fuel and nuclear industries. Douglas Koplow, founder of Earth Track, calculated in a 2006 study that annual U.S. federal energy subsidies have a total value to the industry of $74 billion. Of this, the oil and gas industry gets $39 billion, coal $8 billion, and nuclear $9 billion. At a time when there is a need to conserve oil resources, U.S. taxpayers are subsidizing their depletion.

Just as there is a need for tax shifting, there is also a need for subsidy shifting. A world facing the prospect of economically disruptive climate change, for example, can no longer justify subsidies to expand the burning of coal and oil. Shifting these subsidies to the development of climate-benign energy sources such as wind, solar, biomass, and geothermal power will help stabilize the earth's climate. Shifting subsidies from road construction to rail construction could increase mobility in many situations while reducing carbon emissions. And shifting the $22 billion in annual fishing industry subsidies, which encourage destructive overfishing, to the creation of marine parks to regenerate fisheries would be a giant step in restoring oceanic fisheries.

We can describe this new economy in some detail. The question is how to get from here to there before time runs out. Can we reach the political tipping points that will enable us to cut carbon emissions before we reach the ecological tipping points where the melting of the Himalayan glaciers becomes irreversible? Will we be able to halt the deforestation of the Amazon before it dries out, becomes vulnerable to fire, and turns into wasteland?

What if, for example, three years from now scientists announced that we have waited too long to cut carbon emissions and that the melting of the Greenland ice sheet is irreversible? How would the realization that we are responsible for a coming 7-meter (23-foot) rise in sea level and hundred of millions of refugees from rising seas affect us? How would it affect our sense of self, our sense of who we are?

It could trigger a fracturing of society along generational lines like the more familiar fracturing of societies along racial, religious, and ethnic lines. How will we respond to our children when they ask, "How could you do this to us? How could you leave us facing such chaos?" These are questions we need to be thinking about now—because if we fail to act quickly enough, these are precisely the questions we will be asked.

Today, more than ever before, we need political leaders who can see the big picture, who understand the relationship between the economy and its environmental support systems. And since the principal advisors to government are economists, we need economists who can think like ecologists. Unfortunately they are rare. Ray Anderson, founder and chairman of Atlanta-based Interface, a leading world manufacturer of industrial carpet, is especially critical of economics as it is taught in many universities: "We continue to teach economics students to trust the 'invisible hand' of the market, when the invisible hand is clearly blind to the externalities and treats massive subsidies, such as a war to protect oil for the oil companies, as if the subsidies were deserved. Can we really trust a blind invisible hand to allocate resources rationally?"

In a troubled world economy, where many governments are facing fiscal deficits, these proposed tax and subsidy shifts can help balance the books, create additional jobs, and save the economy's eco-supports. Tax and subsidy shifting promise energy efficiency, cuts in carbon emissions, and reductions in environmental destruction—a win-win-win situation.

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Production in Context: The Concept of Sustaining Production

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6.1 INTRODUCTION

My first encounter with ecological economics was through Herman Daly' s work when I was a graduate student at the Universität Göttingen in Germany. At the time, I worked in agricultural economics on production intensity related 'externalities'. These externalities were anything but 'external' to the farming communities that experienced levels of nitrate in their drinking water wells that far exceeded the standards recommended by the World Health Organization. The resulting policy debate had led me to the United States and to a simulation model (CREAMS) that could be calibrated to supplement empirical data to estimate nitrate emission functions of agricultural production. Herman Daly's work had raised questions about the scale of production – questions that resonated in the context of the expanding European Union and its agricultural policies. How much? How much of what? What is 'optimal' both in terms of scale and intensity? What are effective policies to arrive at such an optimal, second best, or desired level and mix of output? And what recommendations should be offered regarding production methods and best management practices?

The story that made an especially big impression on me was Daly' s recalling a graphic that was to be included in a World Bank report. It depicted a box labeled 'economy' within a larger box labeled 'environment'. After all, where did those things come from that made the generation of output first possible and where did they go, whether the end products produced or the emissions released and waste products left behind? As Daly related the story, every time an edited version of the report came back the 'environment' box had been removed. In the end, no graphic was included in the report - no context for the economy.[1]

Since then, much work by ecological economics and other fields has focused on the side effects of our ever-expanding economy. Yet the production side of the debate has moved somewhat to the back burner. Scale is rarely questioned and even the desirable mix of output generation and input use is not much of a topic. Allocation, after all, is left to the market. This is especially true in the U.S. where the failure of the planned economies and the resulting affirmation of the superiority of unimpeded markets has diverted attention from such issues as sustainable production and social and environmental cost based pricing. And the planned economies certainly did not offer any useful insight, given their complete lack of attention to social and environmental contexts, resulting in the widespread environmental destruction left in their wake.

It is therefore not surprising that, despite growing evidence of the environmental and social costs of economic activity, Herman Daly' s story is still relevant almost 30 years later: social/cultural and environmental/physical context is still not commonly considered in economic theory in general and in the theory of production in particular. The most recent economic crisis and its social and environmental impacts are but one example in a long line of exhibits that illustrate the neglect of context systems. A considerable body of recent work has also raised questions about the validity of the rational economic actor model of modern welfare economics that forms the basis of the demand side of the model[2]. Yet the supply side of the model has not received equal attention. As Georgescu-Roegen (1984) pointed out repeatedly:

> " In contrast to the immense literature dealing with the utility function, … the production function formed the object of no critical analysis ever since Philip. H Wicksteed [1894] introduced it almost one hundred years ago by the slick tautology: the product being a function of the factors of production, we have P=f(a,b,c,…)." (pg. 22).

This chapter argues that it is critically important to attend to the work of developing a context-dependent concept of production, especially in light of the power of aggregate product (final goods and service produced = GDP) as a driver of economic policy. The chapter begins with a brief review of key problems and recent advancements in production theory. It then offers a context-based conceptual framework of production that takes Georgescu-Roegen's work as its starting point. This contextual view sees production as inextricably linked to the social/cultural and environmental/physical contexts within which it takes place and makes evident that those processes that take place outside of the production process itself are critical to the creation of economic output and to the benefits derived from output generation. In fact, it is the context systems that sustain input flows, material transformation and waste absorption that first make the production of economic output possible. A production process that maintains or enhances the underlying sustaining services that support its input flows and transformation capacity can be considered a sustaining production process that enhances the value of economic output. Production that undermines or destroys them is unsustainable and diminishes value. The value of production thus is not solely determined by its consumptive value nor is an increase in economic output necessarily valuable.

The context based view of production therefore changes the economic policy mandate from a strictly 'output protection' view to the recognition that production itself has broader social and environmental implications and thus consequences for economic policy. Context, after all, does more than deliver inputs for economic production, be they ecological or social, natural or human made inputs. Context also receives the by products of our input use and of our output generation. Context thus serves both as a source and as a sink. Losing the sink functions supplied by social and environmental context systems may be as serious (or more) than losing the inputs they supply. Four particular policy aspects are briefly discussed. They are: (1) the role of communication, (2) public participation, (3) regulation and (4) incentives. Addressing these aspects will be critical to a successful transition to a context based production and resultant policies that move beyond the growth and consumption mantra to long-term sustained production.

6.2 OUTPUT WITHOUT CONTEXT

Historically, production was a key focus for economics. Classical economists like Smith, Ricardo, Malthus, Mill and Marx all viewed production as central to economic analysis. A significant part of this analytical work related to the interaction between production and humans and natural resources. Production was viewed as embedded in a social (human) and environmental (natural resources) context that described constraints and capacities.

In contrast, Neoclassical Welfare Economics (NWE) has devoted limited attention to production theory. Its notion of output generation is chiefly driven by utility theory (consumption). According to this understanding it is the goal of satisfying consumer needs and wants (maximizing utility) that drives how much and what kind of output is generated. Since one of the characteristics of utility theory is non-satiation – more is better – output must grow. The fact that marginal utility is generally declining, is not necessarily the saving grace it may appear to be. Since utility is based on subjective preferences, rising expectations may well outpace declining rates of return. The shortcut equation of consumption = utility = social welfare has therefore profound consequences. Its power is evident in our national accounts and in the sheer hypnotic focus of policy makers on GDP (aggregate output measured in monetary terms). Not surprising, aggregate output has occupied a significant place in recent economic history despite the limited attention to its theoretical underpinnings. Output feeds the insatiable hunger of the demand side of the economy and thus fuels the economy itself.

The chief consequence of this view is that marketable output has value while non-market or un-used goods and services do not. Likewise, inputs invested in the production of marketable goods and services have value as measured in marginal product and marginal cost of production. Unused resources or those dedicated to the production of non-market household, community, subsistence and informal sector contributions are considered valueless. Production in this view is "any activity that creates present or future utility" (Frank 1994, pg. 311) with the underlying assumption of a steadily rising utility function.

This view also introduces a qualitative distinction between counted (valuable) and unaccounted for (valueless) production that promotes a preference for allocating resources to produce marketable product. According to this framework, decisions regarding the prices and quantities of inputs and utility generating outputs are mediated by the market via the price system. Improvements in the production process thus focus on technological change and efficiency increases to reduce costs and increase output per unit of costly input. The predictable result is that " free" inputs are overused while the consequences of the underlying value biases remain invisible. The context within which production takes place thus remains at best a source of input streams and a recipient of output and waste streams with little concern for the impact of these delivery streams on the context itself.

The limitations of this notion of output generation and input allocation have long been recognized. Production is depicted as outputs being a function of inputs with no consideration for the production process itself or its social and environmental context. Changes in inputs, their transformation, or the context conditions of their delivery and use remain external to the purview of production. To address possible distortions in the efficient allocation of inputs or in the utility of outputs, negative externalities may need to be internalized. The internalization of externalities, however, demands a production concept that looks closely at the production process itself. This runs counter to the aggregation of inputs into broad categories of stocks of land, labor and capital. As Georgescu-Roegen argued, what is needed instead is a concept of production that pays far closer attention to the flows of useable inputs and to their impact on the capacity to generate future flows. Pasinetti describes the limitations of the NWE model of production as follows:

> " The model clearly has nothing to do with the phenomenon of production. The problem it deals with is the optimal allocation, through exchange, of a certain initial endowment and distribution of resources… It became necessary to shape the theory of production (which by its nature is concerned with flows) in such a way as to meet the requirements of a preexisting theory concerning the optimal allocation of certain stocks of resources." (1977, pg.25-26)

Georgescu-Roegen makes a similar point. He writes: "The boundary only identifies the process. It does not tell us the most important aspect, namely, what the process does." (Georgescu-Roegen 1984, p.23).

A somewhat different perspective on the shortcomings of standard production theory is offered by feminist scholars who focus on the valuation biases of production and their implications for social and environmental contexts outside of the boundaries of the production process (see for example Bernhard Filli et.al.

1994, Mies 1986, Ferber and Nelson 1993, O' Hara 1995b, 1997, 1999, Perkins 1997). According to this view, production does not take place in isolation, but draws instead upon a web of services provided in households, communities and the environment. The non-market, subsistence production and the productive and re-productive services provided in households, communities and ecosystems add value both to the production process and to aggregate output. The valuation bias associated with undervalued and neglected context systems leads to their overuse as unremunerated input flows and the restorative and reproductive work necessary to maintain them never enters productions cost considerations. The effects of input substitutions, such as longer work hours and time pressure, on ecosystems and on social relationships or on the engagement in democratic institutions remain unaccounted for despite their consequences for both social and ecological context systems.

These same valuation biases also translate into considerable pressure to move activities out of households, communities, volunteer organizations and subsistence production and into the market where they are first assigned value. Sadly, those least able to shift activities into the market sphere, and those whose contributions receive low remuneration for their work, pay the highest price for the underlying distortions in value. Mary Mellor writes:

> "If payment is not made in economic terms someone will pay in other ways: they will die before their time, sleep on the street, be nursed by a relative, go without shoes, walk miles to the well." (1994, pg.3)

Within the human community women have most often paid the price for the neglected maintenance needs of input flows and transformative capacity. This is true even as subsistence services of support, care and nurture move from the invisible economy of households, communities and the environment into the official market economy of service sectors and manufactured ecosystems services. A longer commute, longer work hours, less time to socialize and increased demand for so-called time-saving devices all increase the pressure on social and ecological support services provided outside of the boundaries of economic production (Tisdell and Blomqvist, 1999).

Similarly, the rapid deterioration of ecosystems and their ability to buffer, absorb and process the steady stream of emissions and waste is evidence of the price being paid by the non-human community. The list is alarming: an estimated 90 percent of large predatory fish are gone; 75 percent of marine fisheries are either overfished or fished to capacity; half of the world' s wetlands, temperate forest and tropical forests are gone; in drier regions more than half of the agricultural land is suffering some degree of deterioration and desertification; 40 percent of the world's population faces water scarcity and former United Nations Secretary-General Kofi

Annan identified water as a key issues during the 2002 World Summit on Sustainable Development.

This points not only to the overuse, but also to the time dependency of the biological and social processes associated with sustaining human labor inputs and ecosystems services. As Herman Daly and others have pointed out, the notion that human-made capital offers a substitute for land and labor without consequences or limits is deeply flawed (Daly 1997, 2008, Gowdy 2004, Gowdy and McDaniel 2000, Gowdy and O' Hara 1997). Substitution has consequences. Ecosystems services, for example, cannot be replicated without considerable expense and substitution attempts often fall short given our limited understanding of the complexities involved. And as impressive as the substitution of labor has been, particularly in the primary production sectors, even the most technologically sophisticated production process requires some labor input. In addition, the substitution of labor and pressures to increase labor productivity, have consequences as well. These include job-less economic recoveries, a growing bifurcation of the labor market and declining social engagement. What has been perceived as a substitution relationship is in fact a complementary one. The inside and the context of production, the valuable and the seemingly valueless, are inseparably linked.

6.3 RECOVERING CONTEXT

Several concepts have been developed to address the shortcomings of standard production theory. One approach brings the environmental context of production into view by adding emissions. Different products and production methods generate different emissions that are in turn associated with different external costs. Adding this 'external' dimension of production typically leads to a reduction in output levels below those that would be otherwise considered optimal or desirable (O'Hara 1984)[3].

Leontief's work in Input-Output (IO) analysis (1966), which represents each individual production process as a distinct description of input to output transformations, adds further detail to the analysis. The methodology makes it possible to depict production patterns as networks of processes described as interconnected input-output flows. As a result, production can be re-conceptualized as a network of processes and structural patterns (see also Scazzieri's task-process definition of production, 1993).[4]

In addition to adding detail about the production process itself, Input-Output analysis can also add context information. Ecological economists, for example, have used the methodology to describe the relationship between economic activity and environmental impact. One such example adds emissions coefficients to each production sector in a regional input output framework (Vazquez 2001). Natural resource accounts (NRAs) add further information about the supporting environmental context and/or the natural resource base that provides inputs to the production process and receives outputs and waste (Lange et.al. 2003, 2007). And Social Accounting Matrixes (SAM) add social context to the IO framework. SAMs link economic flows to the interconnections between production sectors, households, and primary inputs. This makes it possible to characterize the complementary relationship between output generation and consumptive activity. An increase in consumption requires that the socio-economic system increase its investment both in terms of capital goods and human activity (Zipf 1941, Duchin1998). IO, NRAs and SAMs thus offer a way to describe quantitative flows that make it possible to analyze complex scenarios of economic, social, and environmental change.

One of the well-know critiques of the IO model has been its fixed coefficient assumption and its inability to represent changing input-output ratios at different production scales. Recent studies, however, suggest that fixed coefficients may not be an unreasonable assumption. Average variable costs curves seem to exhibit constant returns to scale as changes in production levels are typically the result of entire operations being shut down and re-opened, which implies proportional changes in all inputs (Miller 2000).

Another context based analytical framework is the so-called Multi-Scale-Integrated-Analysis-of Societal-Metabolism (MSIASM) developed by Giampietro and Mayumi (2000a, 2000b, Giampietro 2003, Giampietro et al., 2009). MSIASM is a bio-economic model that investigates the constraints imposed on production by the structure of the human economy expressed as inputs in human activity and exosomatic energy. Total Human Activity (THA) is determined by population size and represents the endowment of hours available for economic production and consumptive activity per year. The delivery of human activity includes required investments in reproduction, recreation and restoration that are necessary to sustain production and consumption thus taking account of the context of economic activity. Total Exosomatic Throughput (TET) represents the total energy dissipated by a socioeconomic system in support of the productive and consumptive activities per year. The two primary inputs, Total Human Activity (THA) and Total Exosomatic Throughput (TET) are disaggregated into productive and consumptive activity defined as the fractions of human activity and energy invested in economic production and consumption respectively. The model then further disaggregates productive and consumptive activity into three broad sectors – agriculture, products & services and government. Empirical work using the MSIASM model yields valuable insights regarding the constraints associated with sectoral shifts and with the overall expansion of productive and consumptive activities.

Work on activity analysis (Koopmans 1951) focuses more on the inside of the production process. Similar to Input-Output analysis it represents production as a network of interrelated operations, processes and production stages that are carried out by a distinct set of production factors in specific operational and organizational patterns (Georgescu-Roegen 1969, 1989, Hackman and Leachman 1989, Scazzieri 1993). Activity analysis offers considerable detail of the production process itself, and can also provide insights into the demands different production processes and organizational patterns impose on various environmental and social context factors. Social impact, for example, can be described as the different demands on restorative and reproductive time and on the required preparation (education and training) associated with different processing patterns.

Building on the work of Ricardo, Sraffa (1960) developed a model of production that arrives at an invariant measure of value. His work also inspired the Cambridge Economists' critique of neoclassical capital theory (see for example Joan Robinson 1969, 1974; for an extension of Sraffa's work see Roncaglia 1991 and Kurz 2006). Kalecki's work too built on the work of classical economists by developing a cost-of-production based theory of price as opposed to the demand-based theory of price that characterizes neoclassical economic theory (1969).

One of the most comprehensive representations of a system of production that takes both the production process and its contexts into account is Georgescu-Roegen's flow-fund model (1984). It distinguishes between factors and processes associated with stocks/flows and funds/services. A stock is a type of productive input that may be used at any given rate, akin to the MSIASM model's Total Exosomatic Energy throughput. A fund is a type of productive input that can be used only at a certain rate. While "the decumulation of a stock may, conceivably, take place in one single instant" or over time, the decumulation of funds is time dependent and may be used only at a given rate determined "... by the physical structure of the fund." (Georgescu- Roegen 1971, p.226-27). For example, seven tons of coal can be burned in one day or one ton can be burned every day for seven days; yet one laborer can only dig one ditch a day for a week, but cannot dig seven ditches in one day. A stock is capable of producing a flow at any desired rate, but a fund is capable of producing a service only at a given rate that is subject to the constraints of biological time and physical context. These constraints also find expression in social and environmental contexts that provide rest, restoration, and reproduction.

The stock/flow and fund/services distinction then differentiates between viable and feasible production. Viable production is characterized by processes that maintain the corresponding material structures, that support the resourcing and sink functions of production (outside); and it is characterized by a production process that maintains the factors that transform inputs (internal). Our current economy does neither. It relies on stocks of fossil fuel that cannot be maintained; and it depends on funds, the agents of production (transformation), that are over-utilized. The result, a reduced availability of flows and reduced processing capacity, invariably impairs future production.

While new technology may allow for the substitution of scarce stocks by abundantly available ones, the substitution process may increase the demand imposed on fund factors. The increased pressures on labor associated with ever growing expectations of work hours, speed, and skill may serve as an illustration. As pressures on labor inputs (funds) increase, the resulting burden is shifted and translates into higher requirements of care and restoration provided by households, and into higher demands on buffer and absorptive capacities provided by ecosystems. All production depends on the ability to sustain the fund factors that facilitate the processing of flows -- that is it depends on maintaining the physical, intellectual and creative services provided by labor funds and the processing services provided by manufactured capital inputs. As funds are utilized to a different degree or in different combinations, their capacity to generate services may be increasingly challenged. Every production process may thus be feasible, but not every process is viable since "…a technology is viable if and only if it maintains the corresponding material structure and necessarily the human species." (1984, p.29) Georgescu-Roegen writes:

> " In every enterprise, in every household, a substantial amount of labor-time and material are steadily devoted to keeping the buildings, the machines, the durable goods, in a useful, workable state.... Undoubtedly, when a worker leaves a process, he is a tired individual. But when the same individual returns to work next day he is again a rested worker after being restored in an adjacent household." (Georgescu-Roegen, 1984. p. 24).

The proper consideration of social and environmental context factors that sustain economic production has macro-economic implications as well. It points to the inadequacy of aggregate economic output (GDP) as a guide for economic policy. Various efforts have been made to develop an alternative measure that challenges the shortcut assumption that welfare equals utility equals GDP. These include Daly/Cobb' s Index of Sustainable Economic Welfare (ISEW) and its refinement in the Genuine Progress Indicator (GPI). Both measures take personal consumption as their starting point and adjust for (1) defensive expenditures necessary to repair damaged social and environmental systems features, (2) non-renewable energy resources borrowed from future generations, and (3) shifts in the functions provided in households and civil society to the market economy (Daly and Cobb 1989, Cobb et al 1995).[5]

Other measures build on the so-called 'needs theory' of Quality of Life research that traces its roots back to Maslow's theory of human motivation (1970). It suggests at least four generalizable categories of human material (economic) and non-material (cultural) needs – physical needs, safety needs, affection and belonging needs, and esteem needs. As each successive category of needs is satisfied, the quality of life increases. Similarly, multi-criteria measures like the UN Sustainable Development Index use distinct social, economic and environmental indicators in their respective (non-commensurate) dimensions to obtain information about the impact of different scenarios and levels of economic activity. This approach has also been applied to the analysis of regional economic activity and its impact (see for example O' Hara and Vazquez 2006).

What these efforts to re-conceptualize production have in common is that they seek to paint a more accurate picture of the complexities of economic production – including accounting for its impact on social and environmental context factors and resulting corrections in the value of output. What follows is a systematic conceptualization of production as an embedded process termed sustaining production. The concept builds chiefly on Georgescu-Roegen's notion of viable production and argues that the short-hand model of production that has so influenced our economic policies is insufficient and leaves out critically important components. The concept of sustaining production adds the missing pieces and identifies information gaps and accounting deficits that will require continued attention in order to improve decision-making.

6.4 TOWARD A SUSTAINING PRODUCTION THEORY

Georgescu-Roegen's analytical framework of production and his distinction between feasible and viable technologies drew attention to the role of the invisible contributions provided outside the boundaries of the production process long before the sustainability debate was fully under way. Viable technologies imply that flows and funds will be sustained in the long run. Applying this condition to the buffering, assimilative, restorative, re-creative and reproductive processes provided in ecosystems, households and communities, yields the characteristics of a sustaining production process. The term Sustaining Production implies more than sustainability defined as maintaining intergenerational welfare, the productivity of economic systems (Tisdell 1991), or capital stocks – including natural capital stocks (Costanza et.al. 1992). Instead, the term is more akin to Hueting's definition of sustainability as maintaining the regenerative capacity of the environment (Hueting 1989, Hueting et.al. 1992). Sustaining Production implies a network of processes that sustain the social, biological, ecological and physical context within which all production takes place. Only this sort of production is sustainable in the long term. In Georgescu-Roegen's language, the practical problem of sustainability is concerned with working out the tradeoffs between the stock-flow space and the fund-service space of the networks that characterize production processes.

Much of the sustainability discussion in ecological economics has focused on weak versus strong sustainability and on maintaining natural resource stocks to generate sustainable levels of flows. An example is the definition of maximum sustainable yields of renewable resources. Some consideration has also been given to the quality of resource stocks and the underlying support functions that maintain them (Bishop 1987, Costanza et.al. 1991, Daly et.al.1991). The 'fund factors' of human labor power (L), manufactured capital (K), and Ricardian land (N) that ensure the sustained processing of input flows have received considerably less attention. An exception is the work of feminist economists that has focused on the productive and reproductive role of households and communities.

A sustaining production process that is defined in terms of its impact on social and environmental context funds and flows is depicted in figure 6.1. Each quadrant is a schematic representation of the processes associated with a systems component of the overall production process. The depiction does not claim to be comprehensive, but serves as a schematic summary of the concept of production as a context based process. Its graphical representation builds on economists' familiarity with the schematic description of a production function and illustrates expansions to this familiar concept that are needed to arrive at a sustaining production concept.

The first quadrant in figure 6.1 depicts the common formulation of production (output q) as a function of input flows of labor (l), capital (k) and natural resources (n) summarized as inputs i whereby $q = f(i)$. The input vector (i) reflects the technology, management practices, labor skills, and material and energy resources necessary to generate the production described. This treatment of the input vector (i) as input flows into the production process follows the assumption of standard production theory that is focused principally on the ratios of inputs to outputs, but contextualizes all flows as merely a small portion of the complex processes at work in any production process regardless of the types of inputs used and/or transformed.

The function underneath in the second quadrant of figure 6.1 depicts the emission function that corresponds to the production process described in the first quadrant, whereby emissions e are a function of input flows k, l and n or $e=f(i)$. E describes the common conception of externalities yet acknowledges that every production activity is accompanied by emissions and waste, and no production process can claim to fully utilize its inputs without side effects. As technology changes, not only is the relationship between inputs and outputs altered, but the emissions generated change as well. In some cases technological change may reduce both input flows and output flows of emissions and waste; in other cases, technology may lead to different types of emissions, but not necessarily to their overall reduction.

Quadrant three of figure 6.1 describes the processes (care, rest, assimilation, absorption, restoration, recreation etc.) that take place between the emission source and the social and environmental context to which they are released. This processing capacity is a function of multifaceted criteria characterized by complex interactions at work in environmental, social and cultural contexts. The functional relationship between emissions and their impact depends on the ability of the environment to absorb, assimilate, buffer, restore and reproduce; and on the ability of human social systems to heal, support, care for, restore and reproduce. As fund factors deteriorate, the functional relationship between sustaining environmental and social sink functions (s) and emission levels e, with e=f(s), will result in the declining ability of environmental and social systems to ameliorate the effects of emissions, waste, physical exhaustion, emotional stress, mental ineffectiveness and so much more. This third quadrant thus makes explicit the context relationships introduced by Georgescu-Roegen's distinction between funds/services and stock/flows. In fact, it pushes the distinction a step further and asserts that all input use and processing activity draws on the sustaining services of context systems. The distinction between funds/services and stocks/flows may thus be merely temporal or location specific. All labor inputs, for example, require rest that is provided in the adjacent households; and creative labor inputs may require not only physical rest, but also restoration and recreation through social interaction and education. Groundwater inputs used in crop production can only be maintained if water filtration is sustained at a rate higher than the rate of extraction; and if the water absorption capacity of the soil is reduced as a result of declining organic material, for example, the same amount of irrigation water (input) no longer has the same effect on crop production.

This then allows the formulation of a production process q as a function of sustaining services s in the fourth quadrant of figure 6.1 where q=f(s). A process of output generation that qualifies as sustaining production will sustain three simultaneous solutions: increased efficiency in input transformation; reduced emissions and waste; and sustained processing capacities in environmental/physical and social/cultural context systems. These sustaining services can be viewed as the sink capacities that are an integral part of any production process. A production process that will reduce or undermine sustaining services (s) either by adding outflows of emissions and waste, or by placing constant demands on sink capacities is unsustainable and can in fact turn destructive. An unsustainable production process will not be able to reach the same levels of output as a sustaining process without further investments in compensatory services. To meet the definitions of a sustaining production process the vector depicting sustaining services must at least be maintained, if not increased.

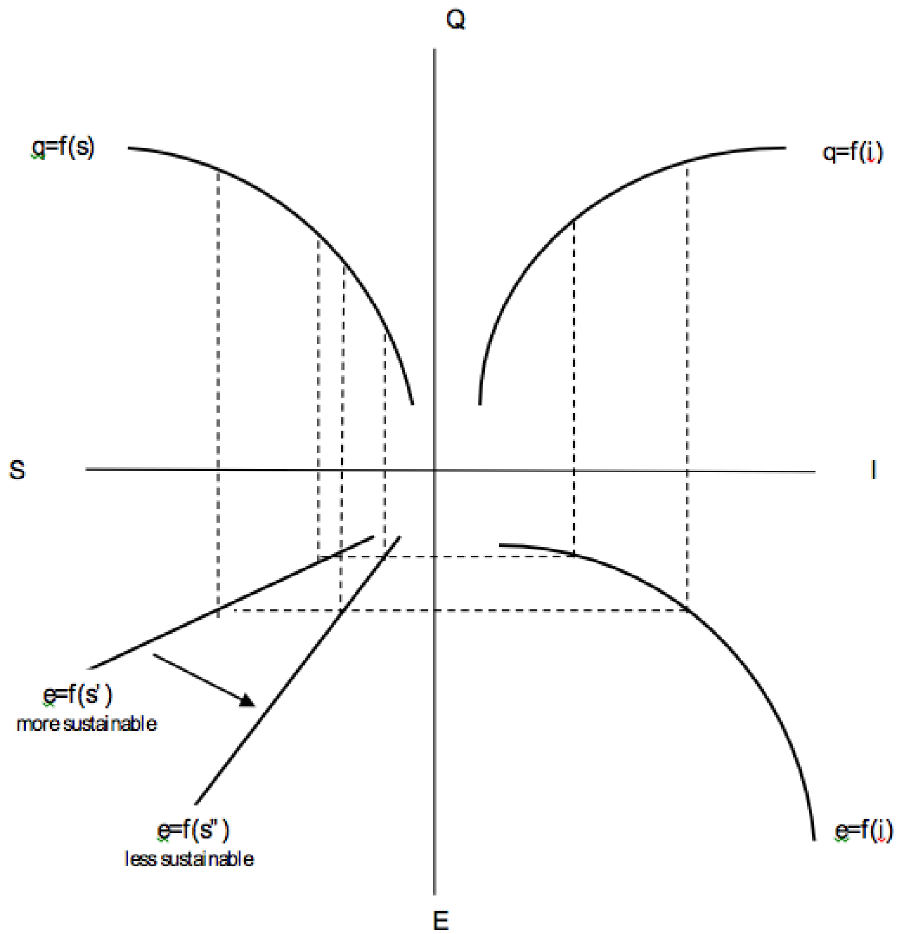

Figure 0.1 Sustaining Production Concept

The familiar two dimensional depiction of the complex processes expressed in the four-quadrant model, however, can be misleading. The model is a two-dimensional projection of four different planes involved in any process of material, energy and entropy transformation. All are interacting simultaneously. The concept of sustaining production (depicted in the fourth quadrant) is therefore the result of three simultaneous processes. It is important to recognize that a sustaining production process as described in this crude graphical form must be understood in relationship to a whole integrated system and not simply in relationship to individual systems components. Groundwater quality, for example, is not simply a function of nitrogen use (i), and emission levels (e), but it is also a function of soil type, aquifer condition, precipitation patterns, and numerous other factors (s). And labor productivity is not simply a function of equipment, education and training, but also of rest, care, recreation, support, social connections, meaning and so much more. Likewise, the concept of sustaining production must consider a wide range of diverse criteria, including region and culture specific ones. This then is one of the significant challenges the concept poses: it is possible to identify some generally applicable social and environmental context criteria that must be sustained almost regardless of time and place; yet others cannot be generalized, but carry instead the expressions of context and culture specific information associated with a specific place and time. This is true not only for the fund factors defined by Georgescu-Roegen, but holds in general. Resource flows too are context dependent and it matters whether one ton of coal is burned every day for seven days, or whether seven tons are burned in one day followed by six days of rest. Entropy is created in both cases, yet entropy is not conserved. Timeframes therefore matter whether in the case of tired labor, of worn out machines, or of near exhausted water reservoirs.

Defining natural resource funds and the functions necessary to maintain them is thus no easy task and will require much interdisciplinary dialogue. Yet it offers the opportunity to re-think production processes and networks with an explicit aim toward maintaining and utilizing social and environmental funds and stock, services and flows, rather than undermining them. This may include global environmental systems like maintaining the atmospheric gas balance; regional ones like providing genetic material for pest-resistant plants or utilizing soil filtration to support zero emission manufacturing parks; and local ones like the nutrient cycling necessary for food production or the absorptive and assimilative capacity of stream ecosystems to retain water quality (Westman 1977, Wilson 1989, Cairns and Niederlehner 1994, Munasinghe and Shearer 1995). And it also includes social systems of households, communities and institutional arrangements that are particularly important to maintaining labor flows and funds including those that maintain capital and natural resource funds. The assumption that labor is abundantly available neglects the fact that worker substitution through relocation or technology places significant demands on the support services provided outside of the production process. The impact of the recent economic downturn is a case in point. While unemployment levels remain high those in the workforce are expected to achieve ever-higher levels of productivity. Those excluded from the workplace suffer from the emotional and financial pressures associated with under- and unemployment. Both the loss of job security and work related stress are thus demanding growing levels of physical and emotional care and support. 6 The accompanying erosion of leisure time also reduces participation in civic society and participation in social and democratic institutions. And added pressure will invariably result from the growing discrepancy between rich and poor, the skilled and the unskilled, the sought after and the unwanted.

The concept of sustaining production offers an extension of Georgescu-Roegen's flow- fund structure matrix that makes visible the costly difference between feasible and viable production (1971 and 1981). As Georgescu-Roegen pointed out, while this kind of analysis is necessary to escape the "save-invest-grow cycle… one should not overlook the gigantic problem of applying the model to actual situations." (Georgescu-Roegen 1981 p. 60). Table 6.1 offers a starting point for identifying environmental and social funds and flows that must be maintained to meet the conditions of sustaining production. Not maintaining them translates into real costs associated with social unrest, floods, droughts, wildfires, food production disruptions, and other (often unpredictable) effects of changed context conditions.

Table 0.1 Indicators of sustaining functions

	Social sustaining functions	**Environmental sustaining functions**
Sustaining Flows	Work force replacement Work force development and training Capital-embedded labor Capital-embedded technology (skill, know-how) Land-embedded labor Land-embedded technology (skill, know-how)	Maximum sustainable resource yields Resource conservation Buffer capacities (i.e. to maintain water quality) Adsorptive capacities Soil fertility Freshwater replacement
Sustaining Funds	Education Health care Rest Safety Shelter Social Interaction Support Meaning	Capital-embedded natural resources Ecosystems health Species reproduction Buffer capacities (i.e. to maintain habitats) Adsorptive capacities Hydrological cycles Temperature buffering Reliability/Predictability Stabilization

Much inter-, multi-, and cross-disciplinary work is needed to further define and operationalize particularly the third quadrant of the model. Much analytical work also remains to define the general versus context specific criteria that describe the web of sustaining services that must be maintained in order to move from mere output generation to sustaining production. The concept of Sustaining Production then offers a visual image of the work ahead. The long time neglect of this work, and the true costs and accounting needs associated with it, is no longer viable. Gus Speth summarizes its consequences as follows:

> " … key features of the system work together to produce a reality that is highly destructive. An unquestioning society-wide commitment to economic growth at almost any cost; powerful corporate interests whose overriding objective is to grow by generating profit, including profit from avoiding the environmental costs they create and from replicating technologies designed with little regard for the environment; markets that systematically fail to recognize environmental costs unless corrected by government; government that is subservient to corporate interests and the growth imperative; rampant consumerism spurred by an addiction to novelty and by sophisticated advertising; economic activity now so large in scale that its impacts alter the fundamental biophysical operations of the planet – all combine to deliver an every-growing world economy that is undermining the ability of the planet to sustain life." (2010).

6.5 A NEW POLICY AGENDA

The concept of sustaining production has significant policy implications. Markets alone are not able to set the signals necessary to communicate the costs associated with maintaining the social and environmental context factors that assure a sustaining production process. The fact that deliberate attention must be paid to the context of production runs counter to the prevailing economic policy agenda – to maintain growth in aggregate output (GDP) at any cost to meet consumer needs/wants. Even in light of the current economic crisis with its stubbornly high unemployment rates, with its collapsed real estate market that has eliminated the bulk of household assets, with shrinking credit scores for millions of US consumers that defy the logic of lower interest rates = increased borrowing = increased consumption; and even in light of mounting evidence of global environmental disruption with massive water management problems, storm events, and vulnerable food systems; the message in Washington continues to be: stimulate consumption, stimulate growth!

Even if one corrected the costs of input streams and transformation services used in the production process to reflect their social and environmental costs (however incomplete), it is doubtful that this would result in a fundamental change of the economic policy message. What is needed is a new message that drastically shifts attention from maintaining output generation to maintaining the sustaining activities on which all current and future production depends. What follows is a brief discussion of four aspects of this change in economic policy – communication, participation, regulation and incentives. All four aspects would warrant a chapter of their own. They are offered here merely as an invitation for further discussion and much needed action.

6.5.1 Communication

One of the big success stories of US economic policy is how effectively it has communicated its message of " more is better". This message, which is fueled by the underlying valuation biases of NWE discussed earlier in this chapter, holds that increased per capita output in final goods and services produced and resultant growth in per-capita income are the very drivers of social welfare and economic health. If consumption grows, so does production, so do jobs, so does income, so does well-being, and the 'more-is-better' equation is complete. US consumers have taken their responsibility as drivers of economic health quite seriously as evidenced in negative savings rates and growing debt. While there has been a slight reversal in savings rates during the recent recession the underlying message remains firm: consumption is good no matter what.

The expected increase in well-being, however, has not been as forthcoming. In fact, recent research shows a picture of increased dissatisfaction, insecurity and depression. Gus Speth quotes psychologist David Myers in describing the American paradox of " …big houses and broken homes, high incomes and low morals, secured rights and diminishing civility." (2010). This should not be too surprising. Quality of life research has long shown that material needs make up only a portion of what constitutes well-being. Economic development must therefore address more than materials needs. It must also address non-material needs such as security, social connection, self-esteem, recreation and other factors that constitute a part of human well-being (Sen 1992, Nussbaum). Rather than keeping track of the single indicator of GDP the real story of economic well-being must therefore also include information about multiple other factors. Building on earlier work in economic development I have termed these key areas of well-being the ' five pillars of economic development' to bring into focus the need for development strategies that improve (1) education, (2) health (3) social and cultural amenities, (4) environmental quality, and (5) access to communication and transportation infrastructure (O' Hara and Vazquez 2006). Addressing these five areas offers a positive starting point for improving the quality of life while also improving the conditions for economic development itself.

Other recent work also addresses the need for positive alternatives that can help illustrate solutions rather than pointing to problems (McKibben 2010, 2008, Schor 2010, Wackernagel). It is unclear, however, how much of this work has penetrated popular awareness and much seems to be reaching those who are already sensitized. One possible way of structuring communication efforts may be to focus on three circles of sustaining production: in order to be productive and generate the goods and services we need and want in the long term, we must sustain self/individuals, other/communities and the environment/nature (O' Hara 1998b). Framing these three categories in terms of personal stories that offer easy connecting points may be a possible starting point for new communication strategies.

Calculations of the Genuine Progress Indicator 7 and the Human Development Index offer similar alternatives. Many countries also already publish a Social Progress Report that captures broader measures of the quality of life. These examples illustrate that it is not the lack of information, but the lack of an effective communication strategy that seems to be at issue. GDP is one convenient number that enjoys universal brand recognition. More complex indicators are less convenient, less familiar, and more difficult to track. Developing an effective communication strategy that highlights the value proposition of an economy built on the principles of sustaining production, and that presents the concept in easily digestible form is a critically important element of a new economic policy agenda. This communication strategy must succeed in connecting the dots between output generation and the social and environmental context factors that undergird it. This is not an easy story to tell. Big catastrophes like large scale deforestation, the oil spill in the Gulf of Mexico, mass foreclosures and unemployment are not easily communicated no matter how much one would expect them to galvanize public attention. Recent research suggests that individual stories are more effective in generating sympathy, support and a sense of urgency (Slovic 2010). Large-scale disasters tend to create a sense of paralysis and detachment. Translating them into stories of individuals, families and neighborhoods appears to be far more effective.

Yet neither economists nor policy makers can resolve the critically important need to identify an effective narrative that redefines the economic policy agenda. The best communication strategists must be put to work to alter the public discourse from growing output to sustaining production. How formidable the communication challenge is can be seen in the recent US health care debate where close to half of the general public still feel uninformed or misinformed even after months of debate. Developing an effective communication strategy that shifts the debate then will require nothing less than the political will to launch a sustained, broad based effort to set the story right. It is not likely that those who have benefitted most from the compliance of US consumers in the growth story will want to alter the narrative. It is therefore all the more important that those who remain outside of the special-interest network are represented in a broad-based education and communication strategy that will change the successful more-is-better narrative.

Beyond changing the focus from any kind of output to the kind of output that sustains the social and environmental context of output generation, the sustaining production narrative also raises broader issues of obligation versus rights. These are expressed in the moral debate of Kantian and Rawlsian versus Communitarian values (for example Macintyre) that raises fundamental questions about present generations obligation to future generations and intergenerational notions of welfare and justice (see for example Dryzek et al 2011, Howarth 1992, Padilla 2002).

6.5.2 Participation

A critical question in conceptualizing a sustaining production process is who gives expression to the sustaining functions that form the social and environmental context that undergirds the flow and fund factors of production. Commonly, professional experts have been consulted to define relevant social and environmental indicators and critical quality thresholds. Relevant fields of expertise cover a wide range including biology, ecology, hydrology, public health, agricultural science, ecological economics, neuroscience, psychology, sociology and cultural studies to mention just a few. It has been less common to consult those with context specific local knowledge or those whose knowledge systems have been marginalized (Clement Tisdell 1995, O' Hara 1999).

As feminist scholars have pointed out, the reliance on credentialed experts and their underlying assumptions ignores the fact that different academic fields and knowledge systems bring distinct biases to the process of selecting indicators of social and environmental context systems and their health (Harding 1986, Ferber and Nelson 1993, O' Hara 1995, 1996, 1998a). Such biases are typically expressed in quantitative over qualitative information, universalizable over context specific, reducible over complex, and specialized over variable indicators. Since the perspective of credentialed experts and agents tend to dominate, valuable social and environmental dimensions of long-term sustainability may be ignored (Dryzek 1987, 1990).

Yet admitting marginalized and less familiar perspectives to the debate is no easy task. The burdens associated with the erosion of social and environmental sustaining functions are not evenly distributed. The poor, those without access to education, the sick who have no access to proper care, those with limited access to communication and those saddled disproportionately with the burdens of a deteriorating environment (i.e. those with no air conditioning, no portable water, no refrigeration) have less opportunity and less power than the wealthy, well-educated and well-connected to bring their life-world (Habermas' term Lebenswelt) to bear. An added challenge is that expressions of environmental context factors and their quality demand that non-human perspectives are considered as well. This calls for new approaches and sensibilities in the assessment process that bring those areas to the fore that are in critical need of support. Successful efforts will require leveling the playing field and bridging persistent information and communication gaps so that those whose voices have gone unheard can become accepted partners in the process of defining critical social and environmental sustaining functions (see O'Hara 1996).

To add to the challenge, informed participation in the public sphere is in jeopardy irrespective of existing biases and exclusions. As pressures mount to move services from households, volunteer organizations and the subsistence sector to the market economy, and as the demands of the market economy grow, the time and energy available for civic engagement continues to decline. This dilemma has been well documented. A recent bright spot has been the engagement of younger US voters in the 2008 presidential election. For the majority of them access to political participation happened via the Internet and its array of social networks, blogs and tweets. Sustaining their engagement and extending it to an issue focus, however, has proven challenging and it is not self-evident what channels for informed public participation and engagement exist, and how expressions of informed public discourse can reach decision makers.

New social media certainly play a role in expanding and redefining participation. Yet serious consideration must also be given to such traditional institutions of public discourse as the Vermont town meetings and face-to-face hearings. One of the dangers of virtual participation is that it attracts networks of like-minded advocates, including niche groups. The anonymity of the medium has also been shown to lower barriers of civility resulting in unproductive name-calling and dismissive attitudes toward those with opposing views. This is a far cry from institutionalizing participation in an informed public discourse. Behavioral research confirms the benefits of face-to-face interaction in decision-making. As I have argued previously, what is needed is a significant expansion of participation in a broad based discourse that makes transparent the relevance of sustaining social and environmental funds and flows at the local, regional and national level (O' Hara 1996, 1997, 1999). This kind of discourse is also indispensible to expanding our knowledge about the impact of social and environmental services on economic production and innovations that improve viable options of sustaining production alternatives. Context based knowledge, informed by the diverse life worlds of people and bioregions, is indispensible to a successful application of the concept of sustaining production in concrete situations and to operationalizing the concept on a broad scale. Its flipside, the continued lack of broad based discourse and the exclusion of diverse perspectives, leads to the continued loss of socio-diversity defined as " …the diverse ways of social and economic arrangements by which peoples have organized their societies including the underlying assumptions, goals, values and social behaviors guiding these economic arrangements and processes" (O' Hara 1995 pg.32). The growing homogeneity of social and economic institutions around the globe should alarm us as much as the loss of biodiversity.

Preserving socio-diversity (and possibly reversing its loss) may in turn yield invaluable information, restorative capacity, resilience and innovation potential.

6.5.3 Regulations

The effectiveness of markets as allocation mechanisms notwithstanding, their usefulness is limited when it comes to operationalizing the concept of sustaining production (see for example Bromley 2009, 1992). Regulations are therefore an indispensible element of the new policy agenda of sustaining production. Regulations are also firmly embedded in current economic policy, albeit their main role is to protect the unimpeded economic growth agenda. This is despite significant differences between those policies that view the role of regulations as providing social and environmental protection and those that view it as protecting the market from interference. The latter is especially prevalent in the United States and its result is an almost unequivocal suspicion of regulatory policies and the role of government in general. Overcoming the resistance to regulations then is critical to a broader acceptance of policies that protect the social and environmental context that ensures the long-term viability of production. The question thus becomes how can regulatory policies be framed more effectively?

Two basic views offer themselves: (1) regulation can be viewed as a purely economic policy tool, and (2) it can be viewed as a tool to achieve broader ethical frameworks. This latter view stands in the tradition of the father of modern market economics: Adam Smith. Smith viewed the invisible hand of the market as working within an ethical framework of compassion that he saw as inextricably rooted in his Calvinist tradition. Smith argued that it is only within this ethical framework and constrained by its imperatives of compassion for ones fellow men that the invisible hand of the market brings order to the chaos of individual, self-interested pursuits of individuals and leads to social welfare. By abdicating to the market the responsibility of setting an ethical framework, the framework itself is reduced to the minimalist norms of market rationality (Pareto Optimality) without any guarantee that accepted societal norms and objectives are achieved. The history of US social and environmental policy is evidence of the fact that ethically motivated goals like the protection of children, the elderly, minority populations, air and water quality and endangered species are not achieved without explicit action; and neither are the values of social justice, the protection of natural beauty of the rights of future generations. These goals must be expressly stated in regulatory targets that are motivated by ethical norms that call for the protection of that which we value and of those who cannot protect themselves.

Alternatively, the protection of social and environmental sustaining functions can be viewed as motivated by a purely economic policy agenda. As the pursuit of economic growth undermines the quality and long-term availability of social and environmental services the economic, social and environmental costs associated with their loss become increasingly burdensome. Deteriorating infrastructure, declining civic engagement, the neglect of children and youth, lower groundwater tables, loss of fish and wildlife and the pervasiveness of invasive pests, all have real economic costs. The aim of effective economic policies must therefor be to correct the resulting misallocation of resources in order to ensure long-term economic production.

While this may seem like a pretty straight-forward argument for regulatory policies that enforce enlightened economic interests, one of the challenges is that social and environmental costs are frequently displaced over space and time. Effective regulations must therefore be foresighted and anticipate the losses and associated costs of exhausted and overburdened context systems even if they are half-way around the globe or ten years into the future. The history of the commons with its long list of examples of free riding and displaced social and environmental costs is not encouraging in this regard. Much has been written about the contradictory aims of short-term electoral goals and long-term sustainability goals. Yet as the costs of deteriorating social and environmental systems become more ubiquitous, support for regulatory policies that assume responsibility for improving the global commons may improve.

A change in public attitudes toward regulations, however, will require more than growing evidence. It will also require significant efforts in communication and education to raise public awareness of the role of regulatory policies and the limitations of free markets despite their significant allocative strengths. A growing number of studies indicate that there may be support for a reformed regulatory agenda. 81 percent of Americans now indicate that the country is too focused on shopping and spending; 83 percent state that society is not focused on the right priorities; and 88 percent state that American society is too materialistic (New American Dream, 2004). These numbers indicate that there may be a viable basis for reframing regulatory policy as a strategy for advancing long held values of relationship wealth over material wealth and giving over getting. Regulatory policy as a strategy for a return to basic values may thus offer a more promising approach than the enlightened economic policy approach that relies heavily on support for an intergenerational ethic.

Effective regulatory policies then will have to rely as much on scientific information as on information about shared values and norms. In fact, the concept of sustaining production inevitably points to the fact that the two are linked. As Robert Frank has so eloquently argued, the pursuit of individual competition and selection of the fittest may in fact lead to a development path that results in significant disadvantages for the group as a whole and a departure from shared goals (Frank 2011). Similarly, the lessons we have learned from systems behaviors suggest that complex, nested systems defy our notions of analysis through compartmentalization and optimization based on individual aims. They point instead to multiple layers of connectedness even as systems success measures, scales and timeframes may vary. To sustain production in the long term then, regulatory policies must focus on the whole and dare not neglect the social, cultural, biological, ecological and spatial context systems that undergird production itself. Ignoring context turns out to be not only a violation of norms such as responsibility for the common good and future generations; it is simply poor allocation that burdens even those who benefit from free-riding in the short term.

6.5.4 Incentives

The notion of taxing bads and incentivizing goods has long been an integral part of economic policy. Incentives are a tool for making the market work for rather than against sustaining social and environmental context systems. Regrettably, public debate in the US on the role of energy taxes or carbon taxes has been stuck for some time. Both appear to be politically unfeasible. This is despite the undeniable effectiveness of carbon taxes in increasing energy efficiency and reducing carbon emissions. The same resistance is evident when it comes to other strategies to tax bads like the use of non-renewable materials or excessive executive salaries that amplify social divides. And there may be some inadvertent upside to this a priori resistance to taxes. Behavioral research suggests that incentives that penalize undesirable outcomes are not equal to incentives that encourage desirable outcomes. This does in no way imply that one should abandon disincentives for bads. In fact, taxing emissions or inputs that burden environmental and social sinks may be an indispensible part of a policy-mix that signals the real costs of production. Yet differentiated strategies that incentivize the support of sustaining functions are also an important part of the mix, and both strategies will have to be employed.

Successful incentive strategies may be found in more differentiated measures that support innovative models of sustainable communities, local living economies and community owned businesses (see for example McKibben 2008, Schor 2010). Such incentives will be locally and regionally focused, support human scale production, and incentivize growth of those activities that protect or increase the health and productivity of social and environmental context factors. This may include economic and non-economic incentives for creating jobs that earn a living wage; for locally oriented businesses; for businesses whose salary structures do not exceed a ratio of 1:25 between non-exempt workers and CEO salaries; for providing improved access to health care; for improved access to education and training; for relevant research that improves the living conditions of local communities and regions; for improved safety; for expanding citizen participation in planning and decision making; for increased social and ecological diversity; and incentives for improving the communication infrastructure in remote areas. These kinds of incentives encourage qualitative growth rather than the un-reflected quantitative growth of aggregate output. Incentives can range from taxes and fees, to tax breaks and rewards, to citizen salary models and non-economic incentives.

Re-envisioning incentive policies to support the implementation of a sustaining production concept may start with a visioning process that develops scenarios of economic activity that improve local and regional living conditions (O'Hara and Vazquez 2006). Broad based participation in developing such scenarios will be essential. It forms the basis for defining what the new goals and objectives are and what incentives can be most productively employed to achieve them. An indispensible element of the policy agenda must therefore be incentives for public space (virtual or real), institutional arrangements and communication channels that support informed ethical discourse, information sharing, and consensus building. Such public space is defined as a communication space that engages a broad range of stakeholders who act as participants in an ethical discourse process and not as advocates of pre-formed agendas (O' Hara 1996, 2001). This kind of communication space can make visible the essential contextual details of history, culture and social groups that form the basis for a change agenda that can bridge traditional divides.

And there are hopeful signs of new community based alliances that can point the way to a successful transition from policies that are purely growth oriented to those that support sustaining services. It is these new formations of viable alternatives that effective incentive policies must first and foremost seek to strengthen. They may include:

- Regional and local economy alternatives that strengthen the five pillars of economic development (education, health, social amenities, environment, communication)
- Models of social and environmental entrepreneurship
- Free knowledge transfer between communities and regions both nationally and internationally
- Merging social and environmental agendas across social institutions and movements (incl. religious, non-governmental, educational, municipal…)

Incentives then can be an effective tool to jump-start a process of rethinking, re-envisioning and realigning actions. At the same time, caution is in order. There is a rich literature of research results that raise questions about the effectiveness of purely economic incentives.8 As has been suggested earlier in this chapter, there is an important place for civic virtue and for doing the right thing. Yet the growing urgency of addressing the continued erosion of sustaining social and environmental context factors may require a multi-pronged approach of moral suasion, incentives and regulatory strategies.

6.6 CONCLUSIONS

Production has received relatively limited attention in new economic welfare theory, which has been chiefly concerned with the demand side of the economic model. Despite this limited theoretical attention, aggregate production has been the driver of economic policy as nations around the world pursue continued, if controlled, growth in GDP (final goods and service produced) or GDP per capita. The concept of production that underlies this economic growth model is rather simplistic. It views output as a function of inputs without consideration or concern for the social and environmental context that first makes the flow of inputs or their transformation into productive output possible.

In contrast, the concept of sustaining production recognizes the importance of social and environmental context factors. It acknowledges that their loss poses real economic costs and even jeopardizes production itself. Since their substitutability is limited, production itself cannot be sustained as social and environmental context factors are degraded or lost altogether. A graphical representation of the concept of sustaining production offers a more complete picture of the production process and its impact and illustrates that the dominant view of production is woefully incomplete. This dominant view renders invisible the very sustaining services that maintain input flows, receive output flows, and sustain the factors necessary to process and transform input and output flows.

The sustaining services that maintain funds and flows take place in households, communities, ecosystems and biophysical context systems that have been relegated to the periphery of the production process. A sustaining production process is one that shifts attention away from the sole focus on output generation and to the context of production and the production process itself. The model of production as a function of inputs ($q=f(i)$) is expanded to include also the emissions generated in the process of input use and transformation ($e=f(i)$), and the buffering, absorptive, restorative and reproductive processes that ameliorate or exacerbate the impact of emissions and waste ($e=f(s)$). The model then arrives at the formulation of production as a function of three simultaneous processes of (1) efficient input use, (2) reduced emissions and waste, and (3) strengthened sinks that are capable of maintaining absorptive and restorative sustaining services ($q=f(s)$).

Operationalizing the concept of sustaining production will require much definitional work to expand our understanding of the specifics of the underlying sustaining processes that keep production viable in the long run. Yet while further definitional work is important the realization of past neglects needs no further proof. The concept of aggregate output that has so shaped our economic policy agenda is inadequate and overly simplistic. Given the far greater complexity of the concept of sustaining production, what is needed is an immediate shift in economic policy that reframes the story of economic production and acknowledges the need to explicitly protect the social and environmental context functions that first make economic production possible.

Four elements of this new economic policy agenda are briefly discussed: communication, participation, regulation and incentives. All four elements stress the need for political will. At the top of the list of this new economic policy agenda is the need to reframe the exceedingly successful message that higher GDP is better and that more aggregate output (in final goods and services) implies a higher quality of life. The fact that a growing segment of the American public has doubts about the long-standing equation of "more is better" offers a hopeful starting point.

Equally as important as a deliberate communication strategy is the need for a broad based, informed, public discourse that brings new perspectives to the process of assessing sustaining social and environmental context functions. Particularly valuable will be the contributions of those non-credentialed, local experts whose views have been marginalized or excluded, but who often carry the main burden of non-viable and unsustainable economic production. Such participation must meet the standards of a discursive ethics as opposed to the unproductive advocacy of entrenched positions and party lines. These two elements of the policy agenda (communication and participation) also play an important role in reframing regulatory and incentive based policies and in overcoming resistance to any form of government intervention that is so prevalent in the US.

Policies that can bring about a shift from a purely output based to a sustaining production concept do not stand in contrast to a strong economy. Instead, they are indispensable to a strong economy and a high quality of life in the long run. As Adam Smith stated in his ' Moral Sentiment' the invisible hand of the market can work only within a moral and ethical framework. It cannot provide that framework. The concept of sustaining production then requires more than scientific evidence. Its implementation requires the best science we can muster, and the best values and ethical framework we know. Apart from its own merits, the concept of sustaining production may also clarify long neglected links between micro and macroeconomics, individual and social context, and humans and the world in which we live and whose fate is inextricably linked to ours.

NOTES

1. Rees relates this same story in Chapter 7 of the companion volume.
2. For more details on problems with the rational actor model, see Vatn, Chapter 5; Gowdy, Chapter 6; and Rees, Chapter 7 in this volume.
3. This is true even if one does not follow the optimization logic of producing at levels where marginal revenue equals marginal cost.

4 . Building on Pasinetti's work on vertical integration (1977, 1981) the IO framework has also been extended to account for intermediate production and for the reproduction of capital inputs (Rhymes 1986, Gowdy and Miller 1990, Miller and Gowdy 1998).

5 . Data for the United States indicates a parallel development of GDP per capita and a 'corrected' General Progress Indicator (GPI) between 1950 and 1970. Since the 1970s GDP per capita and GPI per capita show dramatic differences. Between 1973 and 1994, for example, per capita GDP increased by 73 percent while per capita GPI fell by 45%. This indicates a growing disparity between aggregate consumption and the social and environmental costs associated with defensive expenditures, resource depletion and the loss of non-market service contributions.

6 . Growing evidence shows that inequality increases stress hormones, undermines physical and mental health, and results in a variety of social problems (Sapolsky, R. 2004, Wilkinson and Pickett 2009).

7 . See Lawn, Chapter 8, this volume for more discussion of the Genuine Progress Indicator.

8. See Vatn, Chapter 5 and Gowdy Chapter 6 of this volume for a more detailed discussion of this literature.

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6. Herman Daly and the Steady-State Economy

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7.1 INTRODUCTION

Among Herman Daly's many contributions to ecological economics none is likely to have a greater and more lasting significance than his analysis of and advocacy for a steady-state economy. As is typical of so much of his work, Professor Daly has been inspired by and has built on the work of predecessors including most notably John Stuart Mill, Frederic Soddy and Nicholas Georgescu-Roegen. But he has also brought his own imagination and insights as well as his remarkable capacity for expressing complex ideas in simple terms. It is fair to say that he has virtually single-handedly ensured that the steady-state economy remains an alternative to be considered in discussions of the future of the economy and society.

In this chapter we trace the main strands of the history of the steady-state economy. In summarizing the ideas of various writers we consider their definitions of a steady-state economy, especially what is to be held steady, the case they make for a steady-state economy, and their proposals for policies and operational principles, to use Professor Daly's phrase.

This historical review of a steady-state economy provides the context for an account of this author's investigations into the macroeconomic conditions for a steady-state economy, based on several simulation models, two of which are highlighted in this chapter. The first is a simple model of the U.S. economy in which long range (100 year) scenarios are explored showing relationships between economic growth, energy prices, and possible transitions from non-renewable energy sources to renewable ones. The second model is a more detailed, medium term (30 year) simulation model of the Canadian economy that generates macroeconomic scenarios in which the rate of economic growth is reduced ultimately to zero but where important economic, social, environmental and fiscal objectives can be achieved.

Many questions about steady-state economics remain including for example, its compatibility with capitalism in one form or another. As we proceed further into the 21st century we will have to address these questions or face the unpalatable consequences of striving for continued economic growth in a world which mounting evidence shows is being stressed to its limits. Fortunately, with the contributions of Professor Daly and others as a springboard we have a fighting chance for success.

7.2 A SHORT HISTORY OF THE STEADY-STATE ECONOMY

John Stuart Mill was not the first economist to write about the steady-state economy (he used the term stationary state), but he was among the first to contemplate it with pleasure rather than distaste as Adam Smith, Thomas Malthus and David Ricardo had done before. In his Principles of Political Economy first published in 1848 (Mill, 1970), Mill devoted an entire chapter to the stationary state, 'a stationary condition of capital and population' which he pointed out did not imply a 'stationary state of human improvement.' (ibid. 116). According to Mill, 'in the richest and most prosperous countries' the arrival of the stationary state would soon follow 'if no further improvements were made in the productive arts, and if there were a suspension of the overflow of capital from those countries into the uncultivated or ill-cultivated regions of the earth.' (ibid. 111).

What distinguished Mill from other earlier and contemporary economists, was that he looked on the prospect of the stationary state as a positive rather than a negative development. He did so for several reasons that resonate today and which have found their way into more current treatments, including that by Professor Daly. In his own much quoted, eloquent language Mill writes:

> "I am not charmed with the ideal of life held out by those who think that the normal state of human beings is that of struggling to get on; that the trampling, crushing, elbowing, and treading on each other's heels, which form the existing type of social life, are the most desirable lot of human kind, or anything but the disagreeable symptoms of one of the phases of industrial progress…the best state for human nature is that which, while no one is poor, no one desires to be richer, nor has any reason to fear being thrust back, by the efforts of others to push themselves forward.'' (ibid. 113,114)

Mill was careful to note that in the 'backward countries…increased production is still an important object' and argued that 'in those most advanced, what is economically needed is a better distribution, of which one indispensable means is stricter restraint on population' (ibid. 114). However, he gave few details of how such restraint is to be implemented.

Mill continued making the case for the stationary state by stressing the disadvantages of too many people even if they enjoy a good material living standard. 'A population may be too crowded, though all be amply supplied with food and raiment. It is not good for man to be kept perforce at all times in the presence of his species. A world from which solitude is extirpated, is a very poor ideal...' (ibid. 115) One can only wonder what he would say if confronted with a world of nearly seven rising to nine billion inhabitants, a large and increasing proportion of which are in continuous electronic communication.

With respect to the stationary state, technology (which Mill called the' industrial arts') and time spent working, Mill anticipated later writers when he said:

> 'there would be… as much room for improving the Art of Living, and much more likelihood of its being improved, when minds ceased to be engrossed by the art of getting on. Even the industrial arts might be as earnestly and as successfully cultivated, with this sole difference, that instead of serving no purpose but the increase of wealth, industrial improvements would produce their legitimate effect, that of abridging labour.' (ibid. 116)

It would be a considerable stretch to say that Mill anticipated much of the current environmental arguments for a steady-state economy that have become so central among more recent contributors. Yet we are reminded of such modern analytical tools as the ecological footprint (Wackernagel, 1996) and HANPP, the human appropriation of the products of photosynthesis (Haberl, 2007) when Mill wrote that there is not

> …much satisfaction in contemplating the world with nothing left to the spontaneous activity of nature; with every rood of land brought into cultivation, which is capable of growing food for human beings; every flowery waste or natural pasture ploughed up, all quadrupeds or birds which are not domesticated for man's use exterminated as rivals for his food, every hedgerow or superfluous tree rooted out, and scarcely a place left where a wild shrub or flower could grow without being eradicated as a weed in the name of improved agriculture …' (op. cit. 116)

Mill concluded his remarkable chapter on the stationary state with a thought for the future saying, 'I sincerely hope, for the sake of posterity, that they [the population] will be content to be stationary, long before necessity compels them to it.' (ibid. 116)

Karl Marx is far more well known for his analysis of capitalism and his prediction of its ultimate collapse than he is for what he had to say about steady-state economics. In the mid-nineteenth century while mainstream economists were concerning themselves with the conditions for and implications of single and multi-market static equilibria, Marx devoted his attention to the dynamics of capitalism. He used the concept of 'reproduction', the process by which an economy, and more broadly, a society, recreates the conditions at the end of each period necessary for it to continue to he next. His analysis of capital accumulation and the declining rate of profit in a growing capitalist economy led him to conclude that eventually capitalism would fail to reproduce the conditions required for its ongoing existence.

As a prelude to this analysis Marx analyzed the requirements for 'simple reproduction', where workers receive a wage sufficient to reproduce themselves and the owners of capital replace worn out capital but do not expand it, spending all the surplus value generated in the economy on consumption. Burkett (Burkett, 2004) argues that Marx was well aware of the 'natural conditions' required even for simple reproduction and he takes issue with those who claim that Marx was just as guilty of abstracting the economy from its dependence on the biosphere as mainstream economists. Within the larger discussion of steady-state economics we learn from Marx that there is value in discerning which economic, social and environmental conditions must be recreated and which can be varied without compromising the fundamental requirements of a steady-state economy. Not only must the economic system be capable of reproducing itself, but it must do so in a way that is consistent with reasonably stable social and environmental systems.

Like Marx, John Maynard Keynes contemplated the steady-state economy without using that particular terminology. Unlike Marx, Keynes thought that the steady-state was a very real possibility for those living in the second quarter of the 21st century, some 100 years after he wrote his essay: 'Economic Possibilities for our Grandchildren' (Keynes, 1963). Considering economic growth in Britain since 1580, when Drake stole treasure from Spain, Keynes concluded that: '…assuming no important wars and no important increase in population, the economic problem may be solved, or be at least in sight of solution, within a hundred years.' (ibid. 365, 366)

Keynes did not define what he meant by 'important' with respect to war and population, but World War II and a more than tripling of the world's population since 1930 likely qualify. Accordingly, we might extend his projection of when the economic problem could be solved somewhat further into the 21st century. But that is really not the point. Rather it is that Keynes anticipated the dramatic increases in economic output ensuing from technological change and recognized that 'the economic problem is not - if we look into the future – the permanent problem of the human race.' (ibid. 366).

In contemplating the future, Keynes was concerned about 'technological unemployment …unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour.' (ibid. 364) As it turned out his own prescriptions for maintaining full employment set out some years later in the General Theory of Employment, Interest and Money (Keynes, 1935) has gone some way to prevent this scenario from arising, at least to the extent he forewarned.

More pertinent to the subject of this chapter are the concerns expressed by Keynes at all the changes in work habits, moral codes, 'all kinds of social customs and economic practices, affecting the distribution of wealth and of economic rewards and penalties, which we now maintain at all costs, however distasteful and unjust they may be in themselves, because they are tremendously useful in promoting the accumulation of capital, we shall be free, at last to discard.' (op. cit. 369, 370) In particular, 'The love of money as a possession – as distinguished from the love of money as a means to the enjoyments and realities of life – will be recognised for what it is, a somewhat disgusting morbidity, one of those semi-criminal, semi-pathological propensities which one hands over with a shudder to the specialists in mental disease.' (ibid. 369)

Keynes' view of the steady-state economy was one of abundance and not in any respect a response to the need to bring economies into some sort of balance with the rest of nature, a theme that Mill had discussed nearly 100 years earlier. Nonetheless, Keynes' observations of the challenges presented by an adjustment to such circumstances are a valuable reminder of difficulties likely to be faced in a transition to a steady-state economy.

The day has long passed since economics was called the 'dismal science' in part at least because of Malthusian expectations that the human population would outrun food production. These days it is fair to say that natural scientists are more readily persuaded than economists of the ultimate requirements for economic growth to come to an end because of resource and environmental constraints. This is especially true of those with a background in the life sciences where carrying capacity is a widely used concept that is understood to limit the growth of populations. Humans of course are a biological species so the argument goes that we must also be subject to some sort of carrying capacity limit. Whether or not this applies to growth of the economy as well as population is a complex question. Its answer depends on the definition of what is growing, possibilities for substitution among whatever may become scarce, and the role of technology in enhancing carrying capacity for humans.

One natural scientist who contributed to the discussion of the steady-state economy was geologist M. King Hubbert. Hubbert is best known for his work on peak oil and his accurate prediction published in 1956 that oil production in the lower 48 sates in the U.S.A. would peak in 1970. (Hubbert, 1956) In 1974 Hubbert appeared before a Subcommittee on the Environment of the Committee on Interior and Insular Affairs in the U.S. House of Representatives. In his testimony he stated that 'a system is said to be in a steady-state when its various components either do not change with time, or else vary cyclically with the repetitive cycles not changing with time.' (ibid. 2) Hubbert contrasted the steady-state with the 'transient' state when 'various components are undergoing noncyclical changes in magnitude, either of increase or decrease.' (Ibid.) He used these concepts to describe the historical transition of human societies from a steady-state to a transient state made possible by the utilization of fossil fuels.

Taking the long view, from 5,000 years in the past to 5,000 years in the future, Hubbert argued that 80 percent of all fossil fuels combined 'coal, oil, natural gas, tar sands, and oil shales' (ibid. 7) would be consumed within a span of about 300 years and that we were already well into this brief period. '..the epoch of the fossil fuel era can be but an ephemeral and transitory event – an event, nonetheless, that has exercised the most drastic influence so far experienced by the human species during its entire biological existence.' (ibid.)

Hubbert went on to argue that 'the exponential phase of the industrial growth which has dominated human activities during the last couple of centuries is drawing to a close…[because] it is physically and biologically impossible for any material or energy component to follow the exponential growth phase…for more than a few doublings, and most of those possible doublings have occurred already.' (ibid. 10) Interestingly, in his testimony Hubbert admitted to having changed his mind about nuclear power based on fission as a substitute for fossil fuels since 'it represents the most hazardous industrial operation in terms of potential catastrophic effects that has ever been undertaken in human history.' (ibid. 8)

Hubbert concluded by saying that since 'our institutions, our legal system, our financial system, and our most cherished folkways and beliefs are all based upon the premise of continuing growth…it is inevitable that with the slowing down in the rates of physical growth cultural adjustments must be made. (ibid. 10) However, he is not clear on whether he welcomed these adjustments, as Mill might have done, or whether he simply thought they were inevitable.

Kenneth Boulding made several contributions to our understanding of the dependence of economies on the biosphere in which they are embedded. His seminal essay 'On the Economics of the Coming Spaceship Earth' (Boulding, 1966) is the most well known and deservedly so since it provides a remarkably effective outline of what was later to become the framework of ecological economics. As I have written elsewhere:

> In 11 short pages Boulding gave an account of the economy and its relation to the environment that distinguished between open and closed systems in relation to matter, energy, and information; described the economy as a sub-system of the biosphere; considered the significance of the second law of thermodynamics for energy, matter and information and the extent to which they are subject to entropic processes; argued that knowledge or information is the key to economic development; noted that fossil fuels are a short-term exhaustible supplement to solar energy and that fission energy does not change this picture; considered the prospects for much better use of solar energy enhanced perhaps by the biological revolution; argued that human welfare may be better understood as a stock rather than a flow; presented an ethical basis for conservation; acknowledged that human impacts on the environment have spread from the local to the global; observed the

> limited contribution that corrective taxation might play; and commented that technological change has become distorted through planned obsolescence, competitive advertising, poor quality, and a lack of durability. Boulding summed up his analysis by comparing a 'cowboy' economy which is designed to maximize throughput (for which GNP is a rough measure) with a 'spaceman' economy in which stocks are maintained with minimum throughput. (Victor, 2009)

Boulding alluded to steady-state economics when he said that 'the closed earth of the future requires economic principles which are somewhat different from those of the open earth of the past' (op.cit. 9) and expounded on these in his paper. He developed his ideas further in a paper devoted specifically to a consideration of the 'stationary state' (Boulding, 1973) which he described as 'an integral part of the "economic imagination"'. (ibid. 89) In this paper Boulding stressed that 'the quality of the stationary state depends almost entirely on the nature of the dynamic functions relating the stocks to the flows…' and that '... all stocks, of course do not have to be stationary at the same time.' (Ibid. 92) He also distinguished among a number of 'quasi-stationary states in which some elements of the system are stationary while others are not.' (ibid. 92) Harking back to Mill, Boulding described one such state as having 'a stationary population and a stationary capital stock with…a change in the character of the capital stock…' However, in connecting this to 'a larger throughput and a larger production and consumption with the same overall size of the capital stock' (ibid. p. 92) this particular quasi-stationary state does not fully embody all of the different economic principles a spaceship economy would seem to require.

Perhaps the most important point that Boulding made in his treatment of the stationary state is that 'no matter what element in the system is stationary…the critical question concerns the nature of the controlling mechanism which keeps it so." (ibid. 92) Such mechanisms may be draconian (e.g. forced population control) or more passive, even voluntary, or according to Boulding, they might engender 'mafia-type societies in which government is primarily an institution for redistributing income toward the powerful and away from the weak." (ibid. 95) This is a warning to be heeded as we move from discussing the rationale for a steady-state economy to its implementation. '…the problem of building political and constitutional defenses against exploitation may emerge as the major political problem of the stationary state.' (ibid. 95) Anticipating Hubbert, Boulding concluded his comments on institutional considerations with a trenchant comment on existing institutions and their compatibility with the stationary state: '…precisely because existing institutions – political, economic, educational and religious – have exhibited survival value in a very rapidly progressing society, their survival value in a slow or stationary society is an open question. (ibid. 100)

In his 1966 paper, Boulding included a paragraph or two about the second law of thermodynamics, increasing entropy, and economics. He was not the first to make this link. As Professor Daly has pointed out (Daly, 1996) Fredric Soddy did so forty years earlier (Soddy, 1926) but nobody noticed or if they did, thought it important. This began to change with the publication of Nicholas Georgescu-Roegen's magisterial treatise 'The Entropy Law and the Economic Process' in which he argued forcibly for the relevance of the second law of thermodynamics to an understanding of economic processes. (Georgescu-Roegen, 1971) Georgescu-Roegen's account of this law has engendered considerable debate, especially over his attempt to refute its interpretation as a statistical improbability and his application of the law to matter as well as energy. Nonetheless, he succeeded in convincing many ecological economists of the need to include the second law of thermodynamics in their analytical tool box. Some, such as Professor Daly, have used it as part of their rationale for a steady-state economy (Daly, 1996), a position with which Georgescu-Roegen was not entirely in agreement. Georgescu-Roegen described those from Malthus onwards who 'were set exclusively on proving the impossibility of growth' as being' deluded by a now widespread, but false syllogism: since exponential growth in a finite world leads to disasters of all kinds, ecological salvation lies in the stationary state.' (Georgescu-Roegen, 1980) He challenged this position on three grounds. First, any rate of growth, positive, zero and even negative depletes a fixed stock of resources and so this process must eventually end. Second, if the steady-state is understood as an open thermodynamic steady-state then Georgescu-Roegen pointed to the special conditions and delicate balance that must hold for such a steady-state to endure. Third, he questioned the plausibility of mechanisms by which technological change manages to compensate for a declining resource base, all the while with the capital stock remaining constant, whatever that may mean.

Georgescu-Roegen ended his discussion of the steady-state by challenging the assumption of Mill and others that intellectual activities might flourish in a steady-state by pointing to many contrary historical examples, ' the Middle Ages, for one, of quasi-stationary societies where arts and sciences were practically stagnant'. (ibid. 68) Yet despite his withering criticism of the steady-state, Georgescu-Roegen offered a menu of policy directions derived from 'bioeconomic' principles that are very similar to those proposed by others who still find virtue in the steady-state. Summarizing and paraphrasing Georgescu-Roegen (ibid. 69-72) these policy directions include:

- Cessation of the production of all instruments of war, not only war itself;
- Aid the underdeveloped nations to arrive as quickly as possible at a good (not luxurious) life;
- Gradually lower the human population to a level that could be adequately fed only by organic agriculture;

- Until either solar energy becomes a general convenience or controlled fusion is achieved, all waste of energy should be avoided and, if necessary, strictly regulated;
- Cure ourselves of the morbid craving for extravagant gadgetry;
- Eliminate fashion, emphasise durability;
- Make durable goods even more durable by designing them to be repairable;
- -Come to realize that an important prerequisite for a good life is a substantial amount of leisure spent in an intelligent manner.

One other contribution to steady-state economics that has had a lasting impact is The Limits to Growth (Meadows 1972). This short book described a simulation model of 'the world system' and some of the scenarios that it generated including several in which the system collapses some time in the 21st century. One such scenario, 'the '"standard" world model run assumes no major changes in the physical, economic, or social relationships that have historically governed the development of the world system…the behaviour mode of the system…is clearly that of overshoot and collapse.' (ibid. 124) Other scenarios based on different assumption showed how the system could be stabilized, at least over the duration of the model run (i.e. to 2100), approximating a steady-state.

The Limits to Growth was subjected to an immense amount of criticism and is often dismissed out of hand today incorrectly as having been proven wrong. (See Victor 2008, 89-94 for more discussion). And yet when comparing what actually happened in the world since The Limits to Growth was published with the scenarios described in the book: Turner observes "30 years of historical data compare favourably with key features of…the "standard run" scenario, which results in collapse of the global system midway through the 21st century." (Turner 2008, 1)

Herman Daly is Georgescu-Roegen's most famous student and it is to his contributions to steady-state economics that we now turn. Professor Daly began writing about the steady-state in the 1960s (Daly, 1968) and has continued to the present day (Daly, 2008). In 1996 he wrote 'For over twenty-five years the concept of a steady-state economy has been at the center of my thinking and writing.' (Daly, 1996, 3) His book Steady-State Economics (Daly, 1977) still stands as the single most comprehensive treatment of the subject , one made more relevant with the passage of time. The subtitle of this book summarizes Daly's rationale for examining steady-state economics: 'the economics of biophysical equilibrium and moral growth.'

In his 1977 text Professor Daly defined a steady-state economy (SSE) as:

> 'an economy with constant stocks of people and artefacts, maintained at some desired, sufficient levels by low rates of maintenance "throughput" that is, by the lowest feasible flows of matter and energy from the first stage of production (depletion of low-entropy materials from the environment) to the last stage of

> consumption (pollution of the environment with high-entropy wastes and exotic materials). It should be continually remembered that the SSE is a physical concept. If something is non-physical, then perhaps it can grow forever.' (Ibid. 17. Italics in the original).

More recently and more succinctly, Daly says 'following Mill we might define a SSE as an economy with constant population and constant stock of capital, maintained by a low rate of throughput that is within the regenerative and assimilative capacities of the ecosystem.' (Daly, 2008, 3)

These two definitions focus on keeping constant the stocks of people and artefacts with low rates of throughput that respect the limited capacities of the environment to generate resources and assimilate wastes. Counting people is easy, we do it on a regular basis through the census and so we know what is happening to the stock of people. Counting artefacts is an altogether different matter. Statistical agencies do not keep systematic and complete inventories of artefacts and to the extent that they do, they usually aggregate them in monetary units using market prices. A constant stock of artefacts in value terms is at odds with Daly's insistence that SSE is a physical concept. What does it mean to keep the stock of artefacts constant in physical terms? To simply add them up by weight or volume is not very meaningful and fails to allow for qualitative improvements in the stock and changes in its composition.

Of course Daly realizes this (Daly, 1994) and offers an alternative, more operational, definition of a steady-state economy that focuses on flows rather than stocks: 'we might define the SSE in terms of a constant flow of throughput at a sustainable (low) level, with population and capital stock free to adjust to whatever size can be maintained by the constant throughput that begins with depletion and ends with pollution.' (ibid. 2008, 3)

While it may be easier to obtain more comprehensive information on the physical magnitude of flows to and from an economy and the environment, the problem remains of determining whether physical inflows and outflows are rising, falling or remaining constant unless we abstract completely from changes in their composition. To do so overlooks the dramatically different environmental impacts of flows of materials and energy of equal magnitude and again is unsatisfactory.

One of the many ways in which Professor Daly has advanced the analysis of steady-state economics is the distinction he makes between growth and development. He defines growth as an 'increase in throughput , which is the flow of natural resources from the environment, through the economy, and back to the environment as waste. It is a quantitative increase in the physical dimensions of the economy and/or of the waste stream produced by the economy'. (Daly, 2004) Daly contrasts growth which 'must end' with development which can continue indefinitely because it is 'qualitative change, realization of potential, evolution toward an improved, but not larger, structure or system – an increase in the quality of goods and services…provided by a given throughput.' (ibid.)

On the surface this definition of development and the assumption that it can continue essentially without limit is at odds with his former teacher Georgescu-Roegen's critique of the steady-sate economy that it is ultimately doomed to fail. In all likelihood, this difference in views stems more from a difference in time horizon than it does about the nature of the biophysical world and the dependence of economies on it. In the exceedingly long term, when the sun expires and likely much before that, human economies are bound to fail so in that sense Georgescu-Roegen is correct. But with a time horizon of say, a few hundred years or a millennium or two, then arguably Daly's perspective is sound and more relevant.

A more pressing concern than the very, very long run is the lack of a metric for measuring growth as defined by Professor Daly. He eschews the use of changes in gross domestic product (GDP) or gross national product (GNP) for measuring economic growth because they conflate quantitative and qualitative change. 'Note that an SSE [steady-state economy] is not defined in terms of gross national product. It is not to be thought as "zero growth in GNP." ' (Daly, 1996, 32) But Professor Daly does not provide an alternative metric for a steady-state economy unless by implication he means simply the aggregate tonnage of throughput, which runs into the problem of aggregating flows of very different qualities noted earlier. In the absence of such a metric some analysts, this author included, have chosen for pragmatic reasons to address questions about a steady-state economy, or at least about alternatives to a reliance on growth, using the conventional measure of growth: changes in real GDP and real GDP per person for which ample statistics exist.

Another useful analytical distinction emphasized by Professor Daly, based on Georgescu-Roegen's work, is between stock-flow resources and fund-service resources. Stock-flow resources are 'materially transformed into what they produce…they can be used at virtually any rate desired…; their productivity is measured by the number of physical units of the product into which they are transformed; can be stock-piled; are used up, rather than worn out.' (Daly 2004, 440). Fund-service resources are 'not materially transformed into what they produce…can only be used at a given rate, and their productivity is measured as output per unit of time; cannot be stockpiled; and are worn out, rather than used up.' (ibid. 433)

Human made machine tools are funds which provide services. They wear out but material from them does not end up in the goods they produce. Raw materials and semi-finished products are stock-flow resources which do get used up and are incorporated in the final goods. What nature provides to the economy can also be categorized as stock-flow and fund-service resources but unlike human artefacts, which are typically one or the other, natural capital can be fund-service and stock-flow resources simultaneously. Examples include forests which as a fund provide services such as habitat and soil stabilization, and as a stock provides a flow of timber. This distinction between stock-flow and fund-service resources can be helpful in understanding the excessive pressures that humans place on the environment. Because of market failure, flows are valued more highly than services from the same resource so that the value of the resource as a stock overrides its value as a fund resulting in depletion rather than preservation. In a steady-state economy attention should be paid to maintaining stocks and funds separately and in combination.

In addition to expounding on the meaning of a steady-state economy, Professor Daly has built a strong case for moving in that direction with developed economies taking the lead. He appreciates the need for operational principles if we are to make the transition to a steady-state economy in a careful and minimally disruptive way. To this end he has proposed a set of principles for sustainable development (understood as a steady-state economy):

1. Renewable resources: harvest rates should equal regeneration rates (sustained yield).
2. Waste emission rates should equal the natural assimilative capacities of the ecosystems into which the waste are emitted.
3. Maintain natural and manmade capital intact at the optimal level. (Principles 1 and 2 accomplish this for natural capital.)
4. Investment in the exploitation of a nonrenewable resource should be paired with a compensating investment in a renewable substitute.
5. Emphasize technologies that increase resource productivity (development), the amount of value extracted per unit of resource, rather than technologies for increasing the resource throughput itself (growth).
6. Limit the total scale of resource throughput to ensure that the scale of the economy (population times per capita resource use) is within the carrying capacity of the region, avoiding capital consumption. (Summarized from Daly 1990, 2,3)

These six principles are inter-related and mutually supportive. For example, principles 1 and 2 are required to accomplish principle 3. They are also not the only such set to have been proposed. Douglas Booth turned 'Daly's original formulation of a steady-state …on its head' (Booth, 1998) by emphasizing the control of emissions rather than throughput '…and the result will be a sustainable throughput of energy.' Booth offered the following principles (Booth called them 'components') for a steady-state U.S. economy:

1. a reduction in CO_2 emissions by 90 percent of forecasted levels over the next century and emissions stability thereafter;
2. the preservation of all remaining undisturbed habitats and ecosystems on the national forests and the conversion of previously exploited national forest lands to natural habitat;
3. reduction of nonpoint pollution to levels sufficient to preserve and restore habitat for native aquatic life; and
4. reduction and elimination of pesticides harmful to human beings, species, and ecosystems. (ibid.143)

Booth's principles complement Daly's rather than replace them. Throughput needs to be controlled at the input and output end of the economy. While material and energy resource inputs to an economy are related to the material and energy waste outputs they present distinct problems and challenges. Concentrating on one end or the other will not suffice. Also, Booth's inclusion of habitat preservation and restoration is essential for protecting other species whose livelihood is under constant and increasing pressure from the expanding human population and economies.

One of the shortcomings of many of these principles is that they are difficult to operationalize without more clarity about measurement. Perhaps it is because of this that Professor Daly entitled the widely referenced paper in which his six principles appear as 'Towards Some Operational Principles of Sustainable Development'. (Daly, 1990) Given the ambiguities that can arise from using only physical magnitudes and the lack of comprehensive data, an alternative approach is to work with GDP and examine what might be accomplished if its constancy is used as the definition of a steady-state economy. Providing energy and material intensities (measured as physical amounts per dollar) do not increase when GDP is constant, then a steady-state defined in terms of GDP will coincide with constant or declining material and energy throughput so that all agendas are satisfied.

In the remainder of this chapter we will continue to discuss steady-state economics using GDP and GDP per person and use two different models for simulating a steady-state economy. The first, simpler model, is based fairly explicitly on Professor Daly's writings and is a model of the US economy. The second is a more detailed model of the Canadian economy used in this chapter to examine a transition to a steady-state.

7.3 SIMULATING A STEADY-STATE ECONOMY

It is quite possible to map out the structure of a simulation model of a steady-state economy as defined by Professor Daly, one in which the stocks of people and artefacts are maintained at desired, sufficient levels by low rates of maintenance "throughput" and which satisfies all of the principles stated above. It is a much more challenging task to do so in a way that can be fitted to the available data for reasons given earlier about the lack of physical data and metrics as well as because statistical agencies, especially in North America, do not collect comprehensive data on the relevant stocks, flows, funds and services.

Figure 7.1 shows the high level structure of a steady-state economy that embodies some of the aspects highlighted by Professor Daly and other contributors but uses constant real GDP and constant population to define a steady-state rather than relying entirely on non-monetary measures. The model has been fitted to data for the U.S.A. and its main focus is on energy.

As shown in figure 7.1, total energy use is related to gross domestic product. An income elasticity of demand for energy less than 1 captures the relative decoupling of energy use and GDP that has been experienced for many years in the USA. A default value of 0.55 is used (Gately, 2002) but this can be varied in the simulations. A higher value for this elasticity could be used to reflect increasing energy conservation efforts.

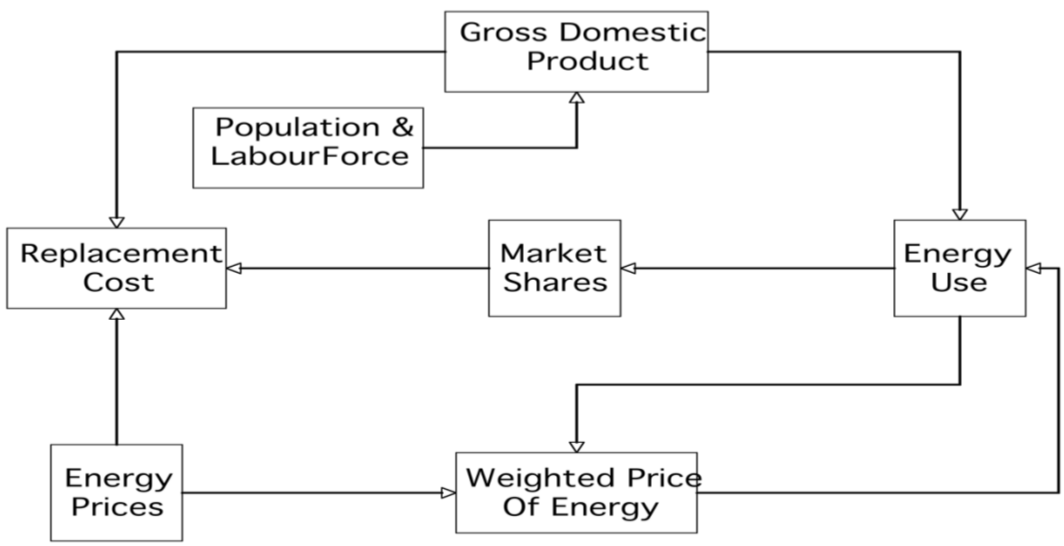


Figure 6.1 High Level Structure of a Steady-state Economy Model

The total amount of energy used is also influenced by the weighted price of energy which is calculated in the model from the prices and quantities of the four energy sources: 1) fossil fuel, 2) nuclear, 3) biomass, and 4) geothermal, hydro, solar thermal, photovoltaic, and wind which are treated as a single group following the US Energy Information Administration. (US Energy Information Administration, 2008) A default value of the price elasticity of demand for energy of -0.5 (ibid.) is used and can be easily changed and, as with changes to income elasticity, can be used to simulate increasing energy conservation measures.

The rate of growth of GDP is set exogenously as is the rate of change in productivity (output per employed worker.) Combined with the labour force these variables determine the rate of unemployment. (Victor 2008, 156 -158). The rate of growth in population and the labour force, which are assumed to be the same, are set exogenously.

After calculating total energy use, the market share obtained by each of the four energy sources is calculated using an equation that allocates market shares according to the relative prices of the competing energy sources. (River 2005). The changes in energy prices are set exogenously.

The sensitivity of the market shares to the relative prices can be varied using a scale of 0 (no sensitivity) to 20 (high sensitivity). A default value of 5 was selected because it generated market shares very close to those prevailing in the base year for the model, 2004. The simplifying assumption is made that each of the four sources of energy could ultimately provide all the of the energy used in the U.S.A.

The final component of the model as shown in figure 7.1 is replacement cost. This refers to an estimate of the cost of replacing non-renewable sources of energy (fossil fuels and nuclear) with the renewable substitutes. This is similar to the approach taken in Daly and Cobb (op,cit. 484-487) in their development of the Index of Sustainable Welfare and, in this instance, replacement cost as a percent of GDP can be interpreted as an indicator of how far from or close to the US economy is to sustainability, at least for energy. This indicator also has implications for sustainability in relation to waste generated by the economy since the waste products from producing and using fossil fuels and nuclear energy also threaten sustainability.

The model can be used to examine a wide range of scenarios for the U.S.A.; just three are discussed here. 2004 is the base year and the time horizon is 100 years. The scenarios are:

1. 'Business as usual (BAU)': The rates of growth in GDP, population and labour force, and labour productivity continue at rates typical of the past few decades, and in which average annual hours per employed worker declines very slowly so that the rate of unemployment remains virtually unchanged. The prices of energy from non-renewable sources rise at 1 per cent per year and the prices of energy from the renewable sources remain constant.
2. Steady-State, Constant Prices of Alternatives: The rates of growth of GDP, population and labour force are set to zero to give a steady-state. The rate of growth of labour productivity is maintained at the same level as in the BAU scenario. The average annual hours worked per employed worker declines at almost the same rate as productivity increases so that the rate of unemployment remains virtually unchanged. (Such a decline in time spent at work begins to capture an important aspect of development as defined by Professor Daly, i.e. a

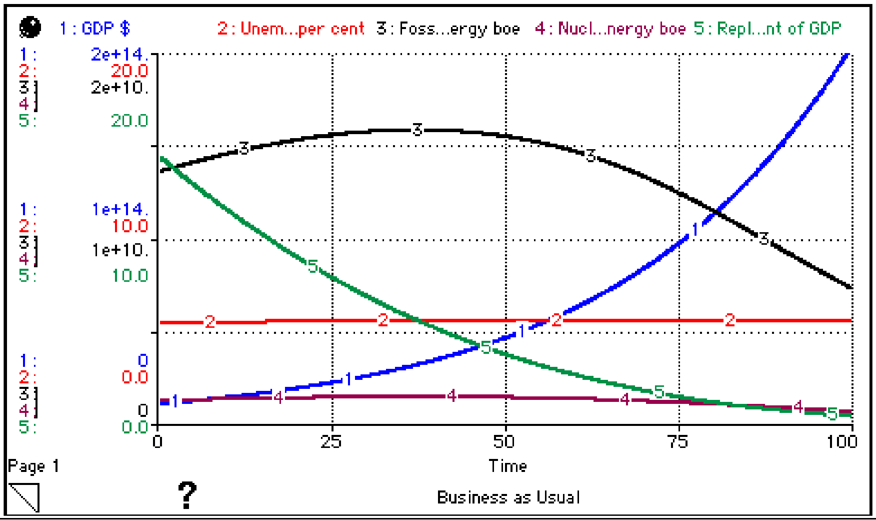
qualitative, beneficial change in peoples' lives.) The same assumptions are made about energy prices as in the BAU scenario.

3. Steady-State, Declining Prices of Alternatives: This is the same as scenario 2 except that the price of energy from geothermal, hydro, solar thermal, photovoltaic, and wind declines at 0.05% per year to reflect gains from technological improvements and economies of scale as market share increases. The price of biomass is kept constant since as its scale increases it will encounter increased competition from other land uses that may, in fact, make energy from biomass more rather than less expensive over time.

These assumptions are summarized in table 7.1 and results from the six scenarios are shown in figures 7.2 – 7.7.

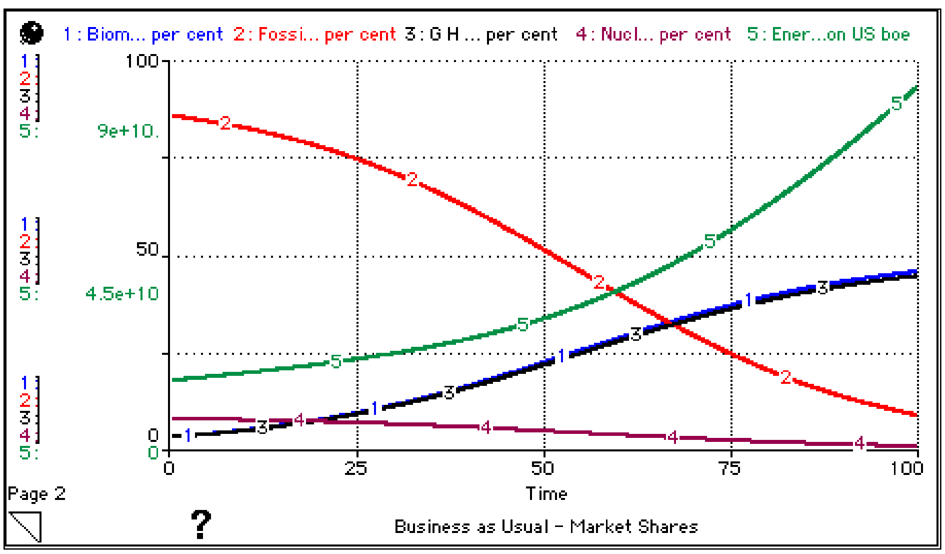
Table 6.1: Summary of Assumptions

		BAU	Steady State Constant Prices of Alternatives	Steady State Declining Prices of Alternatives
Rate of growth of GDP	per cent	3	0	0
Rate of growth of productivity	per cent	1.8	1.8	1.8
Rate of growth of population and labour force	per cent	1.2	0	0
Rate of growth in average annual hours worked	per cent	-0.02	-1.77	-1.77
Sensitivity of technology diffusion to costs	0 to 20	5	5	5
Annual increase in fossil fuel prices	per cent	1	1	1
Annual increase in nuclear energy price	per cent	1	1	1
Annual increase in G H S PV W prices	per cent	0	0	-0.5
Annual increase in biomass prices	per cent	0	0	0



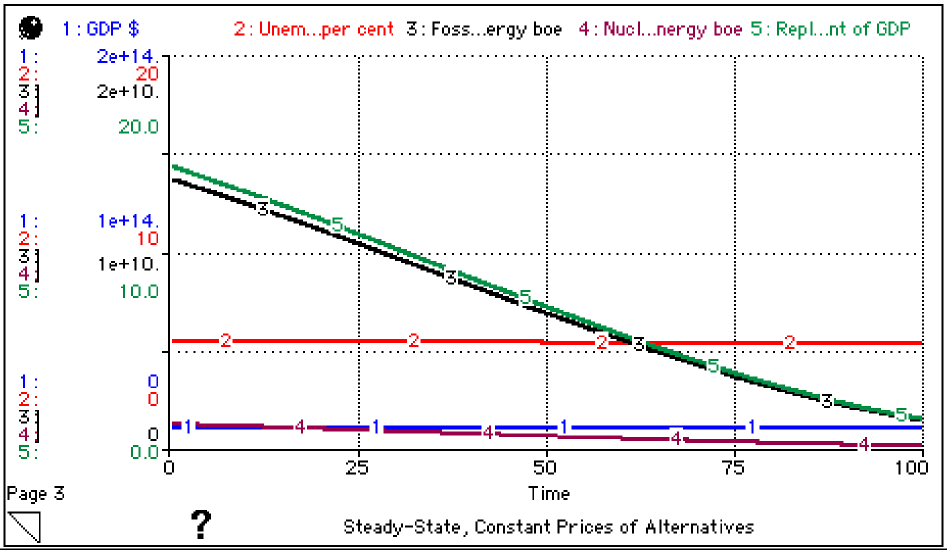
1. GDP $ 2 Unemployment percent 3. Fossil energy BOE 4. Nuclear energy BOE
5. Replacement cost of non-renewable energy as percent of GNP

Figure 6.2 *Scenario 1: Business as Usual. GDP, Unemployment, Non-Renewable Energy, Replacement Cost*



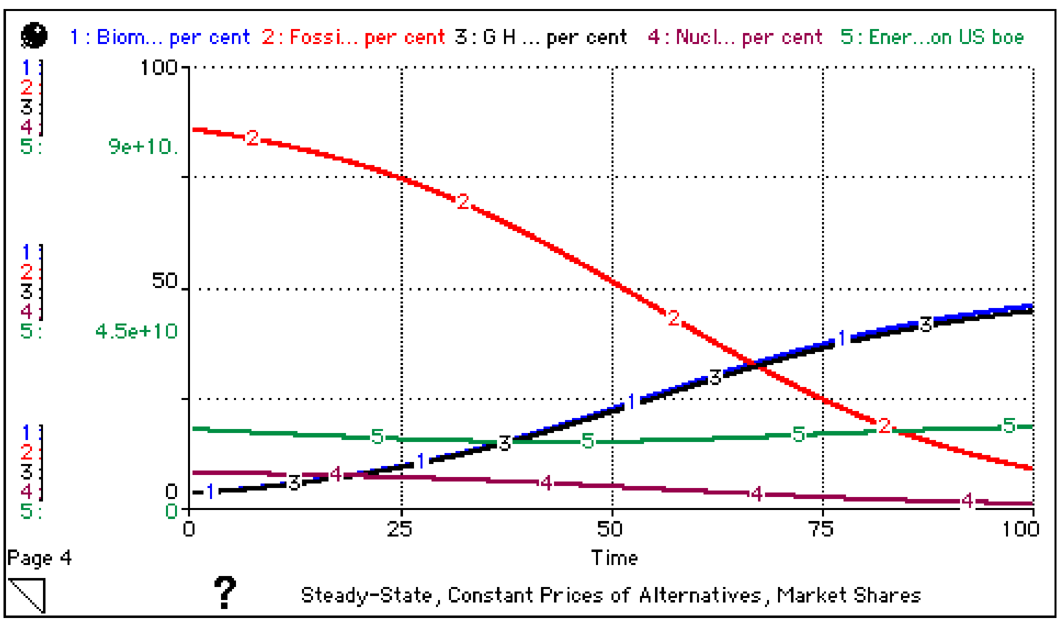
1. Biomass % 2 Fossil Fuel % 3. Other renewable % 4. Nuclear % 5. Total (BOE)

Figure 6.3 *Scenario 1: Business as Usual: Energy Use and Market Shares*



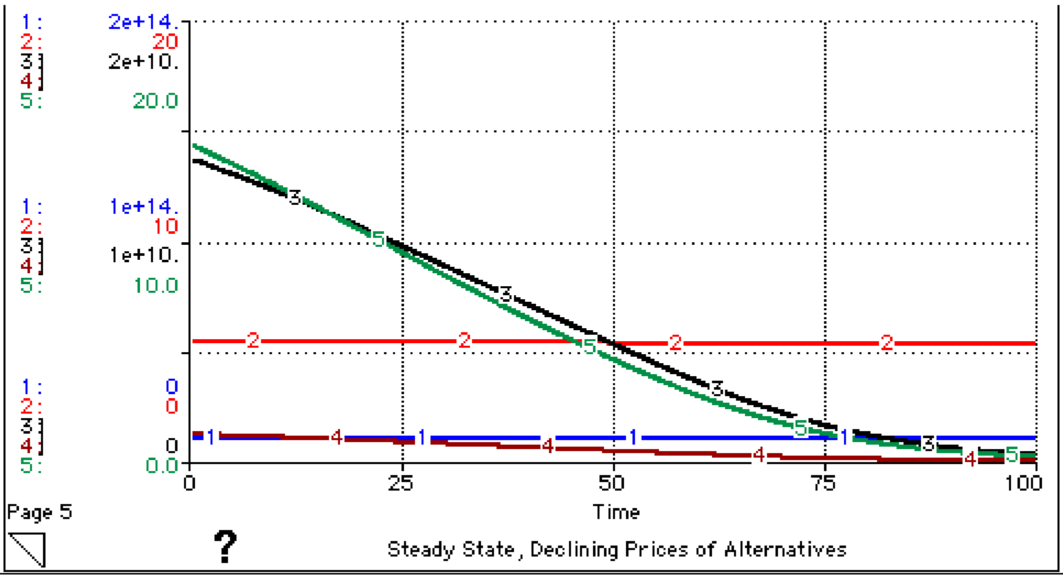
1. GDP $ 2 Unemployment percent 3. Fossil energy BOE 4. Nuclear energy BOE
5. Replacement cost of non-renewable energy as percent of GNP

Figure 6.4 Scenario 2: Steady-State, Constant Prices of Alternatives: GDP, Unemployment, Non-Renewable Energy, Replacement Cost



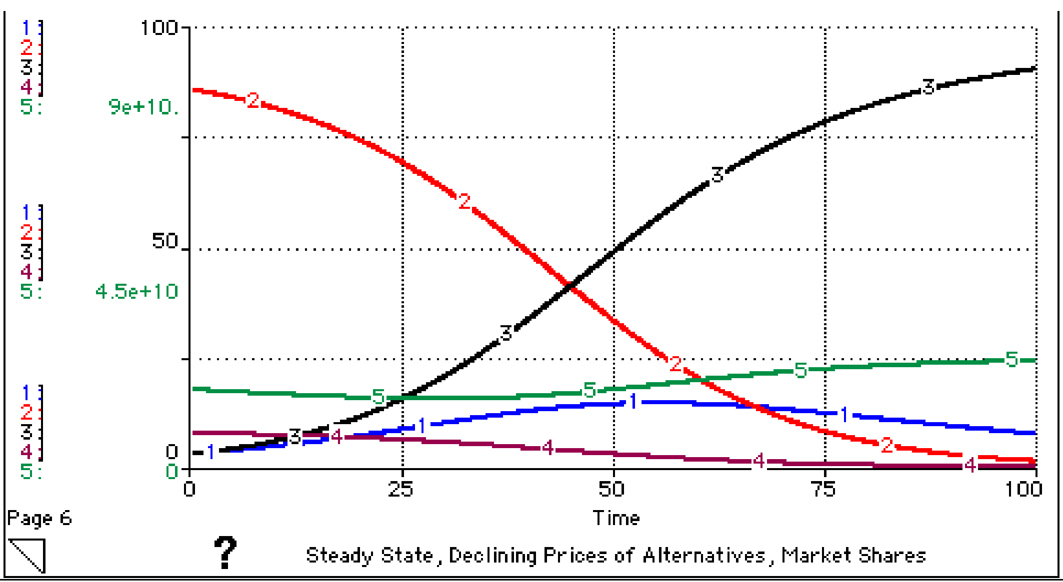
1. Biomass % 2 Fossil Fuel % 3. Other renewable % 4. Nuclear % 5. Total (BOE)

Figure 6.5 Scenario 2: Steady-State, Constant Prices of Alternatives: Energy Use and Market Shares



1. GDP $ 2 Unemployment percent 3. Fossil energy BOE 4. Nuclear energy BOE
5. Replacement cost of non-renewable energy as percent of GNP

Figure 6.6 Scenario 3: Steady-State, Declining Price of Alternatives: GDP, Unemployment, Non-Renewable Energy, Replacement Cost



1. Biomass % 2 Fossil Fuel % 3. Other renewable % 4. Nuclear % 5. Total (BOE)

Figure 6.7 Scenario 3: Steady-State, Declining Price of Alternatives: Energy Use and Market Shares

The BAU scenario shown in figures 7.2 and 7.3 is not presented as a realistic possibility for the future of the U.S.A. over the next 100 years. It is inconceivable that the population of the U.S.A. will more than triple to 928 million but that is what would happen if it continues to increase at a rate of 1.2% per year which was the average annual rate of growth from 1990 to 2000. Equally implausible because of the adverse implications for resource use and environmental degradation, is a nineteen-fold increase in real GDP and yet this would be the outcome of a 3% annual growth rate for 100 years. It is the implausibility of projected levels of growth such as these that underlie much of the interest in and case for a steady-state economy. The BAU scenario scopes out implications of the continuation of past trends. It is not a prediction of a likely or a desirable future.

In the BAU scenario energy total energy use increases five-fold. Energy from fossil fuels and nuclear rise for about 40 years even though their market shares decline throughout the 100 year simulation as they become increasingly more costly relative to the renewable alternatives. The replacement cost of non-renewable energy as a per cent of GDP decline from 14.3 to 0.4 at the end of 100 years in this scenario since GDP is so large and the market share of fossil fuels and nuclear falls to very low levels.

The second scenario shown in figures 7.4 and 7.5 illustrates a steady-state: GDP and population are constant. Total energy use declines in response to an increase in the weighted price of energy. After about 40 years this trend reverses because the market shares of the now relatively cheaper renewable energy sources have such a large market share that the weighted price of energy begins to decline. This is an example of the Jevons Paradox or 'rebound effect'. The market shares of the four energy sources is the same as in the BAU scenario because the assumptions are made about prices. Throughout this scenario, the replacement cost of non-renewable energy declines in parallel with the decline in the use of fossil fuels, the predominant form of non-renewable energy and nuclear energy.

The only difference between the second a third scenario is that in this steady-state scenario the price of the composite renewable energy source (geothermal, hydro, solar thermal, photovoltaic, and wind) declines at 0.5% a year rather than stays constant while the price of biomass remains constant. Over the 100 year simulation period both sources of renewable energy become increasingly competitive with the non-renewable energy sources but biomass less so than the composite alternative. The main difference that this makes is with respect to market shares as shown by comparing figures 7.5 and 7.7. In figure 7.7 the composite renewable energy source ends up with 91% of the energy market and biomass with 8% whereas in figure 7.5 after 100 years their shares are about equal at 45% each.

These scenarios suggest that energy prices can be very important in determining the role that non-renewable and renewable sources of energy have played and will play in determining their use. Energy prices have never simply been set by the market without considerable government intervention through a vast array of subsidies, taxes, direct investment, purchases and regulation. Much of the impact of these interventions has been on prices, directly via gasoline taxes for example, and indirectly through measures such as more or less stringent regulatory limits. The same will be true in the future so while we can get an insight into the potential impact of prices on the replacement of non-renewable energy with renewable energy, it will be as much a matter of public policy and inter-national politics as geology, biology and engineering as to what these prices will be.

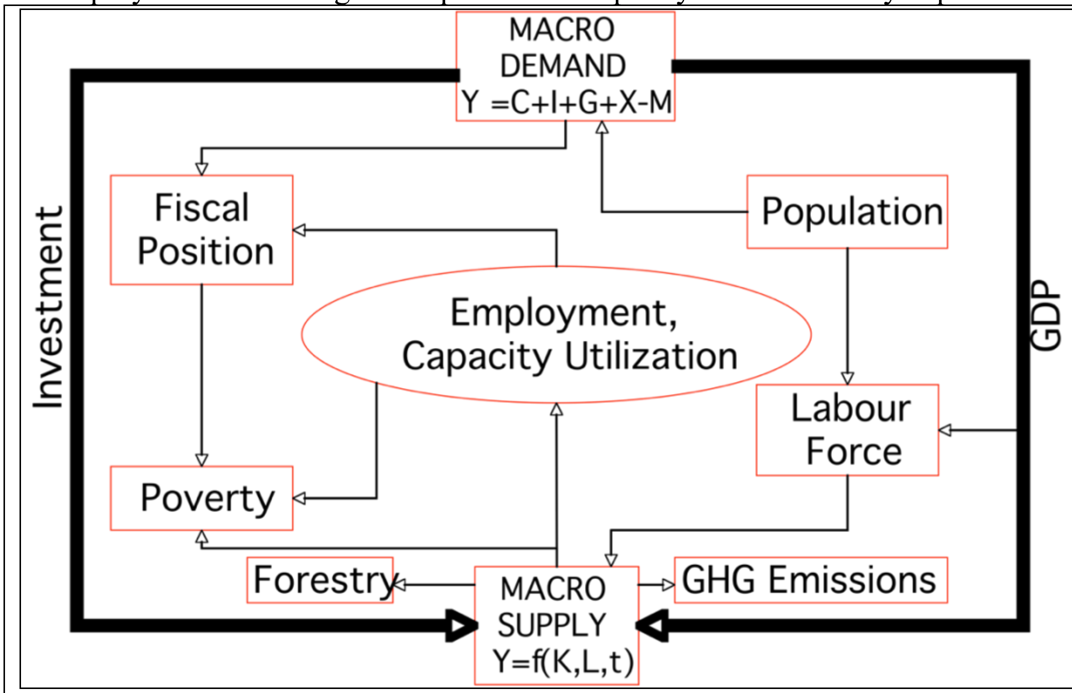
Equally telling are the very different implications of continuous growth in GDP and population versus a steady-state. These are placed in stark contrast in the simulations described above. Of course, it is most unlikely that the economy of the USA would suddenly switch to a steady-state defined either in terms used in the model (stable GDP and population) or using a purely physical definition as proposed by Professor Daly. What is more realistic is that it will converge to a steady-state over a period of decades, in a more or less smooth process of transition. This steady-state model gives little insight into what such a process of convergence might look like and how other matters of concern such as the alleviation of poverty, the governments fiscal position, employment and a reduction in greenhouse gases might simultaneously be addressed in a transition to a steady-state. For this we turn to the second simulation model, LowGrow, which was developed to examine considerations such as these for the Canadian economy based on low and no growth.

7.4 MANAGING WITHOUT GROWTH[1]

LowGrow is an interactive computerized model of the Canadian economy designed to explore different assumptions, objectives and policy measures related to slowing the rate of economic growth. Figure 7.8 shows the simplified structure of LowGrow. At the top, aggregate demand (GDP) is determined in the conventional way as the sum of consumption expenditure (C), investment expenditure (I), government expenditure (G), and the difference between exports (X) and imports (I.) There are separate equations for each of these components in the model, estimated with Canadian data from 1981 to 2005. Production in the economy is estimated by a Cobb-Douglas production function in which output (GDP) is a function of employed labor (L) and employed capital (K). The time variable (t) represents changes in productivity from improvements in technology, labor skills and organization. The production function is shown at the bottom of Figure 7.8. It estimates the labor (L) and employed capital (K) required to produce the GDP (aggregate demand) allowing for changes in productivity over time.

There is a second important link between aggregate demand and the production function shown in figure 7.8 by the arrow connecting aggregate demand

and the production function. Investment expenditures (net of depreciation) which are part of aggregate demand, add to the stock of capital in the economy. Also over time, capital and labor become more productive. It follows that without an increase in GDP these increases in capital and productivity reduce the requirements for labor. Unless an alternative approach is adopted, growth in GDP is needed to prevent unemployment increasing as the productive capacity of the economy expands.



Key: Y = GDP; C = consumption; I = investment; G = government; X = exports; M = imports; K = capital; L = labour; t = time

Figure 6.8 The High Level Structure of LowGrow

LowGrow includes population growth, which is exogenous, and growth in the labor force, which is estimated as a function of GDP and population. Population is also one of the variables that determines the consumption expenditures in the economy.

There is no monetary sector in LowGrow. For simplicity it is assumed that the Bank of Canada, Canada's central bank, regulates the money supply to keep inflation at or near the target level of 2 percent per year. LowGrow includes an exogenously set rate of interest. A higher cost of borrowing discourages investment, which reduces aggregate demand. It also raises the cost to government of servicing its debt. LowGrow warns of inflationary pressures when the rate of unemployment falls below 4 percent but the price level is not included as a variable in the model.

While LowGrow lacks these features, it includes others that are particularly relevant for exploring low or no growth scenarios. LowGrow includes emissions of carbon dioxide and other greenhouse gases, a carbon tax, a forestry sub- model, provision for redistributing incomes, and HPI-2, the UN's Human Poverty Index for selected OECD countries. (United Nations Development Programme, 2006). LowGrow allows additional funds to be spent on health care and on programs to reduce adult illiteracy (both included in HPI-2) and estimates their impacts on longevity and adult literacy with equations obtained from the literature.

Implications of changes in the level of government expenditures can be simulated in LowGrow through a variety of fiscal policies including a balanced budget and an annual percentage change that can vary over time. LowGrow keeps track of the overall fiscal position of all governments combined as measured by the ratio of the combined debt of all levels of government to GDP.

In LowGrow, as in the economy that it represents, economic growth is driven by: net investment which adds to productive assets, growth in the labour force, growth in productivity, growth in the trade balance (i.e. the difference between exports and imports), growth in government expenditures and growth in population. Low and no growth scenarios can be examined by reducing the rates of increase in each and any combination of these factors. In an economy that is dependent on economic growth a sudden dislocation in any and all of these growth drivers can be extremely disruptive as witnessed in the global recession that began in 2008. But as Professor Daly reminds us 'a failed growth economy and a steady-state economy are not the same thing; they are the very alternatives we face.' (Daly, 2008. Also O.Neill, 2008) LowGrow can show how catastrophic a cessation of growth could be if all of the contributors to growth were to fail suddenly and simultaneously. (Victor, 2008, 178-180) It can also show that a more measured convergence to a steady-state might be achieved if approached systematically over a number of years.

One example of a steady-state scenario for the Canadian economy is shown in figure 7.9 which displays the time path of five key variables all indexed to a value of 100 in 2005: GDP per capita, the rate of unemployment, greenhouse gas (GHG) emissions, poverty, and the debt to GDP ratio. In this scenario a variety of measures are phased in over a 10 year period stating in 2010. The rate of growth in GDP per capita begins to slow down and falls to zero by around 2030. Since population growth is declining to zero at about the same time, GDP (not shown) also ceases to grow. As figure 7.9 shows, this decline in the rate of economic growth is accompanied by a reduction in the rate of unemployment to 4% by 2035 (commonly regarded as full-employment in Canada), a substantial reduction in the level of poverty as measured by the UN's Human Poverty Index, a 25% reduction in greenhouse gas emissions, and a decline then stabilization of the ratio of government debt to GDP.

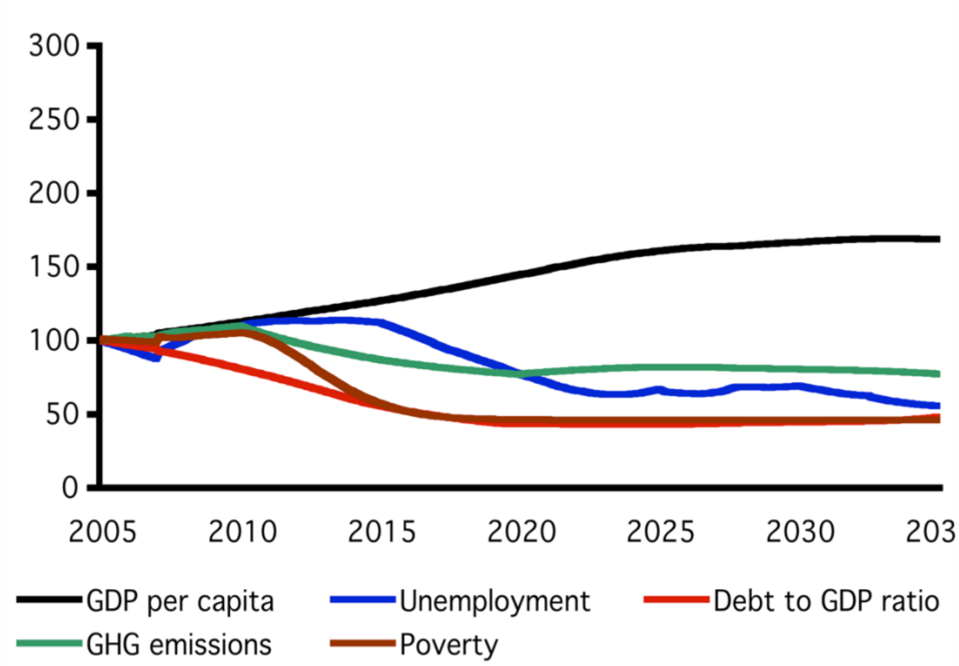


Figure 6.9 Toward a Steady State Economy

Each of these outcomes can be traced to one or a few specific changes although they also result from the interactions and feedbacks contained in the structure of LowGrow. The reduction in the growth in GDP per capita results from reduced net investment, a slower rate of increase in productivity, stabilization of government expenditure, and balanced international trade. Increases in consumption expenditure slow as a result of the lower rate of economic growth brought about by these other changes. A decline in the rate of growth of population coincides with the decline in GDP per capita so that growth in GDP is also reduced, eventually to zero, in this steady-state scenario.

The rate of unemployment is reduced by a 15 per cent reduction in the average number of hours worked by Canadians by 2035, effectively sharing out a stabilized level of labour among a larger number of employees. Even then the average time spent by Canadians would be higher than levels already reached in 2007 in some European countries. (OECD, 2008)

The reduction in poverty shown in figure 7.9 comes from a lower rate of unemployment and a redistribution of income to bring all Canadians up to the 'low income cut-off' Giles, 2004) and widely used as the unofficial measure of economic poverty in Canada. Poverty is also reduced in this scenario through an expansion of adult literacy programs and health care which address components of the UN's Human Poverty Index.

The decline and stabilization of the ratio of government debt to GDP starts from the fiscal regime existing in Canada in 2005, the base year for the simulation. Between 2005 and 2009 this regime changed for several reasons. In particular the federal government reduced the General Sales Tax from 7% to 5% substantially reducing the federal budget surpluses that this level of government had been running for several years. In late 2008 when the global recession took hold in Canada, revenues for all three levels of government declined and expenditures increased so that the decline in the debt to GDP ratio shown at the start of the scenario in figure 7.9, before the various measures in the simulation which start in 2010 take effect, did not materialize. This outcome is a useful reminder that LowGrow is useful for illuminating possibilities for the longer term rather than for simulating short-term changes in the economy.

The reduction in greenhouse gas emissions shown in figure 7.9 come from a combination of the ongoing decline in greenhouse gas intensity, assumed to continue at the same rate as the rate of increase in overall productivity (which is reduced in this scenario but remains positive), and the introduction of a revenue-neutral carbon tax on energy related GHG emissions. A cap and trade system which resulted in a similar price on these emissions to the carbon tax would have a similar effect.

Beyond 2035 further adjustments would be required to some of the growth drivers to maintain a stable GDP per capita so that the scenario shown in figure 7.9 is a quasi steady-state. Increases in productivity could continue without increasing GDP if the gains are enjoyed as reduced time spent in paid employment rather than as increased output.

This brief account of a possible transition to a steady-state economy answers some questions (i.e. it is feasible to have full employment, much reduced poverty and greenhouse gas emissions, and maintain fiscal balance without relying on economic growth) and raises others. For example, is the top-down, heavy hand of government required or is it just as important, indeed essential, that a steady-state come about in response to changes initiated at the grass roots? Will a steady-state economy engender more rigid, controlling political and social institutions or will people have more freedom to choose how they spend their time as individuals, families and communities? In a steady-state economy will it become more difficult to achieve an equitable distribution of income and wealth or easier because other measures of success will have supplanted material living standards? Will paid employment and the private ownership of capital remain the principal means by which income is distributed or will new arrangements be required, and if so, how will they affect incentives to work, save and invest? Is it feasible for a single country to strive for a steady-state economy if the rest of the world pursues growth as usual? Will it help or hinder developing countries to achieve their development objectives if rich countries pursue a steady-state for their economies? What will a steady-state economy mean for the rate of profit and the rate of interest; will it be necessary to limit the outflow of capital as it pursues higher profits elsewhere? What are the resource use and waste generation levels required to sustain the economy at the steady-state level of GDP per capita in 2035 which is projected to be over 50% higher in 2035 than in 2005? Are these levels compatible with the biophysical limits that are a major reason for contemplating a steady-state future? Is this kind of scenario compatible with capitalism? Will new and different types of business organizations be required?

On this last question Robert Solow, one of the architects of the modern theory of economic growth, is reported as saying: 'There is no reason at all why capitalism could not survive without slow or even [with] no growth.' (Stoll, 2008) Booth is more circumspect when he says that 'for a steady-state macroeconomy to function effectively, the requirements at a macroeconomic level are an incomes policy, an expanded government sector, and a reduction in the workweek, and the central need at a microeconomic level may be new organization forms that embody principles of economic democracy…(op.cit . 169)

With respect to the larger rationale for a steady-state economy, Solow showed sympathy for concerns not usually heard from mainstream economists when he observed that 'it is possible that the US and Europe will find that…either continued growth will be too destructive to the environment and they are too dependent on scarce natural resources, or that they would rather use increasing productivity in the form of leisure.' (ibid. 94) The case for a steady state economy could not have been stated more succinctly.

7.5 CONCLUSION

It is more than 160 years since John Stuart Mill wrote favourably about the steady-state economy and over 30 years since Herman Daly wrote the book, so to speak, on the subject. In the mean time economic growth has proceeded apace, and for the past half-century or so has been the over-arching economic policy objective of countries and their governments around the world. With the emergence of 'sustainable development' in the 1980s as a possible alternative paradigm, the primacy of economic growth has been called into question and in some circles at least, more attention has begun to be paid to the environmental and social dimensions of development. New measures of progress have been proposed such as the Index of Sustainable Development (Daly and Cobb, 1994, 443-507), the Genuine Progress Index (Redefining Progress, 2007), Genuine Wealth (Hamilton, 2006), and the Human Development Index (United Nations Development Programme, 2006). These take a broader view of progress than just GDP and GDP per capita. Likewise measures such as the Ecological Footprint (Wackernagel, 1996), the Living Planet Index (Hails, 2006), and HANPP (Haberl, 2007) provide quantitative estimates of the environmental burden placed on the planet by people and our economies.

To a greater or lesser extent the rationale for these alternative indicators stem from concerns similar to those expressed by the many contributors to steady-state economics, some of whose ideas have been discussed in this chapter. Yet it would be premature to say that the option of a steady-state economy has made it on to the public or political agenda in a significant way. The OECD, for example, remains committed to economic growth even as it writes about sustainable development and struggles to reconcile the demands of growing economies with the biophysical limits of the planet. (Strange, 2009). In contrast, the UK's Sustainable Development Commission has questioned the viability of economic growth over the long term and raised for serious consideration the possibility of seeking prosperity without growth. (Jackson, 2009). Going even further, the governments of Bolivia, Cuba, Dominica, Honduras, Nicaragua and Venezuela declared in 2009 that 'the global economic, climate change, food and energy crises are products of the decadence of capitalism that threatens to put an end to the existence of life and the planet. To avoid this outcome it is necessary to develop an alternative model to that of the capitalist system.' (ALBA, 2009)

In developed countries outside officialdom, there is a dialogue especially in France about 'degrowth' or décroissance (Latouche, 2007), a lively website discussing steady-state economics run by the Centre for Advancement of the Steady-State Economy in the United States (CASSE, 2009), and numerous energy, environment and other groups increasingly making the links between their more specific concerns and the character and conduct of the economy.

In the words of Herman Daly 'The closer the economy approaches the scale of the whole Earth the more it will have to conform to the physical behaviour mode of the Earth. That behaviour mode is a steady-state – a system that permits qualitative development but not aggregate quantitative growth.' (Daly, 2008, 1) Whether we will make a careful and thoughtful transition to the steady-state remains to be seen but at least through the work of Professor Daly and all those he has inspired, we are better able to delineate the options.

NOTES

1. This section of the paper is adapted from chapter 10 of Victor (2008) where more details of LowGrow and more scenarios can be found. Chapter 11 provides a discussion of policies for managing without growth.

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7. Socially sustainable economic degrowth

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8.1 INTRODUCTION

Key words of environmental politics of the past twenty years have a hollow ring in the present economic downturn. The IPCC scenarios never contemplated (self-imposed censorship?), a decline in the rich countries' GDP of 5 per cent and then a long period of non-growth as might perhaps be the case. This was not in the economists' and industrial ecologists' script. For twenty years, the orthodox slogan has been Sustainable Development (Brundtland Report, 1987) meaning economic growth that is environmentally sustainable. We know however that economic growth was not environmentally sustainable. The discussion on décroissance or degrowth that Nicholas Georgescu-Roegen started thirty years ago, is now a topic for discussion in the rich countries because la décroissance est arrivée. Now it is the moment to substitute GDP by social and environmental indicators at the macro-level and to trace progress towards a socio-ecological transition by the behavior of such indicators.

The economic crisis of 2008-09 affords an opportunity to put the economy of the rich countries on a different trajectory as regards material and energy flows. Before 2008, world carbon dioxide emissions were growing by 3 per cent per year, we would have reached 450 ppm in 30 years. Carbon dioxide emissions peaked in 2007. Now is the time for a permanent socio-ecological transition to lower levels of energy and materials use, including a decrease in the HANPP (human appropriation of net primary production). The crisis might also give an opportunity for a restructuring of social institutions. The objective in rich countries should be to live well without the imperative of economic growth.

Moreover, we are on the path for a reduction in world population once it peaks at 8,000 or 8,500 million, thereby reducing pressure on resources and sinks in the second half of the 21st century.

Georgescu-Roegen's explicit sponsorship of the concept of décroissance (degrowth) in 1979 (Grinevald and Rens, 1979), Herman Daly's views on the steady-state since the early 1970s, Serge Latouche's success in France and Italy in the last ten years insisting on economic degrowth (Latouche, 2007), have prepared the terrain. Now is the time in rich countries for socially sustainable economic degrowth reinforced by an alliance with the "environmentalism of the poor" of the South.

8.2 THE ECONOMY HAS THREE LEVELS

Frederick Soddy's Cartesian Economics was published in 1922, and Wealth, Virtual Wealth and Debt in 1926. He had a Nobel Prize in Chemistry and was a professor at Oxford as explained in my book Ecological Economics of 1987. My interpretation of Frederick Soddy's views is similar to that Herman Daly's article on Soddy of 1980, which I read later. Soddy's teachings of the 1920s became easy to understand for ecological economists who had read Georgescu-Roegen's The Entropy Law and the Economic Process (1971). Soddy's main point was simple and applies today. It is easy for the financial system to increase the debts (private or public debts), and to mistake this expansion of credit for the creation of real wealth. However, in the industrial system, growth of production and growth of consumption imply growth in the extraction and final destruction of fossil fuels. Energy is dissipated, cannot be recycled. Real wealth would be instead the current flow of energy from the sun. Economic accounting is false because it mistakes depletion of resources and the increase of entropy for wealth creation.

The obligation to pay debts at compound interest could be fulfilled by squeezing the debtors for a while. Other means of paying the debt are either inflation (debasement of the value of money), or economic growth - which is falsely measured because it is based on undervalued exhaustible resources and unvalued pollution. Economic accounting does not properly count environmental damages and the exhaustibility of resources. This was Soddy's doctrine. He was certainly a precursor of ecological economics.

In other words, the economy has three levels. At the top there is the financial level that can grow by loans made to the private sector or to the state, sometimes without any assurance of repayment as in the present crisis. The financial system borrows against the future, on the expectation that indefinite economic growth will give the means to repay the interests and the debts. The financial system creates "virtual" wealth. Banks give credit much beyond what they have got as deposits, and this drives or pulls economic growth at least for a while. Then there is what the economists describe as the real economy, the so-called productive economy. As reported in The Economist (11th April 2009), Hakan Samuelsson, chairman of the German truck-making firm MAN, made this distinction very clearly when he said: "Creating value through financial leverage will be harder in future, so we can get back to our real job which is creating industrial value through technology, innovation, and efficient manufacturing".

When the economist's real economy grows, it indeed allows to pay back some or all the debt, when it does not grow enough, debts are defaulted. The mountain of debt had grown in 2008 much beyond what the increases in GDP could pay back. The situation was financially not sustainable. But the GDP itself was not ecologically sustainable. Down below, in the basement and foundations of the economic building, underneath the economists' real economy, there is the third level: the ecological economists' real-real economy, the flows of energy and materials (carried by trucks and ships). Their growth depends partly on economic factors (types of markets, prices) and in part from physical limits. At present, there are not only resource limits but also conspicuous sink limits. Climate change is caused mainly by of the excessive burning of fossil fuels.

Returning to "debt-fuelled growth" after 2009 would not only be financially dangerous. It is indeed impossible for the time being, as banks are loaded with "toxic assets" and therefore reluctant to lend. The phrase itself is misleading. Growth is not "fuelled" by debt and by money, it is prosaically fuelled by coal, oil and gas. The fossil fuels are not produced by the economy, they were geologically produced a long time ago.

8.3 GREEN KEYNESIANISM OR SUSTAINABLE DEGROWTH?

The economic crisis of 2008-09 has brough John Maynard Keynes back to the main stage. In Keynesian language, we can say that economies have unused productive capacity, there is a gap between effective demand and full-capacity utilization of labour and industrial equipment. Unemployment is increasing, and the appropriate remedy is to increase public expenditure, "deficit spending" as it is called. Public spending is good because it will indirecly lead to buying cars, and paying off mortgages and even buying new houses, getting such industries out of the doldrums. Governments are under pressure not only to increase spending for public investments or consumption but to refinance private debts to banks that will not be paid ("toxic assets"), converting to some extent such private debts into public debts.

Keynes wanted to get out of the crisis of 1929. The pre-Keynesian prescription of waiting for the market to reach equilibrium, waiting therefore for increasing unemployment to depress wages so much that employers would want to hire workers again, was a receipt for disaster. To make this point clear, Keynes famously said that he did not care what happened in the long run once the economy would recover from the crisis. In the 1950s economists such as Roy Harrod and Evsey Domar converted Keynesianism into a doctrine of long term growth. Provided there was enough private or public expenditure in consumption and investment to keep effective demand close to potential supply at full capacity utilization, the economy would not fall into crisis. Meanwhile, the investment would have increased potential supply, so that new expenditure would be required in the next round in order for the economy not to fall into a crisis, in a virtuous path of continuous growth. Such economic models were metaphysical in the sense that they did not consider exhaustible resources or pollution.

Keynesianism was triumphant in the 1960s, the era of very cheap oil. Later, both short-run and long-run Keynesianisms were left aside. Neoliberal thought resurrected. The neoliberals, like Hayek, thought that markets knew much more than the state. But one unanswered objection to neo-liberalism raised by environmentalists was that the market did not value future, inter-generational scarcities (as Otto Neurath had already pointed out in Vienna in the 1920s against Von Mises and Hayek in the socialist calculation debate, cf. Martinez-Alier, 1987).

In the crisis of 2008-09, neoliberalism is suffering from ill health. Some bankers are asking for the State to take over their banks. Keynes has come back, reincarnated in Stiglitz and Krugman. As ecological economists we must ask, is this a short-run Keynes to get out of the worst aspects of the crisis, or also a long-run Keynes to get into a path of continuous economic growth?

Those who propose a short-run Green Keynesianism or a Green New Deal as a temporary measure, are close to ecological economics. If public investment must grow, as indeed it must to contain the rise in unemployment, it is better to channel it to the welfare of the citizens and to “green” energy production, than into motorways and airports. However, Green Keynesianism should not become a doctrine of continous economic growth. Until now, growth has come with the use of energy from coal, oil and natural gas. In Green Keynesianism it seems desirable to increase public investment in energy conservation, photovoltaic installations, urban public transport, housing rehabilitation, organic agriculture. But it does not seem desirable to persevere in the faith of economic growth. In rich countries a slight economic decline is already taking place and it could easily be socially sustainable. We are not in the 1930s – in Europe we have economies with incomes per capita of over 25 000 euros. Going back ten per cent (with a corresponding decrease in energy and material flows) can be managed if institutions of redistribution are in place. Thus, we shall enter into a socio-ecological transition. There is already an agreement in Europe for the carbon dioxide emissions be cut by

20% compared to 1990. In fact, emissions and GDP are in early 2009 decreasing faster than required to reach this target..

The feminist movement made clear many decades ago that GDP does not value what is not in the market, like unpaid domestic work and voluntary work. A society rich in "relational goods and services" would have a lower GDP than an (impossible) society where personal relations would be exclusively mediated by the market. The sustainable degrowth movement insists on the non-chrematistic value of local, reciprocal services. Moreover, economists (or rather, psychologists) now agree that above a certain threshold GDP growth does not lead necessarily to greater happiness. This research updates the literature on the so-called Easterlin Paradox. Therefore, GDP should no longer have the dominant position in politics that it now has, to the detriment of environmental and social considerations.

However, degrowth might lead to social problems that we must face for the degrowth proposal to be socially accepted. If labor productivity (e.g. number of cars that a worker produces per year) grows by 2% annually, but the economy is not doing the same, this will lead to increased unemployment. The answer must be twofold. Increases in productivity are not well measured. If there is replacement of human energy by machines, does the price of energy take into account the depletion of resources and negative externalities? We know that it is not so. Furthermore, we should separate the right to receive remuneration from the fact of being employed. This separation already exists in many cases (children and young people, pensioners, persons receiving unemployment benefits), but it should be extended further. We have to redefine the meaning of 'job', taking into account the unpaid domestic services and the voluntary sector and we must introduce or expand the coverage of a universal Basic Income or Citizen Income.

Another objection is raised. Who will pay the mountain of debts, mortgages and other debt if the economy does not grow? The answer must be that no-one will pay. We can not force the economy to grow at the rate of compound interest at which debts accumulate. The financial system must have rules different from today. In the United States and Europe what is new is not, therefore, Keynesianism, not even Green Keynesianism. What is new is a growing social movement for sustainable degrowth. The crisis opens up opportunities for new institutions and social habits.

8.4 THE PRICE OF OIL

The teaching of economics in universities is still based on an image of the economy as a merry-go-round between consumers and producers. They encounter each other in markets for consumer goods or in markets for the services of production factors (like selling labour time for a wage). Prices are formed, quantities are exchanged. This is Chrematistics. Macroeconomic accounts (GDP) aggregate the quantities multiplied by the prices. The economy may be described however in a different way, as a system of transformation of (exhaustible) energy and materials (including water) into useful products and services, and finally into waste. This is Ecological Economics (from N. Georgescu Roegen 1966, 1971, Herman Daly 1968, A. Kneese and R.U. Ayres, 1969, Kenneth Boulding, 1966).

The critique of conventional economic accounting often emphasizes the forgotten current values of environmental services from ecosystems. The environmental services from coral reefs, mangroves, tropical rainforest may be given a notional money value per hectare per year, and then the lost hectares are translated into virtual economic losses. This approach is good in order to impress the public with the importance of environmental losses but it is certainly insufficient in order to grasp the relations between economy and environment because our economy depends on the photosynthesis of millions of years ago for our main energy sources. It depends on ancient biochemical cycles for other mineral resources that we are squandering without replacement. In the case of oil, the extraction peak in the Hubbert curve has perhaps been reached. In 2007 we were taking almost 87 mbd – in terms of calories, the world average was equivalent to about 20,000 kcal per person/day (ten times the food energy intake), and in the USA it was equivalent to 100,000 kcal per person/day. In exosomatic energy terms, oil is then far more important than biomass. In early 2009, extraction has decreased down to 84 mbd.

The European Union, Japan, the United States and some parts of China and India are large net importers of energy and materials. The United States, having reached the internal peak-oil in the 1970s, imports more than half the oil it consumes. These imports of energy and materials into rich countries must by necessity be relatively cheap for their social metabolism to work properly. As Hornborg put it in 1998, “market prices are the means by which world system centres extract exergy (i.e. available energy) from the peripheries”, aided some times by military power. The attempt to make Iraq produce an extra 2 or 3 mbd failed after 2003, as Alan Greenspan noted sadly in his memoirs. OPEC after the drop in the price of oil in 1998, and helped by efforts of Hugo Chavez from Venezuela and the economic boom in China and India, had successfully managed the restriction of supply. The price of oil peaked in 2007-08.

During the building boom in the United States, houses were sold to people who were unable to pay the mortgages, or houses were built (as in the large acreage of new empty houses in Spain) on the hope that credit-worthy buyers would appear. Real salaries in the United States did not increase much in the last years but credit to consumers had indeed grown. Income distribution had become more unequal. Household savings were at a minimum when the crisis started. The bankers apparently thought that economic growth would continue and would increase the value of the houses that were mortgaged. They “packaged” the mortgages and sold them to other banks which sold or tried to sell them to innocent investors. The housing boom ended in 2008. The private building industry has nearly stopped in some countries.

Part-nationalization of some banks in the EU and the USA avoided sudden widespread bank failure, at the cost of raising the public deficit. Deficit spending in a situation of lack of aggregate demand is a Keynesian prescription with which one might agree at present – it should go to solve the most pressing social problems and to environmental investments, and not to military spending (to secure oil?) or to the car and motorway industries. In any case, the financial free-for-all was not the only cause of the crisis, which was triggered by high oil prices due not only to the OPEC oligopoly but also to the approaching peak-oil. In fact, economic theory does not say that an exhaustible resource should be sold at the marginal cost of extraction. One could argue that oil at 140 US$ a barrel is still cheap from the point of view of its fair inter-generational allocation and the externalities it produces.

The present economic crisis is not only a financial crisis, and it was not caused only by a supply of new houses in the United States that exceeded the demand that could be financed sustainably. It was also caused by high oil prices. The stock exchange started to drop in January 2008 but until July 2008 the price of oil kept increasing. As the crisis deepened, the price of oil went down but it will recover in real terms if and when the economy grows again. There is here an automatic "de-stabiliser" for the economy. It is difficult to find new oil, as we go down the Hubbert curve. Moreover, a low price of oil implies a declining supply in a few years because of declining investment in the fields with higher marginal costs. On top of this, OPEC tries to reduce oil extraction during the crisis to keep the price up.

8.5 ECONOMIC DE-GROWTH AND CARBON DIOXIDE EMISSIONS

The economic crisis will mean a welcome change to the totally unsustainable increase of carbon dioxide emissions. The Kyoto objective of 1997 was generous with the rich countries because it gave them property rights on the carbon sinks and the atmosphere in exchange for the promise of a reduction of 5 per cent of their emissions relative to 1990. This modest Kyoto objective will be fulfilled more easily. One could easily foresee by October 2008 that the carbon trade would collapse unless lower caps were adopted. Air travel, housing starts, car sales decreased in the second half of 2008 in many European countries and the USA. Motorists in the USA were buying 9 per cent less gasoline in early October 2008 than in early October 2007, so that the figures released in February 2009 showing a 6 per cent decline in output of the USA economy in the last quarter of 2009 were not a surprise.

However, the apostles of growth are not willing to use the current crisis to shift the economy to a different technological and consumption pattern. On the contrary, they find reasons to think car sales would remain strong because, while the United States have nearly one car for every person of driving age, China has less than three cars for every 100 people and India fewer still. “Once people have a roof over their heads, meat on the table and a good job, the next thing they want is a set of wheels” – pontificates The Economist (14 November 2008), announcing that in the next 40 years the world’s fleet of cars is expected to increase from around 700 million today to nearly 3 billion.

The economy of India and also that of China (propelled by internal demand) might well continue to grow at rates of 4 or 5 per cent in 2009 and beyond. Provided the oil price remains low, the car industry will grow faster than the economy and will be an engine of economic growth together with the building industry. However, a world of 3 billion cars would require a much increased expenditure of energy. How will the real economy impact on the real-real economy? How will the cars be fuelled? Electricity? Hydrogen? What will the energy cost be?

There is a historic trend towards increasing energy costs of obtaining energy (a lower EROI). Brazil’s recent discovery of 30,000 million barrels of oil (one year of world consumption) thousands of meters under the sea, might become a bottomless sink for energy and money. Coming down from the peak of the Hubbert curve will be politically and environmentally difficult. Conflicts arise in the Niger Delta and in the Amazonia of Peru and Ecuador against companies such as Shell, Repsol, Oxy. Appeal to some other energy sources (agro-fuels, nuclear energy) will compound the difficulties. Wind and photovoltaic energy are fortunately increasing. They will help to compensate for the dwindling supplies of oil over the next few decades. Coal supplies are increasing (they already grew seven times in the 20th century) but coal is noxious locally, and also globally because of carbon dioxide emissions.

8.6 THE PEAK IN CARBON DIOXIDE EMISSIONS HAS BEEN REACHED

The world peak in carbon dioxide emissions has been reached because of the economic crisis. Emissions are now (finally?) going down. This might become a unique historical chance.

In May 2008 it was announced that carbon dioxide concentration in the atmosphere was at a record level of 387 parts per million (ppm) according to the measurements at the Mauna Loa observatory in Hawai. This meant an increase of

30 per cent above the level of 300 ppm that Svante Arrhenius used in his article of 1895, when he pointed out that burning coal would increase the concentration of carbon dioxide in the atmosphere and would increase temperatures. Between 1970 and 2000, the concentration had increased by 1.5 ppm per year, since 2001 and until 2007 growth in concentration reached 2.1 ppm. In early 2008 the world was still travelling at all speed towards 450 ppm to be reached in about thirty years. The great increase in the prices of oil, gas, and other commodities until July 2008, and the economic crisis in the second half of 2008 and in 2009, stopped economic growth and changed the trend in carbon dioxide emissions. From the point of view of climate change, the economic crisis should certainly be welcome.

Carbon dioxide concentration in the atmosphere will still increase, although not so quickly. Emissions are still much higher than the absorption capacity of the oceans, the soils and the new vegetation. The IPCC argues in its reports that emissions should go down by 60 per cent (and not by the paltry 2 or 3 per cent likely to occur in 2009 that hopefully signals a permanent change in the trend). The objective of 60 per cent reduction is far from today's reality, and also from the Kyoto and likely post-Kyoto comittments. Nevertheless, the IPCC recommendation is today's closer to implementation than previously.

8.7 THE EMISSIONS PEAK IN SPAIN

Spain has been the worst offender to date among the European countries that have not complied with the Kyoto targets under the European "bubble", followed by Italy and Denmark. This makes the Spanish case interesting although her emissions per capita are "only" double the world average. In 2007, Spanish emissions grew still over 2 per cent in comparison to 2006, reaching an increase of 52.6% compared to 1990, the base year for the Kyoto protocol. Inside Europe, Spain was allowed to have an increase of 15 per cent in 2012 and she had increased already 52.6%. The government said in 2008 that it would buy permits from Eastern Europe and use also the Kyoto flexibility mechanisms.

Now, however, in Spain the emissions peak has coincided with the world peak. The Spanish 2007 peak is likely to be definitive. This is after all an economy with a high level of income per capita that is now declining somewhat while unemployment increases but where the car and electricity markets cannot easily grow as in China and India. Economic degrowth can be to a large extent socially sustainable.

Spanish carbon dioxide emissions went down in 2008 and are going down in 2009. They are likely to keep going down in 2010 because of the continuing economic crisis and because of changes in the energy mix. The decrease of 5% or 6% in 2008 (there are still no official figures) is to be explained by decreased electricity production in the last four months of the year (compared to 2007), the decrease in oil consumption, and the relative increase in wind energy and combined-cycle gas electricity (instead of coal). Industrial production declined nearly 20 per cent in December 2008 compared to one year earlier. Cement production has gone done to 30 million tons per year from a previous peak of 50 million tons that was propelled by a building boom that produced a large excess of unsold houses and flats, and very large financial debts.

Lack of demand for their products led several industries (such as ceramics from Villareal in Valencia) to sell their carbon emission permits at the end of 2008. In April 2008, industries in the energy, cement, paper sectors, had got "grandfathered" permits under the European emission trading scheme. The crisis has produced in Spain as elsewhere in Europe an abundance of permits and a decline in the price of carbon dioxide allowances. A low price is a disincentive for the introduction of technical changes that would avoid carbon emissions. The European Union and also the Spanish government should rapidly decrease the allocation of permits. The present amount of permits is excessive because it was based on economic projections that did not include an economic crisis. Economic degrowth could not be imagined by the competent European bureaucracy.

It must be emphasized that the market for carbon dioxide allowances is an artificial market. The supply depends on the political will to restrict emissions, not down to the necessary level (e.g. 60 per cent reduction), but what is seen as politically and economically bearable in a mindset that assumes continuous economic growth even in the richest countries.

While the reduction of carbon dioxide emissions in Spain in 2008 was perhaps about 6 per cent, in 2009 (as foreseen in April) it could reach 8 per cent, because of the economic crisis and because this will be an excellent hydroelectric year because of abundant rain.

The Spanish government spoke too early when it announced that it would buy "hot air" permits from Eastern Europe when the price was still high in 2008. "Hot air" is a name for the overflow of permits from Eastern European countries whose economies decreased after 1990 (and whose energy efficiency improved), such as Russia, Poland, Romania, Ukraine. In the Kyoto Protocol of 1997 the European Union gave itself a generous quota (equal to 1990 emissions minus a reduction of about 8 per cent for 2012), therefore large amounts of "hot air" will now appear also in western and central European countries such as Germany (that is already on the Kyoto path and whose economy seems to be decreasing by 5 per cent in 2009). The creation of cheap "hot air" is counterproductive for further reductions of emissions.

8.8 TOWARDS COPENHAGEN 2009

The GDP of the world will decrease by one or two per cent in 2009, while economic degrowth in the United States, the European Union and Japan will be larger than this. Between August 2008 and March 2009, consumption of gasoline in the United States decreased not less than ten per cent. Emisions from these countries plus Russia will decrease by not less than 5 per cent. This is really high in comparison with the objectives that were admitted politically up to now. However, because of a problem of mental censorship, neither the IPCC nor Lord Stern's report, had contemplated a scenario of slight economic degrowth in the world economy followed by a period of non-growth in the European Union and the United States. This is the scenario that would convert the carbon dioxide emissions peak of 2007 into a unique historical event.

The economies of South America, that in the neoliberal period "reprimarized" themselves and became (again) raw material exporting economies in greater amounts than ever before, now will pay an economic price. Their growth is stopping because of the economic crisis, and declining terms of trade.

Increased carbon dioxide emissions from China and India are expected, more or less in line with economic growth in India (of about 5 per cent), and a little lower than economic growth in China. India's emissions are per capita much below the world average (India has over 15 per cent of world population and about 4 per cent of emissions). China's emissions are per capita much closer to the world average. As a country it is now the largest emitter, a little bit over the USA. Increased emissions in India, China, Indonesia and a few other countries whose economies are growing in 2009 will not compensate for the decrease in the USA, the European Union, other European countries and Japan. There is a chance that 2007 was not an isolated peak, but on the contrary a historical peak, a unique event.

How will such developments be received in the climate change conference in Copenhagen in December 2009? Will the positive effects of the crisis be acknowledged? Will a slight economic degrowth and a socio-ecological transition towards a steady state in the rich economies be accepted as a plausible and beneficial scenario? Will raw material exporting countries change their tune and ask for exporting less and at higher prices, by introducing natural capital depletion taxes, and taxes that compensate for negative local externalities? Will the Copenhage conference favour the idea that OPEC briefly considered in 2007, introducing the Daly-Correa tax on oil exports to help finance the world energy transition? Or, on the contrary, will carbon emissions recover and increase again with economic recovery?

8.9 TOXIC ASSETS AND POISONOUS LIABILITIES

The assets that take the form of claims to debts that will remain unpaid, have been given the funny name of Toxic Assets. In the balance sheet of banks, the value of such assets will have to be downsized or written off. On the liability side of the balance sheet, our accounting conventions do not include damages to the environment. An enormous "carbon debt" is owed to future generations, and to the poor people of the world who have produced little greenhouse gases. Large environmental liabilities are also due by private firms. Chevron-Texaco is being asked to pay back 16 billion dollars in a court case in Ecuador. The Rio Tinto company left behind very large liabilities since 1888 in Andalusia where it got its name, also in Bougainville, in Namibia, in West Papua together with Freeport McMoran... debts to poor or indigenous peoples. Shell has very large liabilities in the Niger Delta. Don't worry. These poisonous debts are in the history books but not in the accounting books.

Look at the current case of Vedanta bauxite mining in the Niyamgiri hills in Orissa. The decline in the price of aluminium if the economic crisis deepens might save the Niyamgiri hills. It has dropped more than half in the last months of 2008. Therefore, bauxite is also cheaper. We may still ask: how many tons of bauxite is a tribe or a species on the edge of extinction worth? And how can you express such values in terms that a minister of finance or a Supreme Court judge can understand? Against the economic logic of euros and dollars, the peasant and tribal languages of valuation go unheeded. These include the language of territorial rights against external exploitation, the ILO convention 169 which guarantees prior consent for projects on indigenous land, or in India the protection of the adivasi by the Constitution and by court decisions. Appeal could be made also to ecological and aesthetic values. The Niyamgiri hills are sacred to the Dongria Kondh. We could ask them: How much for your God? How much for the services provided by your God?

8.10 FROM THE SOUTH: THE ENVIRONMENTALISM OF THE POOR

One may readily agree that conventional economic accounting is certainly misleading. The experience that Pavan Sukhdev (with Haripriya Gundimeda and Pushpam Kumar) gained in India trying to give economic values to non-timber products from forests, and to other environmental services (such as carbon uptake, water and soil retention), has been an inspiration for the TEEB process (The Economics of Ecosystems and Biodiversity) sponsored by DG Environment of the European Commission and by the German Minister of Environment. As the TEEB team states, a monetary representation of the services provided by clean water, access to wood and pastures, and medicinal plants, does not really measure the essential dependence of poor people on such resources and services.

Decisions may indeed be improved by giving money values to environmental resources and services which are undervalued or not valued at all in conventional economic accounting. But there are other considerations. First, don't forget our uncertain knowledge about the working of ecosystems, and about the future impacts of new technologies. Second, do not exclude non-monetary values from decision making processes. Don't practice the fetishism of fictitious commodities.

In National Income Accounting one could introduce valuations of ecosystem and biodiversity losses either in satellite accounts (physical and monetary) or in adjusted GDP accounts ("Green Accounts"). The economic valuation of losses might be low compared to the economic gains of projects that destroy biodiversity. However, which groups of people suffer most by such losses? In their project "Green Accounting for India", Sukhdev, Gundimeda and Kumar found that the most significant direct beneficiaries of forest biodiversity and ecosystem services are the poor, and the predominant impact of a loss or denial of these inputs is on the well-being of the poor. The poverty of the beneficiaries makes these losses more acute as a proportion of their "livelihood incomes" than is the case for the people of India at large. Hence the notion of "the GDP of the Poor": for instance, when water in the local river or aquifer is polluted because of mining, they cannot afford to buy water in plastic bottles. Therefore, when poor people see that their chances of livelihood are threatened because of mining projects, dams, tree plantations, or large industrial areas, they complain not because they are professional environmentalists but because they need the services of the environment for their immediate survival. This is the "environmentalism of the poor".

In Down to Earth (15 August 2008), Sunita Narain gave current examples from India where the economy still will grow firmly in 2009 driven by internal consumption, cheap oil imports, and public expenditure: "In Sikkim, bowing to local protests, the government has cancelled 11 hydro-electric projects. In Arunachal Pradesh, dam projects are being cleared at breakneck speed and resistance is growing. In Uttarakhand last month, 2 projects on the Ganga were put on hold and there is growing concern about the rest. In Himachal Pradesh, dams are so controversial that elections were won where candidates said they would not allow these to be built. Many other projects, from thermal power stations to "greenfield" mining, are being resisted. The South Korean giant Posco's iron ore mine, steel plant and port are under fire. The prime minister has promised the South Korean premier the project will go ahead by August. But local people are not listening. They don't want to lose their land and livelihood and do not believe in promises of compensation. In Maharashtra, mango growers are up in arms against the proposed thermal power station in Ratnagiri. In every nook and corner of the country where land is acquired, or water sourced, for industry, people are fighting even to death. There are wounds. There is violence. There is also desperation. Like it or not, there are a million mutinies today... After I visited Kalinganagar, where villagers died protesting against Tata's project, I wrote this was not about competition or Naxalism. These were poor villagers who knew they did not have the skills to survive in the modern world. They had seen their neighbours displaced, promised jobs and money that never came. They knew they were poor. But they also knew modern development would make them poorer. It was the same in prosperous Goa, where I found village after village fighting against the powerful mining lobby …"

These movements combine livelihood, social, economic and environmental issues, with emphasis on issues of extraction and pollution. They set their "moral economy" in opposition to the logic of extraction of oil, minerals, wood or agro-fuels at the "commodity frontiers", defending biodiversity and their own livelihood. In many instances they draw on a sense of local identity (indigenous rights and values such as the sacredness of the land) but they also connect easily with the politics of the left. However, the traditional left in southern countries still tends to see environmentalism as a luxury of the rich.

8.11 FROM THE SOUTH: A REFUSAL TO PROVIDE CHEAP COMMODITIES?

The question is not whether economic value can be determined only in existing markets, inasmuch as economists have developed methods for the monetary valuation of environmental goods and services or of negative externalities outside the market. Rather, the question is whether all evaluations in a given conflict (on extraction of copper and gold in Peru or bauxite in Orissa, on a hydel dam in the North-East of India, on the destruction of a mangrove in Bangladesh, Honduras or Brazil to the benefit of shrimp exports, on the determination of the suitable level of carbon dioxide emissions by the European Union), must be reduced to a single dimension. Such an exclusion of values should be rejected favouring instead the acceptance of a plurality of incommensurable values.

With the economic crisis, will now be an end to the boom in exports of energy and materials thus diminishing pressures at the commodity frontiers? Grandiose plans for more and more exports from Latin America were pushed particularly by President Lula of Brazil. More roads, pipelines, harbours and hidrovias, more exports from Latin America of oil, gas, coal, copper, iron ore, soybeans, cellulose, biodiesel and ethanol, this was the credo of President Lula. In October 2008, and in total opposition to the views of Via Campesina and the MST (Movimento dos trabalhodores rurais Sem Terra, or landless farm workers movement) in Brazil, Lula was still pushing for generally opening the world markets to agricultural exports. He went to India to try and increase the rate of farmers' suicides by asking for the liberalization of agricultural imports and exports in the Doha round. True, the export boom gave Lula money for social purposes and increased his popularity. Petrobras was not less dangerous to the environment and to indigenous peoples of Latin America than Repsol or Oxy. Lula's obsession with primary exports made him do nothing about deforestation of Amazonia and drove environment minister Marina Silva to resign in 2008. What will the strategy of President Lula and the Latin American left be after the crash of 2008-09? Lula's insistence on the virtues of ethanol for export, is misguided. Agrofuels have a low EROI (especially taking into account the vegetation that already existed before agrofuels occupy the land), they increase the HANPP to the detriment of the biomass need of other species, and they imply large unpaid-for "virtual" water exports.

In fact, the crisis should be an incentive to focus on internal development, and not to sell the environment so cheaply. The prices of commodities have gone down, and moreover other values (social, environmental) have been sacrificed. In this respect, some proposals from Ecuador in 2007 (supported to a degree by president Rafael Correa, who is a traditional left-wing economist more than an ecological economist), are interesting. At the November 2007 OPEC summit meeting in Vienna when Ecuador came back to this organization, OPEC approved in principle a resolution in support of the Yasuni-ITT proposal (to leave oil in the ground in a territory with uncontacted indigenous people and of great biodiversity value), and it also voiced interest in the so-called Daly-Correa ecotax. The tax, proposed by president Correa at that OPEC meeting, is based on the concept by Herman Daly in a speech to OPEC in 2001 (Daly, 2007). OPEC countries have dismissed the existence of the enhanced greenhouse effect. This eco-tax would show their concern for climate change. An OPEC imposed carbon tax at the oil wellhead instead of attempted regulation of emissions from the tailpipe (by carbon taxes or cap-and-trade) would be fairer to exporting countries and perhaps more effective in reducing global carbon dioxide emissions. This ecotax would make acceptance of climate change easier for oil exporting countries (and also, if imitated, for gas and coal exporting countries). The principle is, export less at a higher price. Money generated from the tax would go towards financing an energy transtion away from fossil fuels, towards helping poor people around the world, and towards helping countries like Ecuador and Nigeria to keep oil (or gas or coal) in the ground when located under fragile and culturally sensitive ecosystems. (Martinez-Alier and Temper, 2007).

In late 2008 the economic crisis was bringing down the prices of commodities including oil, and the moment for such as tax seemed to have passed. Since July 2008, wheat, maize and soybeans declined in price by 60 per cent, as also copper, nickel, aluminium. Part of the financial boom in Iceland was based on outside investments in the expectation of a multiplication of aluminium smelting. Environmentalists complained strongly against smelters and electricity plants that ruined pristine environments, a cost not factored into the economic accounts. The economy of Iceland stopped in October 2008. Banks could not give the money back to deposit holders. They have been nationalized.

While in the 1920s, commodities decreased in price a few years before 1929, this time the increase in commodity prices (helped also by misguided agro-fuel subsidies, by the OPEC cartel, and by financial investment in the futures market) continued for some months after the strong decline in the stock exchange had started. However, in late 2008 commodity prices are declining because of declining demand. The Baltic Dry Index measures shipping rates. It declined precipitously since July 2008 partly because of decreasing Chinese imports of iron. The Mexican multinational CEMEX on 16 October 2008 already announced that it would reduce its labour force by ten per cent around the world because of declining demand of "aggregates" and cement, while car factories in Europe and the USA reduced output since mid-2008. The price of oil went down in late 2008 not because of increased supply but because of decreased demand. Some oil projects (with low EROI and high marginal costs) such as the Alberta oil sand production and the Orinoco heavy oil exploitation might be stopped, as also the small but economicallly, environmentally and socially costly Yasuni ITT project in Ecuador.

For commodities other than oil, the exporting countries might react irrationally, maintaining or even increasing the supply in an attempt to maintain revenues. There might be a soybean price war between Argentina and Brazil. Instead, this would be the moment for Latin America, Africa and other net energy-and-materials exporters, to think of endogenous development, moving towards an ecological economy. Many Southern countries will also suffer from smaller migrants' remittances.

A refusal from the South to provide cheap commodities to the industrial economy, imposing natural-capital depletion taxes and export quotas, would also help the North (including some parts of China) in its necessary long-term path towards an economy that uses less materials and energy.

8.12 BOTTOM-UP NEO-MALTHUSIANISM

The socio-ecological transition towards lower levels of use of energy and materials will be helped if the world demographic transition is completed, and even more, if population after reaching a peak at 8,500 million inhabitants goes then down to 5,000 million, as some projections indicate (Lutz at al, 2001). Remember that world population increased four times in the 20th century from 1.500 million to 6,000 million. Environmental awareness might influence birth-rates (as in the European Neo-Malthusianism of 1900 and in China since 1980).

The importance of population growth in the increase of Social Metabolism is obvious. Paul Ehrlich's equation I = PAT could be applied historically, with an adequate indicator for T (technology).

There were many debates around 1900 on "how many people could the Earth feed" focusing only on the needs of the human species. The Neo-Malthusians of the late 19th and early 20th centuries were political radicals and feminists. There was a large difference between the original Malthusianism of T.R. Malthus and the neo-Malthusianism of 1900. Scholarly historical work on neo-Malthusianism has clearly documented the radical, feminist movement in favour of limiting births in Europe and the United States around 1900. In France this movement took the name of la grève des ventres. In South India, the "self-respect" movement launched by E.V. Ramasamy (called Periyar, a Tamil thinker and political activist, 1879-1973) took a similar line. In Brazil the feminist neo-Malthusian anarchist Maria Lacerda de Moura wrote: "Love one another more and do not multiply so much". This intellectual and social history allows me to present the following definitions.

MALTHUSIANISM.- Population undergoes exponential growth unless checked by war and pestilence, or by chastity and late marriages. Food grows less than proportionately to the labour input, because of decreasing returns. Hence, subsistence crises.

NEO-MALTHUSIANISM OF 1900.- Human populations could regulate their own growth through contraception. Women's freedom was required for this, and desirable for its own sake. Poverty was explained by social inequality. "Conscious procreation" was needed to prevent low wages and pressure on natural resources. This was a successful bottom-up movement in Europe and America against States (which wanted more soldiers) and Churches. (Ronsin, 1980, Masjuan, 2000).

NEO-MALTHUSIANISM AFTER 1970.- A doctrine and practice sponsored by international organizations and some governments. Population growth is seen as a main cause of poverty and environmental degradation. Therefore States must introduce contraceptive methods, even without women's prior consent.

ANTI-MALTHUSIANISM.- The view that assumes that human population growth is no major threat to the natural environment, and that it is even conducive to economic growth as Esther Boserup and other economists have argued.

8.13 SUSTAINABLE DEGROWTH

A transition to sustainability requires new thinking on demography and on the socio-ecological transition. Marina Fischer-Kowalski and Helmut Haberl of the IFF in Vienna, influenced by the work of environmental historian Rolf Peter Sieferle and by ecological anthropologists, ecological economists, and industrial ecologists, recently edited a book entitled "Socio-Ecological Transitions" (Fischer-

Kowalski and Haberl, 2007). From hunter-gatherer societies to agricultural societies to industrial societies, the authors of this book uncover quantifiable patterns of use of energy and materials, population densities, land use and working time. They try also to distinguish possible from impossible futures. For instance, is it plausible to think of a world of eight billion people with an energy expenditure of 300 GJ and a use of materials of 16 tons per capita/year? Are we on the contrary on the verge of a socio-ecological transition that will reduce energy and material use in the rich economies even if this implies economic de-growth?

The transition needs a reform of social institutions (to deal with unemployment), and also a reform of financial institutions to stop the financial level of the economy from growing without reference to the underlying physical realities. The imaginative selling of derivatives (financial “products”), and the existence of unregulated offshore banking, have taken a knock in public opinion. Sensible proposals are made by moderate political forces to turn banking into a nationalized public service. Beyond this, the crisis provides an opportunity for thinking about the real-real economy. Taxes at origin on the extraction of resources to finance an environmentally sustainable society should be introduced. There is need to reduce energy consumption and the use of materials by rich people. Frivolous calls in OECD countries for population growth in order to increase employment that will help pay for old age pensions, are not at all convincing from an ecological point of view, or even from a purely financial point of view as rates of unemployment increase. This is an opportunity for starting a socio-ecological transition.

In some countries, not only the absolute amount of materials but also material intensity (tons of materials / GDP) was increasingly indicating more pressures on the environment. Convergence to a European average of 16 tons per person/year (only materials, water not counted here) would multiply Material Flows in the world by three, with the present population. Economies can be characterized by such Material Flows. We may analyze patterns of external trade. While South America exports six times as many tons as it exports, the European Union imports four times as many tons as it exports. We can understand characteristic patterns of social conflicts, for instance mining and oil extraction conflicts, or resistance against tree plantations for paper pulp or agro-fuels, or the international conflict caused by unequal access to the carbon dioxide sinks (oceans) or the temporary “reservoir” (atmosphere). Convergence towards 300 Gigajoules per capita/year in a European pattern would mean to multiply by 5 the present energy in the world economy. If gas and especially coal are used, this would also multiply by 4 or 5 the carbon dioxide produced. The HANPP is also increasing – human appropriation of net primary production of biomass. Population growth, soil sealing, meat eating, paper production, and agro-fuels increase the HANPP. The higher the HANPP, the less biomass available for other species.

At first sight, Southern countries have something to lose and little to gain from Degrowth in the North because of fewer opportunities for commodity and manufactured exports, and less availability of credits and donations. But, the movements for Environmental Justice and the "environmentalism of the poor" of the South are the main allies of the Sustainable Degrowth movement of the North. These movements complain against disproportionate pollution (at local and global levels, including claims for repayment of the "carbon debt"), they complaint against waste exports from North to South (e.g. the "Clemenceau" and so many other ships to the reekngg beaches of Alang in Gujarat, or electronic waste), they complain against biopiracy, and also against Raubwirtschaft, i.e. ecologically unequal exchange, and the destruction of nature and human livelihoods at the "commodity frontiers". They also complain against the socio-environmental liabilities of Transnational Companies.

The world conservation movement should criticize conventional economic accounting and push for the introduction of an economic language that reflects better our relations with nature, while not forgetting the legitimacy of other languages: territorial rights, environmental and social justice, livelihood, sacredness. This is needed for the alliance between the conservation movement and the environmentalism of the poor, as proposed in the IUCN booklet, Transition to Sustainability, by Bill Adams and Sally Jeanrenaud, published in 2008. This alliance is difficult because, to judge from the visibility of sponsorship at the World Conservation Congress in Barcelona in October 2008, the world conservation movement has sold its soul to companies like Shell and Rio Tinto. John Muir would have been horrified.

The "environmentalism of the poor" combines livelihood, social, economic and environmental issues, with emphasis on issues of extraction and pollution. In many instances these movements draw on a sense of local identity (indigenous rights and values such as the sacredness of the land). Such movements explicitly oppose annexation of land, forests, mineral resources and water by governments or business corporations.

There could be a confluence among conservationists concerned with the loss of biodiversity, the many people concerned with climate change who push for solar energy, the socialists and trade unionists who want more economic justice in the world, urban squatters who preach "autonomy", agro-ecologists, neo-rurals, and the large peasant movements (as represented by Via Campesina), the pessimists (or realists) on the risks and uncertainties of technical change (post-normal science), and the "environmentalism of the poor" that demands the preservation of the environment for livelihood. The international environmental justice movements have as objective: an economy that sustainably fulfils the food, health, education and housing needs for everybody, providing as much joie de vivre as possible. They know that in decision-making processes, economics becomes a tool of power. This is the case when applying cost-benefit analysis to individual projects, and also at the level of the macro-economy where increases in GDP trump other dimensions. The question is, who has the power to simplify complexity and impose a particular language of valuation? The environmental justice movements know in their bones and in their brains that conventional economic accounting is false, that it forgets the physical and biological aspects of the economy, the value of unpaid domestic and voluntary work, and it does not really measure the welfare and happiness of the population. What is needed is an Aristotelian buen vivir (as the World Social Forum proclaims) guided by oikonomia rather than chrematistics.

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8. May There Be Dalyists: Politics for a Steady State Economy

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9.1 HERMAN DALY: CAREER TRANSFORMER

Herman Daly is more than a giant in the economics of sustainability; he is a gentle giant, in and out of economics. The fact that he is widely recognized as a good fellow in addition to a scholar should not be lost in a festschrift. Of course, the mere existence of a festschrift indicates that the scholar, and not just the scholar's work, is held in high regard. Yet the fact that Daly is a good fellow, with accolades such as the Right Livelihood Award, bears revisiting in a chapter on politics. After all, assessments of "good" and "bad" rule the political hearts and minds of many citizens.

For those who haven't met Daly in person, a measure of the man may be ascertained from *For the Common Good*, where Daly's ethical and theological concern for human wellbeing shines as brightly as his steely logic for a steady state economy. Daly doesn't settle for some supposed "rising tide" to lift all boats out of poverty. For one thing, he recognizes that the tide may rise only so far, leaving some boats stranded in the mud. Yet Daly wouldn't settle for the rising tide plan even if the tide *were* unlimited. He believes justice can and should be encouraged in economics curricula and pursued with public policies, not left to the tides.

But Daly isn't interested exclusively in justice. He is also concerned with truth. This will help to explain how a wildlife biologist in mid-career (like myself in the 1990's) becomes an ecological economics instructor, establishes an organization to advance the steady state economy, and authors a chapter in a Daly festschrift, especially this particular chapter.

After an exhilarating 15 years in the field, working with elk, bighorn sheep, bears, mountain lions, and many more of the "charismatic megafauna," I wanted to make a lasting contribution to wildlife conservation at a national level. So I went from the San Carlos Apache Reservation, where I was serving as the Recreation and Wildlife Department director, to the University of Arizona for a Ph.D. in renewable natural resources studies. I minored in political science so I could work my way into public policy. My dissertation was a policy analysis of the Endangered Species Act (ESA), and I used an approach called "policy design theory," developed in part by another renowned scholar, political scientist Helen Ingram, who I was honored to have on my committee.

Policy design theory requires the analyst to account for the context within which a policy functions (or doesn't). I analyzed numerous angles of the context, but I always felt the most direct and relevant angle was the causes of species endangerment. After all, if weren't for those causes, we wouldn't need an ESA. Conversely, the ESA was all about preventing or rectifying the causes. Tabulating the causes was a laborious (and often depressing) task; the resulting database included all 877 species listed as threatened or endangered at the time, with 18 columns representing distinct causes of endangerment. Although the causes were distinctive enough for categorization, the "average species" was imperiled by approximately 4 such causes, and all the causes seemed intertwined.

After populating this database night after night for many long nights, followed by a bit of reflection on policy design theory, it suddenly struck me that the causes of species endangerment could aptly be described as a Who's Who of the American economy! This, I felt, was an important finding. In a way, it seemed like a no-brainer, but it was important because the *policy* context of ESA was one in which a primary, perennial, and bipartisan goal of the American public and polity was economic growth. So here we had two stated goals of the United States – economic growth and species conservation – that seemed to be fundamentally at odds. Meanwhile the primacy of economic growth as a policy goal was especially clear in the 1990's. During the 1992 presidential campaign, when asked to identify the most important policy issue, candidate Bill Clinton responded, "It's the economy, stupid!" Once elected, he and his cabinet were fond of exclaiming, "There is no conflict between growing the economy and protecting the environment!"

After reporting on the causes of endangerment in Science (Czech and Krausman 1997), while still a student (albeit an older-than-average student), I started broaching this topic – the conflict between economic growth and wildlife conservation – in classes, conferences of professional natural resources societies, and papers (e.g., Czech 2000a, Czech et al. 2000). The responses astounded me. From one side would come, "No Czech, you're wrong, there is no conflict between economic growth and wildlife conservation," as if they were all members of the

President's cabinet. Oddly enough, the other camp would submit, "Of course there's a conflict between economic growth and wildlife conservation! But we're wildlife biologists. We don't do economic policy." The cumulatively response was to the effect, "Go away!"

So I went away, to the library. I was less concerned about the fatalists in the second camp than the argumentative folks in the first camp who disagreed with my assessment. Did they know something I didn't? It didn't seem like they'd even studied the topic, but they were outspoken about it, so I had to investigate further to assure them and myself that I knew what *I* was talking about. Using keywords and phrases such as "economic growth," "wildlife conservation," and numerous others, I eventually stumbled upon the ecological economics literature, which wasn't nearly as prominent then as it is now. I also noticed that, with the phrase "economic growth," I kept seeing the name "Daly."

It is a fuzzy memory, that first Daly article. I think it was "Introduction to the Steady-State Economy," not even the whole article but rather the condensed version from an amazing collection of papers in *A Survey of Ecological Economics* (Krishnan et al. 1995). Condensed or not, the material in that introduction alone gave me the sense that I was suddenly onto the most potent policy implications ever written for wildlife conservation! It basically had "the" answer: the steady state economy in which wildlife and biodiversity in general could be conserved indefinitely. It seemed my highlighter couldn't get enough of that article, but it would take me a little longer to realize that the implications of Daly's work went far, far beyond wildlife conservation.

When I "discovered" ecological economics and in particular Daly's work on the steady state economy, I hadn't yet completed my dissertation on the ESA. That was a good thing, for I still had time to conclude by interpreting the ESA as an implicit prescription for a steady state economy, albeit one with numerous species lined up on a ledge in the one-way canyon of extinction (Czech and Krausman 2001). But the conclusion of my dissertation was only the beginning of my immersion in ecological economics, and I continued to find the steady state economy the most distinguishing feature in ecological economics and the most important concept for ecological and economic sustainability (Czech 2009).

9.2 TESTING THE WATERS OF STEADY STATE POLITICS

Empowered and emboldened by ecological economics and the concept of the steady state economy, I went back to the wildlife profession to set the record straight on economic growth and wildlife conservation. I discovered that some of the older members, especially, of The Wildlife Society (TWS) were more-or-less familiar with Daly's work. I was puzzled why they weren't espousing it for the rest of the members (more on that later.) I proposed that TWS adopt a position on economic growth, a position that would identify the steady state economy as an alternative to economic growth and an alternative that was consistent with wildlife conservation (Czech 2000*a*). I said that a TWS position could help refute the fallacious political rhetoric that "there is no conflict between growing the economy and protecting the environment," which by then I'd learned was not just Clintonian but bipartisan.

To my knowledge, this was the first attempt to get a professional natural resource society to venture into the policy terrain of economic growth. It was also a rude awakening for me. It turned out that the two earlier camps I'd encountered in the wildlife profession weren't about to break ranks and rally around the proposed position, anointing me a new buddy for whom to buy beers. Instead, it seemed like they circled the wagons and fired arrows at the proposal – lots of arrows! To describe all the sordid details of what it took to get TWS to adopt a position on economic growth is beyond the scope of a festschrift (or maybe anything in print). Suffice it to say that it took much more than the six years of debates, symposia, papers, committees, working groups, and other conventional professional society communications that go on the record. Lectures, visits, emails, listserves, phone calls, pleasantries, arguments, negotiations, exhortations, pleas… the ratio of unpublished written and spoken words to words published in the literature seemed an exorbitant price for someone seeking to establish an academic publication record. It turned out to be well worth it, but let this be a warning to any young (or old) man or woman who would advocate a steady state economy: Be prepared for a lot of silly, and some not-so-silly, even slanderous accusations. According to some, you're probably already a communist, an elitist, a pessimist, or a combination of these and sundry pariah traits.

After I wrote *Shoveling Fuel for a Runaway Train*, Stanley Marsh (the Texan known for burying Cadillacs on his "Cadillac Ranch," rear ends thrust toward the heavens in a Texas-sized attempt at art) wrote to tell me flatly, among other things, "You don't like them [the Cadillacs] because you are an old stick in the mud. You don't understand the American dream… You, Czech, are a communist and an anarchist."

As I've learned over the years, a lot of people just don't want to hear about limits to growth, the conflict between economic growth and environmental protection, or the steady state economy. People are uncomfortable with conflict in general and many won't deal with what they label "pessimistic" analyses of economic growth, no matter how accurate the analyses are. Still others, with a strategy of sorts, think that dwelling on such "negative" prospects doesn't keep them in the pleasant majority where politics are easier and grant money flows. Let's brace ourselves for the fact that this is the same type of convenient escapism that led Prime Minister Chamberlain and the rest of Europe to stand by idly, presumably practicing their positive thinking, while the Nazis rolled into Poland.

"Wait just a minute," some may be thinking, "did I just hear what I thought I heard? Did we really have to infest a pleasant festschrift with a violent World War II metaphor?" Unfortunately, the metaphor could hardly be more relevant, and we ought to think about it deeply. One of the underlying pressures that empowered the Nazis was the German need for the land, space, and natural capital they called "lebenschraum." All the Nobel prize-winning economists in the rarefied world of the ivory tower couldn't have convinced the Nazis that unlimited economic growth could be administered within the confines of the German state! In the real world, economic growth requires more land, and those with overly aggressive aspirations for growth will take the land from others. That's not a negative or positive vision; that's just reality.

We can only wish that the steady state economy, or at least progress toward establishing steady states, had become a source of civilized national pride long before the wars in Europe took on their industrial, globalized, genocidal nature. Surely then the international financial institutions borne out of World War II would have taken a different course. The World Bank (or whatever it would have been called), for example, may have focused more on ecological sustainability and international economic justice than global economic growth. Unfortunately, the World Bank wouldn't have a Herman Daly until 1988, and by then, crisis wasted, the World Bank wasn't ready to listen.

9.3 "WHATEVER HAPPENED TO DALY'S STUFF?"

Numerous times I've heard people inquire, as I would paraphrase the collective inquiry, "Whatever happened to Daly's stuff?" The articles and books are published, pulsing with policy implications, yet we see precious few implications circulating into the policy arena. Early on, I was asking the same question; for example, during my experience with The Wildlife Society. Now, after ten years of advocating the steady state economy, I've developed enough understanding of what happened to Daly's stuff to write about it. The basic categories to explain what happened include: 1) political economy, in particular the effects of "Big Money;" 2) lack of transdisciplinary experience in academia and the polity; 3) non-newsy nature of steady state economics; and, 4) egos and competition for leadership in academia and politics. These categories are presented in estimated order of importance, but it is also important to understand that these categories tend to be mutually reinforcing.

9.3.1 Political Economy and Sustainability

Daly's work won't be championed by Big Money anytime soon, which makes it more difficult to get it into the New York houses, broadcast media, big-screen documentaries, and the policy arena itself. By "Big Money" I mean the most prominent and powerful growth interests such as the World Bank, Wall Street, corporations, and the Federal Reserve System. First, Big Money is unlikely to encounter a Daly publication. Second, if it does, it is more likely to ignore or suppress it than to study or circulate it. That is not to say there aren't individuals within Big Money who have studied Daly's work and agree with it. Of course there are. But here we are talking about political economy; the systemic functioning of the integrated political and economic system, replete with trends and probabilities. For every Daly thesis that might be circulated by a corporate shareholder, how many antitheses are circulated by a corporate board or corporate think tank? Or by a university's economics department whose research is corporately funded?

Compare Daly with the late business professor Julian Simon, who argued that perpetual population growth is not only possible but desirable because it results in perpetually more brains to compensate for the problems of growth, and then some. He called this salesmanship a "grand theory." Various forms of "enterprise institute" lined up to praise such an "optimistic view" and "positive vision," to get more of Simon's books on the shelves, and to construct a sort of pro-growth folk hero who had proved all those negative tree-huggers wrong. Few people know that Simon's first book was about how to establish a mail-order service, because Big Money didn't include that in the hype.

Simon's salesmanship lives on with the new poster child of the enterprise institutes, the self-proclaimed "skeptical environmentalist" Bjorn Lomborg. Meanwhile, the aspiring Dalyists are kept down by lack of support. That experience may come as a discouraging surprise to the Dalyists, because most of them come out of an academic background and are accustomed to publications rising to the top based on peer review and scientific merit. But this brings us to the topic of transdisciplinary experience. With regard to Big Money, let me close by recommending *Global Spin* (Beder 2002) as a cure for acute cases of naiveté. For those with less acute cases (or less time on their hands), an overview of the iron triangle of economic growth is much better than nothing (Czech et al. 2003).

9.3.2 Lack of Transdisciplinary Experience in Academia and the Polity

Ecological economics arose partly as a response to the fact that economists didn't know enough about ecology, and ecologists didn't know enough about economics. That much is still true in conventional economics and ecological circles.

The ecological economics community stands out as a refreshing exception (although there are non-refreshing non-exceptions mingling therein). The mutual ignorance between economics and ecology is especially problematic for addressing limits to growth, or the "scale" issue as it's known in ecological economics, thanks to Daly.

In my experience, the more vexing ignorance is among ecologists, who often do not know so much as the meaning of economic growth. It's easy to argue that there is no conflict between economic growth and environmental protection, Big Money smiling down on you and your program, when you invent your own meaning of economic growth. Of course this problem is exacerbated by the fact that the phrase "economic growth" is often used in multiple ways among economists themselves. But this isn't much of an excuse. "Cat" is used in many ways, but that seldom derails a meaningful discussion about *Felis catus*. If terms may have more than one meaning, they simply have to be clarified when necessary. That is why Daly's long-standing effort to distinguish between economic growth and economic development is so important for policy purposes. But again, not many ecologists are yet familiar with Daly, for all of the reasons in this section on Daly's stuff. And there are other problems within the ecological sciences community when it comes to engaging macroeconomic policy, including an understandable propensity to eschew social and political affairs (Czech 2002).

This is not to say that the ecological ignorance of neoclassical economists is *far* less vexing than the economic ignorance of ecologists. Perhaps in a technical sense it is even more vexing, because as Daly pointed out early on, the economist begins with a different pre-analytic vision, and that vision was derived without paying heed to some basic natural science. Most importantly, and most prominently revealed in Daly's work, is the ignoring of the first two laws of thermodynamics. A good grasp of those two laws, greatly aided no doubt by some real-world experience with materials and mechanical devices, is essential for "getting" limits to growth. Conversely, without citing these laws, the ecologist cannot authoritatively refute an economist's (or any freewheeling technological optimist's) argument that we can have perpetual economic growth through technological progress (Czech 2008).

Economists are even less likely familiarized with principles of ecology. That is why they also don't realize that ecologists *are* economists; namely, economists of nature, dealing with production and consumption, competition, allocation of resources, and many of the same phenomena that "regular" economists deal with. (Ecologists don't realize that either.) Ecologists just happen to practice their economics with any or all species, and of course their jargon is distinct. Perhaps the only thing that is truly, fundamentally distinctive about the human economy is the monetary sector. Ironically, monetary economics would benefit most of all from the basics of ecology, most notably trophic theory, which so clearly demonstrates that real money originates from agricultural and extractive surplus and is therefore a real reflection of throughput (Czech 2000*b*).

The point here is not to sling mud left and right, but to help readers understand that ecological economics is not amenable to conveying with sound bytes or word-of-mouth. Ecological economics is not the proverbial rocket science, but it is a distinct combining of the social and natural sciences that many scholars have not been inclined to undertake. One can't go to a conference of the American Economic Association and get an open forum back on the track to reality by citing Daly's application of the entropy law to productive efficiency. It is quite possible in such a venue to be totally correct and concurrently castigated as a kook. Economists and ecologists alike will need to digest for themselves at least the basics of Daly's work, and for such basics I still recommend 36 pages: "Introduction to *Essays Toward a Steady-State Economy*" (Daly 1994:11-47).

Unfortunately, many ecological economists with a solid background in Daly's work will still fall short of steady state political productivity. Ecological economics is transdisciplinary in nature, but thus far the ecological economics community has produced very little political science, much less action. Bringing a Dalyist movement into public policy will require a much more sophisticated understanding of concepts pertaining to the framing of rhetoric, the development of political power, and the political characteristics of the macroeconomic policy arena. It will also require much more fortitude to "tell it like it is" in the face of political pressure, on the campus and in the polity per se.

9.3.3 Non-Newsy Nature of Steady State Economics

It would greatly help to increase the political viability of the steady state economy if the news media were actively investigating and reporting on it. Unfortunately the steady state economy isn't the type of thing that grabs the media. It's not a person, place, or event. Herman Daly is a person, but is, as noted above, a gentleman. He is not an elected official, a movie star, or a raving lunatic gunning down innocents, so he won't be in the national news based on his profile or behavior.

Sometimes a scholarly gentleman with a world-changing idea will make the news, but it's because the idea will result in an observable, dramatic event or otherwise have an observable dramatic effect. When it comes to moving from the goal and process of economic growth to the goal and process of a steady state economy, perhaps nothing could be less observable or dramatic. This is not the kind of transition that will inspire (thank goodness) a bloody revolution. Of course it will make very big news if the steady state economy is ever signed into law as a policy goal, for example as an amendment to the Full Employment Act, but there are a great many lesser, incremental policy developments toward a steady state economy that, unfortunately, will not make the news and will not, therefore, help to empower *further* movement toward a steady state.

For example, consider the adjusting of the federal funds rate by the Fed. This invariably makes the news. It features a high-profile person (Fed Chairman) announcing a decision that results in an observable and often dramatic event (bedlam at the New York Stock Exchange). Let us assume that the Fed has been planning to lower the rate to stimulate economic growth. The question for the news is how much the rate will be lowered. If the decision comes down to the Chairman, who happened to finally read Daly's *Beyond Growth* in response to another financial meltdown, it is conceivable that the Chairman, with new and unsettling thoughts of uneconomic growth, would lower the rate an eighth of a percentage point less than he or she would have. This would be a compromise and, in a sense, could even be classified as an incremental movement toward steady state monetary policy because it amounts to a slightly less pro-growth adjustment. Yet this part won't make the news. No one will even know about it unless the Chairman makes a point of acknowledging it publicly. Once again, forthrightness and fortitude are required, in this case for making the steady state economy newsworthy and connecting it explicitly with monetary policy.

The newsworthiness of steady state economics may be changing, though. At the time of writing, the steady state economy seems to be appearing in opinion columns, editorials, and letters to editors more frequently than ever. This is due primarily to the financial crisis of 2008, which could be the beginning of a protracted and deep depression. It is one of those moments in history when people far and wide are looking for alternatives to conventional economic thinking – a "teachable moment." But the uptick of steady state journalism shouldn't be exaggerated. Ecological economics and the steady state economy remain virtual unknowns in the world of politics and policy, and that is unlikely to change unless the media covers it prominently and for a protracted period.

This brings us back to the previous two sections on Big Money and transdisciplinarity. Mainstream media are controlled to a significant extent by Big Money, and journalists and reporters suffer from the same lack of transdisciplinary expertise as economists and ecologists. Journalism and newscasting on the steady state economy is not out of the question, but it will take charismatic people, creatively crafted events, and maybe some dumb luck to attract the mainstream media.

9.3.4 Egos and Competition for Leadership in Academia and Politics

There aren't many academics in politics, but there are plenty of politicians in academia. As with elected officials, many of the figures in academia are attracted to the limelight or driven there by ego. Many a student and incidental campus visitor has commented on the arrogance effused by well-known scholars. This isn't the place for analyzing or speculating on the psychology of scholarship, especially when the subject of the festschrift is known for undue modesty, but it is a phenomenon that plays a role in hampering the political advancement of the steady state economy.

Scholars rise to a place of prominence for different reasons than politicians per se. Politicians can become quite renowned simply for pleasing or appeasing enough constituents; providing enough pork as it were. Scholars usually become prominent because they have done something intellectually original, or at least something they have been able to package in an original manner. The latter is an important distinction with direct relevance to steady state politics. Scholars are jockeying for positions as leaders in sustainability science. A scholar may fully realize that a sustainable economy *is* a steady state economy. The problem is that the phrase "steady state economy" has already been "taken" in the academe. When the phrase is uttered, it invariably invokes the name of Herman Daly. Therefore, developing a research or community service program around the steady state economy, at least by that name, will make it more difficult to carve out a unique niche in the upper echelons of sustainability science. The result is a constant re-packaging and re-branding process in which precious little original contribution is made. I wrote about this with regard to the part-fad, part-original 1990's movement toward "ecosystem management," which provided elbow space and grant-writing opportunities for numerous academics (Czech 1995).

Unfortunately, in real-time politics, where decisions are made that directly affect or create public policy, name recognition is a key variable. This means that the continual coining of new phrases in academia has the effect of disempowering the common subject matter – economic sustainability in this case – in the polity. It's a real tragedy of the campus commons.

9.4 A FOUNDATION FOR A STEADY STATE POLITICAL PLATFORM

Due to its transdisciplinary and non-newsy nature, the steady state economy is unlikely to inspire a grassroots political movement. Certain grassroots movements (for example, away from conspicuous consumption) will be *conducive* to the establishment of a steady state economy, but for the steady state to be established as an economic policy goal, focused political activity by a dedicated cadre of Dalyists is required. Where do we start?

First, we need to consider where we are coming from. Most Dalyists are, or are going to be, relatively highly educated, transdisciplinary students and scholars, which means a logical starting place for advancing the steady state economy is the scientific or scholarly professional community. It's where we are and where we know people. We may not have been born with a silver spoon in our collective political mouth, with a leg up on Capitol Hill, but we are in a key position nevertheless, for purposes of political and economic reform. That's because we can provide leverage for individuals and organizations that are "players" in the development of public opinion and public policy.

Let us consider the professional society position statement as a means by which to advance the steady state economy. I believe these positions are crucial to advancing the steady state economy and keeping it supported once it reaches critical mass in political affairs. I wouldn't claim that professional society position statements are the *only* means or an absolutely essential condition for the establishment of a steady state economy. Miraculous alternatives toward any objective are theoretically possible. However, I would argue that the professional society position statement constitutes the optimum approach for Dalyists, at this point in history, when we consider not only our starting point but the nature of the subject, the opposition, and the economic policy arena. An adequate collection of these position statements will comprise a firm foundation for organizations and politicians to stand upon as they seek to educate the public on the perils of growth and as they propose macroeconomic policy reforms (Czech 2007).

After ten years of advancing such positions in professional natural resources societies, and even given the modest results, I am more convinced than ever that not only the positions themselves but the position-taking efforts are key to establishing steady state economies. To start with, these efforts have helped Dalyists to identify one another and capitalize on our complementary strengths. For example, The Wildlife Society's Working Group for the Steady State Economy, by virtue of its name, assembles TWS members who can safely surmise that they are indeed among members who are interested in advancing the steady state economy. The working group provides an official voice to other TWS interests and leadership, helping to spread awareness of the steady state economy as the macroeconomic condition necessary for wildlife conservation. Its mere existence, with strength in numbers, helps to empower individuals and units in other professional natural resources societies to form groups with similar traits and effects; for example, the Working Group for Ecological Economics and Sustainability Science in the Society for Conservation Biology.

An overlooked benefit of these position-taking efforts is the political experience gained by the participants. A professional natural resources society, and for that matter any similarly sized society or group, is like a crucible in which many of the same types of issues, concerns, and personalities are squished together and forced to react. Taken together, these efforts among the various professional societies constitute an experiment of sorts, an uncontrolled experiment with elements of "adaptive management." Participants learn about the technical issues of the steady state economy, the political issues, the personal concerns of career-minded members, the comparative effectiveness of rhetorical style in different types of venues (for example, the symposium vs. the committee meeting vs. the open forum), and the uses and abuses of political power that affect collective decision-making. In this crucible, political leadership is forged for advancing the steady state economy in "real" polities ranging from municipalities to international unions. A few people involved in these professional society efforts are already advancing a steady state economy as a policy goal in city, state, and national political offices, using their campaigns to educate voters about the steady state economy.

And that is only the fringe benefit of professional society position-taking! The prize is the position itself, or rather the positions. Thus far, positions have been taken by the U.S. Society for Ecological Economics (2003), The Wildlife Society (2004), Society for Conservation Biology's North America Section (2004), American Society of Mammalogists (2007), and British Columbia Field Ornithologists (2007). Semi-professional organizations have also adopted positions, including the Federation of British Columbia Naturalists ("BC Nature") (2008). These positions mean something; they are no mere slips of paper. For example, as a conservation biologist in the national office of the U.S. Fish and Wildlife Service, toward the end of the second Clinton Administration, I proposed that we (Fish and Wildlife Service) develop a campaign to educate the public on the trade-off between economic growth and wildlife conservation. The relevant assistant director (the one between me and the director) brought me to his office and stated, in a nutshell, "Brian, you get us a position on economic growth by The Wildlife Society and some of the other societies, and then we'll talk about it." This was a straight-shooter who was dead serious. Unfortunately, his ability to act was compromised by political developments subsequent to that. But the point is that political appointees striving to do the right thing need cover, or a foundation to stand upon, if they are going to support an initiative that could make waves for the politician who does the appointing. It is also worth noting that this particular appointee modified his own speeches to avoid the win-win growth-conservation rhetoric and help educate the public about the trade-off.

I could list dozens, and with a better memory probably hundreds, of experiences in which the presence or absence of a professional society position statement on economic growth made a difference in the decision or decision-making process of a leader in a capacity to direct significant resources toward advancing the steady state economy. Frankly it would be inane to think such positions *wouldn't* make a political difference! Another way of looking at the utility of the professional society position statement is to consider nascent attempts at steady statism in the absence of such positions. For example, toward the end of the Environmental Movement in the U.S., after *Limits to Growth* was published (and Daly's *Steady State Economics*), a few environmental organizations took up the topics of population growth and economic growth. Friends of the Earth, for example, began raising awareness about limits to growth, and even received some coverage in *U.S. News and World Report* as a result. But they were quickly washed away in the tide of political economy, discredited as nothing but "friends of the earth." Now if they had been able to base their educational campaign upon a stack of dry, scientific, professional positions that clarified beyond a doubt the fundamental conflict between economic growth and environmental protection, the campaign would have been far more durable and effective. This should be a matter of common sense, but in conversations with me, Brent Blackwelder (President of Friends of the Earth, then and now) has verified that, indeed, professional society position statements would have been – and would be – of great help.

Yet naysayers will claim such positions are useless, and perhaps to them they will be. A vehicle is only as useful as the operator. I'll take my cue from Herman Daly himself, who once told me that these professional society position statements, few as there were (and still are, at the time of this writing), were the most encouraging development he had seen in the advancement of the steady state economy!

9.5 OTHER MEANS AND MOVEMENTS

Plenty of political efforts and movements have shown that the steady state economy is a potentially viable policy goal. For anyone doubting this observation, I recommend using Google news alerts to monitor the phrase "steady state economy" for a while. You'll see letters to editors around the world urging politicians and governments to move toward the steady state economy. Book authors have a renewed or new interest in limits to growth and the steady state economy. Politicians pop up here and there advocating the steady state economy. This is a trend that, while certainly accelerating in 2008, is certainly not guaranteed a long continuance or a high plateau. What is needed is an expanding group of Dalyists: people with enough knowledge of ecological economics, fortitude, and savvy to function effectively in the polity.

The foundation of professional society position statements needs to be laid thicker and firmer. More such professional societies should take such positions, and the positions need to be stronger than some of the existing positions (see for example Gates et al. 2006). But the professional society position-taking needn't delay all other prospective efforts. It is time for the less academic non-governmental organizations known as "the NGO community" to get to work for the steady state, beginning with the conservation and environmental NGOs. There is already enough of a platform of scientifically derived, professional society technical papers and position statements for them to stand upon. They should be developing educational campaigns to refute the fallacious political rhetoric that "there is no conflict between growing the economy and protecting the environment," and they should not shy away from the phrase "steady state economy" to identify the sustainable economic policy.

Any individual or organization contemplating steady state advocacy will be empowered not only by Daly's original work and the professional society position statements, but also by the growing list of signatories to the position on economic growth taken by the Center for the Advancement of the Steady State Economy (CASSE). By January 1, 2009, this position had been signed by over 2,100 individuals and endorsed by more than 50 organizations concerned with a wide range of issues including the environment, social justice, and public health. Even a mutual fund had endorsed the CASSE position. At this point, no one has to feel like they are sticking their neck out by advocating a steady state economy. With Daly as the key advisor on a highly reputable Board of Advisors, CASSE is developing unprecedented political support for the steady state economy, and the CASSE position on economic growth may be taken and tailored to produce positions with more focus on particular aspects of social welfare (see inset). For example, the North America Section of the Society for Conservation Biology took a position on economic growth that is virtually identical to the CASSE position, except for including additional references to biodiversity conservation.

When enough positions and educational campaigns have been developed, the time will have come to advance the steady state economy into mainstream political and policy-making venues. In fact, for smaller polities, enough leverage already exists for serious dialog on the steady state economy as a policy goal. For example, a commission in Bloomington, Indiana has tailored the CASSE position on economic growth to advance the steady state economy within the Bloomington polity and to the broader American polity (Bloomington Environmental Commission 2008). The commission is now working with the city council, seeking adoption of the position by the city at large.

As the signatures and endorsements of the CASSE position grow, larger polities and policy-making units will be approachable. The obvious entities will include city councils, county commissions, and state and national legislatures, executives, and even judiciaries. For example, the 2007 U.S. Supreme Court ruling in the case of *Kelo v. New London*, which should be infamous among ecological economists and especially Dalyists, may be used as precedent to rule in favor of municipalities using economic growth and development as a reason to exercise eminent domain over long-standing, low-footprint homeowners. Steady staters should be ready to issue an amicus brief, heavily footnoted with Daly references, noting that economic growth is not a "public purpose" (the phrase used in *Kelo* to describe increasing economic activity) when growth has actually become uneconomic. Such a brief may not win the day in court, but it will surely produce an educable moment, and perhaps a sustained one.

Political parties are other venues for advancing the steady state economy. The Green Party of the United States installed a plank on the steady state economy in its 2004 platform. Several other Green Parties around the world have explicitly supported the steady state economy, including at least the Green Party of England and Wales, the Green Party of Ireland, and to a less explicit degree the Green Party of the Netherlands. Provincial governments in Ontario and British Columbia have also adopted the steady state economy in their platforms.

Political movements mustn't necessarily explicate the steady state economy as a policy goal to have the effect of advancing the steady state. For example , the movement for "La Décroissance," emanating from France to other parts of Europe, has followers and observers wondering what comes after an episode of "degrowth," for in the long run degrowth is no more sustainable than growth. Clearly they, too, will "discover" the steady state economy as the sustainable alternative, much like those of us who discovered it as an answer to biodiversity conservation and environmental protection in general. In fact, the Declaration of the Conference on Economic Degrowth for Ecological Sustainability and Social Equity (Paris, 2008) included the establishment of a steady state economy as the long-term goal. At least two other economic movements, toward the "Sufficiency Economy" in Thailand and the pursuit of Gross National Happiness in Bhutan, are conducive to raising awareness of the steady state economy as an explicit and desirable economic policy goal. The same may be said for the "transition towns" arising in the U.K. and other parts of Europe. In the U.S., Community Solutions and other NGOs are assisting local communities to adapt to Peak Oil and build self-sufficient, stabilized economies. Community Solutions has also endorsed the CASSE position on economic growth.

9.6 THE BIGGEST IS YET TO COME

In ecological economics, where limits to growth are acknowledged, the measure of success is qualitative development, not quantitative growth. However, when it comes to politics, a lot of qualitative results boil down to quantities, as in quantities of voters, initiatives, candidates, parties, and policy proposals. We need big numbers for the steady state economy: big numbers of ecological economists, Dalyists, and steady staters in general, initiating big numbers of campaigns in big numbers of organizations.

Only after the numbers are sufficient will we have a legitimate chance to have an effect in venues such as national legislatures and presidential transition teams. We can go talk to the U.S. Department of Commerce, the Council of

Economic Advisors, and even the Fed, but they are unlikely to be impressed until we have tens of thousands of individuals and hundreds of organizations on record as supporting the establishment of a steady state economy. It is certainly not too early, however, to engage communities far and wide in working toward local steady state economies with stabilized populations and ecological footprints. The nascent Citizens for the Steady State Economy is an organization that could help to precipitate a widespread movement of this nature.

Perhaps in a future commemorative for Herman Daly, authors will be waxing joyously on ubiquitous political movements and mainstream parties that have adopted the steady state economy. Perhaps, some years after that, the steady state economy will be a commonly adopted public policy goal and a standard of good citizenship in international diplomacy. This is a vision of the future sufficient to proceed with. We already know plenty about what needs to be done to get there. May there be plenty of Dalyists to do it!

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15. The unfinished journey of ecological economics: toward an ethic of ecological citizenship

Peter G. Brown

'Use' as our primary relationship with the planet must be abandoned . . . Intimacy with . . . its wonder and the full depth of its meaning is what enables an integral human relationship with the planet to function. It is the only possibility for humans to attain their true flourishing while honoring the other modes of earthly being. The fulfillment of the Earth community is to be caught up in the grandeur of existence itself and in admiration of those mysterious powers whence all this has emerged.

Berry (2000, p. xi)

15.1 INTRODUCTION

The fundamental insight of ecological economics is to insist that the human economy must be seen as embedded in the Earth's biophysical systems. An essential property of those systems is that they are open to energy from the sun, but closed to matter – that for all practical purposes nothing ever leaves or arrives on the Earth. This perspective dates from the work of economists Kenneth Boulding in the 1960s and Nicholas Georgescu-Roegen in the 1970s and has been developed in the work of Herman Daly whose life and work we celebrate here. Further advances have been secured by Robert Costanza and many others educated in physics, biology and ecology.[1] This profound paradigm shift is still relatively new. It is determinedly unrecognized by mainstream economists who simply do not know what to do about a finite world. Indeed, in many contexts, mainstream economics has been able to mount a counter attack under the rubric of 'environmental economics' – a phrasing that may seem to be synonymous with ecological economics.[2] The epistemic shift propounded by ecological economics is founded in our understanding of the relationship between the human economy and its host planet. It is of fundamental importance in securing the future of life's long sojourn on Earth. To those who have pioneered this field, all Earth-bound living beings now, and in the future, owe a debt of gratitude.

Yet, the paradigm is incomplete in important ways, and thus the task of reaching a new worldview remains to be completed. There are two main limitations of the current theory that I discuss here – but the larger task ahead is to formulate the foundations of an ecological political economy. First, ecological economists insist that the economy be seen as embedded in the biosphere, but retain, for the most part, the valuing system of the economic paradigm they seek to overturn. At this time the field contains a variety of points of view about its ethical foundations. In the main these are very similar to the neoclassical point of view they seek to escape, but there are those who wish to emphasize respect for nature. This lack of consensus makes it difficult for ecological economists to escape from other assumptions of that worldview they seek to overturn. Second, this also has the effect of retarding the development of new terms of discourse – the vocabulary we have to discuss ideas like money, cost, efficiency and the like. These two factors account, in part, for the 'tar baby effect'[3] that afflicts this discipline at the stage of its maturation it remains attached to the thing it is trying to escape. It will get free and 'into the briar patch' – to continue the metaphor – only when it develops an embedded ethics, and terms of discourse derived from that ethical system. By an 'embedded ethics' I mean an ethics that is fully informed and shaped by, but not reduced to, the findings of contemporary science. Since ecological economics has insisted on seeing the economy in the context of thermodynamics it is especially germane to trace some of the implications of these laws for ethics. This, of course, only begins the vast task of constructing a scientifically informed ethics – a task well beyond the scope of this chapter, but essential for enabling a human presence on a flourishing Earth.

Accordingly, in this brief chapter my aim is four fold. First, it is to show how the journey of ecological economics remains unfinished; second, to suggest some of the characteristics of an embedded ethics; and third, to describe some of the effects of this repositioning on the ways we discuss what is at stake. Lastly, I briefly discuss the idea of an ecological political economy as an essential element in completing the journey.

15.2 THE UNFINISHED JOURNEY FROM ONE WORLDVIEW TO ANOTHER

For the last 150 years Western culture has been in the throes of a great dispute about the nature of the world and our place in it. On the one hand, there is the Thomistic-Enlightenment Synthesis (TES), which includes

Deism and Newtonian mechanics. On the other hand, there is the Scientific Evolutionary Paradigm (SEP) emphasizing thermodynamics, evolution and emergence; beginning in the early part of the nineteenth century with the fields of geology and thermodynamics. Darwin's *On the Origins of Species* published in 1859 (Darwin, 1859) is, of course, a centerpiece of this worldview.

15.2.1 A God and Human Centered Worldview

The TES synthesis was masterfully constructed in the thirteenth century of Thomas Aquinas out of the Old and New Testaments, and the works of Aristotle rediscovered in the West after being kept and studied by Muslim scholars. Essential elements of this amalgamated paradigm are at least three fold. First, there is the idea of Creator God who gives form to an initial chaos and who subsequently stands largely apart from it, but at the same time is nevertheless able to intervene in history, at least in most versions of this worldview. God is thus both immanent and transcendent. Second, another crucial element is the idea of human superiority – humanity is seen as created in the image of God and standing above and apart from nature. In the Old Testament narrative nature itself is degraded from its perfect state due to the fall of man. Third, there are thus fundamental dualisms built into this narrative from the beginning: God apart from both humanity and nature; and mankind apart from the rest of nature. These separations are less prominent in certain strands of Judeo-Christian theology than others. Aquinas also harvests a dualistic feature from Aristotle who emphasized that man was the uniquely rational animal.

The scientific revolution undertaken by Copernicus (1473–1545), Galileo (1564–1642), Kepler (1571–1630) and Newton (1642–1727) kept much of the basic underlying structures of this paradigm, but undertook to explain the world in material terms with God relegated to the role of initiator of the process. In this conception God is often referred to as a clock maker – who starts the universe on its way, but does not intervene thereafter, and could not, given the lawful nature of the universe described by scientists like Isaac Newton. In this era a major purpose of scientific discovery was understood to be the power over and control of nature; as contrasted to Aristotle's goal of understanding. And a core method of science within this understanding is analytical: the aim is to conceptually, and where possible literally, break things down into parts to better understand them. Its epistemological atomism thus precedes scientific atomism of the nineteenth century. It is within this conceptual womb that contemporary economics was nurtured and given birth in the work of Adam Smith, particularly in *The Wealth of Nations* published in 1776

(Smith, 1776). Smith took over the Deist assumptions of the paradigm and argued that economics was the study of the lawful behavior pre-ordained by the clockwork God. To attempt to interfere with the natural operations of the market was to interfere with God's plan – and hence could not avoid making things worse.

Now what is truly astonishing in the whole matter is that neoclassical economics of the twentieth and twenty-first centuries has not rejected or even examined its eighteenth-century assumptions. As Robert Nadeau has pointed out, 'the creators of neo-classical economics disguised the scientific and metaphysical foundations of Smith's natural laws of economics under a guise of mathematical formalism borrowed wholesale from the equations of a badly conceived and soon to be outmoded mid-nineteenth century physical theory' (Nadeau, 2006, p. 100). The scientific study of evolution, quantum physics, complexity theory, ecology and its relation to far from equilibrium thermodynamics were and are simply ignored, or given marginal attention at the very best. Economists have forgotten their roots and ignored or misunderstood scientific developments of the nineteenth and twentieth centuries and so have not questioned this dimension of their basic theories.

15.2.2 An Evolution Centered Worldview

While it grew out of the TES the evolutionary paradigm (SEP) takes strong exception to two of its dimensions: (1) the view that the world was created at a particular time in a final form and (2) the dualisms that sets humanity (and God) apart from nature. With regard to the first, the current consensus within this view is that the current universe began some 13.8 billion years ago in what is called the 'big bang.' (What, if anything, existed before then is unknown.) Since the beginning of the current universe there has been a long process of evolution characterized by emergent entities and processes (Chaisson, 2006). An emergent entity or system has characteristics where the whole has properties beyond those of the parts that make it up. A molecule of water has physical and chemical properties that the hydrogen or oxygen atoms that make it up do not possess, nor even suggest might occur. Living beings like butterflies have properties that neither the atoms nor the molecules that make them up have. The upshot is that the whole may be surprisingly different than its parts suggest.

Second, the idea of emergence helps to explain the phenomena that the idea of dualism tries to characterize. At the same time it helps to reframe the issue in more informative terms. Butterflies are different than the molecules that make them up – but they are not completely different. Humans have a much more complex form of consciousness than butterflies – so we are different, but not wholly different. Human consciousness is not a special creation of the universe, but rather, though emergent from it, nevertheless embedded in it. Our evolutionary heritage is inscribed in our flesh, bone, brain and mind. We are not only in the world, but of the world (Lakoff and Johnson, 1999).

In the first half of the twentieth century it was unclear how the fundamental theory of biology – evolution – was compatible with the second law of thermodynamics – a fundamental descriptor of the universe. This law holds that all things tend toward simplicity, chaos or lack of complex structure; while the theory of evolution is an account of life's growing diversification and complexity. At least two ideas from thermodynamics are essential to reconciling these two apparently diverse perspectives. The first is to distinguish between isolated, closed and open energy systems. Isolated systems exchange neither energy nor matter, closed systems receive energy but not matter, and open systems receive both. The universe is isolated, and as a whole is characterized by increases in entropy overall.

But within the universe there are systems closed to matter, but which receive energy from the outside. The Earth is one of these. Living things, like human beings and snakes, are open to both matter and energy since they, to use Schrodinger's famous phrase, 'suck orderliness' from their surroundings. People take in new energy and matter in the form of things such as sandwiches and milkshakes. They allow us to maintain our bodies in what is called 'a far from equilibrium condition' characterized by body temperatures of around 37 degrees centigrade, which is generally higher than the background temperature of the ambient environment. The idea of using external energy to create complexity explains macroscopically how far from equilibrium conditions can be maintained. But how are sandwiches and milkshakes possible? In answering this question the role of plants is crucial.

Photosynthesizing organisms, for instance, green plants, take in certain highly selected wavelengths of light. Plants use light in several ways. Some of the light is absorbed into the plant and surrounding air and degrades to heat. The heat evaporates water from the leaves and helps to draw more water up from the ground through the roots and stems of the tree to the leaves. However, certain wavelengths of light are used by the photosynthetic apparatus in the leaves of the plant, to break one oxygen atom from water so that the remainder can interact with carbon dioxide from the atmosphere. Through a process that is complex in itself, the water and carbon dioxide combine to form simple sugars retained by the plant, and oxygen is released into the atmosphere. While the energy stored in the new sugar molecule is less than the photic and heat energy that went into its making, the sugar molecule can be utilized and stored in many ways, and forms the basic energy source for much of the rest of metabolism on Earth. Some forms of the stored energy are so stable that they can become fossilized and stored below ground as coal, oil and natural gas, for millions of years. By using this transient light energy a more stable energy is created that can easily be said to retard the sometimes slow, sometimes fast, process of increasing disorder. The whole of biology depends on slowing the tumble toward disorder. The energy stored is always less than the energy input, but the transformation has permitted the abundant flourishing of life on Earth and the development of all its marvelous complexity at scales from sub-cellular organelles to the functioning of the ecosphere. The slowing of disorder through the capture of energy by the process of photosynthesis and its subsequent storage and utilization by complex life systems is one part of the very definition of life.[4]

But how are far from equilibrium conditions possible to begin with? Why isn't everything like everything else? Why do complex systems like you and me exist? The universe is characterized by profound differences in temperature – and in accordance with the second law of thermodynamics it is 'trying' to reach thermal equilibrium. It seeks ways to be as cool as it can be (Schneider and Sagan, 2005). To do this it needs mechanisms to reduce temperature gradients – to get rid of heat. Here the idea of 'dissipative structures' plays a key role, an idea coined by Prigogine (Schneider and Sagan, 2005, p. 81). When we boil water on a stove, as the water reaches the boiling point little bubbles form. As it passes the boiling point, these bubbles become larger as it reaches what we call a rolling boil. These bubbles are dissipative structures – ways to get cool. Macro equalizing processes on Earth are wind and ocean currents – attempts to cool, respectively. the air and ocean water, which are hotter at the equator than at the poles because of the angle at which the sun's rays strike the Earth. Another earthly heat dissipater is life itself. Life on Earth, including plant life, takes in high grade energy from photosynthesis and degrades it, resulting in a net cooling. Complex ecosystems are efficient heat dissipaters, which, if left unperturbed, do the 'best they can under the circumstances' to degrade the exogenous radiant energy they receive from the sun (Schneider and Kay, 1995). Both cosmic and biological evolution are macro dissipative processes. However, complex ecosystems retard the dissipation of some energy by storing it in complex carbon compounds for longer or shorter durations, though overall they accelerate energy dissipation.

As noted above, mainstream economics remains isolated not only from the implications of thermodynamics, but also from the idea of evolution, complex systems theory and the science of ecology to name just a few. It is a conceptual framework with no systematic integration of biological and physical processes that govern the planet and is thus at odds with the science of the last 200 plus years. With the vast expansion of the human population and even far vaster expansion of economic output the world's macroeconomic system endeavors to rule the world without even trying to understand it. The sciences may offer interesting analogies or metaphors for thinking about economic processes, but this is not the point I am making here. I am arguing that the economic system and finance must be understood as a fully integrated part of the Earth's biophysical systems. Until we ground macroeconomics and finance in science and an Earth-respecting ethics we can only expect increasing carnage and mayhem.

15.2.3 The Location of Our Knowledge Systems

One way to characterize what we think we know about the world is to look at how universities have organized it. This is typically done in departments and faculties – a way of dividing up our understanding of the world that will likely prove to be a major factor in our undoing. Imagine that we took a pair of scissors and cut out the names of these units, magnetized them and put them in a jar. Then we placed two relatively powerful magnets on a table – one standing for the TES paradigm, the other for SEP. If we then shake all the magnetized slips of paper out of the jar many of the bits will be drawn to the SEP – generally the sciences with other fields such as psychology falling – at least provisionally – somewhere in the middle, though edging toward SEP as it becomes more and more informed and shaped by neuroscience. But some of the slips will head straight for, and be stuck hard to, or remain in the field of, the TES magnet. These are the bits with the names neoclassical economics, finance, ethics, much of philosophy and theology, law and politics on them to name just a few.

Looked at in this way, ecological economics is an attempt to get from one paradigm to the other – to escape from the magnetic field of TES and fall into the field of the SEP. This is the main feature of the paradigm shift from a vision of the economy in standard economics textbooks as a closed, circular flow to one that is embedded in the Earth's biophysical systems, and accordingly subject to the laws of and the limitations imposed by thermodynamics and other laws as played out on this lively planet. This is a beginning of the crucial journey, but it is not its end. Ecological economics is suspended in between – pulled toward SEP by its embrace of thermodynamics and the idea of an economics embedded in the Earth, and pulled toward TES by an ethics (and theology, politics and often philosophy) that belongs to the TES.

15.3 THE ETHICS OF ECOLOGICAL ECONOMICS

In this section I will (1) show that the current ethics used by most ecological economists is firmly rooted in the TES paradigm that they seek to escape; (2) discuss a different point of departure found in the work of Aldo Leopold; and (3) illustrate some of the implications of an embedded ethics for how we think about the human place in Earth's systems and in the universe.

15.3.1 The Tar Baby Problem

Ecological economics is bonded to what it is trying to escape from. In *Ecological Economics: Principles and Applications* Herman Daly and Josh Farley state: 'Although we shrink from trying to define the ultimate end, . . . we suggest a working definition of the penultimate end for the ecological economy: the maintenance of ecological life support systems far from the edge of collapse . . . and healthy, satisfied human populations free to work together in the pursuit and clarification of a still vague ultimate end – for a long, long time' (Daly and Farley, 2003, p. 57). The principle of penultimate value continues to be use of the world in support of (sustainable) consumption, and key terms like 'natural capital' and 'ecosystem services' reveal that many of its premises are still derived from the TES framework. This language signals that ecological economics remains committed to dualism, anthropocentrism and a kind of materialism that views the world as a collection of objects to be used for human satisfaction.

Yet, the dualism is eroding. Josh Farley points out that 'one could hold that humans are one of many species, with no special rights to the low entropy generated by ecosystems. This view explicitly recognizes that humans are a part of nature, and as natural systems unravel, human survival is compromised. It can easily acknowledge that we do not understand ecosystems adequately to state authoritatively that any individual element is expendable, and therefore even for anthropocentric reasons must act as if life were sacred.'[5] From this point of view, 'ecosystem services' is simply a name we use to point out our interdependence; but it still hovers close to the idea that the world is property. To Farley, the phrase 'ecosystem services' refers to specific physical characteristics rather than values. Ecosystem services are fund-fluxes in nature. On this view the ecosystem fund is not transformed into what it produces, services are produced at a fixed rate over time, cannot be stockpiled and so on. Some fund services can be non-rival, in which case their value in terms of human use is maximized at a price of zero. They fall completely outside the transaction dimension of the market model, though it is still important to allocate resources toward their conservation and restoration. This is in distinct contrast to ecosystem goods, which are stock-flow (funds) in nature and always rival. The idea of ecosystem services is discussed in Daly and Farley (2003, pp. 103–10). But fortunately they do not take the next step of trying to assign prices to these 'services.' Nevertheless, their vocabulary on this topic is largely within the neoclassical framework.

In terms of completing its journey from one worldview to another a highly regrettable development has been the current frenzy to assign dollar values to these 'ecosystem services,' a term and way of thinking made popular and legitimated by Costanza et al. (1997).[6] The point of view enshrined in this article still lives in the disenchanted world of the Enlightenment that sees humans as distanced from the world, or better within a fantastical enchantment with the alleged vast power of humans to subordinate the world for our benefit. This is a step back toward environmental economics – a branch of neoclassical economics that tries to analyse the economy-nature relationship primarily through the ideas of 'externalities' and 'public goods.' Tragically, this framework also underpinned much of the work of the Millennium Ecosystem Assessment – an empirical tour de force in terms of understanding the current and evolving, and deteriorating, state of the Earth's life support systems. But it is also a metaphysical and theological disaster in terms of relying, without apparent recognition, on the premises of the TES worldview. (And these questionable but unstated assumptions are independent of the methodological conundrums that often plague these estimates such as 'willingness to pay,' 'existence value,' or to the fact that market valuation's 'one dollar, one vote' assigns much more weight to the values of the rich than to anyone else.) Ironically, some of the world's best ecologists embraced a way of thinking that imperils the very thing to which they have devoted their life studies, and about which many, if not most of them, care about deeply. By embracing 'ecosystem services' many ecological economists cannot get free of the tar baby of concepts from mainstream.

There are six reasons why this way of practicing ecological economics puts the world ecological systems at grave and irreversible risk. For this reason they could undercut Daly and Farley's goal of maintaining ecological life support systems. The root problem is that as in a French restaurant, we may want nature services à la carte – perhaps we don't want the whole meal. Rather than order the whole menu – table d'hôte – let's just have the soup and desert. Here are four ways our 'ordering' could help dismember natural structures. First, the value of services will depend in large part on the price assigned to it by the market. So we value bees for their pollination services of a coffee plantation and we value the copse where the bees have their hives for giving the bees a place to live. But when world coffee prices plummet and the coffee trees are cut down, then the 'services' of the copses lose their value.

Second, technical innovation may render nature's services less valuable or even irrelevant. It may be 'cheaper' in dollar terms to build a water filtration plant, thus replacing the 'services' of a forest that is protecting a reservoir than to forego the profits from clearing the forest for timber and replacing it with houses and shopping malls. Third, we can improve on what nature has to offer. For example, in the rush for bio-fuels we plant fast growth eucalyptus trees by cutting down the 'inefficient' old growth forest that is in the way. Or, as done in Lake Victoria, we improve nature by introducing the commercially more attractive Nile perch that extirpated a vast number of smaller native fish species. Fourth, nature not only offers gifts, she is also full of menaces – poisonous snakes, deadly viruses like AIDS, trees with rotten tops that kill us when we try to cut them – what foresters call 'widow makers.' The ecosystem services approach suggests that in adding up nature's services we should subtract all the bad things and see where the net value is. And once we have determined what and where bad things are, we get rid of them – if there is a net benefit to some humans, to do so (McCauley, 2006). We may value what a forest does in terms of water filtration and erosion control, but feel menaced by the fact that the woods are also homes to coyotes who control the deer population but also feed on small household pets. And it is this control that keeps the woods diverse and adaptive to begin with since too many deer often retard regrowth and diversity.

Sixth, and in summary, the idea of 'ecosystem services' flies in the face of what is perhaps the core insight of ecology – that everything is connected. The world is not severable into parts in the way this idea suggests. Put another way, ecosystem services in the neoclassical framework are not valued for the myriad, interconnected interactions that the ecosystem provides for itself so it remains in – or striving toward – a stable state far away from equilibrium. Nature – left to her own devices – is already thermodynamically efficient. Yet, in the name of economic efficiency we dismember nature's older and wiser efficiency without having any agreed on standard to judge what we should and should not do. The reason that ecological economics will fail if it does not complete its journey is that it is an economics of humans and not of the human-planet interdependent interface. The best thing that can be said about the idea of ecosystem services is that it is an interim step on the journey toward recognizing the depth of human/nature interdependence. But it is a very dangerous move for it extends the reach of what it is trying to escape.

15.3.2 Finding a Footing

Why has ecological economics failed to develop an ethics consistent with its own best intentions? Part of the answer is to be found in the disciplinary background of the people who have been its pioneers. They come from the biological and physical sciences or from economics itself. In addition, there have not been many attempts to build a bridge between the relatively new field of environmental ethics and ecological economics.

But there is also great public and professional resistance to the necessary rethinking. A fundamental issue of our era is the relationship between ethics and evolution. Yet, it is one that is seldom addressed head on[7] and is often thought to be too incendiary to tackle. It is hard to know where we should be going without recognizing where we have come from. Along with Albert Schweitzer, who wrote on ethics in the second, third and fourth decades of the twentieth century, Aldo Leopold was one of the leading figures in the first half of the twentieth century to try to systematically address this question (Leopold, 1949).[8] Both rejected the mainstream utilitarian and Kantian traditions of their upbringing; Leopold setting aside Gifford Pinchot's human centered utilitarianism; and Schweitzer the German traditions that tried to rest ethics on the idea of the rational person (Schweitzer, 1949). Since they wrote, much happened, particularly regarding Leopold's beliefs, to ratify and extend his thinking.

I propose using Leopold as the principal reference point for an adequate environmental ethic. For many years he was an employee of the US Forest Service, and was the founder of the field of wildlife management – a way of managing 'wild' populations principally for human benefit, such as hunting. Toward the end of his career he was a professor at the University of Wisconsin. While there he bought and began the restoration of a run-down farm. It was that farm that inspired what is most likely the most influential work in the English language concerning the human relationship to the rest of nature in the twentieth century: *A Sand County Almanac*, published shortly after Leopold's death in 1948 (Leopold, 1949). In that work he wrote:

> Conservation is getting nowhere because it is incompatible with our Abrahamic concept of the land. We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect. There is no other way for land to survive the impact of mechanized man, nor for us to reap from it the esthetic harvest it is capable, under science, of contributing to culture . . . That land is a community is the basic concept of ecology, but that land is to be loved and respected is an extension of ethics. That land yields a cultural harvest is a fact long known, but latterly often forgotten. These essays attempt to weld these three concepts. (Leopold, 1949, pp. viii–ix)

For Leopold the fundamental principle of ethics is summarized as follows: 'A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise'

(Leopold, 1949, p. 224). In reading the often lyrical account of Leopold's time on his farm one senses his deep respect for 'the land,' and that he laments in a most profound sense that he lives in a society that has lost touch with the fundamental reciprocity that must govern the human-Earth relationship.

Leopold's work helps illuminate an age old question: how do we go about justifying one ethic while rejecting another? What processes of reflection will allow us to assent to one view, and will fail to affirm another? A way to begin answering this question is: we should accept those ethical views that most accord with our other considered and well-grounded beliefs. This can be broken down into four parts following Daniels (1979): (1) what is the ethical principle or disposition in question? (2) how does it accord with other concepts such as our theoretical views about the nature of the universe, persons, society, evolution, God, the state, the family and the like? (3) how does it accord with our moral intuitions about fairness, duty, liberty and so on? and (4) are all these ideas taken together feasible? Can we do what they suggest? Taken together these four steps should be used reflexively – so that our beliefs reach an equilibrium where all elements are in accord. In this way it incorporates and adjusts our intuitions, but does not assign them more weight than the other elements. This is how it escapes the trap of intuitionism where each person simply insists that his or hers are authoritative.

In a mature, or rather maturing person, this is not a one-time event, but rather an open-ended process of adjustment, insight and self-expansion. The connection between ethics and science is both integral and extensive, particularly in reference to numbers 2 and 4. In a healthy, adaptive society this discourse is also a public process by which society reflects on its own values. In this process science can and should play a key role for it influences our views about matters such as the nature of the universe, the divine, the characteristics of the person, the earth. It also helps us understand what can and cannot be done; what resources there are and how long they are likely to last, what medical interventions are likely to work, how to design an airplane and ways to run our farms and economies.

Understanding how our beliefs can be justified also helps us understand how they are undermined and sometimes collapse. The unraveling of the TES narrative has been a lengthy process stretching over centuries. In the nineteenth and twentieth centuries we have seen the reconstruction of another, especially since the 1940s. It is changing the story from created to creative – the thermodynamic account of how creation happens. It undermines the idea of human dominion, and the two dualisms that separate the self from 'the environment' and the sacred from nature. For ecological economics to be part of the worldview toward which it wishes to travel a standard of respect for nature must inform both its theories and practices.

Since Leopold wrote, many scientific developments have helped put his scientific and ethical insights into larger contexts by connecting them to chemistry and physics; thus providing them with important, but not conclusive, support. Of course, Science is not the sole determinant of our ethical beliefs, but it is not irrelevant either. The significance of the developments in physics, chemistry, and molecular and evolutionary biology since the 1940s, when Leopold wrote, is that they 'fill in' much of the background needed to support, understand and operationalize Leopold's 'land ethic.' A wonderful, and to me beautiful, coherence appears on the horizon, in which our moral, scientific, political and theological views, like a geodesic (Buckminster) Fuller dome, support and strengthen each other. The ethical and policy implications of these discoveries are fundamental but nearly wholly unexplored. Therefore, we must begin afresh. A few ideas follow.

15.3.3 Toward a Value System for Ecological Economics

A new beginning will be based on understanding what we can about the origins and evolution of the cosmos, the place of the Earth in this epic, life's emergence on Earth, the biophysical functioning of the planet, and human origins, capacities and institutions. Any contemporary ethic would be incomplete without including an ethic of atonement and reconciliation for the enthusiastic carnage our 'civilization' has wrought on the natural world. Ideas of penance and the like, of course, have deep roots in the Judeo-Christian and many other religious traditions and fit well into a Leopoldian framework.

Ironically, ecological economics itself calls attention to a place to begin reconstructing our understanding of ourselves and our place in the world, though for reasons we have discussed it makes little or no use of this perspective in rethinking its value premises or many of its key ideas. The basic insight that for all practical purposes Earth is a system of systems closed to matter and open to energy has profound implications for ethics (Daly, 1996, pp. 27–30). As a way to begin, let's look at the implications of these two points – closed to matter and open to energy – in turn from the perspective of Leopold's ethic.

15.3.4 What Goes Around Stays Around

15.3.4.1 Closed to matter

Judged by mass and frequency hardly anything arrives here – small amounts of cosmic dust and an occasional meteor, and very little ever leaves – a rocket now and again. According to the first law of thermodynamics – the conservation of energy and matter – this means that whatever is done here stays here in one form or another. There is no such thing as production as orthodox economics would have us understand this idea, only transformation (Faber et al., 1996, p. 218). If we had an economics connected to the idea of the planet closed to matter, climate change would not be seen as an inconvenient truth (Gore, 2006), but as a necessary and fully foreseeable consequence of a carbon based economy. Destabilized climate is just one example of our failure to integrate economics with how the Earth works. The vast dead zones in coastal waters, fish loaded with mercury, flame retardants in the flesh of living beings, PCBs (polychlorinated biphenyls) in the breast milk of women living in the Arctic are the predictable consequences of the systems *we* have designed and promulgated globally as the 'best' way to live.

We must recognize at least three sources of these dangers to understand what we are doing. One is the societal concentration in the ecosphere of elements found in the lithosphere typically in very dilute concentrations – such as lead we use in our batteries. Another is the dispersion of such heavy metals and other toxic natural elements that persist in the ecosphere even after their primary use is terminated – such as lead in batteries; or from the release of elements as a side-effect – such as in the burning of coal containing mercury. Third, the processes of chemical engineering that lie at the foundations of industrial society also often constitute assaults on the Earth's living systems and the plants, and human and other animals that make them up. This results from introducing compounds to which life has little or no opportunity to adapt. These same three phenomena threaten human rights around the globe due to the toxic effects of these elements and compounds on human health (Pimentel et al., 2000).

From both a Leopoldian and human rights point of view we should favor those chemical and physical transformations that are respectful of ecosystems, and avoid those that impede their functioning and resilience. Building society around ideas like 'green chemistry' and certain understandings of industrial ecology are mandatory from the point of ethics of respect and reciprocity. These ideas have to include, at a minimum, careful imagination of potential side-effects, exhaustive testing and observation over appropriately long terms, continued alertness to unexpected side-effects and a willingness to say 'No' to proposed chemicals. All approvals should be tentative, preserving the option to stop production, distribution and use should this be required. An adequate value system for ecological economics has to build in from respect for Earth's life support systems, not out from human desires and satisfactions. Ecological economics must seek to be embedded in a conceptual revolution that constructs an ecological political economy.

It is essential to distinguish between the 'operating ethics' of an economy – what actually motivates peoples' behavior – and the overall goals toward which the economy strives. For example, Keynesian economics is an attempt to design an economy that achieves social stability by dampening the business cycle, but relies on stimulating people's propensity to consume to reach this goal during economic downturns. Tragically, contemporary macroeconomics has partially lost sight of Keynes's counter cyclical goals and now seeks growth in consumption all the time. An adequate ethic for ecological economics would build on Keynes's ideas by taking social and ecological stability, or better a resilience respectful of a flourishing Earth, as its goal and design its institutions accordingly.

Keynesian economics could not be thought through without ideas like the 'liquidity trap' and 'aggregate demand.' Similarly, ecological economics needs to build a vocabulary that begins where it does – with the fundamental processes that govern Earth's life support systems. Ideas like 'public goods' and 'externalities' will likely be retained in such a system but they will not be the key conceptual points of intersection between the economy and Earth's systems. Rather, like a smaller 'Russian doll' in a set, they will be part of a nested system that begins with the characteristics of the Earth's ecosystems. A step toward designing such a system will require a rethinking of our vocabulary – a preliminary step in this direction is taken in Section 15.4 below. Once we have a new and more functional vocabulary we will need to design new institutions and policies, as Keynes did in the development of macroeconomics.

15.3.4.2 Open to energy

Open to energy is also critical in understanding and enhancing life's prospects. On Earth there is substantial negative entropy – the capacity to enhance complexity due to free energy from the sun. The sun also powers Earth's ability to process the waste generated by human activity and all other life forms. Put in its simplest form, almost all of Earth's complex life is made possible by photosynthesis' success in temporarily slowing the conversion of light energy to heat. The current levels of the human population and consumption are simply taking the natural world apart faster, and increasingly far faster, than sunlight and photosynthesis can put it back together again. Humans now appropriate a substantial percentage of the Earth's terrestrial life support budget (Haberl et al., 2008; Vitousek et al., 1986). From a Leopoldian perspective this trend is a, likely *the*, paramount injustice – the confiscation of more and more of the Earth's life support budget. This is why we must reconceptualize what it means to budget, and bring the whole ecosphere and its flourishing into consideration.

Understanding, metering and carefully regulating (by reference to physical quantities, not prices alone – which are means to alter behavior) the Earth's 'complexity-support-budget' (that is, photosynthesis and all that it supports) is more fundamental and vastly more intricate and meaningful than doing the same things for the money supply. The ecosphere budget is the fount of wealth on which all other wealth depends. An ethic that sees humans as members of the natural community rather than its masters is led in the direction of compassionate retreat from the global project of human domination of Earth (Brown and Schmidt, 2010, p. 278). As Thomas Berry has stated, 'our own special role, which we will hand on to our children, is that of managing the arduous transition from the terminal Cenozoic to the emerging Ecozoic, the period when humans will be present to the planet as participating members of the comprehensive Earth community' (Berry, 2000, pp. 7–8).

Any satisfactory value system for ecological economics will have to come to terms with issues of fairness in the use of Earth's life support budget, and the fact that by any account the human population is already much too large. These equity issues pertain to shares among living persons, between generations of people and between people of all generations and other species. In the Western tradition issues of fairness are thought of primarily, even exclusively, as matters between persons. Here again a reinvention of our vocabulary is essential to think through these issues. Current macroeconomics has a vocabulary for thinking about the money supply in support of growth, such as M1 and M2. Ecological economics urgently needs to develop a vocabulary that systematically connects economic management to a fair and flourishing Earth.

But we can go beyond these initial insights stimulated by understanding the Earth as both a closed and open system. Overall, there should be an isomorphism between ethics and a holistic science of nature. This is only the very simple point that responsible community membership requires knowing the characteristics of the community in which you are a member; for instance, being Amish requires knowing the rules and expectations of their community. We need an ethics that reflects the evolutionary paradigm with regard to the characteristics of the complex system in which we live. As Robert Costanza has noted, some of these characteristics include at a minimum: (a) path dependence; (b) recognition of multiple equilibria – there is no one best way; (c) optima are seldom achieved and are always unstable; and (d) lock-in – which Costanza characterizes as 'path dependence, multiple equilibria and sub-optimal efficiency [must] be the rule rather than the exception in economic and ecological systems' (Costanza et al., 1993, p. 550).

Here are some of the ways ethics and complex systems theory relate to each other. Path dependence suggests that any ethical framework will have to take into account how the present situation came to be; for example, history matters. What makes sense for the forest of the future is heavily influenced by the soil conditions laid down by the forest of the past. What we can and should do will be substantially influenced by antecedent conditions. Historical trajectories produce complex interdependent systems at scales from the sub-cellular to the ecosphere. The capitalist system that dominates in the Anglophile countries has rewarded and hence reinforced behaviors that have contributed to the rapid decline in life's prospects. Yet, this is a fact with which we must work at this point as we try to set a new, more responsible course. The idea of multiple equilibria suggests that there is no one best state of affairs toward which to aspire; but multiple ways of flourishing that are themselves path dependent. It is akin to the idea of tolerance in political liberalism, which suggests that there are multiple ways of understanding and living 'the good life.' But, also akin to political liberalism, there are boundary conditions such as an 'equal liberty for all' – as John Rawls put it (Rawls, 1999). We should seek individual and ecosystem flourishing that supports and enhances the flourishing of others. The erosion from a clear cut on my property can impede the flourishing of my neighbor's woodlot. But this is an inter-human example; we must now purposefully extend the principle of care for the flourishing of others to all of nature with all its interdependent participants, including humans. The concept of rare and fragile optima should help us understand that any optimization project, such as gross national product (GNP) maximization, will bring ruin in a world of complex interdependent systems. Lastly, lock-in should help us recognize that the road not taken is often the road that cannot be retaken. If we take a wrong turn in traffic we can usually retrace our steps and come out where we intended. But this is typically not the case in complex biophysical systems. Once the top predator from an ecosystem is eliminated, the system will head off in a new direction even if that predator is restored. The massive soil erosion following tropical storms in the Philippines strips the land of its fertility, and the resulting silt destroys the inshore fishery in ways that are not restorable in historic time.

15.4 RETHINKING HOW WE THINK

If ecological economics is to complete or at least approach the shore toward which it so boldly set sail in the second half of the twentieth century it will require new terms of discourse that reconsider and reposition ideas like 'ecosystem services' and 'natural capital.' In an embedded ethic some common economic terms take on new meaning that reflects how the economy relates to the biosphere. This is what I call a ‘whole earth economy’ (Brown and Garver, 2009). Here are some of the core ideas.

15.4.1 Wealth

Wealth, which we now tend to think of in terms of money and what it can buy, takes on a fundamental new sense. Wealth in a whole earth economy is not monetary wealth. Low entropy stocks are wealth; and flows are income. Photosynthesis is a flow while biomass and stored carbon are stocks created from that flow. Fundamentally, fairness is the share of photosynthesis rightly available to each species (or individual), a share of the Earth’s life and what supports it and keeps it going. Thus, for humans as community members in Leopold’s sense, wealth can only be conceived and held as a trust.

15.4.2 Budgets

Normally, a budget refers to a flow of money – it is a record and often a projection of income and expenses. In a whole earth economy, the primary income is sunlight. Spending is a matter of using up life and other matter and energy. It’s important to remember that the Earth’s capacity to support life, in part made possible by life itself, is limited but not fixed. We need to develop indicators for measuring the health of the Earth and its living systems. Photosynthesis is the primary agent of transformation in support of life, and the primary limiting factors on it are: (1) the ability to capture sunlight that is used to create the food that plants and animals (for example, humans) consume, and to absorb or process the wastes we throw back into the environment and (2) toxins, which, if allowed to build up in the ecosystem, will affect the ability of plants to survive and perform photosynthesis; and/or the destruction of the land that allows plants and animals to live. Over the course of life’s earthly evolution, some 3.8 billion years, the budget of complexity-creating capacity has, for the most part, been in surplus. That means that life has been able to create more apples, more wildebeests or more sardines than are needed for a species to survive; the surplus is available for feeding other life forms and for evolutionary change. There are substantial deficits from time to time, however, such as the mass extinctions we humans are now causing.

15.4.3 Absolute Advantage

Absolute advantage in a whole earth economy is a country’s or region’s ability to transform and consume material and energy with the lowest draw on the Earth's capacity to create and maintain complexity (the complexity budget). That would mean that a country that produces goods to sell on the global market at the lowest cost to life's budgets, not the lowest cost in terms of money, would become the one with lowest absolute cost. Countries could pursue comparative advantage, producing for trade the goods with the lowest draw relative to other goods they produce. For example, Brazil might be able to produce both aluminum and timber with a lower draw on Earth's reproductive capacity than Canada, but if it can produce timber with a much lower draw and aluminum with only a slightly lower draw, then by trading timber for aluminum, the total draw could be reduced.

15.4.4 Cost

In a whole earth economy, the cost of something is how much of the integrity, resilience and beauty of Earth's life support systems must be exchanged to get it. The idea of costs and prices reflects the full cost to life, as grossly measured by the use of Net Photosynthetic Productivity (NPP), or other such measures of Earth's life support capacities. The gross measure must be further refined to reflect enormous geographic variation in NPP and the robustness or fragility of ecosystems in specific places.

15.4.5 The Relativity of 'Opportunity Cost'

From the neoclassical point of view if we do not cut a forest that we own there are opportunity costs in foregone income and consumption. But from the point of view of ecological citizenship this can be a benefit because the citizen looks at the effect on life's abundance. In complete contrast to the neoclassical viewpoint, to cut the forest is to forego something, not to gain it. The meaning of opportunity cost is relative to the conception of the self who is making the choice. The self can be understood narrowly in terms of interests, or broadly in terms of identification with the widening community or ecosystem, up to and including the commonwealth of all life. And the universe itself.

15.4.6 (Re)Distribution

Claims on shares of Earth's budget(s) in a whole earth economy are not limited to persons, but can be made by and on behalf of life generally. Distributive justice in terms of distributing stocks and flows (wealth and income) concerns shares of the capacity to build, sustain and enhance the entire commonwealth of life. Fair distribution in our time is often a question of limiting people's or species' ability to take for themselves more of Earth's complexity and assimilation capacity than they deserve.

15.4.7 Money

In a whole earth economy, money, and its many surrogates like credit, is a socially sanctioned right to intervene, now or in the future, in the Earth's life support complexity budget – in essence, a license to exert an influence on the local or global ecology. It may count as a cost because it uses up complexity or produces wastes and toxins. It may count as investment by acting to maintain or build up the complexity producing capacity of the ecosystem. Inequalities in income and wealth give people different power over the Earth's complexity.

15.4.8 Production/Transformation

Production and transformation normally describe processes of manufacturing or growing something that is useful. In a whole earth economy, there is no actual production of matter, only transformation. All transformations are net entropic – which means that they convert useful energy to dissipated heat and increase the disorder, or loss of complexity. The concept of 'goods' is a partial illusion. All consumption causes a net increase in entropy and decrease in usefulness to humans, though some high entropy wastes may still be rich resources for other parts of the ecosystem.

15.4.9 Resources

What we know as natural resources all have a role in natural systems that human use alters. For example, logging a tree removes habitat and changes ecosystem function; mining metals or tar sands uses up energy and contaminates the environment with substances previously held safely at some depth beneath the Earth's surface. Humanity is a product of evolution and cosmological processes but not their goal, and hence does not have any special privilege with respect to any aspect of the natural system, living or non-living. The Earth and all life on it should be looked at as the commonwealth of life – as the result of biological and cosmic evolution.

15.4.10 Waste

From the point of view of a whole earth economy, industrial processes have to be analysed with a view to their effects on the whole commonwealth of life. Every time something is made there is a waste stream, and the energy used in the process always declines in its ability to do work. Thus, industrial processes and waste must be reconceptualized because there is no production as normally understood; only transformation. The key to applying this principle is to think of costs in terms of elimination of self-organizational capacity or the interference with recovery – as with toxins that impede life's resilience. The final waste is heat at too low an energy level to do any more work, to maintain self-organizational capacity.

15.5 SOME STEPS TOWARD AN ECOLOGICAL POLITICAL ECONOMY

To bring these ideas of an ethic for ecological economics and its terms of discourse into a broader context we must begin the construction of an ecological political economy. In my view there are six questions that are essential to answer in furthering the journey begun by Herman Daly and the other pioneers of the twentieth century. Beginning with a scientific understanding of the world we need to rethink:

1. Who we are.
2. What we know about what we know, and what we do not know.
3. What we should do.
4. What we should measure.
5. An economics for the anthropocene; and a politics informed by an Earth systems point of view.
6. The place of religion and spirituality in light of our answers to these questions.

Though many will fear that the SEP is a threat to religion this need not be so. What this perspective tells us is that we are in the presence of, and also are a part of, a vast evolving, learning system (of which consciousness is one manifestation) that is far older and more powerful than we are. It has a scale, a beauty and a glory that cannot be fully grasped. Wisdom is to be found in respect and reverence for all that is. And achieving a state of self-transcendence, however temporary, allows us to return to a question nearly forgotten in our frantic and tragic age: what is civilization for? Here is my tentative answer: civilization is for the cultivation and elevation of the mind and spirit of the human animal who lives respectfully on the Earth with reverence for life and the sources of its being. 'Citizenship' should be understood as the dimension of human self-conception that takes the long view. Ecological citizenship is to recognize our role as co-celebrants in the evolution of life and the world in an entropic universe.

To me, this is the challenge and gift that my dear friend Herman has set before me and us.

NOTES

1. I have worked on the ethical dimension of such a shift in some of my earlier works (Brown, 2007; Brown and Garver, 2009), and I am indebted to my colleagues and co-authors for many of the ideas herein.
2. I am indebted to Brendan Mackey for reminding me of this point.
3. The *Brer Rabbit Story* is a tale of a rabbit who gets stuck to a scarecrow made of tar and covered with straw. When Brer Fox captures the trapped rabbit, the rabbit begs the fox not to throw him into the 'briar patch' where he would be safe. Finally, not understanding the ruse, the fox frees the rabbit by throwing him into the briars.
4. I am indebted to Paul Heltne for assistance in drafting this paragraph.
5. Personal correspondence.
6. A thorough discussion of the case for 'ecosystem services' is contained in Ruhl et al. (2007). It documents how, in the United States, law, policy and social norms all fail to protect natural systems. Regrettably, the overall framework of this book remains neoclassical.
7. Wilson (1975) is an exception to this, though it is unfortunately very reductionist.
8. Parts of my discussion of Leopold draw on Brown (2009).

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