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Designing for nature and sustainability

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SUMMARY

Humankind is now using natural resources more rapidly than natural systems can replace them and has been doing so for approximately two and one half decades. Moreover, both natural capital and the ecosystem services it provides are being diminished at an unprecedented rate. Finally, the human population is expected to increase by 3 billion by 2050. This situation is clearly unsustainable, but it can be made less so by redesigning societal wastes so that they benefit the biospheric life-support system. Nature initiates and maintains a system of energy and nutrient cycling and, if the system integrity is maintained, provides alternative and redundant means that help stabilize functional capacity. The system is composed of opportunistic individuals that compete with other individuals to acquire the resources essential to their survival. The interrelationships within this aggregation of individuals (i.e., system components) are based on energy flow. This self-organizing and self-maintaining system is increasingly stressed by human activities. Humans are a part of, not apart from, this system and are governed by the same laws of nature. In short, an ecologically based economic system is essential to sustainable use of the planet. The planet's life-support system has been a superb model of sustainability, which humans should emulate and become a part of more than they now are. When the biospheric life-support system is stressed to the point of disequilibrium, the results are disastrous for societies, individuals, and ecosystems. Evolutionary processes have produced replacement systems following the five great biological extinctions. However, the probability is high that the next replacement system will not be as suitable for humankind as the present system. Sustainable practices are intended to prevent biospheric disequilibrium and maintain the present environmental conditions so favorable to humankind, including posterity.

INTRODUCTION

The ultimate test of a moral society is the kind of world that it leaves to its children.

Dietrich Bonhoeffer

Sustainable use of the planet requires:

1. Use without abuse of natural systems.
2. Limiting humankind's demands on natural systems so that they do not exceed nature's regenerative capacity.
3. Human practices that preserve the self-organizing and self-regulating capabilities of natural systems.
4. Emulating nature's use of resources, including producing wastes that are beneficial to natural systems

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5. Optimizing humankind's use of natural resources.

6. Following the economic model of natural systems in the production, utilization, and recycling of all resources, including societal wastes. This model includes use of resources in such a way that the use and resulting wastes benefit natural systems.

Non-human societies have economic systems quite different from those developed by humans (e.g. Tullock 1994). Tullock notes that human society does not act, at times, in a completely cooperative manner because individual entities decide matters on their own. Further, although humans have hierarchies in some societies, individuals may leave or join hierarchies voluntarily, which leads to a different pattern than that of nature. Economist Tullock assumes that organisms have something that is functionally equivalent to the preference function (found in humans), which may result in a mutualistic behavior (he uses the word *cooperation*). A key point in Tullock's analysis is what he calls *environmental coordination* — each entity displays its unique pattern of behavior that alters the environment for other entities, which then respond to the new environment. These factors must be considered by humankind when developing a mutualistic relationship with its biospheric life-support system.

TIME REMAINING FOR VOLUNTARY CHANGE

Earth is approaching a number of tipping points (e.g. Cairns 2004a) that could cause major ecological and societal disequilibrium. A special issue of *Scientific American* (September 2005) selected 2050 as The Crossroads for the Planet Earth (see also Friedman 2005). Musser (2005) states that how humankind manages the next few decades could usher in either environmental sustainability or collapse. Making adjustments to protect such things as Earth's climate will make both consumers and businesses richer (Lovins 2005). As economist Daly (2005) remarks, the economy is a subsystem of the finite biosphere that supports it, and humankind may have already entered an uneconomic growth phase.

Major ecological damage is increasing, indicating that an immediate shift to a mutualistic relationship between humankind and natural systems is long overdue. For example, Revkin (2005) reports that Kenneth Caldeira, a climate expert to the Department of Global Ecology of the Carnegie Institution based at Stanford University, stated that the question is no longer whether society will need to address the climate problem but when humans will need to address it (Revkin 2005). The process of switching to alternative energy sources (e.g. solar, wind) is long overdue since the long-range forecast for oil is grim (Williams and Bahree 2005).

CLASSICAL ECOLOGISTS VS EXPONENTIAL GROWTH ECONOMISTS

Both economics and ecology are derived from the Greek word *oikos*. Examination of journals produced by these two groups today would not indicate this close relationship. Notable exceptions to this current dichotomy are economists Herman E. Daly and Kenneth Boulding and ecologists Edward O. Wilson and Paul R. Ehrlich, as well as transdisciplinary journals such as *Ecological Economics*. Neither the status quo for economics or ecology can be maintained unless substantive changes occur in human behavior and societal goals. A casual examination suggests that economics is homocentric and ecology is ecocentric. However, it is in humankind's enlightened self-interest to maintain the health of the biospheric life-support system, which has made the planet livable for *Homo sapiens* for the 160,000 years the species is estimated to have been on the planet. Since humankind is now dependent upon both technological and ecological life-support systems, economics, which is essential to the technological life-support system, must be maintained without endangering the biospheric life-support system. Sustainability ethics (Cairns 2003, 2004b) is both ecocentric and homocentric, so, if these two views can be integrated into a harmonious relationship, both humankind and natural systems will benefit. The obstacles to a harmonious relationship are formidable, but the penalties of failure are appalling. Focusing the two disciplines on the two life-support systems requires only two assumptions: (1) with present densities and demographic distributions, humankind is dependent upon both an ecological and a technological life-support system (the latter only became a major factor in the last 10,000 years) and (2) a cost-effective technological substitute for the biospheric life-support system will unlikely be developed.

Daly (2005) notes that, in order to cope with resource scarcity, 'full world' economics is needed to replace 'empty world' economics now in vogue. Ecologists must adjust to a 'humanized' world. Both ecologists and economists must accept that the quest for sustainable use of the planet is not a fad but rather a concern for the quality of life for posterity. Daly (2005) also notes that the human economy is a subset of the biosphere that supports it. Continued exponential growth on a finite planet is simply not realistic (Cairns 2001).

SOCIETAL WASTES

In natural systems, the wastes of one species are used as a resource by other species. The wastes from human society are all too often a threat to natural species and to the society that produced them. Nuclear wastes have been one of the most intractable to reintroduce into the environment in a beneficial way. However, some promising, but yet environmentally untested, solutions have emerged to this problem. One is a high-temperature method of recycling reactor waste into fuel, coupled with advanced fast-neutron reactors capable of burning that fuel (Hamm *et al*. 2005), This method, if feasible, is still a long way from producing wastes beneficial to natural systems. It reduces risk to humankind and its life-support system but does not reduce the risk as much as eliminating profligate use of energy globally, especially in countries with a disproportionate use of energy, such as the United States. Of course, zero risk is a hopeless goal, but simple policy changes (e.g. eliminate subsidies to high risk energy companies) and changes in human behavior (e.g. increased use of public transport) would markedly reduce environmental impacts of fossil fuel energy sources, as would increased use of alternative energy sources such as wind and solar power.

During the transition to sustainable use of the planet, another promising approach is sequential use of industrial waste discharges (Hawken 1993). Some wastes of agribusiness could be substantially reduced by a reduction in world consumption of animal protein, for which world demand has increased annually for 40 consecutive years (Brown 2001: 158). Now that range and grazing land is being fully utilized and oceanic fishery stocks are declining, feed lots are used for producing beef and pork, indoor production of poultry, and field enclosures for such protein sources as salmon and shrimp. The UN Food and Agriculture Organization (FAO 2002) estimates that 840 million people are chronically hungry. Chronically hungry people are more vulnerable to disease and are unable to maintain adequate levels of physical activities and full physical and mental development. At the other end of the nutritional spectrum are the diseases of the rich, such as obesity, clogged arteries and difficulty with normal physical activity. Redirecting the human diet from an ever increasing protein intake to one lower on the food chain (e.g. the Mediterranean diet) could eliminate concentrated feed lot waste problems. In addition, some of the grains used in feedlot production of protein could be redirected to starving or inadequately fed people. As a caveat, such redirection of foodstuffs can only benefit waste disposal and sustainable use of the planet if coupled with an effective population stabilization policy.

RELOCATION AND LONGEVITY

Hazardous wastes produced by human society are dispersed over extremely large areas. Pesticides have deleterious effects far from the areas in which they were produced. For example, high concentrations of pesticides are found in polar bears and the milk of Eskimo mothers. Most of the transport occurs in natural systems (e.g. rivers and ocean currents), but increasingly by humankind's transportation system. For example, in the United States, wastes from New York State are transported to both my home state of Virginia and my state of origin Pennsylvania. Wastes are even moved from developed countries to third world countries, which usually regard waste disposal as a source of income. One promising way to address these problems is an industrial ecology that advocates hybrid industrial/ecological systems (Tibbs 1992, National Academy of Engineering 1994, Gradel and Alllenby 1995, Gradel 1996, Ehrenfeld and Gertler 1997). Daly (2003) provides an interesting analysis of the relationship of economics and the life sciences.

> The pre-analytic vision from which steady-state economics emerges is that the economy, in its physical dimensions, is an open subsystem of a finite, non-growing and materially closed total system — the earth-ecosystem or biosphere. An 'open' system is one with a 'digestive tract,' i.e. takes matter and energy from the environment in low-entropy form (raw materials), and returns it to the environment in high-entropy form (waste). A 'closed' system is one in which only energy flows through, while matter circulates within the system.

Designing for nature is based on the assumption that all, or most, anthropogenic wastes can be designed to not only not harm natural systems but actually benefit them. Surely humankind's creativity, ingenuity, and technology can rise to this challenge.

The basic assumption of sustainable use of the planet is that humans can follow the model of natural systems in which every waste produced by one component (e.g. species) of the system can be used beneficially by some other component of the system. Although humankind once fit this model well, the Agricultural and Industrial Revolutions disrupted this harmonious relationship. Humankind is now so dependent on the relatively recently (in evolutionary time) developed lifestyle that a return to the original condition is neither possible nor attractive at present human population densities and high level of affluence. Of course, a major failure of the biospheric life-support system could eliminate *Homo sapiens* or reduce it to a relic population surviving as hunter/gatherers. Humankind could achieve a more harmonious relationship with natural systems, which is essential to sustainable use of the planet. Hybrid industrial/ecological systems might not only facilitate a more harmonious relationship with natural systems but could also diminish the belief that the natural systems (the biospheric life-support system) are merely appendages to the industrial systems rather than systems entitled to comparable or greater nurture and respect.

The hybrid systems would have, if properly managed, many positive features.

1. If wastes are beneficially reincorporated into natural systems, this practice would both increase corporate responsibility (since the wastes would not be widely dispersed) and facilitate environmental monitoring of waste effects upon natural systems.

2. Toxicity effects would be directed to the local system rather than distant systems.

3. If each industry were embedded in a healthy ecosystem, it should be a more attractive work place.

4. If done properly, both natural capital and ecosystem services would be increased.

5. Clustering industries that can use each other's wastes would be cost effective.

It would also make it possible to expand the ecosystem space by pooling the space from each industry. Other important advantages are (a) larger ecosystems are more likely to be self maintaining than smaller systems, (b) ecosystem monitoring costs should be markedly reduced if the industries agree to have one group of professionals responsible for the entire system, and (c) there should be many other economies of scale, up to a certain size, at which point diseconomies are highly probable.

Inevitably, major obstacles will affect the outcome. For example, most ecotoxicologists, chemists, environmental engineers, etc. are accustomed to methods and procedures designed to prevent damage to ecosystems rather than on ways to design wastes that will improve ecosystem health. However, increasing natural capital will make achieving sustainable use of the planet more probable, which would benefit all humankind. Furthermore, most industries are accustomed to a competitive viewpoint that benefits their stockholders despite the fact that failure of the biospheric life-support system will endanger all human enterprises. Industries are embedded in a larger system and their survival and well being are closely linked to the health of that larger system. The first view of Earth from the moon should have driven this point home forcefully. Earth is a tiny blue dot in a vast space devoid of life. No other planets are near enough to replace Earth if humans destroy it.

THE TRANSITION PERIOD

In some cases, industries will be so close together that a hybrid industrial ecosystem is not feasible at that location. In such situations, a more remote, suitable ecosystem can be chosen, as long as this solution is regarded as temporary until the industry is no longer economically feasible. If a damaged ecosystem is near the industry, a created naturalistic ecosystem is well worth consideration. My own experience has been primarily in wetland creation (e.g. Atkinson and Cairns 2001, Atkinson *et al.* 2005), but literature is available on a wide range of created ecosystems. Much can be learned about created ecosystems, especially those that are not self maintaining. Despite the difficulties of population stabilization and major lifestyle changes, the consequences of continuing present unsustainable practices are almost certainly at least an order of magnitude worse.

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REFERENCES

Atkinson RB and Cairns JJr. Plant decomposition and litter accumulation in small depressions: functional performance of two wetland age classes that were created via excavation. *Wetlands* 2001;21(3):354-62

Atkinson RB, Perry JE and Cairns JJr. Vegetation communities of 20-year old created depressional wetlands. *Wetlands Ecology and Management* 2005;13(4):469-78

Brown LR. *Eco-ecology*. New York, NY: WW Norton; 2001

Cairns JJr. The age of transition to sustainability: the end of the exponential growth period. *Politics and the Life Sciences* 2001;20(2):121-8

Cairns JJr. *Eco-ethics and Sustainability Ethics, Part 1*. Ethics in Science and Environmental Politics, Eco-Ethics International Union, Oldendorf/Luhe, Germany. http://www.esep.de/journals/esep/esepbooks/EB2pt1.pdf; 2003

Cairns JJr. Ecological tipping points: a major challenge for the experimental sciences. *Asian Journal of Experimental Sciences* 2004a;18(1,2):1-16

Cairns JJr. *Eco-ethics and Sustainability Ethics, Part 2*. Ethics in Science and Environmental Politics, Eco-Ethics International Union, Oldendorf/Luhe, Germany. http://www.esep.de/journals/esep/esepbooks/EB2pt2.pdf; 2004b

Daly HE. Steady-state economics: concepts, questions, policies. *The Social Contract* 2003;XIII(3):163-70

Daly HE. Economics in a full world. *Scientific American* 2005;292(3):100-7

Ehrenfeld J and Gertler N. Industrial ecology in practice: the evolution of interdependence at

Kalundborg. *Journal of Industrial Ecology* 1997;1(1):67-9

FAO (United Nations Food and Agricultural Organization). *The State of Food Insecurity in the World*. FAO, Rome, Italy;2002

Friedman BM. *The Moral Consequences of Economic Growth*. New York, NY: Random House; 2005

Gradel TE. On the concept of industrial ecology. *Annual Review of Energy and the Environment* 1996;2:69-98

Gradel TE and Allenby BR. *Industrial Ecology*. Englewood Cliffs, NJ: Prentice Hall; 1995

Hamm WH, Marsh GE and Stanford GS. Smarter use of nuclear waste. *Scientific American* 2005;293(6):84-91

Hawken P. *The Ecology of Commerce*. New York, NY: Harper Business; 1993

Lovins AB. More profit with less carbon. *Scientific American* 2005;292(3):74-83

Musser G. The climax of humanity. *Scientific American* 2005;293(3):44-7

National Academy of Engineering. *The Greening of Industrial Ecosystems*. The National Academy Press, Washington, DC; 1994

Revkin AC. Climate study warns of warming and losses of Arctic tundra. *New York Times* 2005;2 November:late edition-final, section A, p 5, col 1

Tibbs HBC. Industrial ecology: an environmental agenda for industry. *Whole Earth Review* 1992;77:4-19

Tullock G. The Economics of Non-human Societies. , Tucson, AZ: Pallas Press; 1994

Williams S and Bahree B. Energy agency sets grim oil forecast. *Wall Street Journal* 2005;8 November http://www.online.wsj.com/article _print/SB113140619483590518.html