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Julian Simon and Albert Gore can't both be Right— Who's the Idealist?

Digby J. McLaren

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Introduction

Our species, known as Homo sapiens, (perhaps ironically?), is currently engaged, whether it knows it or not, in a mighty struggle whose outcome will determine whether we shall continue to inhabit this planet. The last 200 years or so have seen unique and astonishing developments in the speed that we have grown in numbers and in our capacity to affect and change our environment, – better known as our home or ecosphere. These are the alternatives:

- Do we consider that we have the knowledge and wisdom to ameliorate much of the damage we are doing to this system, and that there are few limits to our continuing social, economic and technological growth?
- Or, are we destroying the complex planetary life support system which we cannot control and of which we are an integral part, in our accelerating use of the natural endowment of this finite planet, and the equally accelerating production of entropic wastes?

It seems difficult to believe that such a dilemma has indeed arisen, yet these questions are real, and, although seldom voiced, lie behind the concerns, opinions, and beliefs of an increasing number of global citizens representing many political and moral points of view. I shall consider the dilemma, I hope, objectively, but will base my argument as far as possible on observable and measurable facts, and probabilities based on them. Whatever your opinions may be, I hope you will, at least, join me in agreeing that the problem is the most important ever to face humankind, and involves social, political and moral issues, as well as scientific and technological.

Economic models, based on the idea of dollars as the common denominator used to measure all quantities, are at variance with natural science models, with their variety of units, and with the complexity of nature itself (Killam, 1993). The two points of view may be typified by brief quotes. The first, from Julian Simon back in 1983, is cited by Constance Holdren in an article in Science:

"If present trends continue, the world in 2000 will be less crowded, less polluted, more stable ecologically, and less vulnerable to resource

supply disruption than the world we live in now", and, referring to developing countries, *"as people get richer they will have more floor space in their homes"*.

As this was said 10 years ago, it is also a commentary on his powers of prediction. His views are unchanged today, although the time-scale is adjusted to delay Utopia a little longer (Simon, 1992).

The second quote is from Albert Gore (1992), in his book on "Earth in the Balance". He believes that our economic system is partially blind, in that it measures such things as food, clothing, manufactured goods and money:

"But its intricate calculations often completely ignore the value of other things that are harder to buy and sell; fresh water, clean air, the beauty of the mountains, the rich diversity of life in the forest, just to name a few. In fact, the partial blindness of our current economic system is the single most powerful force behind what seem to be irrational decisions about the global environment."

There is a wide range of opinion on what is happening to our planet and this may be illustrated by three discernible points of view on whether or not we are damaging our ecosystem and therefore threatening our future. The first is held by the technologic optimists, who consider that people are our greatest asset and that technology is capable of sustaining and improving the lot of humankind as well as "managing" the ecosystem, until some unspecified equilibrium is reached in the future. The second holds that humankind must question the accelerating use of resources, and use technology to help us achieve a sustainable or even growing economy and life-style possibly in balance with the ecosystem. The third opinion holds that because all life on the planet has maintained balance over time with its ever changing physical and chemical surroundings, that current human induced changes may generate adjustments in the ecosphere that could be highly unfavourable to our species. Such an opinion would attempt to recognize physical reality based on empirical observation, and act accordingly. (McLaren, 1993a)

We find we are now faced with a task that is more difficult than anything we have ever contemplated: to decide how we may continue to live on this small planet. For if we depart from ecological balance to the extent that we destroy most of the remaining life on earth, then, surely we are dooming ourselves to a similar fate

A Look at the Planet

To decide between these alternatives, we must turn to empirical evidence provided by observation and measurement of the world we live in. This is a wet rocky planet upon which life developed not long after the first rains fell, more than 3 billion years ago and thus began the ecosphere, or habitat of life. Energy from the sun is used to generate the primary food source produced by plants which synthesize carbohydrates from water, carbon dioxide and sunlight and release oxygen to the atmosphere. The life cycles of animals and plants are energised by oxidizing carbohydrates and return carbon dioxide to the atmosphere. This is a system of profound complexity in which all living entities interact together with the inorganic and physical world (Cloud, 1988, Fyfe, 1990).

Driven by its internal heat, the planet is in a constant state of change that results in biological and physical evolution. Changes may be slow, e.g. movement of crystal plates, or faster acting, e.g. glaciation and sea-level movements, or rapid to instantaneous, e.g. hurricanes, earthquakes and asteroid impacts. All planetary systems involved in change are complex, and their interactions unpredictable. These include the ecosphere in which sudden changes of varying intensity are not uncommon, for instance population outbursts or mass extinctions. Causes may not be known accurately for many of these happenings, but there are ample empirical observations that confirm their existence.

The life-support system we live within is deeply complex, and not amenable to management, control or prediction. All events, whether large or small, are interrelated and ultimately unpredictable, although we may suggest probabilities for the shorter term.

It is important to recognize that our current knowledge of the systems within the ecosphere is the subject of a program, begun in 1986 by the International Council of Scientific Unions, called the International Geosphere-

Biosphere Programme. This involves physical and biological studies of the atmosphere, oceans and the lands and their interactions with the ubiquitous plants and animals within them. In spite of ongoing pleas for more research, there is already a mounting body of empirical observations that demands immediate action on some of the more destructive activities.

The Industrial Revolution

From the Agricultural Revolution to the 18th century, humans developed within a sustainable ecosystem. This functioned on energy from the sun, but at a rate that was strictly rationed. Humans lived within their income – solar energy fixed by green plants. From slow beginnings, it would be difficult to exaggerate the importance of what then followed. (Vancouver Declaration, 1989).

The Industrial Revolution brought about the largest change in human occupation of the planet since it began, based on a complete reversal of the existing energy system. We learned to use fossil fuels: coal, oil and natural gas, and made a Faustian bargain under which the supply of energy to support life was no longer restricted to photosynthesis but became seemingly infinite. We lived on capital and used past solar energy that had accumulated over a period of 400 million years within the earth's crust. The current rate of total energy use is roughly half a million times faster than before.

Population

During the 19th century, hygiene laws were introduced, and for the first time in history, humanity looked forward to a major increase in expectation of life. This was paralleled by an increase in population. After reaching the first billion early in the 19th. Century, the population continued to grow at an increasing rate: two billion by 1930, three by about 1958, four billion by 1974, five billion by 1988, and it will reach six billion by about 1998. In 1960 the world's population was growing at an annual rate of more than 2.5%, but, as a result of improvements in food distribution, health services, and general economic level, and with increasing availability of contraceptives, the rates have begun to go down, and are currently about 1.73% for the developing world (Horiuchi, 1992). Annual net increments, however, will continue to increase until about 2000, reaching nearly 100 million a year, and will remain at that level for the next 30 years (Bongaarts, 1994a). This is another example of a unique situation in the history of our race. In spite of every effort, and using an optimistic prediction, the "population momentum" will force growth to between 9« and 11 billion by 2100, and in spite of the fact that family size may decrease rapidly. For instance if China were to limit its fertility rate to one child per family today, its population would not level out before it had reached 1.8 billion. The spread in future trends for this growth will depend very largely on actions taken during the next 10 years (Sadik, 1991). Most of the figures suggested for the future are based on optimistic assumptions for rates of change, but reality may be very different if their values are adjusted upwards by slower reduction in rates of increase, or downwards by increased mortality for a variety of causes.

I attended an important event that took place in New Delhi in October 1993. At the suggestion of the Royal Society of London and the US National Academy of Sciences, representatives of some 60 National Academies of Science met to discuss important issues of population growth and resource use (McLaren, 1993c). A statement was signed by 57 countries calling for global action, and warned that we are approaching a crisis point (Population Summit, 1993).

Energy

Cumulative usage of energy has approximately doubled every 20 years for the last 100. Current use annually of industrial energy (largely fossil fuels) is about 14 terawatts (one terawatt is equivalent to one billion tons of coal or 5 billion barrels of oil). Total energy use to date has been about 400 TW. Fifteen percent of the world's population consumes about half its energy. Average per capita use in the developed world is about 7.5 kW versus 1.1 kW in the less developed countries (Holdren, 1991). Any realistic growth in use of industrial energy by the developing world will require a substantial reduction by the developed world and lead to a heavy increase in emissions and particulates.

Current estimates of the world's ultimate recoverable crude-oil resource is in the order of 1600 to 1700 Barrels (GBO), of which more than one third has now been consumed (Fuller, 1993). Forty-two percent of this oil is contained within six contiguous Middle East countries, while Europe, North America and Japan are increasingly net importers. This surely represents a unique strategic situation, and an ever-present source of potential conflict (Holdren, 1981). Tickell (1994) has pointed out that the current pricing of energy is "bizarre". Oil prices, for example, represent extremely short term reactions to supply and demand, and almost ignore the costs of replacing or substituting for a necessarily diminishing resource.

The other side of the Faustian bargain on energy is that the quantity of power in fossil fuels is, in fact, finite and their use is responsible for the forms of waste that we call pollution, solid, liquid and gaseous, as well as for a large and increasing number of petrochemicals. All of these are associated with transportation, manufacturing or agricultural systems, for the most part in the developed world, although the proportion is changing rapidly. All are new to the ecosphere and not in balance with the established chemistry of its biota (McLaren, 1993b).

A much discussed associated problem is the possibility of climate warming. This is a complex issue although, without claiming certainty, there is a global consensus among climatologists that it must be treated as a real and urgent problem, brought about by human-induced emissions of "greenhouse gases": carbon dioxide, methane, nitrous oxide, CFCs, and low-level ozone (Bruce, 1991). Naive demands for scientific proof must not be allowed to mask the need to take immediate action to reduce emissions. It would be unwise to bet that it won't happen (Robinson, Chair, 1993, Schneider, 1994). The probabilities are not zero.

Although nuclear energy has proved to be cleaner and safer than coal, and does not contribute to greenhouse gases, nevertheless the problem of disposal of low- and high-level wastes has not been resolved, and involves both technical and social dimensions. Future cost of nuclear power per unit remains uncertain until the costs of low- and high-level waste disposal and facility decommissioning are known. Disposal of nuclear weapons and military reactors constitutes a global security threat of major dimensions. To this must be added stockpiles of plutonium that are already approaching 300 tons.

The term "renewable energy" is used essentially for forms of solar energy. Although the amount available to the ecosystem is strictly determined by limits set by photosynthesis, the potential for human use is large. A decision to change from a fossil-based energy supply to a solar-based supply would make great demands on industrial capital and would necessarily be a slow process. The advantages, however, by reducing wastes from hydrocarbons and coal, would be huge, as well as economic benefits if combined with adoption of a low-energy life-style.

What's Going On?

We have considered the two main forces that are causing accelerating changes in the environment of life on the planet. We find a combination of formidable hazards largely driven by population increase and expanding resource and energy use, mainly in the industrial countries (Tickell, 1994). We can now attempt to summarize some of the observed results. During the last year the following changes have been reported (Myers, 1993):

- Accelerating destruction of forests, including 150,000 sq. km. of tropical forests, with loss of species habitat, watershed services and climate stability.
- Lost 25 billion tons of topsoil, enough to grow 9 million tons of grain.
- Lost to desertification 60,000 sq. km. that will not return to fertility for many decades.
- Depletion of the ozone layer continues with increasing signs of damage to crop plants and marine food chains.
- Extinction of tens of thousands of species. Global demand for water continues to increase, - it doubled between 1940 and 1980 and will double again by 2000 - competition for water will continue as a prime and growing source of conflict (Homer-Dixon et al, 1993).

There are many other ongoing changes, of which a few should be mentioned:

- It is estimated that about 40% of the terrestrial food supply has been appropriated by Homo sapiens leaving only 60% of the earth's net primary productivity for the rest of terrestrial life, and it may be impossible to double our share in the future (Vitousek et al, 1986). This is but one of the major assaults on the ecosphere as we destroy, alter or appropriate more or the earth's natural systems (Postel, 1993; see Rees & Wackernagel, 1992. for discussion on carrying capacity).
- Previous predictions of immediate impending depletion of non-renewable resources, fuel and mineral, have proved premature, but, paradoxically, we find that we are currently quarrying soils,

groundwater and biological resources at rates that prevent their recovery on a human time-scale, if at all (Ludwig et al, 1993).

- Accelerating use of non-renewable resources leads to increasing wastes at a rate that approximates a country's GNP, and far exceeds the capacity of the ecosystem to absorb or recycle. Such wastes are a measure of the distance we have strayed from equilibrium and sustainability (McLaren, 1993b).
- The disparity between rich and poor countries and between individuals globally continues to widen. The extreme poor have the highest birthrates and currently there are about 1.2 billion with a per capita cash income less than $1 a day, or 1.4% of total global income (Human Development Report, 1993).
- The number of politically defined refugees has grown from 5 million in 1978 to 19 million in 1990 with another 10 million environmental refugees and economic migrants (Shenstone, 1992). Technology induced unemployment, is increasing with consequent increasing loss of social and political stability. (Reford, 1992)..

The above statements are largely global generalizations, backed by empirical evidence of growth, in addition to the hard facts of population and resource use, about which there can be little argument. Not all the news is bad when considered in greater detail. There are signs of improvement, locally, or to some degree, among many of the disruptions listed, and these will continue, although at rates well below current growth rates of the hazards considered here. Most of the human induced changes described above are reversible, and could be stopped and repaired. We have the capacity to do so, but appear to lack the will. But there is one big exception. Damage to the ecosystem, our own life-support, involves irreversible killing of plants and animals, largely by removing their habitats, on a scale that is rare in the geologic past. This may be the greatest single danger facing the planet - and human beings.

Technological Development

Nevertheless, there is a school of thought that maintains that accelerating technological development will be able to reverse many of the current trends, and that this will outpace the problems brought about by current growth in population and wastes. Ausubel (1993), cites evidence of accelerating technical progress and assumes that this is humane and responsible. Thus, for instance, technology will be able to deal with the problems of climate warming, should they occur. By taking timely action we must make the necessary adaptations to adjust to the changes we have induced, including, presumably, to sea-level rise (Ausubel. 1991). Predictions, costs, economic modelling, and coastal zone management, are among the topics discussed by advocates of such measures, but no mention is made of changes to the global environment except as to how they affects humans.

Real dangers are overlooked in discussing technical means to achieve adaptation. Damage to the ecosystem will be considerable, if global warming occurs. The expected rate of change may severely affect the system's already depleted carrying capacity, and exacerbate further effects of many of the human-induced changes already identified. Nordhaus (1992) has examined costs of protective measures that might be taken to reduce global climate warming. This was discussed in the Correspondence columns of Science (1993) by Schneider and others. In assessing costs, Nordhaus states that environmental insurance should be weighed against claims on, for example, investment dollars for education, Russian nuclear reactors and dangerous American streets. In doing so, he makes the familiar error of assuming that physical changes in the ecosystem and economic costs in a human value system may legitimately be included in a single model. The ecosystem cannot be costed and will remain unassessible. It is, in fact, invaluable, for without it all other problems vanish (McLaren, 1993a).

Do we really believe that we can and should manipulate the ecosystem to suit our technical and social needs? And do the proponents of this proposal assume that the global population will necessarily agree to such actions? Or will it be decided for them and by whom? Such a view is held by some scientists and engineers in regard to many of the problems facing humankind resulting from cropping and conversion of ecosphere resources, apparently in ignorance of the inevitable consequences. This is an example of the implicit assumption that humans can control the environment to their own purpose, and stand above nature. A view that dates from a time long before the scale of exploitation was significant and continues to comfort some of today's economists, who believe that technology will solve inconsistencies within their models.

A Holistic View of Disruptive Changes

The phenomenon of growth in technology and energy use, arising from scientific and engineering research and development, is rarely questioned and commonly applauded. From the time of the industrial revolution these rates have kept pace with or exceeded population growth, suggesting a cause and effect relationship either way. In the developed world energy use has begun to decline due to increasing efficiency and conservation, but this is being heavily offset by the desired increase in the developing world. There are, however, other global changes that have also grown in proportion to population that include waste production, growth of cities, poverty, loss of forests, loss of topsoil, loss of clean water and groundwater and others, all leading to further destruction of the life-support system.

Each of these disruptions may be discussed individually and remedial action suggested (Bongaarts, 1994b). Although piecemeal palliatives may be sought for the effects from each source of damage, the disruptions are all interconnected and interactive, and add up to a massive assault on our economic system and our administrative capabilities. These social, political and economic constraints may be more important than the technical aspects of suggested remedies. For instance, poverty is the main cause of starvation in the world, and not shortage of food. It is the distribution system that doesn't work, – surely a problem for all disciplines.

Our socio-economic system is failing in parallel with the enormity of the harm done to the natural life-support system. Such considerations are forgotten by the Utopian idealists who would ask us to "adapt" to climate change should it take place, presumably in the way we have "adapted" to city growth with smog and the motor car, or gross global economic disparity, or to all the manifestations of environmental run-down that surround us. Recently it has been suggested that we can double agricultural output and feed twice the present population on plants (Waggoner, 1994). Even if attainable technologically, in the light of our present incapacity to provide an adequate diet to one fifth of the global population, including many in the developed world, one must ask: Who will make the decision? and What economic system will ensure distribution?

The size and complexity of global disruptive change appears to induce a widespread state of cognitive dissonance leading to an incapacity to accept conclusions and rejection of the evidence (Campbell, 1992). As the problem is global, it requires a global solution. That we are far from discussing this situation seriously is born out by the failure of successive world symposiums to recognize the scale of the developing threat to humankind and the ecosystem, from the 1972 UN Symposium on the Human Environment to the 1992 UN Symposium on Environment and Development. In 1987 the famous Bruntdland Report alerted the world to many of the problems to be faced. It assumed that the current economic system will continue and that sustainable development is feasible, but will require massive and continuing economic growth if conditions in the developing world are to be improved. Is this feasible? How long shall we talk of growth in a finite system?

What Kind of Economics?

Current orthodox economic theory is astonishingly ill-suited to deal with a world beset by runaway population and consumption matched by runaway discharge of pollution and waste. In 1971 Georgescu-Roegen stated that the Law of Entropy governs all closed systems and was central to economic theory. His views have recently been further discussed by Daly and Cobb (1989). The economic process involves production followed by consumption, and is therefore entropic. The economic subsystem takes in resources and excretes wastes. Both input and output are finite and the main variable is the one-way flow of matter-energy. It is thus irrevocably a part of the ecosystem, which has its own set of rules. Natural capital is the concern of this paper, and this introduces the concepts of carrying capacity and sustainability. Daly (1990) has listed three conditions for resource consumption: (1) rate of use of renewable resources should not exceed the rate of regeneration; (2) rate of use of nonrenewable resources should not exceed the rate at which sustainable alternatives can be developed; (3) rate of emission of pollutants and waste should not exceed the capacity of the environment to assimilate them.

The idea of substitutability is central to orthodox dogma and is necessarily linked to resource pricing, as this is the driving mechanism. In dealing with natural resources, however, the rules don't apply. There are no substitutes for water, air, soils, forests, phosphorus, or any life processes, which together constitute the life-support system of the planet. Attempts are being made to price these natural and essential "commodities" for the purpose of economic modelling. But, for instance, the forest is a vital component of the complex ecosystem, involving climate modulation, atmospheric carbon balance, water recycling and a major habitat for life. It is, therefore, together with other natural "commodities", invaluable.

The term sustainable development, was popularized by the Brundtland Commission. No one can quarrel with the principle that humankind must strive for sustainability, but it is far from clear that we all mean the same thing. Current rates of use of many natural resources and production of wastes question the possibility of continuing into the future, and full or partial substitution is not possible for most of them. Some improvements in food production and distribution, water supply, education and health care, including family planning, are taking place, but population growth is too rapid to allow such desirable measures to grow and spread globally, or even hold their own at present levels. We have seen that this growth will continue for another 30 years or more. Our immediate goal, therefore, must be ecological sustainability, or there won't be much left for future generations to sustain (Rowe, 1990).

What Is To Be Done?

Opinions on what to do vary from the extremes on each side, but a middle of the road approach seems to be favoured, in which the importance of the environment is recognized, and remedial actions suggested that would be essentially piecemeal, i.e. each problem studied on its own with little attempt to integrate responsibilities and actions globally, or even nationally. Such an approach appears to have been adopted by the Canadian Government in its Green Plan. Sustainable development has become the rallying cry for many government institutions, Round Tables and NGOs. An increasing number of resource and other industries have also adopted the concept of sustainable development as a working model, and already it figures in their sales promotion and company reports.(e.g. Environment Strategy Europe, 1993, Munroe, Ed.1991)

The question of how large remedial action must be is, however, a proper subject for debate. One conclusion is that the middle way is not enough, based on questioning the current carrying capacity of the planet, combined with the inevitability of further growth in population and human activity. Others would maintain that the planet is quite capable of supporting a larger population and that already technology is well on the way to resolving current problems, and will develop faster than changes induced by human activity, including population growth. Keyfitz (1993) has speculated on ecological limits to population, and has clearly defined the differences of approach between economists and biologists. Continued disagreement between the conflicting worlds of the economist and the ecologist, with the worried layman in the middle, is dangerous, as the damage done already to the life system of the planet becomes increasingly apparent. Dangerous because it weakens action that the world might take should there be common agreement on the seriousness of our predicament. It is time this was resolved.

The stakes are high and concern human survival. Accelerating problems allow little time for further debate or research. We have considered certain measurable facts about the present condition of the world we live in. These include: population growth, growth in industrial energy use, growth in waste and pollution, growth in poverty and disparity, growth in destruction of the ecosphere – life, forests, soils, groundwater, to which must be added the probability of induced climate change, and the final fact, of overriding importance, that we live on a finite planet. All of these must be considered together, the problems and their solutions must be integrated, holistic. Some concerns may be exaggerated, others may be more severe than we thought – it scarcely matters. Nor are we always sure of which is cause and which effect, and here again models hardly matter. We are faced by a daunting body of empirical evidence that cannot be explained away by any postulate or theory.

We find we are now faced with a task that is more difficult than anything we have ever contemplated: to decide how we may continue to live on this small planet. For if we depart from ecological balance to the extent that we destroy most of the remaining life on earth, then, surely we are dooming ourselves to a similar fate.

(Note: References on following pages)

References

Ausubel, J.H., 1991 *Does climate still matter?* Commentary. Nature. 350, 649-652.

Ausubel, J.H., 1993. *Technical progress and climate change.* Workshop on Integrated Assessment of Climate Change. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Bongaarts, J., 1994a. *Population policy options in the developing world.* Science, 263, 771-776.

Bongaarts, J., 1994b. *Can the growing human population feed itself?* Scientific American, March, 36-42

Bruce, J.P., 1991. *Myths and realities of global climate change.* ECODECISION, 1, June, 89-92.

Campbell, M.M., 1992. *Schools of thought: negotiation analysis applied to interest groups active in international policy formulation.* Discussion paper, Population Association of America, Cincinnati, April.

Cloud, P., 1988. *Oasis in Space, Earth History from the Beginning.* New York and London: Norton.

Daly, H.E., 1990. *Toward some operational principles of sustainable development.* Ecological Economics, 2(1): 1-6.

Daly H.E., and Cobb J.B.,Jr. 1989. *For the common good.* Boston: Beacon Press.

Environment *Strategy Europe, 1993. Delivering Sustainable Development.* eds. T. Burke and P Knight. Hong Kong: Campden Publishing.

Fuller, J., 1993. *The Oil Industry Today.* The British Association Lectures. London: The Geological Society.

Fyfe, W.S., 1990. *Dynamics of planet earth. Planet Under Stress*, eds. C. Mungall, and D.J. McLaren, pp. 30-45. Oxford University Press.

Georgescu-Roegen, N. 1971. *The entropy law and the economic process.* Cambridge: Harvard University Press.

Gore, A., 1992. *Earth in the Balance - Ecology and the Human Spirit.* Penguin Group.

Holdren, C. 1983. Report on AAAS Annual Meeting, Detroit, Science, July 22.

Holdren, J.P. 1991. *Population and the Energy problem.* Population and the Environment: A Journal of Interdisciplinary Studies 12 (3): 231-255.

Homer-Dixon, T.F., Boutwell, J.H. and Rathjens, G.W., 1993. *Environmental change and violent conflict.* Scientific American, February, 38-45.

Horiuchi, S. 1992. *Stagnation in decline of the world population growth rate during the 1980s.* Science, 257, 761-765.

Human Development Report. 1993. United Nations Development Programme, New York: Oxford University Press.

Keyfitz, N., 1993. *Are there ecological limits to population?* Proceedings National Academy of Sciences, USA, 90 6895-6899.

Killam, A. 1993. *Valuing natural capital for sustainable development.* Commission on Geosciences, Environment, and Resources, Report on Status of 1993 Workshop

Ludwig, D., Hilborn, R. and Walters, C., 1993. *Uncertainty, resource exploitation, and conservation: lessons from history.* Science, 260, 17, 36.

McLaren, D.J., 1993a. *Population and the utopian myth.* ECODECISION, 9, June, 59-63.

McLaren, D.J., 1993b. *Waste - the human factor. Insights*, Forum for Applied Research and Public Policy. Spring, 140-143.

McLaren, D.J., 1993c. *Population summit of the world's scientific academies.* DELTA: Newsletter of the Canadian Global Change Program, 4(4).

Monroe, D.A. (Project Director). 1991. *Caring for the Earth - A Strategy for Sustainable Living.* Gland, Switzerland: IUCN, UNEP, WWF.

Myers, N., 1993. *World population, environment and development*: symposium statement of the world's Scientific Academies.

The "Population Summit", New Delhi: October.

Nordhaus, W.D., 1992. *An optimal transition path for controlling greenhouse gases.* Science, 258, 1315-1319.

Population Summit. 1993. A Joint Statement of the World's Scientific Academies. Royal Society News, November.

Postel, S., 1994. *Carying capacity: earth's bottom line.* State of the World 1994, pp.3-21. New York and London; Norton.

Rees, W.E. and Wackernagel, M., 1992. *Ecological footprints and appropriated carrying capacity: Measuring the capital requirements of the human economy.* The 2nd. Meeting of the International Society for Ecological Economics. Stockholm, August.

Reford, R., (Rapporteur), 1992. *Population and migration in the 1990's.* Report of Working Group, 42nd Pugwash Symposium, Berlin. Pugwash Newsletter, October, 158-160.

Robinson, J., (Chair). 1993. *Canadian options for greenhouse emission reduction (COGGER).* Canadian Global Change Program Technical Report Series, 93-1.

Rowe, J.S., 1990. *Summing it up.* Planet Under Stress. C. Mungall and D.J.McLaren, pp. 322-332. Oxford Umiversity Press.

Sadik, N., 1991. *The state of world population.* United Nations Population Fund. New York.

Schneider, S.H. 1993. *Pondering greenhouse policy.* Letters, Science, 259, 1381.

Schneider, S.H., 1994. *Detecting climate change signals: are there any "fingerprints"?* Science, 263, 341-347.

Shenstone, M., 1992. *World population growth and population movements: policy implications for Canada.* External Affairs and International Trade Canada. Policy Planning Staff Paper. 92/7.

Simon, J., 1992. *Apocalypse in Rio: the end of the world as we know it?* Cato Policy Report, July/August.

Tickell, C., 1994. *The future and its consequences.* The British Association Lectures. London: The Geological Society.

Vancouver Declaration, 1989. *Science and Culture for the 21st. Century:* Agenda for Survival. UNESCO. Declaration 1989; volume 1990.

Vitousek P.M. et al., 1986. *Human appropriation of products of photosynthesis.* Bioscience, 36(6) pp.368-373.

Waggoner,P.E.1994. *How much land can ten billion people spare for nature?* Council for Agricultural Science and Technology,121.

World Commission on Environment and Development. 1987. *Our Common Future,* Chairman: G.H.Brundtland. Oxford University Press.

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