OPTIMUM POPULATION TRUST JOURNAL APRIL 2002

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The Optimum Population Trust (U.K.): Manchester

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INTRODUCTION

Starting with this issue, the ‘flagship’ publication of OPT will be the *OPT Journal*, to appear in April and October each year. The *OPT Journal* aims to reflect OPT’s primary purpose, which is to carry forward the science of carrying capacity. Whenever possible, peer reviewed papers will be included. However, it has to be said that there are few people working in the fields of eco-footprinting and renewable energy — the keys to carrying capacity — so that often the best that can be achieved is consultation between workers prior to publication. Edmund Davey will explain, on the next pages, his plans for the occasional publication of an *OPT Newsletter*.

One example of an effort to carry forward the science of carrying capacity will be the *2nd Footprint forum*. However, the wheels of academia grind exceedingly slow, so although we already have valuable contributions from David Pimentel and Jill Curnow, *Part I* of the forum is to be postponed until the October issue. In the meantime, as a reminder of what the forum is all about, let me say that *Part I* will address one of the fundamental disagreements among eco-footprinters, namely how to deal with the energy component of Footprints. *Part II* will cover ethics, thus completing the coverage of the two most controversial aspects of eco-footprinting. Now to this issue.

Edmund Davey (page 5) tells us about the evolution of the finally chosen *OPT Position Statement, 2002*, which appears on page 5.

On page 7, you will find Gard Binney’s thoughts on the pre-eminent importance of oil, and the problems of replacing it. Following that comes *The Verdict on the hydrogen experiment*, page, with some thoughts on the much hyped alternative, hydrogen; the piece was a letter sent to the journal *World Watch* in April 2001. It was not published, nor, it seems, did the President of *Worldwatch* pay much attention to it, because in November 2001 he published his book *Eco-economy*, containing such an optimistic spin on a ‘hydrogen future’ that I was compelled to write *A Monograph on Brown’s Eco-economy* (page 11). The endnotes to this piece contain the calculations relevant to the use of *liquid* hydrogen as a replacement for gasoline (petrol) and the energy needed to produce liquid hydrogen. Next are some extracts from a fine piece by the late Donella Meadows, and an oustanding contribution from Canada, by J. Anthony Cassils and Madeline Weld (page 15). This volume closes with a brief report on OPT’s limited success in getting our message into the media.

Another matter which is fundamental to our carrying capacity work is climate change (it is the danger of climate change which demands a reduction in emissions of carbon dioxide). Jill Curnow sent me a book which had some important (although mistaken) views on climate change, by a *geologist* Ian Plimer. It caused me to write *A Monograph on the Carrying Capacity Implications of Plimer’s ‘A Short History of Planet Earth’* (page 18). This is followed by a series of pieces related to climate change.

A general word about this Journal: it will be published in April and October. Many OPT members are also members of EPOC, the European Pherology Organisations Confederation. I will consult with Doeke Oostra, editor of the EPOC newsletter *The Pherologist*, as to what material from the *OPT Journal* it is appropriate to circulate to the European readership of EPOC. I mention this to warn of some inevitable duplication. For instance, *The Pherologist* is soon to set out on a series assessing national carrying capacities. In the course of time, much of that will appear in this journal. Perhaps I should say, too, that while the Journal is obviously intended for the benefit of members, perhaps of equal importance is its distribution to many international organisations doing sterling work in the population field.

CHAIRMAN'S REMARKS: What's happening in OPT

Welcome to the brand new *OPT Journal*! This publication has been created by Andrew Ferguson to maintain the high level of academic research and debate established and heroically carried through the first years of OPT's life by David Willey. I am grateful to Andrew for assuming this challenging task, whilst at the same time taking up the role of chairman of the European Pherology Organisations Confederation (EPOC). I congratulate him, and wish him Godspeed.

Now, read this carefully: the *Journal* henceforth takes on the function of the *Newsletter*; therefore the Newsletter no longer exists — right? Not exactly, because I shall be sending out a *Chairman's Newsletter* which will fill in the gaps between the appearances of the Journal. The Chairman's Newsletter will operate at the more basic level of attempting to bring you, the members, into the limelight; I will expound in the first edition, which should come out around the beginning of May.

Our membership secretary, Betty Adams, who has been working for us since the organisation was founded, has decided to take a break. Betty will remain a keen and interested member, and I am grateful to her for all that I *know* she has done, besides all the things *she had obviously been doing*, before I came on the scene. Thank you on behalf of myself and of all the membership, Betty. Her function will now be the responsibility of Yvette Willey, who already has competent control of OPT's finances. I say "mainly," since Jo Hanson has also rendered valuable service in contacting members over administrative matters.

I am also grateful to all those members (and there were 45 out of a possible 77) who returned the question sheet on the draft Position Papers. Many of the returns were accompanied by detailed commentaries expressing a level of interest which was encouraging, and which occasioned a considerable amount of re-writing and debate amongst all those involved. We, on the Executive, commend the accompanying final Position Statement to you as a paper which seems best to sum up the view of the majority of the membership.

On Monday, January 7th, a seminar was held in London at the invitation of the Population and Sustainability Group (PSG) — that's the group which was set up in June of last year to focus on the population-oriented part of the statement which UNED-UK will carry to the UN World Summit on Sustainable Development in Johannesburg in September. With his usual energy and flair, Professor John Guillebaud was able to secure funding of £20,000 for a part-time secretariat to carry forward the work of PSG. This new office is in the capable hands of Catherine Budgett-Meakin. The January seminar was attended by three OPT members: Jane Buchanan, Rosemary Conway and Val Stevens. Eugene Reuthe and George Bowler, also OPT members, attended, wearing 'different hats'. I have talked to Jane, Rosemary and Eugene, who agree that the focus of the group is rather fuzzy; that is to say, due to the exigent conditions set by UNED-UK to encourage participation by as many non-population groups as possible, the seminar found itself discussing, for example, "Greater support ... to develop economic infrastructures for environmentally sustainable livelihoods . . . ". Because of these wanderings away for our path, onto issues central to other groups, I was inclined to withdraw into the Shire (classical reference) taking OPT with me, and let the rest of the world go by. I have been dissuaded.

PSG's process of preparing a clear document to send to Johannesburg is hindered by two obstacles: the first is the refusal of many of the NGO's consulted (FOE, CAFOD, OXFAM, etc.) to recognize population numbers as a major problem in development; the second is the perception of many groups that the developing world will take severe umbrage at any suggestion of population limitation. Professor Jim Duguid has written a broadside against the myopia outlined in the first problem, entitled *The Great Delusion,* which I shall include in the coming Chairman's Newsletter. Jack Parsons is preparing a piece on the second. The gist of the latter will be that many influential Third World figures have already recognised the need for population policies, and, despite huge difficulties, have had some successes. His article will not be ready for a while, but he has already pointed out to me that: "Third World intellectuals and other leaders have often led the way in explicitly recognising the problems of excess population pressure and the concomitant need to regulate numbers."

I should emphasise here that both Professor Guillebaud and Catherine Budgett-Meakin are wholly sympathetic to the broad aims of OPT: they are following, with all their energies, the only course that is available to them within the policy of UNED-UK.

There are, of course, several other groups preparing statements for Johannesburg. We have at least one OPT member, Roger Martin, who is working on the Land-Use sub-group of the UNED Working Group on Natural Resources.

Jack Parsons has completed the monumental task of transferring his two-volume book, *Human Population Competition*, onto CD. He hopes to have this ready for publication early in May, and I shall include full details with my Chairman's Newsletter, but I can say now that the CD version will bring the price well within the range of most people, and, quoting Jack, I can tell you that: "Two complete copies of the text are included: (a) a single large document to give maximum speed and flexibility in text-handling to those with high capacity computers, and (b) each chapter or other distinct section as a separate document to facilitate a step-by-step approach by readers with less powerful equipment." The CD would be ready now were it not for the fact that Jack is retitling the book and changing the publishing house.

Andrew mentions that I appeared on television: this was the outcome of an invitation from *The Ester* [Rantzen] *Show*, after somebody on their team spotted my letter in *The Times*. I was asked to make some comments on, for example, what I thought about big families. The *Ester Show* does not concern itself with any kind of academic debate, but with the emotional side of relationships. The focus of the show was a couple from Norfolk who had striven mightily to produce eleven children and who occupied, with their young, the stage of the television studio. They had recently been the subject of a documentary which detailed the heroic minutiae of their daily efforts to cope with their self-imposed burden — efforts undertaken in a spirit of cheerfulness intended to be an example to us all. Clips from this documentary were shown to the assembled audience, who applauded at a level previously tested and deemed OK for sound. Entering into the warm human spirit of the moment, I managed to focus on a quotation from an IIED report entitled *Citizen Action To Lighten Britain's Ecological Footprint*. The quotation was the statement of a Bangladeshi rice farmer whose paddies had been turned into lagoons for the purpose of breeding prawns to feed the appetites of UK gourmets. Having given a simple explanation of how more people consuming more over here leads to more land pressure over there, I delivered my quote in ringing terms, and sat back to wait for the assembly to silently and reverentially gather at my feet. Nobody moved, but Ester eyed me slyly, and said: "Well you won't be blaming me will you, because I don't like prawns." Then she turned to the patriarch on stage, and said: "How do you feel about our consuming other people's resources?" The patriarch scratched his head, shuffled in his seat, then observed: "Waall, I s'pose it's hard lines really." Incidentally, I don't know what happened to the show — did anyone see it? My guess is that my bit was edited out.

Best wishes to all, Edmund.

OPT Position Statement, 2002

The problem and ways of reducing it.

The Optimum Population Trust (OPT) is a radical reforming body, set up in 1990. OPT believes that the existing human population is imposing unsustainable pressures on natural resources and global ecosystems; it is therefore a threat to the welfare of human beings and to the millions of other species with whom we share the planet.

The problem is total consumption: that is per capita consumption of key resources — including the natural systems which absorb pollution — multiplied by six billion. A number of options for dealing with this situation exist: one frequently-favoured approach is radical reform of the technologies employed to turn natural resources into goods and services, so that the same 'benefit' to individuals is experienced, but, it is claimed, with far less damage to the resource base, and far fewer waste products to be absorbed. Another way, or an interrelated way, is to persuade everyone with high per capita consumption to consume less. While both approaches have much to commend them, OPT believes that if everyone is to enjoy even a modest level of consumption the present population is too high — globally by a factor of two or three. That is true now because of carbon dioxide emissions; and it is likely to be true in the future for a different reason: when fossil fuels become scarce — probably within this century — it is unlikely that we will be able to produce adequate energy from renewable resources.

OPT's unique approach

OPT believes that it is possible, using a number of internationally accepted indices (for example, sustainable global carbon dioxide emissions) to calculate the human population that could live in each country with a good and sustainable quality of life, without adversely affecting the quality of life either of people who live in other countries or of people who live in future times. (Within the term 'sustainable' is the connotation of protection of bio-diversity and wilderness.) Now that human beings have the ability to control their own fertility, such a future could be planned.

Nation states, working within global parameters, need to decide on the optimum population for their country. A state could decide (democratically, it is hoped) to reduce its numbers gradually, while per capita consumption (standard of living) increases. Or it might allow its population to increase while opting for a lower per capita consumption level (helped perhaps by better technologies) so as to stay within environmental targets. Around the world, different cultures have different priorities and different ecological realities. OPT believes that it is vital for *each nation* to live within its own ecological resources: the only political unit which can exercise some control over the two key variables — population and consumption — is a sovereign state.

An optimum population for the United Kingdom

While looking at the interrelated problems of population and environment, OPT's main focus has naturally been the United Kingdom. The UK now has about 700,000 births a year. Deaths are about 60,000 lower, but with a sub-replacement fertility rate of about 1.7 children per woman, in the absence of net immigration, this rate would allow a gradual fall of population, to about half, in the next 100-150 years. But heavy net immigration in the last 15 years, now approaching 200,000 a year, is contributing largely to further population growth. This situation makes the task of OPT much harder: the UK population needs to be smaller if the country is to be ecologically sustainable and continue to provide its inhabitants with a healthy and satisfying standard of living (even assuming much improved technologies and lower consumption). OPT's task of persuading people to continue to maintain the current sub-replacement fertility rate — to produce a gradual decrease in population — cannot take hold if any reduction is continually turned into an increase by the influx of people from other states.

Let us be clear that it is the numbers that matter. If say 10,000 people from the UK wish to emigrate to India, then we should be willing to accept 10,000 immigrants from India. However it should be noted that it is important for such immigrants to integrate into our lifestyle, because otherwise the educational effort advocated by OPT, to encourage low birth rates, might be made more difficult on account of the existence, within our society, of a culture with a different reproductive norm. All of this is easier said than carried out, but if we fail, we may well bring upon ourselves the disastrous problems of 'competitive breeding', which were root causes of dissension in Kosovo and Macedonia.

In co-operation with other stable countries, our Government must make every effort to help reduce poverty and oppression in those states generating an exodus. Meanwhile OPT supports the present government's commitment to tightening up procedures for vetting all would-be immigrants, so that Britain is less 'attractive' to those seeking a better life. But we must also do all we can to help poorer nations to avoid a headlong rush into the disaster of overpopulation; and we should do this with generosity, aware always that our own populations survive only by appropriating a significant part of the resources of these poor countries — most shamefully through international debt.

The work of the Optimum Population Trust

OPT has two main aims:

1. To promote and co-ordinate research into criteria that will allow the optimum population of a region to be determined.
2. To increase awareness, particularly among those who influence opinion, of the result of this research.

At a more operational level, subsidiary aims include:

3. To encourage UK governments to act on the strong recommendations of the 1949 Royal Commission on Population, the 1971 Parliamentary Select Committee on Science and Technology, and the Government Population Panel in 1973, so as to fully integrate population into all decisions.
4. To oppose the view (absurd, but nevertheless held by politicians, economists and the commercial world) that a continuously expanding economy is not only desirable but possible.
5. To call attention to the short-term dangers of globalisation (specifically 'corporate supremacy'), and its long-term impossibility (as fossil fuels become scarce).
6. To oppose the view that an aging population (the natural consequence of a declining indigenous population) calls for counter-balancing immigration.
7. To make it widely understood that failure to reduce population is likely to lead to a population crash when fossil fuels become scarce.

The overall task is to get people to recognise the links between the quality of life and environmental destruction on the one hand, and (a) high population levels, (b) wasteful consumption, and (c) poor technology. OPT concentrates on (a) because other environmental organisations neglect this component to an almost absurd degree. In addition it is a subject shunned by the mass media. Seeking to reshape people's reproductive behaviour — however democratically — involving as it must intimate decisions of individuals, is seen as an infringement of human rights. OPT believes that all other human rights and needs will suffer if we don't.

How much credit OPT can claim may be a moot point, but our venerable — still very active — 'US Press Liaison', Gard Norberg from Florida, has had notable success in getting population mentioned within the pages of *The Ecologist*. He now has his own column (under the pen name Gard Binney). The article below has already been sent out with *The Pherologist*, but since it provides a succinct summary of the coming energy problem — delivered in Gard's usual humorous style — those who read neither *The Pherologist* nor *The Ecologist* deserve a chance to peruse it.

THE PETRO-POPULATION PARALLEL

by Gard Binney

According to the American geologist Walter Youngquist, PhD — a leading authority on non-renewable resources — oil production worldwide is currently outstripping the discovery of new petroleum deposits by a ratio of 4 to 1, and is expected to peak in the year 2007. In reading his article in the scientific journal *Population and Environment*, entitled 'The Post-Petroleum Paradigm — and Population', one is struck by the congruency of the curves for petroleum production and population growth in the past century. But, while the human propensity for procreating shows no signs of abating, the remaining petroleum reserves are rapidly being depleted.

In many oil-producing countries, including Iran, Libya, Mexico and the US, domestic production has already peaked, and some of the Gulf states, whose economies are entirely dependent on petroleum exports, have been forced to cut down on their social welfare spending, including such benefits as subsidised housing and free universal education. Due to the explosive population growth in much of this Gulf region — which in some cases led to a doubling of population every 10 years — this oil-based largesse had to be curtailed even at peak production. But when the oil revenues are reduced to a trickle, so too will be the welfare handouts, with disastrous socio-economic and political consequences.

What makes this scenario even more chilling is the fact that more than half the people in these countries are now under the age of fifteen, and will reach their reproductive peak at the same time that oil revenues dry up. This in turn will lead to civil unrest, starvation, and mass migrations, posing a threat to the political stability of the whole region — including, but not limited to, Israel, which nation's non-petroleum based prosperity is already viewed with envy by its Arab neighbours.

In oil-consuming, but not producing, nations, the rapidly diminishing supply of petroleum will have different, but equally disastrous consequences, forcing a radical change in lifestyles and the very structure of society. In the US, where the cost of petrol has doubled in little more than a year — even if it still has a way to go before catching up with prices at the pump in Europe — suburban commuters are already feeling the pinch in their pocketbooks. As this trend continues, pressure will be put on the government to divert most of the $50 billion annual expenditure on new roads toward public transportation, and the gas-guzzling Sport Utility Vehicles, or SUV's, will mercifully meet the same fate as the dinosaurs 65 million years earlier. On the positive side, it can also be noted that the rapidly rising prices of petroleum products will bring the current globalisation of trade to a grinding halt. Members of ISEC and other advocates of localised production will see their fondest dreams realised, not because of a change of heart in corporate boardrooms, but because of economic necessity.

What about other energy sources? While it is incumbent on us to develop all other available sources of energy — such as wind and wave power, solar and lunar (tidal) energy —

as rapidly as is technologically feasible, they can be used primarily to generate electrical power, and are no substitute for petroleum products. As Professor F E Trainer of the University of New South Wales so clearly elucidated in an article for Energy Policy in 1995: "Although renewable energy must be the sole source in a sustainable society, major difficulties become evident when conversion, storage and supply are considered."

Along with Youngquist, Trainer agrees that such sources alone will not be able to sustain present levels of energy use. Thus, in the post-petroleum era we will have to resign ourselves to reduced energy use, lower living standards and a zero growth economy. The alternative is a reduction in world population to the pre-petroleum number: about 1.5 billion, or one fourth of the present — and still crescent — figure of 6 billion!

In case you wonder why so few politicians address the issue of overpopulation, there is a simple explanation. By and large they do the bidding of their corporate benefactors, without whose financial contributions they have no chance of being elected to office in today's plutocracies masquerading as democracies. And an unlimited supply of cheap labour is the *sine qua non* for the continued success of the transnational corporations. As Voltaire put it so succinctly more than two centuries ago: "The comfort of the rich depends on an abundant supply of the poor."

But when the oil wells run dry, the survivors of the profligate consumer society will be scrambling for a simpler, more sustainable lifestyle. And then the coming 'reverse industrial revolution' might just be a change for the better — a healthier existence attuned to our natural environment and our fellow denizens of Mother Earth.

Readers may note that Gard mentions the word 'population' eight times. Only those who are acquainted with the strength of *The Ecologist*'s long-standing taboo on that word will fully appreciate his achievement!

Gard mentions ISEC. It stands for the International Society for Ecology & Culture. There is a branch in Devon, in the UK, tel. (01803) 868650, email isecuk@gn.apc.org, and in Berkeley, CA, USA, tel. (510) 527 3873, email isecca@igc.apc.org. ISEC directors form the Editorial Board of *The Ecologist*. Their 56 page booklet, *Small is Beautiful, Big is Subsidised: How our taxes contribute to social and environmental breakdown*, is an incisive review of the bad effects of globalisation. They were happy to supply me with a copy in exchange for a £5 note! I can recommend it as good value.

> "Replacing any very appreciable amount of conventional oil now used with liquid fuel from biomass seems quite unrealistic. Biomass cannot supply even a modest proportion of the current oil consumption in the United States nor anywhere else."

That quote is taken from page 246 of Youngquist's 1997 book, *GeoDestinies: The inevitable control of Earth resources over nations and individuals.* Portland, Oregon: National Book Company. 499 pp. $30 + p&p. It can be ordered via credit card. Call (800) 827-2499. I give the full ordering details, since it is a book which is full of the 'ammunition' that OPT members need to have.

In the year 2000, Walter Youngquist delivered a paper, *Alternative Energy Sources*, to a high-powered conference, titled "Alternative Energy Sources: Water and Energy Sustainability: The Basis of Human Society: Are They Globally Sustainable Through the 21st Century?" I have available a copy of his excellent paper.

The following was sent — as a letter — to the journal *World Watch*, in April 2001. It contained a couple of pages of background notes to allow the editors to check the calculations. However, the endnotes are not included here as the more important calculations are shown in the subsequent piece, the monograph on Lester Brown's book. If anyone wishes to see a version containing the endnotes, I will be glad to supply it. The fact that *World Watch* did not publish the letter is not surprising. Both Jim Duguid and I have found that 'letters editors' prefer to publish letters which express people's feelings, rather than ones which get down to dealing with facts which the editors may not have staff with the competence to check. Anyhow *World Watch*, like *The Ecologist* and *New Scientist* are determined to hold on to their Panglossian view of a 'hydrogen future'.

VERDICT ON THE HYDROGEN EXPERIMENT

by Andrew Ferguson

WorldWatch readers may recall the glow of a volcanic flare on the November/December 2000 cover, with the words, *The Hydrogen Experiment: Descendants of the Vikings Embark on a Bold New Quest to Transform the World's Energy Economy*. But perhaps the significance of the following two nuggets of information did not fully register:

1) Iceland has been producing hydrogen since 1958: the plant "uses about 13 megawatts of power annually to produce about 2,000 tons of liquid hydrogen."

2) In Iceland, the cost of electricity is $0.02 per kilowatt hour (kWh), due to the availability of geothermal and hydro power.

Making due allowance for the fact that in an internal combustion engine hydrogen burns 33% more efficiently than gasoline, the available data allow us to calculate the need for 12 kWh_e of electricity to produce 210 gm (3.0 liters) of liquid hydrogen: an amount which would have the same 'motive energy' as a liter of gasoline (see endnote 2, page 12, for calculation). Paying $0.02 per kWh for electricity, the dollar cost of *the direct energy* needed to produce the liquid hydrogen would thus be 12 x $0.02 = $0.24 (for 3 liters of liquid hydrogen — equivalent to a liter of gasoline). The $0.24 does not cover the transportation or storage of the hydrogen, or the *non-energy* costs of electrolysis and liquefaction. As a ballpark figure, to cover these other aspects, we can perhaps assign $0.05 for each liter of liquid hydrogen. Thus, in Iceland, hydrogen should be deliverable at a cost of about $0.24 + ($0.05 x 3) = $0.39 for an amount equivalent to a liter of gasoline, or $1.48 for an amount equivalent to a gallon of gasoline.

That is good news for Icelanders. In the United Kingdom, with the cost of oil around $32 a barrel ($0.20 per liter), the retail cost of gasoline was about $1.20 per liter, or $4.54 per U.S. gallon, of which about 75% is tax. So, in Iceland, the cost of liquid hydrogen should be only ($0.39 / ($1.20 / 4)) - 1 = 30% higher than the 'real' (i.e. before tax) cost of gasoline; moreover, the British are willing to pay *four times* the 'real' cost.

The wholesale cost of electricity in the United States is significantly above $0.02 per kWh, raising the cost of liquid hydrogen. But, more significantly, can the electricity be made available? Accounting only for the direct electrical energy needed to produce the liquid hydrogen, each person in the States (281 million people as of 2000) would require, in order to replace the gasoline currently being consumed, 20,500 kWh/yr of electrical energy (1.6 times present total electrical use). Were you to suggest to Utility executives that they should be able to produce a significant proportion of this *extra* electricity, they — especially Californians — would fall about laughing. We will be lucky, they would reply, to keep pace with our population growth, which in the US is over 1% a year. Moreover, since natural gas supplies are peaking, we won't be able to do that for long.

A favorite daydream of greens is to produce hydrogen from wind turbines (probably the best source of renewable energy); so let us briefly survey wind energy potential. The American Wind Energy Association estimates that there is space to install 274,000 megawatts of rated capacity. That might appear to be equivalent to about 274 fairly large power stations, but it is about a third of that, since the capacity factor (amount of output compared to rated output) of land-based wind turbines, in the US, is about 25%, whereas coal-fired power stations usually operate at around 70%. The area occupied — though not monopolised — by these wind turbines would be about 7 million hectares (164 miles x 164 miles). Installation of the turbines, and connecting them together, would be a substantial undertaking. Once achieved, the turbines would supply only about 17% of current U.S. electrical demand — equal to 15 years of population growth.

To summarize, it may be possible to overcome the disadvantages of hydrogen as an energy carrier (e.g. its boiling point of -253°C), but producing it will only be possible for nations which have substantial resources of renewable, pollution free, energy. This does *not* include the United States, whose citizens are emitting nearly six times as much carbon dioxide as the average person in the rest of the world.

Convention to combat desertification

David Pimentel kindly send me a press release related to the meeting in Geneva, from 1 to 12 October 2001, of the 176 Parties to the United Nations Convention to Combat Desertification. A few points from it bring out something which is stressed in a later piece (page **Error! Bookmark not defined.**), that the great problem with climate change is simply the fact of *change*, plus the unpredictable nature of the changes. Anyhow, here are some salient points brought out in the press release.

> "Recent crises in Mongolia, Afghanistan, and other drought-prone countries demonstrate just how vulnerable people in dryland countries are . . . "

And one cannot but wonder whether, were it not for the September 11th event, mass starvation in Afghanistan would have gone largely unnoticed for a long time, as it did in Ethiopia some years back. Other points from the release were:

> "more than 135 million people are at risk of being displaced as a consequence of severe desertification."
>
> "Desertification is a major threat on all continents, severely or moderately affecting 110 countries and some 70% of the world's agricultural drylands. . . .
>
> "What's more, global warming threatens to worsen the impacts on dryland ecosystems. According to the recent 'Climate Change 2001' assessment report by the Intergovernmental Panel on Climate Change, many dryland areas could become even hotter and drier over the 21st century. Added heat stress, shifting monsoons, and drier soils may reduce yields by as much as a third in the tropics and subtropics, where crops are already near their maximum heat tolerance. Mid-continental areas, including vast sections of mid-latitude Asia, sub-Saharan Africa and parts of Australia are all expected to experience drier and hotter conditions."

A MONOGRAPH ON BROWN'S "ECO-ECONOMY"

by Andrew Ferguson

Lester R. Brown, founder and President of the distinguished *Worldwatch Institute*, recently published a book called *Eco-economy*. An abridgment of it appeared in *The Ecologist* in three consecutive issues of that journal. Lester Brown deserves unbounded admiration for what he has achieved, but this should not preclude us from making a critical assessment of his recent book. Brown indicates that wind power will be able to provide most of the energy needed to replace fossil fuels. Such is apparent from the following excerpts, taken from the Dec 2001 / Jan 2002 issue of *The Ecologist*.

> Millions of turbines soon will be converting wind into electricity, becoming part of the global landscape. In many countries, wind will supply both electricity and, through the electrolysis of water, hydrogen. Together, electricity and hydrogen can meet all the energy needs of a modern society. . . . (p. 29)
>
> As wind power emerges as a low-cost source of electricity and a mainstream energy source, it will spawn another industry — hydrogen production. Once wind turbines are in wide use, there will be a large, unused capacity during the night when electricity use drops. . . . (p. 29)
>
> In 2000, the world used nearly 28 billion barrels of oil, some 76 million barrels a day. At $27 a barrel, this comes to $756 billion per year. . . . If the money spent on oil in one year were invested in wind turbines, the electricity generated would be enough to meet one fifth of the world's needs. (p. 31)

A footnote gives the data for the above calculation: installed cost of wind turbines, $1 million/megawatt, with 40-percent capacity factor; world electricity consumption of 12.8 trillion kilowatt hours. However, the 40% capacity factor is unrealistically high. The average capacity factor (proportion of the rated power which is produced) for wind turbines is about 25% on land, and slightly above 30% off-shore. Thus 30% would be a more realistic capacity factor. Accepting the above cost assumption of $1 per watt of rated capacity — which is realistic — the $756 billion would serve to install 756,000 megawatts of capacity. At 30% capacity factor, this would produce 2.0 trillion kWh/yr.[1] However, as Brown mentions, some of this would be produced during the night and could be used for producing hydrogen. It would be in the ball park to assume that 30% could be used for this purpose, thus the amount of electricity pumped into the grid, *for direct use*, would be 1.4 trillion kWh/yr; this represents 11% of the world's total electricity consumption.[1]

It requires about 12 kWh of electricity to produce the 3 litres of liquid hydrogen which has the same 'motive' energy as 1 litre of gasoline.[2] The 600 billion kWh/yr of 'night-time' electricity, produced by the 756,000 one MW wind turbines, would thus produce 313 million barrels of gasoline equivalent. Oil has a higher calorific value than gasoline, but as a serviceable approximation, we can say that these barrels of gasoline equivalent are also oil equivalents. On that basis, the 313 million barrels a year represents 1.1% of the total 28 billion barrels a year of world oil supply.[3]

We should also consider the space that these 756,000 turbines will occupy. Turbines need to be spaced so as not to interfere with one another. Of course those placed off-shore, perhaps in a line, are somewhat different in their space demands, but as a rough indication, a 1 MW turbine needs a protected area of 36 hectares, so a total of 27 million hectares of space (520 x 520 km^2) would be needed.[4] About 450,000 km of cable would be needed to connect them up, which is further than the distance to the moon. It becomes apparent that it would be a major undertaking to build and install the turbines. It should be noted that only about 2% of the land would be monopolised by the turbines, but the above figures indicate the overall space needed, and hence the general magnitude of the task.

We are now in a position to review the project suggested by Brown. The investment of $756 billion would produce 11% of the world's electricity and, using 'night-time' generation, would substitute for 1.1% of the world's oil demand. However, this is very much a best case analysis, since a substantial part of the output would be used in building the 756,000 turbines, installing connecting cables, and servicing the whole set up.

By far the biggest problem facing the world — as geologist Walter Youngquist has pointed out in many papers and lectures, particularly in his book *GeoDestinies* — is that of finding a replacement for oil to power moving vehicles. The 1% of current demand, which might be made available from Brown's proposed project, strongly suggests that he is unduly optimistic in claiming: "Together, electricity and hydrogen can meet all the energy needs of a modern society."

Conclusion

While this analysis has only focused on one aspect of Lester Brown's book, it is an absolutely vital aspect. If the project described above can make available only 1% of current oil consumption (and we need a replacement for natural gas too), then his optimistic hopes, for an eco-economy able to support something like the present population, crumble into dust. Hopefully, sufficient detail is given here for readers to judge the true situation for themselves. That is necessary, because Brown's bland optimism — supported by faith rather than calculation — is a feature not only of his own *World Watch* journal, but also *New Scientist* and *The Ecologist*. Moreover, to my knowledge, no calculations are available in scientific journals.

Endnotes, showing calculations

1. Over a year, 756×10^9 watts at 30% capacity factor would produce:
   $756 \times 10^9 \times 0.30 \times 24 \times 365 / 1000 = \underline{1.99 \times 10^{12}}$ kWh.
   With 70% going to direct supply, this gives $0.70 \times 1.99 \times 10^{12} = 1.39 \times 10^{12}$ kWh/yr.
   This is $1.39 \times 10^{12} / 12.8 \times 10^{12} = 0.109$ = 11% of global total.
2. The calorific value of liquid hydrogen is 8.4 MJ/litre, so 4 litres of liquid hydrogen is equivalent to 1 litre of gasoline, which has an energy density of about 33.5 MJ/litre. However, in an internal combustion engine, hydrogen burns 1.33 times as efficiently as gasoline (P&P, 1996:212).
   So 33.5 / 1.33 = $\underline{25.19}$ MJ of hydrogen would provide the same motive power as 1 litre of gasoline.
   Hydrogen has a heat content of 120 MJ/kg (McGraw-Hill, p. 338 of Vol.1, 8th edition).
   So the hydrogen required to produce 25.19 MJ = (25.19 / 120) x 1000 = 210 gm.
   Density of liquid hydrogen = 0.070 kg/litre (McGraw-Hill, p. 338 of Vol.1, 8th edition).
   So volume of 0.210 kg of hydrogen = 0.210 / 0.070 = $\underline{3.00}$ litres.

   No figures are available for the overall motive efficiency using a fuel cell, but the overall efficiency is unlikely to be much better than internal combustion, especially if account is taken of the higher energy inputs needed to manufacture and maintain a fuel cell.

   The calculation that it takes 12 kWh (electrical) to produce 3 litres of liquid hydrogen is as follows (also there is empirical confirmation, using data from Iceland, where huge quantities of liquid hydrogen are produced to make fertilizer):

   Electrical energy needed to produce 3 litres of liquid hydrogen

   Since electrolysis, to produce hydrogen, is 71% efficient, 1 kWh of electricity produces 0.71 kWh_t of hydrogen.
   Since liquefaction uses 30% of the energy in the hydrogen,

the energy needed for liquefaction = 0.71 x 0.30 = 0.213 kWh_e

Thus 1 + 0.213 = 1.213 kWh_e is sufficient to produce, and liquefy, 0.71 kWh_t of hydrogen.

Thus 1.213 / 0.71 = 1.708 kWh_e produces 1 kWh_t of liquid hydrogen.

The heat content of hydrogen is 120 MJ/kg (McGraw-Hill, p. 338 of Vol.1, 8th edition).

So 210 g hydrogen, which has the same 'motive energy' as 1 litre of gasoline (see above), contains 120 x 0.210 = 25.2 MJ = 25.2 x 10^6/ 3.6 x 10^6 = 7.00 kWh_t

Since it takes 1.708 kWh_e to produce 1 kWh_t of liquid hydrogen, the electricity needed to produce 7.00 kWh_t (210 g) of liquid hydrogen = 1.708 x 7.00 = 12.0 kWh_e.

Cross-check

210 g of hydrogen contains 25.2 MJ = 7.00 kWh_t

30% of this is the amount of electrical energy needed for liquefaction, i.e 7.00 x 0.30 = 2.10 kWh_e

Since electrolyis is 71% efficient, to produce 7.00 $kWh_t$of hydrogen requires 7.00 / 0.71 = 9.86 kWh_e.

So total energy required to produce 210 g of liquid hydrogen = 2.10 + 9.86 = 11.96 kWh_e = 12.0 kWh_e

3. The 30% 'night-time' supply would amount to 0.30 x 1.99 x 10^{12}= 597 x 10^{12}kWh/yr.

At 12 kWh_e per litre of gasoline equivalent, this would produce 597 x 10^9/ 12 = 49.75 x 10^9 litres = 49.75 x 10^9 / 159 = 313 x 10^6 barrels of gasoline equivalent.

Annual oil supply is 28 billion barrels a year.

Treating a barrel of gasoline as equivalent to a barrel of oil, this represent 313 x 10^6 / 28 x 10^9 = 1.1 % of world oil supply.

4. P&P, 1996:215, say that in the Altamont Pass, California, each turbine (50 kW) requires 1.8 ha. The area needed is proportional to the rated output, so a 1 MW turbine would require 1.8 x 1000 / 50 = 36 ha. I have tried, for a long time, to get confirmation that these larger turbines do actually require protected areas of the size calculated. I have received indirect indications that this is approximately true, but have no firm data. I suspect that, in many cases, problems of siting make it difficult to make an assessment.

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P&P = Pimentel, D. and M. Pimentel. 1996. *Food, Energy, and Society*. Revised edition. Niwot Co., University Press of Colorado. 363 pp. (£30).

Youngquist, W. 1997. *GeoDestinies: The inevitable control of Earth resources over nations and individuals.* Portland, Oregon: National Book Company. 499 pp. $30 + p&p. Can be ordered via credit card. Call (800) 827-2499.

Stop Press: Lester Brown is 'Founding Publisher' of *World Watch*, the journal of the Worldwatch Institute. Fairly recently, he moved on to be Vice President, *Earth Policy Institute*. On the 30th January, I wrote to him there (at 1350 1350 Connecticut Ave., NW, Suite 403, Washington, DC 20036), to see if he wished to counter any of the points made in the preceding article. It is not surprising that I have not received a response, because, as is apparent from the *Verdict on the Hydrogen Experiment* (page 9), even the staff at *World Watch* are poorly briefed on the energetics of hydrogen production.

There seem to be no easily available sources of information related to the energetics of producing either liquid or compressed hydrogen, although presumably some is available from the ongoing developments in Iceland. When I came across the *Schatz Energy Research Center*, at Humboldt State University, I thought I might get some good data on the energy required to compress hydrogen, but an interchange of letters produced such gross errors, that I came to the conclusion this 'Energy Research Center' functions more like an energy lobby than a scientific organization.

Dr Donella Meadows was, among other things, one of the authors of the 1972 book, *The Limits to Growth,* and the 1992 update to it, *Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future*. What a great loss to the world that in February of last year, at the age of 59, she died suddenly, of bacterial meningitis. Shortly before that, she contributed a superb article to *Pop!ulation Press* (Volume 7, No. 2), from which I take some extracts — to make an annotated half-length version.

EARTH DAY, AS SEEN BY THE EARTH

by Donella Meadows

If, in the thirty Earth Day celebrations we have held since 1970, the human population and economy have become any more respectful of the Earth, the Earth hasn't noticed. What the Earth sees is that on the first Earth Day in 1970 there were 3.7 billion of those hyperactive critters called humans, and now there are over 6 billion.

Back in 1970 those humans drew from the Earth's crust 46 million barrels of oil every day — now they draw 78 million [per year = 28 billion barrels, or 4 cubic kilometers].

Natural gas extraction has nearly tripled in thirty years, from 34 trillion cubic feet per year to 95 trillion [= 645 cubic kilometers per year].

Despite global conferences and brave promises, what the Earth notices is that human carbon emissions have increased from 3.9 billion metric tons in 1970 to an estimated 6.4 billion in 2000 [*Pop!ulation Press* printed <u>m</u>illions but it should be <u>b</u>illions].

Since the first Earth Day, our global vehicle population has swelled from 246 to 730 million. Air traffic has gone up by a factor of six. The rate at which we grind up trees to make paper has doubled (to 200 million metric tons per year). We coax from the soil, with the help of strange chemicals, 2.25 times as much rice, almost twice as much sugar, almost 4 times as many soybeans, as we did thirty years ago. We pull from the oceans twice as much fish.

We have among us die-hard optimists who will berate me for not reporting the good news. There is plenty of it, but it is mostly measured in human terms, not Earth terms. What the Earth sees is that its species are vanishing at a rate it hasn't seen in 65 million years. That 40% of its agricultural soils have been degraded. That half its forests have disappeared and half its wetlands have been filled or drained, and that, despite Earth Day, all these trends are accelerating.

In the same March/April 2001 issue of *Pop!ulation Press,* there was an article, *Global Forest Prospects in a World of Six Billion,* by Annie Faulkner. Here is a salient extract:

> Since just 1950, world population and the total demand for wood have both doubled. Since 1960, global forest cover per capita has halved to about 1.5 acres per person. Currently, 1.7 billion people live in countries with critically low levels of forest cover. Aggressive forest restoration programs have been unable to keep pace with population growth.
>
> What is a globally sustainable level of wood harvesting? Conservative estimates suggest we are cutting 25% more wood than is growing, while more optimistic analyses say we can *sustainably* harvest up to 35% more than current levels. In either case — and despite recent progress in slowing population growth — at least another 4 billion people are expected in the next 100 years, and most of this growth will occur in regions where forest resources are already in short supply.

THOUGHTS ON "WHY CANADA NEEDS A POPULATION POLICY"

excerpts from a paper by J. Anthony Cassils and Madeline Weld

An eight page Paper, of the above title, was submitted by Global Population Concerns to the Standing Committee on Citizenship and Immigration of the House of Commons, Government of Canada, on 1st May 2001. The Paper describes, in small compass, the essence of the population problem. It shows us that those who toil in the population vineyard in Canada share our European problems:

> The assertion is sometimes made that those who wish to limit the population in Canada — which given the low birthrate of native-born Canadians, means limiting immigration — harbour racist motivations. Thus, people may be inhibited from expressing opposition to population growth in Canada, regardless of the ecological and socioeconomic concerns.

For an overview, could there be a better expression of the difficulties we face than this?:

> The major challenge for all humanity in the twenty-first century is to learn to live within the web of life on Earth without destroying it. This will be a difficult undertaking for a species with a misplaced sense of its own importance. It is only in the past few hundred years that humans have come to accept that the Earth (and by inference humanity) is not the centre of the Universe. Now, scientific knowledge about ecology makes it clear that human beings are not of central importance to the continuation of the process of life on Earth except in the negative sense that they have the capacity to destroy it.

That misplaced sense of importance must be particularly rampant in the United States, where, I am assured, substantial parts of the population are so ignorant of geology and biology that they believe in the story of Genesis rather than the theory of evolution. The Paper then goes on to consider something to which OPT has devoted considerable time, namely the need to reshape ethics according to ecological constraints.

> Current human practices and beliefs are on a collision course with the life support system on Earth . . . in many cultures, including the globally predominant consumer culture, there is a bias that recognizes ethics only in terms of human relationships but not in terms of the human impact on other forms of life, regardless of the fact that they make human life possible. . . .
>
> Despite the popular admonition to "think globally, and act locally," any nation that acts with foresight to curtail population and protect its environment, thereby creating an area of order in an increasingly chaotic world, will likely attract more international corporate activity and face enormous pressure to allow the entry of people from less ordered regions. Pressure tactics will include demands for free trade and accusations of racism for restrictions on immigration. The net result of such tactics, if successful, is to accelerate the unraveling of the web of life worldwide. . . .
>
> A small minority of human beings understands the inevitability of the global encounter with environmental limits and warns of the chaos and pain it will bring. The masses, however, do not grasp the dire nature of the situation, and many institutions ignore the looming environmental crisis because they depend on the growth of human numbers and demand. . . .
>
> To extricate ourselves from this trap, we must expand our code of ethics from a set of guidelines governing only interactions among humans to one that includes consideration for other life forms and the impact of our activities on future generations. . . . When humans make the leap in understanding that we are just one species in an interdependent web, a substantial shift in ethics must follow.

Comments: All this lends strength to our oft repeated plea that Clive Ponting's *A Green History of the Earth* should become the basis for teaching history. While the authors do not mention Ponting's *Green History*, it would be hard to quarrel with their policy recommendations: (1) Make a clear statement of the issue; (2) Exercise political leadership; (3) Develop reliable data; (4) Build public support.

An overview of Canada's carrying capacity

The authors mention "the new science called pherology that is emerging in Europe." OPT have been path-finders in this "new science," which attempts to assess carrying capacity on the basis of Footprints and biocapacity, and carbon emissions. Perhaps it will be useful to take a look at Canada. 1996 data are available in the *Living Planet Report 2000* (*LPR 2000*), published by World Wildlife Fund International; carbon emissions data, also for 1996, are available in *People in the Balance* (Engelman et al., 2000). For convenience, we will normally convert the carbon figures to their carbon dioxide equivalent (i.e. multiply by 3.664). Canada presents a special case, making a study of its carrying capacity particularly instructive.

Canada's carrying capacity based on eco-footprinting

Using the data set of Table 2, in *LPR 2000*, the existing biocapacity for Canada's 30 million people is 11.16 global hectares (these are hectares with global average productivity; *LPR 2000* uses the earlier name, area units) per person. So for each person to enjoy the 7.66 global hectares, which constitutes the Footprint of Canadians, population needs to be limited to (30 x 11.16 x 0.88) / 7.66 = 38 million. The factor 0.88 is a biodiversity allowance (based on a proposal by the 1987 Brundtland Commission) to allow 12% of ecologically productive land for preserving biodiversity.

We should be clear about the assumptions underlying that calculation. 3.62 global hectares, out of the 7.66, comprises the 'energy footprint', namely the component of the footprint which accounts for energy. For many years, the concept underlying the energy footprint was based on the 'carbon absorption paradigm'; that is to say, it was based on the area required to absorb the carbon emissions from the burning of fossil fuels. The carbon absorption paradigm has frequently been attacked, and it can be predicted with some confidence that in the *2nd Footprint forum*, which will appear in the next issue of this Journal, it will be thoroughly demolished. Although the paradigm needs to be changed, it does not affect eco-footprinting *figures*. That is because the area of land needed to generate energy from renewable resources is estimated to be approximately the same as that which has been used for the carbon absorption paradigm, namely 100 gigajoules/ha/yr, or 3.2 kW/ha.

Carrying capacities based on eco-footprinting are thus estimates of carrying capacity once fossil fuels are no longer available. The greatest weakness in the 38 million estimate is that it takes no account of the unsustainability of Canadian agriculture, which, like that in the USA, is probably associated with serious soil erosion. Thus the 38 million figure might appropriately be called the *uncorrected* Footprint carrying capacity.

Canada's carrying capacity based on carbon dioxide emissions

In global terms, the constraint on population size is simple. The Earth's carbon sinks are able to absorb about 9 billion tonnes (1 x 10^{12} kg) of carbon dioxide a year, from the burning of fossil fuels. A probable mean lowest acceptable carbon dioxide emission is 4.2 tonnes per person per year (to compare with the USA figure of 20 t/cap, a European average of 10 t/cap, and a world average, in 1990, of 4.2 t/cap). Thus to maintain a constant level of carbon dioxide concentration, global population needs to be limited to 9 / 4.2 = 2.1 billion, i.e, a reduction to 34% of the present 6.1 billion.

The constraints become far less clear when considering individual nations, because this requires decisions about how to allocate the rights to carbon emissions. At present there seem to be three 'methods' under consideration:

1. Requiring each nation to make similar percentage reductions of their emissions, starting from the basis of 1990 national emissions.
2. Dividing up the rights to emission on the basis of 'present' populations.
3. Dividing up the rights to emission on the basis of populations at some fixed point in time, say 1990.

Method 1 is obviously grossly unfair, and would not be worth mentioning, except that it appears to be the method advocated by the United States of America; and voices of dissent are not frequently raised in Australia and Europe.

Method 2 has the disadvantage that if 'present' is not a fixed date, then nations with increasing populations (e.g. Pakistan with a doubling time of 25 years) will have a growing share of the whole.

Method 3 is arguably the most just. Let us choose 1996 as the date, to fit in with the *LPR 2000* data set, and look at Canada.

Canada, with a population of 30 million out of a global population of 5700 million, would have a right to emit 30 / 5700 x 9 billion = 47 million tonnes of carbon dioxide a year.

Although the world averages 4.2 t/cap, this would be very difficult for Canada, which presently emits 13 t/cap. But by using energy more frugally and efficiently, 8 t/cap is plausible. This would constrain the population to 47 / 8 = 6 million. The 8 t per person is only indicative: nations should be able to choose a low population density and a higher physical standard of living, or a high emission with a consequent lower population.

We can now see why Canada is a special case. Canada may have a carrying capacity nearly as high as the *uncorrected* Footprint carrying capacity of 38 million; but if it is to make a fair contribution to the world's task of reducing carbon dioxide emissions to safe levels, then it needs to reduce its population from the present 30 million to 6 million. It may seem fanciful to imagine that a nation could be so altruistic as to reduce its population merely to save the rest of the world from suffering the ravages of climate change, but there are reasons of self-interest too.

It is not only because of the unsustainability of present agriculture that the 38 million figure may be too high. The estimation of an energy/land ratio, using a mix of renewable energies, is very difficult. While there is no space to go into details here, the figure we use, 3.2 kW/ha, may be optimistic for Canada. A survey of this aspect, related to Australia, was given by Jill Curnow, in *Energy Use And Australia's Carrying Capacity* (Curnow, 2001). In brief conclusion, the very least we can say is that self-interest as well as altruism suggests the need for a much lower population in Canada; a longer study of Canada's carrying capacity is available on request.

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A MONOGRAPH ON THE CARRYING CAPACITY IMPLICATIONS OF PLIMER'S "A SHORT HISTORY OF PLANET EARTH,"

by Andrew Ferguson

In October 2001, Jill Curnow, Vice-President of the NSW branch of SPA (Sustainable Population Australia), sent me a copy of Ian Plimer's book *A Short History of Planet Earth*.[1] To the extent that the book keeps within the bounds of the title, I would certainly lack the background knowledge to comment usefully on this impressively compact geological history. However, Plimer implies that the past is a useful guide to the future. He says (p. 221): "My forecast for the future is based on the history of the past written in stone. . . . Major natural climate cycles will continue to dominate the geological record and will swamp any projected human induced climate change." Is it possible that Plimer is right, and by implication that 1800 other scientists are wrong, when they say, "There is new and stronger evidence that most of the warming observed during the last 50 years is attributable to human activities." That climatological question, and implications related to it, are aspects of his book which I am willing to tackle, especially as Plimer's book provides me with relevant new geological information.

Plimer gives data on changes in sea level. He tells us, p. 189, that near the time the Earth started to emerge from the last glacial, more precisely for the 1000 years commencing 12,000 years ago, sea level rose at 2.4 m per century. Fancy having a seaside home in those days! Another period of rapid change was between 7600 and 7200 years ago, over which period there was a 6.5 m rise. This rise, which you will note averages 1.6 m per century, has been attributed to sudden changes in the West Antarctic Ice Sheet. Plimer also mentions that over the last 14,700 years, the sea level rise was 120 metres (p. 216); that works out at 0.8 m per century. Note that the last period of rapid change, 7600 to 7200 years ago, occurred during the current interglacial (which covers about the last 10,000 years), and *that 1.6 m per century is a rate which many parts of the world would find it impossible to cope with today*. For changes were easier to accommodate 7000 years ago — when the population was about 4 million, compared to today's population of 6100 million. While Plimer shows us the great climatic changes that humans have lived through, he rarely brings population fully into the equation.

In covering the enormous changes in the human condition caused by climate changes, during the current interglacial, he points out that many of the changes can be related to volcanoes, variations in solar intensity, and changes in the orbit and axis of rotation of the Earth. He tends to imply that the unpleasant consequences of these changes are matters against which mankind is powerless. Clive Ponting, on the other hand, in his *A Green History of the World*, particularly Chapter 6, *The Long Struggle*, covers the same ground with more emphasis on the population aspect (p. 89):

> For most societies until the nineteenth century, population size and the amount of food available were often out of balance, both in the short term and the long term. In the short term, annual fluctuations in supply as a result of bad harvest or an outbreak of warfare could bring disaster. In the long term, population could increase to a level where it was almost impossible for a large part of the population to obtain an adequate diet. Adjusting either side of the equation was problematic — it was difficult to increase food production at a rapid rate and, although many of these early agricultural societies around the world used fairly crude methods for restricting the growth in numbers (the practice of infanticide or a tradition of late marriage for example), food supply and population size were only rarely in balance.

Plimer's colloquial style of writing may tend to obscure important climatological distinctions. He tends to refer to cold periods as 'icehouse events' and warm periods as 'greenhouse events'. He does not explain to the reader that this is slang, and the greenhouse effect is complicated: without the greenhouse effect of atmospheric gases (mainly carbon dioxide, methane and water), the Earth's surface temperature would be -6°C. The 'greenhouse effect' raises this by 21°C to achieve the 15°C that we enjoy today. What concerns climatologists is the '*enhanced* greenhouse effect', which they believe is likely to be occurring mainly because of the annual addition to the atmosphere of 23 billion tonnes of carbon dioxide (by burning fossil fuels), plus a substantial release of methane and other global warming gases.

We do not know for sure the causes of many of the climatic variations which have occurred, so surely it would be better to avoid describing nearly all periods when temperatures were higher than usual as 'greenhouse events'. Something which troubles nearly all climatologists, but not Plimer, is the current *rate of change* in CO_2 concentration. Before surveying the geological picture painted by Plimer, let us look briefly at some calculations of the climatologists.

According to the *Third Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC), the additional greenhouse gases in the atmosphere, as compared to 1750, are such as to reduce the rate at which heat escapes from the atmosphere by 2.43 W/m^2 — with CO_2 emissions responsible for 60 per cent of that, methane 20 per cent; nitrous oxide 6 per cent; and halocarbons 14 per cent. 2.43 W/m^2 may not seem a lot, until one considers that, over the whole Earth, it amounts to 1.2 trillion kilowatts (1.2×10^{12} kW); that may be more readily appreciated as being sufficient to warm the atmosphere by 7.6°C over a year (although of course it would not do so, the heat being absorbed in part by sea and land).[a]

To fully understand the geological picture painted by Plimer, we first need to get an overall picture of the period that concerns us. Humans have been enjoying the present interglacial for about 10,000 years. The previous interglacial was 120,000 years ago. During that interglacial, the temperature was perhaps a degree or two warmer than during this one. Throughout the glacial, which separates them, as assessed by the ice-core from the Vostok station in Antarctica, the temperature was about 6°C cooler than today. From that overview, we can look at levels of atmospheric carbon dioxide (again as measured from the Vostok ice core).

During the previous interglacial, as in this one *prior to the industrial period*, carbon dioxide concentration was about 280 ppmv (parts per million by volume). During the industrial period, the concentration has been rising rapidly, and by 1999 had reached 368 ppmv. The Vostock ice core is 3623 metres long, allowing us to look back 420,000 years. That core has already shown us that atmospheric concentrations of carbon dioxide and methane are higher today than at any time in the past 420,000 years, and, adding information from sediments, likely to be higher than any time during the last 20 million years.

In view of the 'radiative forcing' figures already mentioned, that raised CO_2 level is alarming enough; what is even more alarming is today's rate of change of concentration compared to previous natural changes. One of the more rapid *natural* changes in carbon dioxide concentration occurred over the 5000 years that it took to emerge from the last glacial. Over a 6000 year period during which there was a steady rise in carbon dioxide concentration, the increase was 80 ppmv. Compare that with the present rate: if we continue to add 23 billion tonnes of carbon dioxide each year (by burning fossil fuels), then we should expect carbon dioxide to continue to accumulate in the atmosphere at about the average rate of the last thirty years; in those circumstances, it would take only 60 years to achieve the same 80 ppmv increase which previously took 6000 years.[b] John Houghton, in his fine book, *Global Warming: The Complete Briefing*,[3] deals with the likely dangers of this rapid change (p. 95):

> The rate of change of global average temperature projected for next century is in the range of 0.15 - 0.3°C per decade with a best estimate of about 0.2°C per decade. Again this seems a small amount; most people would find it hard to detect a change in temperature of a fraction of a degree. But remembering that these are global averages, these rates of change become very large. Indeed, they are much larger than rates of change for the past ten thousand years inferred from paleoclimate data. As we shall see in the next chapter, the ability of ecosystems to adapt to climate change depends critically on the rate of change. For many ecosystems 0.2°C per decade would be a very rapid rate of change indeed.

Looked at over a long period, natural rates of temperature change are very leisurely. During the approximate 5000 years it took for us to emerge from the last glacial, the average rate of rise of temperature, at Vostock, was only 0.12°C per century. The *Third Assessment Report* paints a more dramatic picture of current change than when Houghton was writing in 1991. The estimated rise, from 1992 to 2100, is now indicated as being in a range of 1.4 to 5.8°C, depending on whether the human race makes superhuman exertions to reduce emissions, or 'carries on regardless'. Mid-way between these extremes gives 3.6°C per century. That predicted rate is about *30 times as fast* as the 0.12°C rise which occurred while we were emerging from the last glacial.

Plimer tends to make it look as if human actions are likely to produce *just another* of the many variations in climate that humans have had to deal with during the last ten thousand years. Anyhow, he implies that things are not likely to be worse than the dramatic changes which humans have had to cope with during the change from glacial to interglacial. But then he does not mention that there are now 1500 times as many humans as there were then, or that during that transitional period, the ice was laying bare fertile ground, free for humans to occupy as rising sea levels drove them from the sea shore. On the other hand, if we allow ourselves to press on out of this interglacial into a 'water age' (meaning a time when there is no ice on either of the polar caps, as last occurred about 35 million years ago), it is unlikely that melting ice will reveal much fertile ground *in suitable latitudes*.

It may be true that, for some decades, perhaps a century, we will experience mainly the fluctuations which have already occurred during the present interglacial, with possibly an improvement, for some areas, as we experience a repeat of the Medieval warm period (1000 to 1200). However, the rapidity of change, the large population living near the sea, and the fact that there is no indication that we are going to stop at a doubling of the pre-industrial levels of carbon dioxide, must give cause for serious alarm. If we were to stop at a doubling, the change could prove beneficial by serving to stop us from going into another glacial, which would be the 'natural' tendency, some time in the next thousand years. But if we go much beyond a doubling of atmospheric carbon dioxide concentration, it seems likely that we would soon arrive at the sort of atmosphere which would melt even the polar ice caps, and, in a matter of centuries, take us back to a condition which last existed about 35 million years ago, when, according to Plimer (p. 129), sea level was about 150 metres higher than today (50 million years ago it was more like 300 metres higher than today). What happened 35 million years ago may seem a matter of no concern to us, but to give an indication of the rapidity of change, we may note that *New Scientist* (3 November 2001:37) told us that, "Subsea measurements suggest that summertime ice in Arctic waters has thinned by 40 per cent over the past 40 years. If it continues to shrink at this rate, the Arctic Ocean could be virtually ice-free in summer by the middle of the century."

In brief, Plimer's anodyne remarks about future climate should not detract from the consensus view of the 1800 climate scientists who are responsible for the *Third Assessment Report* of the IPCC. Their message can be succinctly summed up in the subtitle of an article by Fred Pearce, in *New Scientist*, 21 July 2001: "Whatever you thought about global warming, it is probably wrong." To put that another way, the trouble with what we are doing, adding so much carbon dioxide to the atmosphere, is that *no one knows* what will happen. However, most of the likely scenarios are unpleasant.

This commentary has not fully developed some of the points raised, thus I also reproduce a 1998 piece, *Ice Age, Glacial and Interglacial*, together with some comments that I wrote on Houghton's book, originally published in *The Pherologist*. As will be evident from the latter piece, our best efforts at the time failed to elicit confirmation from John Houghton that a safe upper limit to carbon dioxide concentration was a doubling from pre-industrial times. At the time, I found it puzzling that the very person whose job it appeared to be to make a decision on this point refused to make one. However, with the recent publication of *The Ecologist's report on Climate Change* (November 2001), I have come to see that it is a reasonable policy for the IPCC to avoid making any recommendation. When tackled on the point, the Chairman of the panel, Robert Watson, gave an explanation along the lines that whether it is acceptable for 100 million people, say, to have to move because of flooding is a social decision, not a scientific one; the job of the IPCC is merely to make predictions about the likely physical changes. Mike Hulme, of Tyndall Centre for Climate Research, gave similar reasons for avoiding the question of where the limit should be set. Peter Cox, from the Hadley Centre of the UK Met office, had a justification for taking a different line. He set 550 ppmv (about double pre-industrial levels) as a limit, because he estimates that there is a significant risk of the increase then becoming unstable, and continuing of its own accord. No one can be happy with that!

Despite the lack of guidance from scientists, we do not need to make our own decision about how many people it is "all right" to flood out of their homes, etc., because, in 2000, the UK's Royal Commission on Environmental Pollution, in its report, *Energy - The Changing Climate*, set a target of 550 ppmv. If we are to meet that target, it means both reducing population and living less abandoned lifestyles. 'Abandoned' is the fashion that some of us are maintaining: if the USA continues to allow its population to expand at 1.06% a year, as it did in the last three decades of the previous century (70% of this is due to immigration and children born to those who were not themselves born in the US), then, without a decrease in per capita emissions, of which there is no sign, by 2050 the United States *alone* will be emitting as much carbon dioxide as the IPCC recommends as an upper limit for the whole world. For Ian Plimer, coming from Australia, I should add that, in 1996, each Australian citizen was emitting 86% of the amount contributed by an average US citizen.[4] So, for Australians too, not only is a more modest lifestyle needed, but also a determination not to increase the number of people who are living in a lifestyle which will surely remain extravagant — in energy terms — after any *likely* modifications to it.

In a sentence, Ian Plimer supposes that geological and historical evidence provide a useful guide to the future; climatologists tell us that such evidence is providing only background information, because the future will be different, as exemplified by temperature rises in Alaska, statewide, of 3°C since 1960 (4.5°C in winter).

Endnotes

1 Ian Plimer. 2001, *A Short History of Planet Earth*. Sydney, ABC Books, Australian Broadcasting Association.

2 Clive Ponting 1992. *A Green History of the World*. Penguin. 432 pp. First published in 1991, in New York, by St Martin's Press.

3 John Houghton. 1997. *Global Warming: The Complete Briefing*. Revised edition. U.K. Cambridge: Cambridge University Press.

4. Robert Engelman, Cincotta, R.P., Dye, B., Gardner-Outlaw, T., Wisnewski, J. 2000. *People in the Balance.* Population Action International, 32 pp.

Subsidiary endnotes, showing calculations

a The total area of the Earth is 5.10×10^{14} m^2.
Thus total heat flow from 2.43 W/m^2 = $2.43 \times 5.10 \times 10^{14} / 1000 = 1.24 \times 10^{12}$ kW.
Over a year, this amounts to $1.24 \times 10^{12} \times 24 \times 365 = 1.086 \times 10^{16}$ kWh = $1.086 \times 10^{16} \times 3.6 \times 10^{6} = 3.91 \times 10^{22}$ J.
Mass of the atmosphere = 5.14×10^{18} kg (data from Harte, 1988).
So heat input (per year) = $3.91 \times 10^{22} / 5.14 \times 10^{18}$ = 7604 J per kg.
Specific heat of air at constant pressure = 1004 J/kg per °C.
So 7604 J would raise temp of 1 kg by 7604 / 1004 = 7.6°C (over a year with no heat loss).

b Taking data from Schneider (1996), reading off from the graphs of the Vostok ice core, and choosing the period with the longest sustained rise in CO_2 concentration, starting about 22,000 years ago the CO_2 concentration rose over the next 6060 years from 182 ppmv to 262 ppmv = 80 ppmv.
Taking data from *Vital Signs 2000* (Brown et al., 2000), the change over 29 years, between 1970 and 1999, was 325.5 ppmv to 368.4 ppmv.
Thus to change by 80 ppmv would take 80 / ((368.4 - 325.5) / 29)) = 54 years (rounded up to 60).

c From Scheider (1996) again, temperature rose from -5 to +1°C over about 4850 years, giving a rate of rise of 6 / 48.5 (centuries) = 0.124°C per century.
The 3.6°C is actually for 108 years (1992 - 2100), so per century = 3.60 x 100 / 108 = 3.33.
Thus natural rate is 3.33 / 0.124 = 27 times faster, near enough 30.

References for subsidiary endnotes

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> "Six years ago, in its *Second Assessment Report*, the IPCC predicted that the overall warming of the planet during the 20th century would be some 0.45°C. Now, in the summary of its latest report, published in March 2001, the IPCC points out that the Earth's surface has warmed by 0.6°C. . . .
>
> "The IPCC also reports that the planet has lost about 10 per cent of its snow cover since the 1960s and that lakes and rivers in the high latitudes of the Northern Hemisphere remain frozen over for two weeks less than they did a century ago. Glaciers in non-polar regions are also retreating, while Arctic sea ice has not only thinned by some 40 per cent since the 1950s, the surface area that it covers during the spring and summer is also down by 10-15 per cent."

Peter Bunyard, Science Editor of *The Ecologist*, in The Ecologist report, *Climate Change: time to act*, November 2001.

"A QUESTION OF SURVIVAL" (extracts from) [1]

by Edward Goldsmith

The problem of climate change is probably very much worse than the latest assessment of the Intergovernmental Panel on Climate Change (IPCC) makes it out to be. Many members of the IPCC are likely to agree. The IPCC admits that "its models cannot yet simulate all aspects of climate." This is not surprising as mathematical models can only take into account factors that can be quantified and, unfortunately, many important aspects of climate are very difficult to quantify with any great credibility.

The IPCC is quite honest about this. It warns of projected climate changes during the 21st century as having "a potential to lead to future large-scale and possibly irreversible changes in Earth systems." Among these changes it specifies "accelerated warming" due to the release of carbon stored in the world's forests, soils, permafrost regions, oceans and hydrates in coastal sediments.

The amount of carbon that could be released from these natural reservoirs is enormous. The world's vegetation, including its forests, contains some 600 billion tonnes of carbon; tundra, permafrost and other soil contain about 1,600 billion tonnes of carbon; methane hydrates as much as 10,000 billion tonnes; and the oceans nearly 40,000 billion tonnes. In comparison, the atmosphere currently contains just 750 billion tonnes of carbon. Moreover, between them, terrestrial and oceanic sinks absorb some 50 per cent of carbon dioxide emissions. What happens to the biosphere as temperatures rise is thus of critical climatic importance, yet it has been largely been left out of IPCC calculations.

More sophisticated models are beginning to give us an idea of what would happen to global climate if such factors are taken into account. The Hadley Centre has built a new model which projects that within the next 50 years, if emissions continue at the present rate, much of our forest and soil will be transformed into *sources of*, rather than *sinks for*, CO_2 and methane. As a result, the Hadley Centre finds itself forced to project an extra 3°C incease in world temperatures by the end of the century. The IPCC's maximum of 5.8°C now becomes 8.8°C.

Still left out of this forecast, however, is the full impact of higher temperatures on the oceans and on methane hydrates, from which releases are already occurring. . . . .

What makes the whole problem even more worrying is that even if we stop burning fossil fuels tomorrow our planet will go on heating up for possibly another 150 years and the oceans for maybe a thousand or more years. With decisive and effective action, however, we could slow down this terrible process so that when climate eventually stabilises our planet can still remain largely habitable. . . . This brings us to the key issue. What actually has to be done and how can it be done? To begin with, we must obviously phase out, and phase out rapidly, the burning of fossil fuel — coal, oil, and natural gas. . . .

Civil society is beginning to realise the full horrors of economic globalisation, and in particular the globalised poverty it is giving rise to. More so, the anti-globalisation movement is developing incredibly fast. What is urgent is that society be made to understand the even greater horrors of global warming so that an even more powerful movement develops to bring about the transformation required to slow down global warming to a minimum and to enable us to adapt to the climate changes that lie ahead.

1. From page 46-47 of *Ecologist report on Climate Change: Time to act*. November 2001. £3.50 + P&P in the UK. *Think Publishing* Ltd, Vigilant House, 12 Wilton Road, London SW1V 1JZ

This paper was accepted, in 1999, for a mooted *Encyclopedia of Human Ecology* — a project which never came to fruition. This version is occasionally updated with more recent data.

ICE AGE, GLACIAL AND INTERGLACIAL

by Andrew Ferguson

About 35 million years ago, permanent ice started to form in Antarctica. About 2.5 million years ago, the oxygen isotope record suggests that the ice volume on land had increased substantially; this was the start of a cycle of glacials and interglacials lasting into the present time: About every 120,000 years, during the depths of the "glacials," the Arctic ice-cap extended to cover half of North America and Europe. With so much water locked up in ice-caps, sea-level dropped by about 120 metres. During the much shorter interglacial periods, the northern ice-cap retreated to cover only Greenland and the Arctic itself. The last 10,000 years of human history have taken place during just such an interglacial.

That much is generally agreed, although two different terminologies are used to describe it: In *Earth Story*, Simon Lamb and David Sington (1998) use the term "ice-age" to refer to the time during which one or more poles are glaciated. According to this terminology, the Earth has now been in an ice age for 35 million years, so even if we take humans to have emerged 2 million years ago, they evolved quite late in the present ice age. Note that ice ages are not the normal state of the Earth. We have to go back to the Permian-Carboniferous periods, about 280 million years ago, to encounter the preceding ice age (which lasted about 50 million years). Drift deposits suggest that there were even earlier ice ages about 450 and 600 million years ago.

While not disagreeing about the facts of the matter, Stephen Schneider (1996) and Douglas Houghton (1997) use a different terminology, because they refer to "glacials" as "ice ages." Thus, for example, they would refer to the ice age commencing about 310 million years ago, lasting 50 million years, as being a series of ice ages during the Permian-Carboniferous period. As a matter of convenience, we will use the terminology adopted in *Earth Story*, whereby that whole period of 50 million years was merely one ice age, probably being composed of many glacials and interglacials, as has been our present ice age which commenced 35 million years ago. Moreover we might invent a term to describe the long periods during which neither pole was glaciated, namely "water-ages." From the figures already given, it will be readily apparent that water-ages are far more common than ice ages.

During the last interglacial, about 120,000 years ago, which was slightly warmer than the present interglacial, sea-level was about 5 to 6 metres higher than today (Houghton, 1997:108; White, 1997:213, gives 5 to 8 m). The last interglacial, as we have observed, is only a part of the present ice age. Present levels of carbon dioxide concentration (at about 368 ppmv) are already well above concentrations in the last interglacial (about 280 ppmv), and it would be reasonable to expect that the human race will, in time, experience at least such sea levels again. If we are propelled back into a water-age, sea-levels would rise much higher. Plimer, 2001:129, gives a graph which indicates that 30 million years ago sea level was 150 m higher than today, and 80 million years ago about 300 m higher than it is now. These figures are confirmed to some extent by a report in *New Scientist*, 17 April, 1999:29, which stated that melting of Antarctica's ice cap would cause sea levels to rise by 67 metres.

If humans had not released global warming gases into the atmosphere, we could confidently expect that, within a few thousand years, the climate would slip back into a glacial (not desirable, but clearly not fatal to the human race). However, because of human activity, carbon dioxide concentration stands about 30% higher than it did during the last interglacial. In other words, we are already in unknown territory, and marching rapidly further into it; with a business-as-usual scenario, by 2080, carbon dioxide concentration would be about 600 ppmv, double that of the peak of the last interglacial (Houghton, 1997:33). While the interaction between the various negative and positive feedbacks is sufficiently complicated that science cannot predict with assurance what the outcome will be, there can be no doubt that the experiment we are carrying out is hazardous. We are taking the Earth into realms about which the historical record can tell us little, and there is a distinct risk that the Earth will move right out of the present ice age, back into a water-age. Mankind's entire history has occurred during an ice age, and there can be little certainty about how humans would fare in the sort of climate under which the dinosaurs flourished — in which ocean bottom temperature was nearly 20° C warmer than today (Lamb, and Sington, 1998:148). Yet scientists agree that continuing business-as-usual makes this a distinct possibility (Schneider, 1996:153).

From this brief survey, we can be left in no doubt about the great responsibility which lies with humans to prevent our experiment with the Earth's climate from proceeding further. And the greatest responsibility must be borne by the greatest emitter, the United States of America; what contribution can America make to the grand battle to preserve the Earth as a suitable place for humans?

With the population of the USA expanding at about 1% a year, this amounts to about 2.6 million people a year (in 2002 the figure is about 3 million a year). The magnitude of the global impact of an additional 2.6 million Americans is most clearly visualized as an equivalent number of citizens of India, whose individual impact is much more modest. In those terms, the additional *overload* on the Earth's carbon sinks, caused by US population expansion, amounts to about 51 million Indians per year. Over a generation — 25 years — it amounts to 1,270 million Indians (calculation below). From this, it is clear that the USA, without any assistance from the rest of the world, could overload the Earth's carbon sinks sufficiently to push the world back into a water-age. So if United States citizens are to take seriously their responsibilities, then it is of primary importance that they not only cut their own per capita emissions, but also prevent an inflow of people from other lands to share the exuberant American lifestyle. Without such an inflow, it would be possible to achieve a gradual decrease in population, at first towards the 200 million which (on other grounds) has been set as a safe limit for North America by Pimentel *et al* (1998). Indeed it would be possible to aim for an even lower population so as to allow per capita carbon dioxide emissions half of what Americans enjoy today, while still containing national emissions within safe limits. However there is little point of going into detailed computation on that score, while Americans are piling up the odds against the human race at the rate of 1,270 million Indians per generation (calculation below).

It is probably true to say that this conclusion, or at least its general thrust, accords with that of all ecologically aware scientists. For example, Ehrlich, Ehrlich, and Daily (1995:121) say:

> Population shrinkage is especially important in the most over-populated nation of all, the United States. With the third largest population (more than a quarter billion people), the fastest growing population of the major industrialized nations, and with one of the highest per-capita impacts on the environment (about 11 times that of an average developing country), lowering the population size in the U.S. should have top priority, along with lowering consumption levels.

Calculation

We can use the data from the table on page 24 of Engelman, 1998. The table is rather misleadingly titled, "1995 Per Capita Emissions of CO_2 in Metric Tons, by Country." Correctly, the title would refer to the tons of *carbon* contained in the carbon dioxide. Anyhow the relevant data are that in 1995 the United States was emitting 5.27 tons of carbon per capita per year, from burning fossil fuels and cement production, and India 0.27 tC/cap. At these rates:

2.6 million Americans would emit 2.6 x 5.27 million tons carbon per year.

This is equivalent to the annual emissions of 2.6 million x 5.27 / 0.27 = 51 million Indians.

If the addition of 2.6 million people per year remains unchanged, then over 25 years the increase in American population will be 2.6 million x 25 = 65 million people.

65 million Americans are equivalent to 65 million x 5.27 / 0.27 = 1,270 million Indians. Of course all this is an *excess* population, because each year the present world population is emitting about 3,500 million tons of carbon more than the Earth's sinks can absorb (Houghton, 1997:23), of which the USA is responsible for about 1,250 million tons per year.

Calculation of USA being responsible for an excess 1,250 million tons of carbon emission per year:

Taking 1995 population as roughly 260 million, in 1995 USA emits 5.27 x 260 million = 1,370 million tons of carbon (Engelman, 1998).

World could safely emit 9,000 million tons of CO_2/yr, (based on higher limit set by Intergovernmental Panel on Climate Change: 40% of 1990 emissions of 22.3 billion = 9 billion tons).

Dividing emission rights according to 1990 populations (see *Carrying Capacity Ethics*, Willey and Ferguson, 1999) USA should be entitled to emit 250 / 5,300 x 9,000 million = 425 million tons of CO_2/yr

= 425 million / 3.664 = 120 million tons of carbon/yr.

Thus in 1995 USA is emitting an *excess* of 1,370 - 120 = 1,250 million tons of carbon/yr.

References

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The following is a slightly updated version of a review essay that was first published in *The Pherologist*, February 1998. Note that it is based on the first edition of Houghton's book (with occasional references to the second edition). The latter, incidentally, has a slightly more scientific presentation; for example it uses 'yr^{-1}', rather than 'per year', or '/yr'.

This essay has not been updated with all the most recent data, for instance that coming from having extended the Vostok ice core so as to take us back 420,000 years (as mentioned in some of the earlier pieces). Note that in this paper we use the term 'ice age' to refer to a 'glacial period'; a different usage from that adopted for the paper on page 24.

A development that considerably strengthens this essay is that, since it was written a UK Royal Commission has come out with the recommendation that the world should limit carbon dioxide concentration to a *doubling* from pre-industrial times.

Apart from adding a Conclusion, the only change made to the previous edition of this essay is removal of the last paragraph, which rued the fact that we could get no definite guidance from Houghton on a safe upper limit. The reason for his reticence has been fully explained on page 21.

THE POPULATION IMPLICATIONS OF HOUGHTON'S "GLOBAL WARMING: THE COMPLETE BRIEFING"

by Andrew Ferguson

None of the later comments diminish our great respect for Sir John Houghton's book, *Global Warming: the Complete Briefing*.[1] All the intricate details of the Global Warming problem are brought together, complete with graphs and tables, catering both for the layman and, by using separate boxes and endnotes, for readers with a more scientific background. The book is a remarkable achievement. It can be recommended unreservedly to anyone with a concern for future generations.

Let us start by attempting a brief review of the conclusions which we think the book allows. The greenhouse effect is a fact; what is less certain is the 'enhanced greenhouse effect', namely the effect that humans are having by adding carbon dioxide to the atmosphere. However some aspects are not seriously in doubt. A doubling of carbon dioxide, from its pre-industrial level, of 280 parts per million by volume (ppmv), to 560 ppmv, with all other aspects held constant, would increase global temperatures by 1.2°C. That calculation is fairly secure.

Almost as secure is the feedback effect of the increase in humidity which would result from this calculated basic 1.2°C. The effects of water vapour are fairly well understood, on account of the experience with weather forecasting computer models. Water vapour feedback would increase the 1.2°C by about 60 per cent to 1.9°C. Other feedbacks, positive and negative, are less easily quantified, but there is general agreement that overall it would be wise to expect a 2.5°C increase from a doubling of carbon dioxide (without help from other global warming gases).

But what about the things which we currently understand less well, namely the large scale feedbacks which nature applies when left to itself? A picture of this emerges from studies of ice cores in the Arctic and Antarctic. Isotope analysis of ice core gases gives data for the last 200,000 years, which is sufficient to cover the emergence from two ice ages (the processes starting 140,000 and 20,000 years ago).

In each case, during the relatively rapid period — five or ten thousand years — which it took to emerge from the preceding ice age, a fairly steady rise of temperature occurred through about ten degrees Celsius. This was accompanied by an increase in methane (as shown by the ice cores). Increasing methane provides a positive feedback: that is it adds to the temperature rise which was the cause of the rise in atmospheric concentration. In the case of methane the increase in concentration is to be expected: more methane is likely to be released from stores, such as wetland, as the temperature rises. What is surprising is the equally steady increase in carbon dioxide. It might be thought that an increased temperature would soon provide a negative feedback, because more active growth of life, both in the sea and on land, would lead to a *decrease* in carbon dioxide which would tend to counteract the temperature rise. However the ice cores reveal the opposite, namely that carbon dioxide concentration, like methane, rises as temperature rises (and falls as temperature falls). What we can conclude from this is that the natural system is not inherently stable, at least over ten degrees Celsius as measured at the poles. Secondly, the positive feedbacks are fairly effective, since change in the amount of solar radiation falling on the poles (the probable cause of long-term climate fluctuations) is not nearly sufficient to explain a 10°C rise.

Let us now review the overall situation. On good theoretical grounds, taking the more obvious feedbacks into account, it would be wise to expect a rise in global temperatures of about 2.5°C from a doubling of carbon dioxide. Can we see evidence of that actually starting to happen? The answer is that the inherent variability of weather is such that at present it is impossible to clearly separate out the observed temperature rise from natural fluctuations; at best, it will be a decade or more before we can be confident of doing that unequivocally. However, it would seem wise not to delay until this confirmatory evidence is available, in view of: (1) good theoretical grounds for expecting an enhanced greenhouse effect, (2) the inherent instability of global temperature at least over a range of about ten degrees at the poles, (3) the clear evidence that the increase in temperature which is occurring, *for whatever reason*, does lead to unpredictable and damaging alterations in the weather, and (4) the long lead times involved in making cultural adjustments.

So much for what Houghton's book *does* say. But it seems to us that the *most important question* is: "What is the concentration of carbon dioxide above which scientists believe it would be foolhardy to go?" Before we stress the full significance of that question, let us see to what extent the book provides an answer. A safe maximum change in carbon dioxide is, of course, intimately related to the maximum temperature rise which it is safe to allow.

We learn, on page 90, that before the onset of the last ice age, about 120,000 years ago, the global average temperature was a "little warmer" than today, and that average sea level then was about 5 or 6 metres higher than today.[2] From the graph on page 40 showing temperature variations assessed from the Vostok ice core, we can see that the "little warmer", which Sir John refers to, is related to a 2°C increase in temperature in Antarctica. This does not exactly answer the question as to how much it would be safe for *global* temperatures to rise, since we do not know how closely Antarctic temperatures are related to global temperatures.

But a forecast 2.5°C rise does, perhaps, look somewhat dangerous, since we read, on page 36: "Although scientific knowledge cannot yet put precise figures on them, some of the positive feedbacks could be large." The 2.5°C figure does not take account of these speculative 'large feedbacks', so the change may be considerably greater than 2.5°C; perhaps enough to cause a 2°C rise in Antarctica; and this, as we have seen, caused average sea level to be about 5 or 6 metres higher than today. That clearly would be disastrous, especially with the world population anywhere near its present level, and with half of humanity inhabiting the coastal zones (p. 93).

The last three paragraphs have been speculative; yet that is about all the book has to say on the subject. So now we turn to discussing why the question is so tremendously important. Let us look at the consequences were we to decide that the maximum safe increase is a doubling — to 560 ppmv.

First we must work out how many years we have to decrease the excessive amount we are adding. Currently the addition is 1.52 ppmv each year.[3] Being realistic, and knowing that population will increase because of the unavoidable momentum of population growth, due to age structure, we must expect the 1.52 ppmv to continue until say 2040, bringing the total up to 360 + (1.52 x 43) = 425 ppmv. 2040 is a fair choice of date as the UN Low projection shows population growth flattening by then (having grown to 8 billion). Assuming a straight line decrease in emissions from then on, half way through the period of decline the yearly addition will be 1.52 / 2 = 0.76 ppmv. Thus we have (560-425) / 0.76 = 178 years to reach 560, which takes us forward to 2040 + 178 = 2218.

By that time, if doubling is a safe limit, it is necessary to have decreased our carbon dioxide emissions to such an extent that no further increase will occur. The amount which can be emitted each year from burning fossil fuels, without adding to the atmospheric store, is not seriously disputed; we use the figure 9 billion tons of carbon dioxide (though the accuracy is certainly not better than one billion tons).[4] At the moment the world is using about 2 kW[5] of fossil energy per person. There is plenty of room for industrial countries to decrease their use of energy, but there is even more scope for inhabitants of undeveloped countries to increase theirs. Thus even with the greatest efforts at restraint, it seems wise to plan on a continued average use of 2 kW of fossil energy per person. 1 kW of fossil energy releases 2.08 tonnes of carbon dioxide, therefore the maximum world population for 2 kW, in order to limit emissions to 9 billion tons, is 9 billion / (2 x 2.08) = 2.2 billion people.[6]

As mentioned, everyone is agreed that the momentum of population rise cannot be changed rapidly, and that by 2040 it must increase to about 8 billion. Thus on the hypothesis that doubling of carbon dioxide is the upper safe limit, there are two challenges: (1) to decrease, over a period, the carbon dioxide emissions from burning fossil fuels to 9 billion tons; (2) to decrease population from 8 billion in 2040 to 2.2 billion.

Let us see how things will work out if we allow 200 years (a little longer than 178), starting from 2040, to achieve these things; that is ending at 2240. For reasons of population increase, if nothing else, by 2040 world carbon dioxide emissions from burning fossil fuels are likely to be slightly higher than the 1990 figure of 22.3 billion, say 25 billion tons/yr. Thus the required rate of decrease from then on, *per 25 year period*, would be $1 - (9 / 25)^{1/8} = 0.12$, or 12 per cent.[7] Decreasing emissions by 12% every 25 years is a challenging target, even when helped by a decline in population.

The required annual rate of population decline would need to be $1 - (2.2 / 8)^{1/200} = 0.006$ or 0.6% per year. Needless to say *decreasing* population at even half the rate at which it is currently *increasing* is also extremely challenging.

If we could risk trebling, rather than doubling, carbon dioxide concentration, the required rates of change would be different — though *not the ultimate population target*. We believe that most of the arguments, in the preceding four paragraphs, about the need to bring population into line with ecological emission limits, are not in serious dispute, except by madmen and economists.[8]

Conclusion

With immediate effect, it is necessary to *start* plans to reduce global population to around 2 billion, a level which would allow everyone a modest release of global warming gases without there being a concomitant steady growth in their atmospheric concentration.

1 This is essentially a commentary on the first edition; all data come from it unless stated to the contrary. The book is *Global Warming: The Complete Briefing*, John Houghton, 1994, Lion Publishing, Oxford, UK. Paperback ISBN 0 7459 3025 5. The 1997 revised edition is somewhat more technical, and makes fewer concessions to the layman (for instance it uses the less familiar m^{-2} rather than $/m^2$); it runs to 250 pages rather than the 180 of the first edition. It is published under the same title as the first edition, but by Cambridge University Press, U.K. Paperback ISBN 0—52162932 2. Cost about £17.

2 This important datum appears on page 108 of the second edition. Also worth noting is that "towards the end of the ice age, some 18,000 years ago, sea level was over 100 m lower than today;" though it would probably be unwise to deduce that there is a 10 m change per 1° Celsius!

3 On page 31 of the 1st edition, Houghton gives the figure 1.8 part per million by volume (ppmv), but this does not tie up with the graph shown, or the figures listed in *Vital Signs* (from Worldwatch), which give an average increase of 1.52 ppmv from 1982 to 1992. The 2nd edition gives a revised figure of 1.5 ppmv (p 24).

4 A rough check calculation is quite simple: Using the 1982 to 1992 figures of 1.52 ppmv increase per year, and associating it with the 1990 figures of 354 ppmv and a total amount of carbon dioxide in the atmosphere of 2,750 billion tons (page 23 of 2nd edition), gives an accumulation of $1.52 / 354 \times 2.75 \times 10^{12} = 11.8$ billion tonnes of atmospheric carbon dioxide per year. Since 1990 emissions were 22.3 billion, that means that to stabilize concentration the maximum emission needs to be 22.3-11.8 = 10.5 billion tonnes. However, since there is likely to be an increase in other global warming gases, which we cannot control so well, like methane and nitrous oxide, this figure is probably too high. Thus rather than use this rough check, we follow the advice of the *Intergovernmental Panel on Climate Change*. The Panel said, in 1990, that a cut of between 60% and 80% was needed to stabilize carbon dioxide. The less onerous target, of 60%, indicates that an annual emission of about 9 billion tons of carbon dioxide would be an acceptable. Since most people think that it is almost impossible to achieve that, there is little point in arguing for a lower figure, calculated on the basis of an 80% cut!

5 *Food, Energy, and Society*, by David and Marcia Pimentel, 1996, gives 1991 DOE figures of 319.2 quads for world fossil energy use. 319.2 quads/yr = $319.2 \times 0.03345 \times 10^9$ kW = 1.068×10^{10} kW; for a population of 5.3 billion that is 2.01 kW/person.

6 *Our Ecological Footprint*, by Mathis Wackernagel and William E. Rees, 1996, page 74, gives the equivalence of 1.8 tonnes of carbon emitted per 100 gigajoules. 100 GJ/yr = 100 x 0.03171 = 3.171 kW. Therefore 1 kW releases 1.8 / 3.171 = 0.568 tonnes of carbon, or 0.568 x 3.664 = 2.08 tonnes of carbon dioxide. Of course the 2 kW must not be thought of as direct personal consumption: part will be converted to electricity (at about 30% efficiency), and part used for industry.

7 It is probably closer to reality to use a *proportional* decrease for carbon dioxide, as we do here. However our previous estimate of 178 years was based on an assumption of a straight-line reduction. However we adjusted the 178 years — apparently arbitrarily — to 200 years. A proper cumulative assessment of carbon dioxide build up over 200 years, with *proportional* reductions being made over the period, produces almost the 'desired' result; the concentration would be 556 ppmv by 2240, which is near enough the same as the 560 ppmv figure for doubling.

8 Madmen and economists share an ability to remain oblivious to importance aspects of reality. However some economists must be more lucid, since it was an economist who noticed this interesting parallel!

References

Houghton. J. 1997. Global Warming: the Complete Briefing. U.K., USA. Australia: Cambridge University Press. ISBN 0 521 629322.

Pimentel. D, Pimentel, M. 1996. Food, Energy, and Society/ University Press of Colorado, Nivot Colorado 80544. ISBN 0-87081-386-3.

OPT AND THE MEDIA

The definition of 'media' is variable, but here it refers not only to national and local newspapers, but also to *World Watch*, *The Ecologist*, *New Scientist* and academic journals, such as *Population and Environment*. This is a brief report of some of OPT's occasional successes in breaching the sturdy defences of these 'organs of optimism'!

Jim Duguid got some letters into the *Scotsman* on the population aspects of Afghanistan. Here is one that was published on 10 October 2001:

> **Afghanistan's population**
>
> Whilst attention is focused on Afghanistan's present role in harbouring terrorists, note should also be taken of a cause of the nation's poverty and internal conflicts which may play a part in fanning resentments and hatreds.
>
> Afghanistan's population is already greater than the carrying capacity of its land, yet it has a high birth rate (43 per 1000 in the year 2000), enough to double its population in the next 25 years. It needs to follow the example of its devoutly Islamic neighbour, Iran, which promoted births in the aftermath of the Shah's overthrow, but later inaugurated an official family planning programme, which has reduced the fertility rate from 5.2 children per woman in 1989 to 2.6 in 1997 and aims at reaching the stabilising replacement rate of 2.1 in 2004.
>
> Lesley Findlay is wrong to suggest that Western aid for family planning is a major cause of antagonism in Third World countries, though some Muslim leaders have certainly urged their followers to outbreed and replace the 'infidels'.

His letter produced some typical lunatic responses, such as (referring to the birthrate of 43 per 1000): "If that were so, one could only rejoice; the prominence of the young and vigorous in any population are probably its most important economic and, therefore, survival factor." Jim also had other letters published in the *Scotsman*, mainly on the subject of the influx of immigrants into the UK.

My local paper, the *Henley Standard*, published the following comment on the Afghan situation (I have updated it to make use of the new, and more self-evident, term 'global hectares' instead of 'area units'):

> **Afghanistan's Population Explosion**
>
> The attention of the world is focused on *political* events in Afghanistan; yet it behoves us not to forget the ecological and demographic perspectives.
>
> Data from the World Wildlife Fund's superb booklet, *Living Planet Report 2000*, elucidates these aspects. The ecologically productive space available to nations is tabulated therein in terms of global hectares. 1 global hectare is equal to 1 hectare of land at worldwide productivity. The ecological situation in Afghanistan becomes apparent by comparing it, in terms of global hectares per person, to similar nations: China 0.9; India 0.7; Pakistan 0.7; Rwanda 0.4; Afghanistan 0.4. The precarious situations in these countries makes it clear that Afghanistan has already exceeded its human carrying capacity.
>
> The 'natural' increase (births minus deaths) of the population in Afghanistan is 2.5% per year; this indicates an increase of 23 million people over the next 25 years. Since Afghanistan has already exceeded its carrying capacity, this 23 million serves to push Afghanistan further into a state of overpopulation.
>
> In the world as a whole, 40,000 children die each day from malnutrition and other diseases; this represents 11% of births. Since Afghanistan will remain in a state of chronic overpopulation, it is reasonable to estimate that *at least* 4.5 million people (11% of 41 million births) will die over the next 25 years. Perhaps the meaning of this figure becomes clear when expressed as being over 500 times the number killed in the World Trade Center event.
>
> It is not for the West to prescribe what Muslim nations should do, but perhaps we should focus our minds on these three thoughts:

(1) For several years, Iran has been actively and successfully promoting birth control, so controlling population size is not impossible for Muslim nations.

(2) There is a great need for us to break down our taboo on population discussion, because the population explosion in the United States is far more threatening to the world as a whole — through climate change — than the one occurring in Afghanistan.

(3) European populations must stop their politicians, backed by economists and the commercial world, from undermining — through immigration — Europe's great achievement in reducing fertility below replacement level.

Scientist for Global Responsibility are publishing a somewhat similar letter from me, in their newsletter. Needless to say, many letters were sent which failed to get published. Both *World Watch* and *New Scientist* remained impervious to any data which did not support their rosy view of a 'hydrogen economy'. In the academic world, we had a success with publication — in *Population and Environment* — of *The Assumptions Underlying Eco-footprinting*.[1] The Abstract of the paper went as follows:

In essence, the concept of a person's ecological footprint is simple: it is the area of land needed to support *permanently* a specified lifestyle. But in practice eco-footprinting is more complex. It is the purpose of this paper to investigate the most important aspects of that complexity. We avoid discussion of a recent elaboration of eco-footprinting, namely including the sea as a component of the ecological footprint and the use of equivalence factors. The reason is that we see those changes as being less fundamental, and intend to cover them in a separate paper. The current paper — concentrating on the fundamentals — concludes that eco-footprinting is the best method available for making a *quantitative* assessment of the extent to which consumption, by a specified human population, is exceeding biocapacity.

UK newspapers continue to direct their main efforts at encouraging population expansion in Europe. On 15 November 2001, *The Times* devoted their "cover story," of section 2, filling two and a half pages, to an article by Michael Gove: "Breed or die out." It was introduced by the words, "A study reveals that Britain's population is in decline. Is mass immigration the way to support our economy, or do we need a baby boom." Edmund Davey succeeded in getting a letter published in response. It stimulated some interest, and led to his appearing on television.

In the next couple of decades, the situation in the Afghan region should afford opportunities to bombard the media with warnings about the dangers of overpopulation. The essential data (used in some of the letters above) can be extracted from the *Living Planet Report 2000*, (available from WWF International, Gland, Switzerland) as per the accompanying table.

1. A.R.B. Ferguson. 2002. *Population and Environment*, Vol 23, No 3, p.303-313.

[Original was on same page, but see next page for Table 1]

Table 1: Population growth and available biological capacity

Afghanistan, and clockwise around it.	Population in millions, mid-2000	Births per 1000 population	Deaths per 1000 population	Natural increase, annual %	Existing biological capacity in 1996. Global ha / person	Ditto "6" in 2021
Column No.	"2"	"3"	"4"	"5"	"6"	"7"
Afghanistan	26.7	43	18	2.5	0.4	0.2
Iran	67.4	21	6	1.4	0.8	0.5
Turkmenistan	5.2	21	6	1.5	1.0	0.7
Uzbekistan	24.8	23	6	1.7	1.0	0.6
Tajikistan	6.4	21	5	1.6	0.5	0.3
Pakistan	150.6	39	11	2.8	0.7	0.3
Total or mean	281.1	33	10	2.3	0.7	0.4

THE END