OPTIMUM POPULATION TRUST JOURNAL OCTOBER 2006

Vol. 6, No 2, compiled by Andrew Ferguson

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We can now list among life's certainties not only death and taxes, but an endless flow of articles on the newest key to virtually free energy. Granted, such ideas as hydrogen powered cars give meaning to life for entrepreneurs and engineers alike, and hope to the rest of us. Yet, from an ecological standpoint, one is driven to point out that overemphasis on energy panaceas reveals we really don't get it. Cheaper, limitless energy will not create a viable civilization in the 21st century. Far from it. From a historical perspective, one can argue that relatively cheap fossil fuels over the last century have got us into the present environmental crisis. Even if humanity, at the eleventh hour, is able to solve the global warming problem, we are not lacking other means of destroying the ecological systems on which civilization depends.

Dennis Sebian, Kirkland, Ohio, USA, in a letter to *New Scientist*, 19 August 2006.

The Optimum Population Trust (UK): Manchester

<www.members.aol.com/optjournal> & <www.optimumpopulation.org>

INTRODUCTION

Martin Desvaux captures for us, on pages 3 to 13, the essence of Chapter 7 to Chapter 9 of Clive Ponting's magisterial work, *A Green History of the World*. These three chapters are seminal, covering as they do the spread of European settlement; the ways of thought that led to that expansion being so damaging; then, in Chapter 9, *The Rape of the World*, a striking review of that damage.

John Nunn, pages 14 to 19, extends his previous study of sea level changes (OPTJ 4/2). In the process he demonstrates that the distinguished petroleum geologist C.J. Campbell was mistaken in suggesting that we need not be too concerned about global warming, because we will run out of fossil fuels first. Nunn shows that even the reserves (let alone the resources) are sufficient to take us to a carbon dioxide concentration that is generally agreed to be highly dangerous. Moreover his graphs, on page 19, suggest another inconvenient truth about carbon emissions, which even Al Gore, in his film documentary, *An Inconvenient Truth*, found it inconvenient to mention, namely that even if Europe and North America reduce their carbon emissions to 40% of their present value, the projected emissions (linear growth) of China, India, and Indonesia would very nearly cancel out that improbable reduction. Moreover in terms of per capita emissions, these underdeveloped countries, after their projected increase, would still not have caught up with the developed world after the 60% reduction that has just been mooted as conceivable, albeit unlikely.

This inconvenient truth about excessive carbon emissions is brought out again by the diagram on page 20, "Number of Planet-Earths needed.". It is easy to misunderstand the significance of the overshoot when it is based on ecological footprints, as it is for instance in WWF's Living Planet Report series, because those analyses fail to bring out the extent to which overshoot *based on carbon emissions alone* is far greater. On page 21, there is a brief explanation of the Planet-Earths diagram. Referring to the same diagram, Sangeeta Sonak provides a view from the South. Then David and Marcia Pimentel give their overview of the implications of the world needing several Planet-Earths to be sustainable.

On page 27, a short piece is reproduced which I am contributing to the newsletter *Renew*. It points out why there is a probable limit of 20% to "uncontrollables." This is necessarily highly compressed. On the next two pages, in *Lagoons of Silence within the Renewables Lobby*, although only slightly less compressed, I dwell on the various areas in which the renewables lobby keeps silent about the problems of "uncontrollables."

On page 30, Professor Emeritus Jim Duguid, one of our oldest members, contributes his thoughts on how and why there exists such a strong taboo on the subject of population, and why so many organizations deem that it is something that it is better not to talk about.

This issue closes with two pages on *Scientific and Journalistic Goofs II*, showing once again that neither science nor scientific journalism is making much contribution to getting the world to face up to inconvenient truths, but rather confounding the issues.

I am very grateful to Sangeeta Sonak, who having just finished both editing and contributing to a 726 page book, *Multiple dimensions of global environmental change*, might easily have claimed the need for a rest, and to David and Marcia Pimentel for having found time in their busy schedules to contribute their overview. My thanks are owed to Martin Desvaux for checking over many draft papers, David Gosden for advice, and as always I am grateful to Yvette Willey for finding time to peruse the text with her eagle eye.

CLIVE PONTING'S *A GREEN HISTORY OF THE WORLD.* Part 3

A synopsis by Martin Desvaux PhD CPhys MInstP
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There is nothing more frightful than ignorance in action.

Goethe

Introduction to the Third Instalment

In the first two instalments we took a brief look at the history of Easter Island, then stepped back tens of thousands of years to summarise much of what we now know about the impact of early humans on the planet. During this period, the evolving human race sustained itself solely by hunting, gathering, and spreading out to populate all the major continents. By 10,000 BC, when world population levels stood at around 4 million, the story had reached the gradual transition of mankind into an agricultural society. This Neolithic transformation stimulated a slow, but by today's standards insignificant, population growth to 5 million by 5000 BC. As cities, politics and technologies developed in the wake of the Neolithic transformation, the next 4000 years saw the first population explosion (in slow motion!) to 50 million people, which rose further to 200 million by 200 AD. This 40-fold change over 5200 years had an unprecedented impact on the environment. The population then grew by only 80% over the next 1000 years, to 360 million, kept in check by disease, wars and famines, many of which were caused by overuse of the land and water as well as ignorance of the potential effects of the local high population densities caused by large conurbations. In this instalment, we learn how Europeans, having damaged large tracts of their homeland, set sail to do the same elsewhere. It makes sobering reading.

I am grateful to my wife, Karin, and Andrew Ferguson for their valuable suggestions and hawk-eyed proof-reading of the text of all instalments as well as to Clive Ponting[1] for his permission to quote text and reproduce tables and diagrams. I have added some additional data into Table 1. Passages from his book are quoted in italics. The usual uses of ellipsis … indicate where parts of a passage have been skipped. My personal comments have been almost entirely confined to the end notes.

Chapter 7: The Spread of European Settlement

Europe began to control an increasing share of world resources by means that would not bear scrutiny in today's politically correct world. However, history should be judged – initially at least – in terms of the contemporary thinking, knowledge and standards of the time, rather than with self-righteous hindsight.

Before the expansion of Europe, which can be divided into an *internal* and an *external* phase, the first settled societies developed in Egypt and Mesopotamia. These initially led to the hierarchical civilisations of the Mediterranean peoples such as the Minoan Cretans, Carthaginians, Greeks and their colonies as well as those of Alexander's empire. Only when Rome emerged as a power did this Mediterranean nucleus, driven by its need to feed a growing population, expand inland to the North and then to the West and East.

In 200 AD, Europe's population reached 28M (see Table 1) and, limited by its ability to produce food, grew by only 25% to 36M by 1000 AD. Europe was then sparsely populated, its inhabitants living in scattered small villages which between them contained only twice the population of modern London.

Year	**France**	**Germany**	**Italy**	**Britain**	**Europe**
200 AD	3 M	1.5 M	7 M	~ 0.3 M	28 M
1000 AD	5 M	4 M	No data	1.5 M	36 M
1100 AD	No data	No data	No data	*2.5* M*	45 M
1200 AD	No data	No data	No data	*<3 M**	>60 M
1350 AD	No data	No data	No data	*7M* (1347)***	80 M

**Recent data (italics)* [2] ***Population peak prior to the Black Death*

Table 1: Indicative Population Statistics for Early/Medieval Europe

The environment of Europe was predominantly that of temperate forest. As the population grew, more and more woodland was cleared to generate farming land particularly during the 11th to 14th centuries.

Expansion continued with the slow migration of German tribes towards the Elbe. Their more efficient heavy ox-drawn ploughs transformed the land of the Slavs and there eventually settled a mixed-race population which was never fully at ease with itself. Agents acting for princes and bishops parcelled out the land to settlers in the East and South as far as the Danube. European forests, which once covered 95% of the land, had been reduced to 20% by 1200. In addition, several marshes were cleared and land was reclaimed from the sea in Flanders (900) and Holland (1200).

The European population more than doubled between about 1080 and 1300, assisted by the Medieval Warm Period which produced high crop yields. Gradually, as the most fertile land was occupied, the remainder was less able to support the additional population. Thus, in the two decades after 1300, when the climate became wetter and cooler, food output plummeted and the population, which now exceeded the carrying capacity of the land, declined, slowly at first and then rapidly during the Black Death (1348). This plague reduced the population of Europe by 33%. Matters were not helped by land also being lost to rising sea levels[3]. This caused the *Elizabethvloed* in Holland on the 19th November, 1421, when tens of thousands of people died and 40,000 acres of land were lost; in 1507, land at the mouth of the River Ems also had to be abandoned.

After 1550, major reclamation projects were undertaken increasing the amount of land available in Holland by some 2 million acres. Elsewhere, less ambitious reclamation projects were undertaken in France (Narbonne and Rhône regions) and in England, reclaiming parts of the Wash and Canvey Island while other attempts along the Yorkshire and Lincolnshire borders were unsuccessful and had to be abandoned.

In this way, medieval peoples expanded and occupied what we know today as Europe. By the late 15th century, with national boundaries by and large fixed, and changing only occasionally through wars, short of heading into Russia there was nowhere else to go. However, Europe's fortunate geographical position, coupled with increased shipbuilding technology and the development of improved navigation techniques, allowed *external* expansion to the West. This took place in three phases.

Phase 1: Between 1500 and 1750.

a) The Portuguese take control of the Azores and Canary Islands, sail down and trade along the west African coast, round the Cape of Good Hope (1488) and sail on to India and Southeast Asia.
b) 1492: Spain funds Columbus to find the Western route to India thus opening up the West.
c) 1510-1515: Portugal sets up small territories in Goa, Malacca and Hormuz to trade and exploit the local wealth.
d) Portugal and Spain conquer Middle America and South America.
e) Settlement of North America by British and French and, to a lesser extent, Dutch.

Phase 2: Between 1750 and 1850

a) English defeat the French for the superiority of the Indian Ocean and subcontinent and take Mauritius (1815).
b) Trading posts are set up in China to grow trade between Europe and China.
c) Colonisation of Australia (initially as a penal colony), Tasmania and New Zealand.

Phase 3: Post 1850

a) Attention focuses on carving up Africa by Dutch, French, British and to a lesser extent the Germans.
b) Defeat of Ottoman Empire leaves control of much of the Near East in the hands of Britain and France (1919).
c) 1935 sees the last war of conquest as Italy takes over Ethiopia.

In addition, and independently from Europe, Russian expansion to the East and South of Moscow progressed in major phases. These were:

a) 1552-54: Russians conquer Kazan and Astrakan opening up the South and East for settlement;
b) 1550-1850: Russians and Ukrainians move into these wooded steppes and, by 1700, 25% of the Russian population is living there;
c) 1581: Russians cross the Urals and Siberia, covering 3000 miles in 60 years and found Tomsk in 1604;
d) 1707: Kamchatka is conquered and parts of Alaska settled.
e) Between 1800 and 1850: defeat of the Turks makes the Black Sea available for further settlement and 50 million acres of new land are brought into cultivation.

Grand as this all may sound, the detail was horrific. "*Many indigenous societies disintegrated under European pressure ... native peoples lost their land, livelihood, independence, culture, health and in most cases their lives. ... common themes running through European attitudes were a disregard for the native way of life and an overwhelming urge to exploit both the land and the people ...The story of the natives... is one of soaring death rates [from] disease, alcohol and exploitation ... social disruption and the decline of native cultures, especially under the influence of the missionaries"*.
Populations declined quickly and some became extinct due to *man's inhumanity to man.* Table 2 gives a handful of examples which is representative of what happened on a much wider scale.

Wherever Europeans went, their respect for indigenous populations was generally low. Life was cheap and they regarded the natives as little more than primitive savages, often to be treated like animals and exploited for the physical work they could do. Their land was taken and their resources were plundered. In South America, the Incas and Aztecs lost nearly all their treasures; between 1500 and 1650, 200 tons of gold and over 15,000 tons of silver were melted down and sent back to Spain.

Country / Peoples	Date	Population	Date	Population	Attrition %
Mexico / Aztec & Inca	1519	25 million	1600	1 million	95
Santo Domingo	~1500	~1 million	1540	300	99.7
North American Indians	1500	1 million	1844	30,000	97
Tahiti	1770	40,000	1840	6000	85
SW Africa / Herero	1904	80,000	1907	16000	80
Hawaii	1800	300,000	1875	55,000	82.7
Raratonga	1827	7000	1867	1850	74.6
Tasmania /Aborigine	1800	5000	1876	0	100!

Table 2: Impact of European Expansion on New World Populations

"*The expansion of Europe was a disaster for the native peoples for those areas of the world which could not survive as independent or quasi-independent entities ... Some, such as the Tasmanian aborigines were exterminated, others suffered a huge fall in numbers through ... combinations of ...disease, warfare, alcohol and economic and social disruption. ...This saga of displacement and disruption ... continued into the nineteenth and twentieth [centuries]. In many areas of the world it is still continuing as newly independent states continue the assault on the few remaining native tribes in the world who still continue to maintain their way of life."*

This was, and to a reduced extent still is, the way Europe exploited the resources of the world to build its civilization. Until its abolition in the early nineteenth century, enslavement and deportation of native peoples, often with the connivance of the tribal leaders, left a huge and justifiable feeling of guilt.[4] We will let Cook have the last word in this chapter on European history. The following is a note that was written in his diary when visiting Tahiti in 1773:

"We debauch their morals already prone to vice and we introduce among them wants and perhaps diseases which they never before knew ... If any one denies the truth of this assertion let them tell what the natives of the whole extent of America have gained by the commerce they have had with the Europeans"

Chapter 8: Ways of Thought

The way people thought about the world, its environment and contents has underpinned the whole evolution of human society: *"One of the fundamental issues addressed by all traditions is the relationship between humans and the rest of nature. Are humans an integral part of nature or are they separate and somehow superior to it?"* The answer is crucial. It determines the way religions, peoples and politicians think about others and then legitimise the means to their ends.

Classical thought was anthropocentric; it was centred on the concept of the superiority of humans on the world stage. Early philosophers such as Aristotle, Cicero, Socrates, as well as Epicureans and Stoics all took the view that humans were the orderers of nature and generally that nature was there for our use and not the other way round. Humans were therefore placed on a *higher plane* than nature.

This attitude was also prevalent in the Jewish thinking in the Old Testament, which, because of its incorporation in the Bible, influenced later Christian thinking. This 'legalised' the concept that Man '*has dominion over every living thing that moves upon the earth"* and *"to be fruitful and multiply and replenish the earth and subdue it"* (Genesis Chapter 1). This thought is reinforced when God reportedly speaks to Noah after the flood: "*Every moving thing that lives will be food for you; and as I gave you the green plants I give you everything … the fear of you and the dread of you shall be on every beast of the earth … every fowl of the air, upon all that moveth upon the earth, and upon all the fishes of the sea; into your hand they are delivered*."[5] As a result, Man was seen as being below God but above all other earthly entities which are there for him to exploit as he thought fit, and without any preconditions. Christian writers over many centuries reinforced this view. It survived through the Reformation and the development of secular thinking since the sixteenth century. There was a minority of thinkers (among them Maimonides and St Francis of Assisi) who considered that mankind is merely the steward of the Earth, takes what is needed responsibly, nourishes it and passes it on to future generations in good shape. Eastern religious thought took a similar stance. Although wary of generalising, Ponting emphasises the basic difference between European and Eastern thought on the subject. "*The world view of the 'eastern' religious tradition, developed centuries before the rise of Christianity, does emphasise a less aggressive approach of humans to the natural world … humans are only a small part of a much greater whole and what sets them apart – greater intellectual and spiritual capabilities – should be directed to the goal of enlightenment and enable them to act wisely towards other creatures and not take life unnecessarily*."

During the 16th and 17th centuries, European man's actions were seen as an improvement to the world. There then emerged the powerful idea of ***progress***. This concept is so taken for granted nowadays that it appears hard to imagine a time when *progress* had no real meaning. Originally, history was a story of decay as civilisations fell from power, and the feeling was that the world had had its heyday and was in a gradual state of decline. By 1700 however, helped by the development of science and the thought that humans could *actually improve* their lot, history began to be regarded as a chronicle of progress. By the 1800s, this had developed into euphoric ideas about Man's indefinite ability to improve the world. While thinkers like *William Godwin* and *Marquis de Condorcet* propounded such ideas, *Malthus* was less enthusiastic. His view, that the human population always grows to beyond the environment's ability to feed it and then collapses through famine and disease to a lower and sustainable level, found little support in those heady days of progress[6]. Progress, supported by Saint-Simon, Comte, Marx, Spencer, Engels and others, was considered as the inevitable march of Man from primitive tribes to higher, more 'civilised' and developed societies. Today, although dented by two world wars and media exposure of a plethora of genocides, natural disasters and ecological catastrophes, human *progress* is still a strong influence in 21st century thinking. This belief in progress is reinforced by economics, which recognizes expansion as success and stasis as failure.

During the last two centuries, economics has tried to answer the question: *"How should life be organised and scarce resources used and distributed?"* Hunter-gatherers had no concept of economics. Food and flint stones were simply there for the taking and did not need to be stored. Their value was in the present and not the future. Early farmers grew crops and bartered; then priests took their surpluses and distributed them for the greater good of the village, town and/or city; even Rome was committed to provide free food for its people. Bartering became the normal method of trade for centuries and it was only around 1100 that trade, merchants and early forms of banking started to emerge, *"... first in more developed areas such as northern Italy and Flanders and then more widely across the continent.*" In 1776, Adam Smith developed his theory that supply, balanced by demand would bring about improvements, accumulation of wealth and therefore progress through investment. In the 1700s it was generally accepted that progress was the production of personal wealth. Smith's free market approach and those which developed from it work well providing there is an infinite supply of commodity. However, Smith's and others' free-market theories "*only deal with the secondary problem of the distribution of resources between different competing ends. The crucial defect is that the earth's resources are treated as capital – a set of assets to be turned into a source of profit ...It assumes, in defiance of all logic, that resources, in terms of materials and energy, are inexhaustible, that growth in the overall level of the economy can continue for ever and that substitution of one material for another or form of energy for another can continue indefinitely even though in reality the supply is limited."* Ponting makes this point about inter-generational equity: *"But since in the real world resources are finite, consuming them now has a very real price – they are not available for future generations."*

Gross National Product (GNP)[7] has become an important measure of wealth and progress in economics, and a country's success is judged by, among other factors, the annual rate of increase of the GNP. GNP has the drawback that it can only measure what is recorded. It therefore excludes a significant amount of unrecordable economic activity (barter, subsistence agriculture, voluntary work of all kinds, etc.). It also records many non-beneficial items to the economy. As an example, the fact that cars break down and have a short life means more cars can be made. Were they more durable, production would be lower and fewer jobs would exist in the industries associated insuring against and recovering/repairing breakdowns. From a resource viewpoint it is uneconomical to have unreliable cars, but from a GNP viewpoint it paradoxically represents greater 'economic' activity. I am sure the reader can think of many similar examples from personal experience where items included in GNP are non-beneficial to the economy. Ponting remarks: *"In the long term the notion of GNP takes no account of the fundamental question as to whether its level at any one time, let alone continual growth in the future, is in fact desirable or sustainable."*

The preoccupation of Europe with economics was mirrored by Marx and Engels whose philosophy later formed the basis of communism. Lenin in his turn was envious of capitalism's ability to produce goods on a large scale, and the Soviet Union made the development of industry a high priority - with no regard for sustainability.

In summary: "*Europeans came to see humans as being placed in a special position, above and beyond a separate natural world which they could exploit with impunity ... scientific thinking* [placed] *the emphasis on understanding parts of the system rather than looking at the whole…their material position and level of knowledge were greater than that of their predecessors and later became known as progress …* [which] *became associated above all with economic growth."*

"But the way Europeans thought of the world about them ... [helped] *to provide self-justification for what* [they] *did to the natural world, the way they reshaped other societies to their own ends and how they exploited the world's natural resources"*

Chapter 9: The Rape of the World[8]

"Over the last 10,000 years human activities have brought about major changes in the ecosystems of the world. The universal expansion of settlement …creation of fields and pastures …continual clearing of forests …draining of marshy areas … steadily reduced the habitats of almost every kind of animal and plant. The deliberate hunting of animals for food (and in some cases for 'sport') and the collection of plants has drastically reduced numbers of many species. Humans have introduced new plants and animals into ecosystems sometimes with near catastrophic results. The scale of wildlife losses in earlier periods is difficult to assess."

Modern detailed research into the destruction of habitats and species began in 1600 and traces the impact of humans on plant and animal species. In the 20th century, more detailed monitoring began. It has become clear that since the beginning of European expansion in 1500 our impact has grown at an accelerating rate[9].

Our impact started with the first human settlements. By 200 BC *"The lion and leopard were extinct in Greece and areas of Asia Minor and wolves and jackals were confined to the remote mountainous areas. The trapping of beavers in northern Greece had driven them to extinction."* While many of these were destroyed for the safety of inhabitants, the Roman games had an altogether more frivolous and bloodthirsty purpose. "*The Roman addiction to the deliberate killing of wild animals in games and other spectacles added to the slaughter,* [and] *the scale of continuing destruction to amuse the crowds … can be guessed from the fact that 9,000 captured animals were killed during the 100 day …dedication of the Coliseum in Rome …* [and] *11,000 were slain to mark Trajan's conquest of …Dacia".*

After Rome, as settlement spread, vast numbers of species were hunted into extinction. Ponting quotes many examples which, in a synopsis such as this, are best summarised. Table 3 is essentially a partial roll call of the fallen in the unending war with mankind.

Species	**Population *(date)***	**Date**	**Numbers**	**Location**
Auroch	Common *(pre 2000 BC)*	2000 BC	Extinct	Britain
Auroch	ditto	1627	Last seen/extinct	Jactorowa Forest
European Bison	Common *(1200- 1500)*	1920	Last seen/extinct	Bialowieza Forest
Great Auk	Commonplace (*1540)*	1844	Last pair killed	Iceland
Crane	Common	16th Cent	Extinct	Britain
Great Bustard	Common	1838	Extinct	Britain[10]
Osprey	Common	19th Cent	Extinct	Britain*
Dodo	Common	1681	Extinct	Mauritius
Duck-billed Platypus	Common*(1815)*	1850	Extinct	Blue Mountains Australia
Red Kite	Common*(1500)*	1910	5 pairs left	Britain[11]
Passenger Pigeon	5 billion*(Ca 1600)*	1914	Last one died in captivity	N. America
Buffalo	40-60 billion*(1830))*	1991	Ca 5000	N America
Sea Eagle	Common*(1870s)*	2000	Extinct	Britain
Wolves	Large numbers*(Ca 1000)*	1486	Extinct	England
Ditto	Ditto	1576	Extinct	Wales
Ditto	Ditto	1743	Extinct	Scotland
Copper Butterfly	Common	1850	Extinct by collecting	England

*Now returning in small numbers

Table 3: The Total or Partial Extinction of Species - A Casualty List

Table 4 lists just a few of myriads of examples of the attrition of wild species. "*While some of this trail of destruction was the side effect of agriculture and some the deliberate result of hunting and commercial exploitation, it is also evident from contemporary texts that the idea of conservation and preservation of wildlife was mainly noticeable by its absence until comparatively recent times*". An English clergyman, Edward Hickeringill, sums up the mood of the 1700s, *"So noisome and offensive are some animals to human kind, that it concerns all mankind to get quit of the annoyance, with as speedy a riddance and dispatch as may be, by any lawful means."*

In 1533, Parliament passed an *act " requiring all parishes to catch rooks choughs and crows … extended in 1566 so that churchwardens … pay for the corpses of foxes, polecats, weasels, stoats, otters, hedgehogs, rats, mice ,moles, hawks, buzzards, ospreys, jays, ravens and kingfishers."*

Species	Date	No. Killed	Reason	Location
Ducks	1850s	31,200 per annum	Sport	Wainfleet
Wildfowl	1838-68	3,000 per annum	Sport	Lincolnshire village
Migratory birds	Today	200 million per annum.	Sport	Italy
Sparrows	1915-17	39,000	Wartime crop protection	Tring
Golden Eagle and eggs	1819-26	305	Preservation of fish & game for sport	Estate in Sutherland
Wild Quail	1898	270,000	Food	Paris market
Goldfinches	1860	14,000 per annum	Collectors	Worthing
Linnets	1830s	7,000 per week	Collectors	London

Table 4: Examples of the Effects of Sport/Food/Collection on Depletion of species

The reduction of wildlife in Europe was extensive. However, it bore little comparison to the impact resulting from expansion into the rest of the world. "*Explorers were stunned by the sheer profusion of wildlife in areas which had often seen little or no human settlement.*[12]*"*

Contemporary reports paint the picture of cornucopia in bright colours:

French explorer Pierre Radisson remarked in 1758 at Lake Superior on seeing, *"stores of fishes, sturgeons of vast bigness, and pikes seven feet long …"*;

the first Florida settlers in 1788 recorded, *"quantities of wild pigeons, parrots and other birds were so numerous that boatloads of eggs were taken"*;

late 18th century Captain Cook "*arrived in Australia and found that the sea was so full of fish they broke their nets and flocks of thousands of birds could easily be shot since they had no fear of humans*";

Joseph Banks enthused on butterflies, *"the air for the space of 3 to 4 acres were crowded with them to a wonderful degree; the eye could not be turned in any direction without seeing millions of them …"*;

Capt. Thomas Melville arriving in Sydney harbour saw vast shoals of sperm whales, *"we sailed through different shoals of them from 12 o'clock in the day till sunset, all around the horizon, as far as I could see from the masthead."*

Settlers took unrestrained advantage of this great natural new world larder. On islands, the effect was often devastating as species of flightless birds, having no natural predators, were not shy of humans and 90% of bird extinctions took place there. The most infamous of these, the legendary Mauritian dodo, killed by the combined efforts and partiality of *pigs, rats* and … *humans*!

In North America, two examples of unrestrained slaughter stand out in the 19th century. Bison, which originally numbered over 40 million, were culled at the rate of 3 million per year by settlers and, as a result, their numbers collapsed. Now, only a few thousand survive. In excess of five billion wild passenger pigeons were killed between 1840 and 1900, the last one dying in captivity in 1914. They were slaughtered for food and monetary gain.

The impact of man was to cause many once prolific groups of animals to be driven to, and often across the edge of extinction[13]. In parallel with all this, another type of human impact had devastating effects on indigenous wild life; the introduction of non-native species into foreign habitats.

Man brought along with him horses, pigs, cattle and sheep, not to mention stowaway rats and mice, wherever he went. Columbus introduced cattle and horses to the Americas in 1493 where they proliferated on the Great Plains; in Santiago there were over 600,000 sheep by 1614. Australia, where there were no hoofed animals before Europeans came along, had gained 100 million sheep and 8 million cattle by 1800. Bees were introduced into North America, Australia (where they outnumbered the native stingless bee) and New Zealand. Camels introduced to Australia were a failure and went wild. They are now regarded as a pest.

In the 1420s Portuguese settlers brought rabbits to an uninhabited island. The rabbits multiplied and ravaged the flora and the settlers' crops to such an extent that the settlers had to decamp to Madeira – minus rabbits, of course! Then one day, in 1859, the year Col. Drake struck the first oil well in Texas, one Thomas Austin, a farmer near Victoria who clearly had not heard of the Portuguese experience, introduced a few bunnies into Australia (for game!) and produced his own gusher! By 1950 half a billion[14] of these furry fast breeders went rampant on the continent despite numerous attempts to exterminate them along the way. When myxomatosis was introduced from Brazil, 99.8% died. In 1991, with immunity to the disease they were on the increase again.

Rats and mice were other plagues the settlers inadvertently brought wherever they went. These rodents ate the settlers own stores of grain and Jamestown, Virginia (1609) and Sydney (1790) were nearly wiped out as a result. In North America, ornamental starlings *"devastated populations of bluebirds and flickers;"* goats introduced to St Helena (1810) caused 22 out of 33 native species to become extinct; hundreds of European weeds took hold through out the US; artichokes and giant Mediterranean thistles in South America *"went wild and created huge impenetrable areas."* Because many of the plants' predators were left behind, their populations exploded; the prickly pear introduced for hedging in Queensland and NSW in 1829 went wild and invaded sixty million acres by 1935. Potatoes introduced into Colorado attracted, devastatingly, the Colorado beetle.

The mass slaughter of herds of bison and flocks of passenger pigeons illustrates well William Ophuls's[15] "Problem of the Commons". Because no one owned these animals, no one had an interest in killing them sustainably. Market forces ensured that people set out to bag the most in the shortest time for a 'fast buck' thereby ensuring their destruction. This principle has applied to whales and fishing and continues today despite international attempts at co-operation to prevent piracy of fishing grounds.

Fish produced an essential and cheap part of the European diet for many centuries. But overfishing herring in the Baltic occurred as early as 1500. This was followed by cod off the coasts of Western Europe. The real damage occurred in the late 19th century when factory ships were developed, and Newfoundland cod depleted beyond recovery. The same is now well known for the North Sea where cod, haddock, herring and others are under threat.

Whaling is a tragic tale of ignorance, or ignoring sustainability, whereby millions of the creatures were hunted to the edge of extinction to provide oil for, among other things, candles and street lights in the world's cities and meat in Japan. It was now the whales' turn to become one of the world's '*commons*'. Driven by greed and competition, schools of all types were hunted and depleted to the verge of extinction in area after area till it became uneconomical to hunt. The scale of the plunder is illuminated by a few statistics. In 1933, 29,000 whales produced 2.6 million barrels of oil, and only 33 years later 58,000 produced over 40% less, showing how fast the large adult whales were disappearing.

Table 5 shows unequivocally, how this destruction progressed between 1930 and 1980. Within a 50-year period, Iceland, Norway, Japan, Britain, America and other whaling nations managed to almost drive to extinction the world's largest mammals, by having no regard for sustainability and desiring only a quick return before the competition got in first.

Species	**Annual kill (1930s)**	**Annual kill (1960s)**	**Annual kill (1980)**
Blue	170,000	7,000	23 (1970)
Humpback	27,000	*No data*	200
Sperm	20,000	250,000	5,000
Fin	140,000	280,000	22,000
Sei	10,000 (1940s)	250,000	ca 20,000

Table 5: A (very) Brief Extract of Man's Relationship with the Whale

In 1946, the International Whaling Commission (IWC) was formed, and its members voted to continue the attrition despite scientific evidence to the contrary. Fifty percent of the whales slaughtered between 1900 and 1970 were killed in the period after the formation of the IWC. Eventually in 1982 the IWC allowed only 'scientific whaling' (to discover how the stocks were faring) and *"as many as 10,000 whales were being killed for scientific purposes although the value of the 'research' was far from clear and many of the animals ended up as meat in Japanese restaurants. ... In 1990 the IWC did not agree to end the moratorium but the pressure to resume commercial whaling remained strong."*

As a result, by the 1950s, many whaling companies folded and in 1960s the British whaling industry collapsed. Seals suffered a similar fate to the fur trade and wide-scale slaughter occurred until international pressure put a stop to it.

In almost every major sphere of their activity humans were destroying their environments and their fellow species at an increasing pace. Inevitably, and fortunately, public reaction was stimulated by far-sighted people who created movements aimed at conservation. Large areas of natural beauty and scientific interest were created through National Parks. During the 20th century there developed a reaction to the slaughter and such organisations as the Audubon Society and Sierra Club (US), RSPB (Britain), the WWF, Greenpeace and Friends of the Earth have campaigned for the preservation of the world's natural heritage, influencing public and government opinion towards conservationism. But although there are some success stories, these efforts may be too late. The world's flora and fauna are now sinking irretrievably beneath the flotsam and jetsam of mankind, aided and abetted by the illegal traders in a wide range of natural commodities, the latest one published in June 2006 being the poaching by Russian ships of illegal quantities of cod from the Barents sea.

Ponting summarises this chapter succinctly: "*The growing movement for conservation has succeeded in raising public awareness and has, on a small scale, achieved a number of important goals, but it has been overwhelmed by the tidal wave of destruction that continues to sweep across the world. ... Between 1600 and 1900 an animal species was* *made extinct about once in every four years. By the 1970s this has risen to …about 1000 a year.* [By1991] *about 25,000 species of plants, 1,000 species of birds (10% of the world's total) and over 700 species of animal …are on the verge of extinction. In the tropical forests about fifty species of plants and animals are being eliminated everyday. At this rate it is estimated that in the 1990s about 1 million species (almost 20 per cent of the total in the world) will become extinct."* Further comment is superfluous.

The next instalment continues with *Creating of the Third World.*

Endnotes

1. Clive Ponting is currently working on a revised and updated edition to be published in paperback by Pimlico in late 2006/early 2007.
2. Data found at www.ukagriculture.com/countryside/history of countryside.
3. An example of what is now happening all over again but this time due to man-made causes!
4. This has within just the last few decades motivated the developed nations to give aid to the third world with the culmination in 2005 of G8 resolutions to cancel the debt of several African nations.
5. Seen from today's perspective, this is nothing more than a recipe for environmental disaster and has largely come to pass. I personally find it incredible that any God would entrust *carte blanche* the resources of His earthly warehouse to a race which had no idea of how to care for it.
6. There is reason to believe that Malthus's ideas are a fundamental social law, and still valid. Many scientists think that the current population explosion will lead to famine, wars and civil unrest and populations will collapse as a result of the imbalance created by a cheap source of energy, namely fossil fuels. Many 'Peak Oilers' as they are known predict dire catastrophes once oil production declines and prices rise. Others calculate that we are already exceeding our ecological footprint by a factor of three, and without a warehouse of stored energy, a rebalancing of demand to supply is overdue.
7. GNP or Gross National Product is defined as Gross Domestic Product (GDP) plus the net inflow of labour and property incomes from abroad. For a region or country, the GDP is the market value of all the goods and services produced by labour and property located in the region or country.
8. I found this chapter the most difficult one to précis. It is packed with distressing accounts of Man's crimes against nature, and delivers a poor image of our race and ancestors. Nevertheless, one must bear in mind that their actions were a consequence of ways of thought so aptly laid out in the previous chapter. It is tempting to take solace in the thought that now, as the destruction of our environment is better understood, the changes in the way we think about our environment may pull us back from the brink – but I doubt it.
9. The damage has been more than just proportional to the rate of population growth because of the greater destructive power put into human hands by new technologies, such as those which enable us to locate fish by electronic devices.
10. In June 2006, *The Times* reported that a pair of great bustards were breeding again on Salisbury Plains in Britain following an absence of over 170 years.
11. Another example of success is the red kite which ten years after being released in Britain is now breeding again in parts of the Chilterns, East Midlands and in the South.
12. It was almost as though *Homo Sapiens Sapiens* was being given a second chance to visit the 'Garden of Eden', i.e. the world before the first great transition into agriculture (Ch. 4).
13. When we bear in mind that much of this happened in the first half of the 19th century, when the world population was around ¾ billion (Australia ca. 2 million, US < 15million), the carnage must have been conspicuous by its magnitude and wastefulness!
14. Only humans could exceed this level of reproduction in the mammal world, increasing *their* numbers by 3 billion over the same 91 year period!
15. William Ophuls is visiting associate professor of Political Science and Urban Affairs at Northwestern University. He has written *Ecology and the Politics of Scarcity* (1977), which won the American Political Science Association's Kammerer award in 1978.

CLIMATE CHANGE AND RISING SEA LEVEL – AN UPDATE

by John Nunn.

At the time of my review, published in the OPT Journal of October 2004, there was no firm evidence to indicate that the mean annual rate of sea level rise (SLR) had changed significantly from the rate of about 1.8 mm/yr, which seemed to have been constant during the last century.{1} New measurement techniques have now indicated a recent increase in the annual rate of SLR, which is here related to further new developments in the chain of causal factors.

Carbon dioxide emissions

The basis of the whole problem is the unprecedented increase in CO_2 emissions since the start of the industrial revolution in 1750. Between 5000 and 10,000 GtC* of atmospheric CO_2 had been sequestered as fossil fuels in the previous 350 million years. The resultant decline in greenhouse gas effect offset the gradually increasing power of solar radiation since that time, resulting in the world retaining a surface temperature compatible with liquid water and life as we know it. This is unique in the solar system. Mankind is now embarked on a novel and highly dangerous experiment in returning much of this long-term naturally sequestered CO_2 to the atmosphere in the course of only 300 years. Furthermore, this experiment is taking place during a prolonged interglacial, when temperatures are already high. Meanwhile the sun continues the gradual but relentless increase in its radiation.

Emissions for the whole world showed an exponential increase from the start of the industrial revolution up to 1970, the time of the first oil crisis (Figure 1). After this there was a slight decrease in the rate by which emissions were increasing, and there was even some hope of an approach to a plateau. However, from 1980 until 2003, there has been a fairly steady linear increase of about 80 MtC/yr, with no sign of an approach to a plateau. The percentage increase is slightly less than the increase in world population.

So many social, political, economic and geological factors govern emissions that it is difficult to predict what may happen in the future. The uppermost line of Figure 2 shows the current approximately linear increase for the whole world. The lowest line shows the minimal increase in emissions for Western Europe (0.26 MtC/yr), where several countries have made strenuous efforts to limit emissions. The broken line indicates emissions from North America (of which 86 % are from the USA), showing a mean increase of 16.2 MtC/yr. The dotted line shows emissions from Asia and Oceania (in 2003, 43 % from China, 15% from Japan and 13 % from India). Their emissions showed a mean increase of 55 MtC/yr, and overtook Western Europe in 1981 and North America in 1994. By 2003, Asia and Oceania accounted for 32.5 % of the emissions of the whole world.{2}

Per capita emissions for the whole world were 1.09 tC/yr in 2003, having decreased by 0.15%/yr since 1980. Western Europeans emitted 2.18 tC/yr with a mean decrease of 0.24%/yr. North Americans emitted 4.36 tC/yr with a decrease of 0.27%/yr. In sharp contrast, the value for Asia and Oceania in 2003 was 0.63 tC/yr having increased by 2.68%/yr since 1980. Within this group, Indians emitted 0.26 tC/yr, having increased by 5.1%/yr, while Chinese emitted 0.74 tC/yr, having increased by 3.9%/yr.{2}

As regards future projections, there are few grounds for optimism. With the increasing populations and massive growth of industrialisation in developing countries, particularly China and India, it seems inevitable that their emissions will continue to increase in the foreseeable future. China has 13% and India 10% of the world's coal reserves at a time when oil and gas prices are rising. In the last 10 years, the growth of coal consumption has been twice the average of all fuels, and China accounted for 80% of this growth. For an equal energy output, coal produces about twice the carbon emissions from gas.

If consumption of fossil fuels continues at the present rate, proven recoverable reserves of coal will last 155 years. The comparable life time for gas is much less (65 years) and, for oil, only 40 years.{3} Increased use of coal thus appears inevitable. It is unlikely that present trends will continue, and the Hadley Centre of the Meteorological Office predicts emissions of 14,284 MtC/yr by 2050 and 20,559 MtC/yr by 2100 (Jones, personal communication, 2005).

In the fullness of time, exhaustion of fossil fuels must inevitably limit carbon emissions. If all proven recoverable reserves of fossil fuels were burnt, there would be a release of carbon dioxide equivalent to almost 1000 GtC (mainly from coal). Assuming 56 % of this reaches the atmosphere (see below), one could expect the atmospheric carbon dioxide concentration to rise from the present 380 to over 600 ppmv. However, estimation of recoverable fossil fuel reserves is influenced by oil prices and, as prices rise, so will the reserves which are economically feasible to extract. Reserves may therefore expand in line with rising demand for several years, thus postponing the inevitable exhaustion of fossil fuels, as has been the case for oil and gas over the last 10 years, but not coal.{3}

Atmospheric carbon dioxide concentrations

During the last four interglacials, covering the last half-million years, atmospheric carbon dioxide concentration reached a maximum of about 290 ppmv.{4} This was also the case in the present interglacial until the start of the industrial revolution in 1750. Since then there has been a continuous exponential increase (as in compound interest), but with the exponential constant itself increasing (as with a progressive increase in the rate of compound interest). The current rate of increase has now reached 2 ppmv/year, which is about 200 times faster than at the end of the last four glacial periods.

Observations from 1960 until 2003 are shown in Figure 3. The dotted curve shows atmospheric CO_2 concentrations measured at Mauna Loa (Hawaii) from 1960 to 2003. The lowest curve is the simple exponential extrapolation to AD 2100. The upper continuous curve takes into account an exponential increase in the constant of the exponential increase as observed between 1750 and 2000 (comparable to a progressive increase in the rate of compound interest). This agrees quite closely with the multi-factorial predictions of the Hadley Centre. Both approaches indicate that, by mid- century, we may expect to exceed 500 ppmv. That would be the highest known CO_2 concentration since 24 million years ago, when the global mean temperature was about 9^{o}C higher than today.{5}

Currently slightly less than half of CO_2 emissions do not reach the atmosphere but disappear into sinks, of which the most important are the oceans, soil and vegetation. The first is largely a matter of physical solution and is relatively predictable: it does however increase the acidity of the oceans. Soil is a vast sink for root-derived organic carbon compounds, holding about 1,500 GtC, roughly twice the amount in the atmosphere,{6} and currently increasing by 2.8 GtC per year. There is now firm experimental evidence that rising soil temperature results in stimulation of oxidative metabolism of organic carbon compounds by soil bacteria, with net release of CO_2.{7} Global warming may thus reduce the capacity of the soil sink and have a positive feed-back on the rate of increase in atmospheric CO_2 resulting from carbon emissions. This could be extremely serious.

The third sink for carbon dioxide is vegetation, particularly forests (600 GtC[6]). Currently this sink is being progressively reduced by deforestation for agricultural use of the land and also for the supply of timber. The release of above ground carbon is immediate and total in the event of forest fires. The absorption of CO_2 by photosynthesis is currently believed to be about 100 GtC/yr, an order of magnitude greater than current fossil fuel emissions. An approximately similar amount of CO_2 is returned to the atmosphere by aerobic metabolic processes.

Global warming

There is no doubt that CO_2 is a powerful greenhouse gas, and continuing global warming appears inevitable in spite of the uncertainties in the two previous sections. However, there remains doubt on the timing and the magnitude of the changes.

World mean temperature has risen by 0.6^oC during the last century. The system has, however, considerable inertia due mainly to the thermal capacity of the oceans. Since 1950, 84 % of the thermal gain of the earth is in the oceans, some of it carried to a depth of at least 700 m.[8] Temperature change lags CO_2 change by many years.

In 2004, the IPCC estimated that the Earth would warm by between 1.4 and 5.8ºC by the end of this century, at which time the CO_2 concentration is likely to be considerably more than twice the present level. Much attention has been devoted to the expected temperature change for a doubling of the atmospheric CO_2 concentration. The Hadley Centre of the Met Office has estimated that a doubling of atmospheric CO_2 concentration would result in a 95 % probability of a mean global temperature rise between 2.4 and 5.4^oC.[9] The following year, computer modelling, which allowed for interaction between factors causing positive feed-back (see below), expanded the possible range of temperature response to 2 – 11^oC.[10] Whatever happens to world mean temperature, it is expected that northern latitudes will experience a change up to three times as great, as occurred during the last deglaciation; this is important for the melting of Greenland's glaciers and icecap.

The uncertainty expressed in the wide range of predicted temperature change is due to many feedbacks and factors which cannot be accurately predicted. For example, there will be positive feed-back due to reduced solar reflection (albedo) as sea ice gives place to open water, and terrestrial snow fields and glaciers disappear. Albedo is also affected by changes in the pattern of vegetation. A second positive feed-back is increased water vapour in the atmosphere as temperature rises. Water vapour is a more powerful greenhouse gas than CO_2. Potentially very powerful feed-back may be induced by release of sequestered methane, 21 times more powerful as a greenhouse gas than CO_2. There is already release of methane from melting of permafrost, which leaves signs of gaseous eruptions in tundra. However, far more threatening is the release from hydrates, with methane encased in "buckyballs" of polymerised water. The total quantity currently sequestered in this form is thought to be about 3,000 GtC. A previous release of methane from hydrates is believed to have resulted in the Palaeocene-Eocene Thermal Maximum, 55 Ma ago. A repetition of this serious event, as a positive feed-back to global warming, is considered low-probability but high-impact.

Certain human waste products, and major volcanic events, produce aerosols in the upper atmosphere, which reflect solar radiation resulting in a period of cooling. Aerosols formed around certain waste products are expected to decline and so further increase global warming in the next few years.{11}

The present interglacial has lasted much longer than the three previous interglacials, leading many to anticipate that its end must be approaching. The review of 2004 cites the evidence for believing that the geometry of the earth in relation to the sun is now in a phase where the previous pattern of alternating glacials and interglacials will be in abeyance for some tens of thousands of years, and no major decrease in insolation is anticipated. Those who cannot accept the reality of global warming often cite the mediaeval warm period (1000-1200 AD) and the "Little Ice Age" (1400-1900 AD) as examples of climate change without corresponding changes in green house gases. However, the magnitude and rapidity of onset of the present change is far greater.

Resultant effect on sea level

About 25 % of sea level rise (SLR) is currently due to thermal expansion (steric rise), which is difficult to calculate because the heating is highly variable in location and depth (see above). The remainder of SLR is due to the melting of grounded ice causing an increase in the mass of sea water (eustatic rise). Melting of floating ice does not affect sea level.

At present, the major areas of melting of grounded ice are Greenland and West Antarctica, with the ultimate potential of raising sea level by 7 m and 4-6 m respectively. High northern latitudes are warming at about three times the mean rate of the world, and Greenland poses the immediate threat to SLR, with its contribution to eustatic rise increased from 0.23 mm/yr in 1996 to 0.57 mm/yr in 2005.{12}

The latest information is based on satellite observations of global SLR and also the movements of the outflow glaciers of Greenland, recently published as a major group of papers in *Science* on 24 March 2006. Certain large outflow glaciers have approximately doubled their speed between 1996 and 2005, resulting in the net loss of ice doubling to reach 224 $\pm$41 km^3/yr. This is partly due to warmer sea water melting, and so undercutting, the snouts of glaciers, which then collapse into the sea. In addition, summer surface melt water tends to penetrate a glacier through moulins (glacial conduits) and lubricate its bed. Greenland glaciers lurch forward periodically to produce glacial earthquakes which are now being recorded on seismometers worldwide. The incidence of these events is rapidly increasing. Acceleration of outflow glaciers will eventually lead to a thinning of the Greenland Ice Sheet (GIS), and modelling has indicated that it will be warm enough for thinning to have started during this century, and the GIS might disappear during the next millennium. It is also thought that summer Arctic sea ice may disappear by the end of this century.

Similar changes to glaciers are occurring in West Antarctica, particularly the Antarctic Peninsula. However, the rate of temperature rise is less than in comparable northern latitudes, and the contribution of West Antarctica to eustatic SLR is currently only about two thirds that of Greenland. However, it seems certain to increase.

SLR, as measured by tide gauges, was 2.35 mm/yr in 2000, and was predicted to reach 3.65 mm/yr by 2100.{1} However, a recent SLR of 2.6 $\pm$ 0.04 mm/yr has been reported and satellite altimetry has recorded 3 mm/yr.{13} We thus appear to be already approaching the rate of SLR predicted for 2100. If present trends continue, it is expected that sea level will be 0.28 – 0.34 m above that of 1990 by the end of this century. A highly relevant comparison has been made between current changes and those in the last interglacial (130

– 127 kyr ago), when temperature was barely 2°C higher than today, but sea level was 4 – 6 m higher.{13} It now seems that SLR could be moving in the direction of 11 mm/yr, which occurred during the millennia immediately before the last interglacial.

There are still too many uncertainties to give firm predictions for the future. However, if the latest changes continue to accelerate, the predicted upper limit of SLR of 0.34 m for the present century will almost certainly be exceeded. A rise of 0.5 m has been suggested for the end of the century, and the process is likely to continue into the next century. Total melting of Greenland and West Antarctica would raise sea level by 12 m.

Population and arable land are heavily biased towards low lying land, which must inevitably contain all the ports of the world.{14} Parts of Holland, East Anglia and some coastal parishes of Louisiana are below sea level, and a great many other heavily populated areas would be threatened by SLR of more than a meter, particularly Bangladesh. Rising sea level must inevitably result in not only the eviction of many people from their homes, but also involve the loss of much exceptionally fertile land.

SUMMARY

The world seems set to continue increasing carbon emissions until finally limited by the exhaustion of fossil fuels. That could take more than a century and would probably increase the atmospheric CO_2 concentration from its present level of 380 ppmv to the highest for at least 24 million years, a period when the earth was some 9°C hotter than at present. Sea level rise (SLR) is due to thermal expansion and the melting of grounded ice. It has only recently become clear that the latter is now rapidly increasing and will continue to do so. Predictions for 2100 include a temperature increase within the range 2.4 – 5.4°C and a sea level rise of 0.35 - 0.5 m.

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Endnote

* Quantities of carbon dioxide are here cited in terms of the mass of carbon, GtC or MtC (billion (10^9) or million tons of carbon). They may alternatively be expressed as the mass of CO_2, for which conversion the carbon number should be multiplied by a factor of 3.66. It is always important that the units should be stated, as both systems are in use.

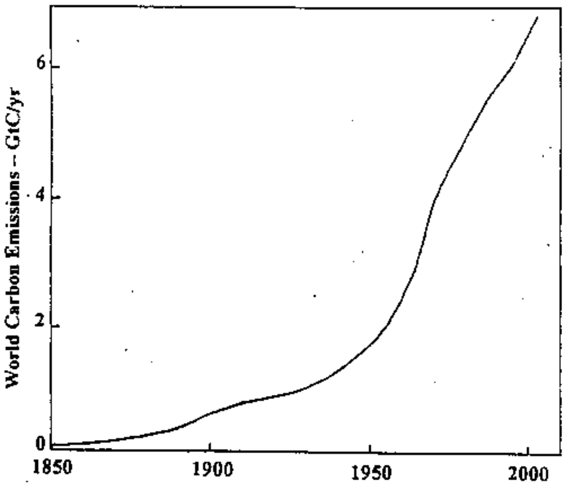

Figure 1. Whole world carbon emissions from burning fossil fuels in giga (10^9) tons of carbon per year. For giga tons of CO_2, the carbon emissions should be multiplied by 3.66.

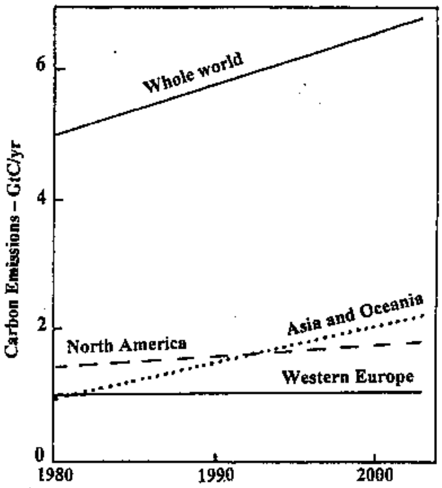

Figure 2. Regional carbon emissions between 1980 and 2003. The increase contributed by North America (broken line) and by Asia and Oceania (dotted line) together account for 83% of the total increase for the whole world.

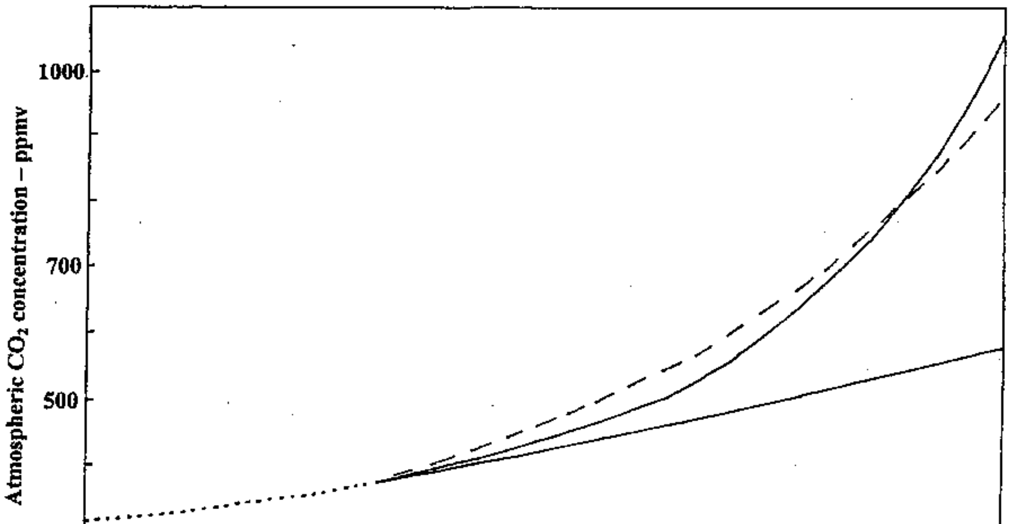

Figure 3. The dotted curve shows atmospheric CO_2 concentration (measured at Mauna Loa Hawaii) from 1960 to 2003. The lowest curve is an extrapolation to 2100, based on the assumption that the exponential increase from 1960 to 2000 continues unchanged. The upper continuous curve is an extrapolation based on the assumption that the exponential constant (as for the rate of compound interest) itself increases exponentially as it did for the 250 year period between 1750 and 2000. The broken curve is the prediction of the Hadley Centre of the Met Office (personal communication, 2005).

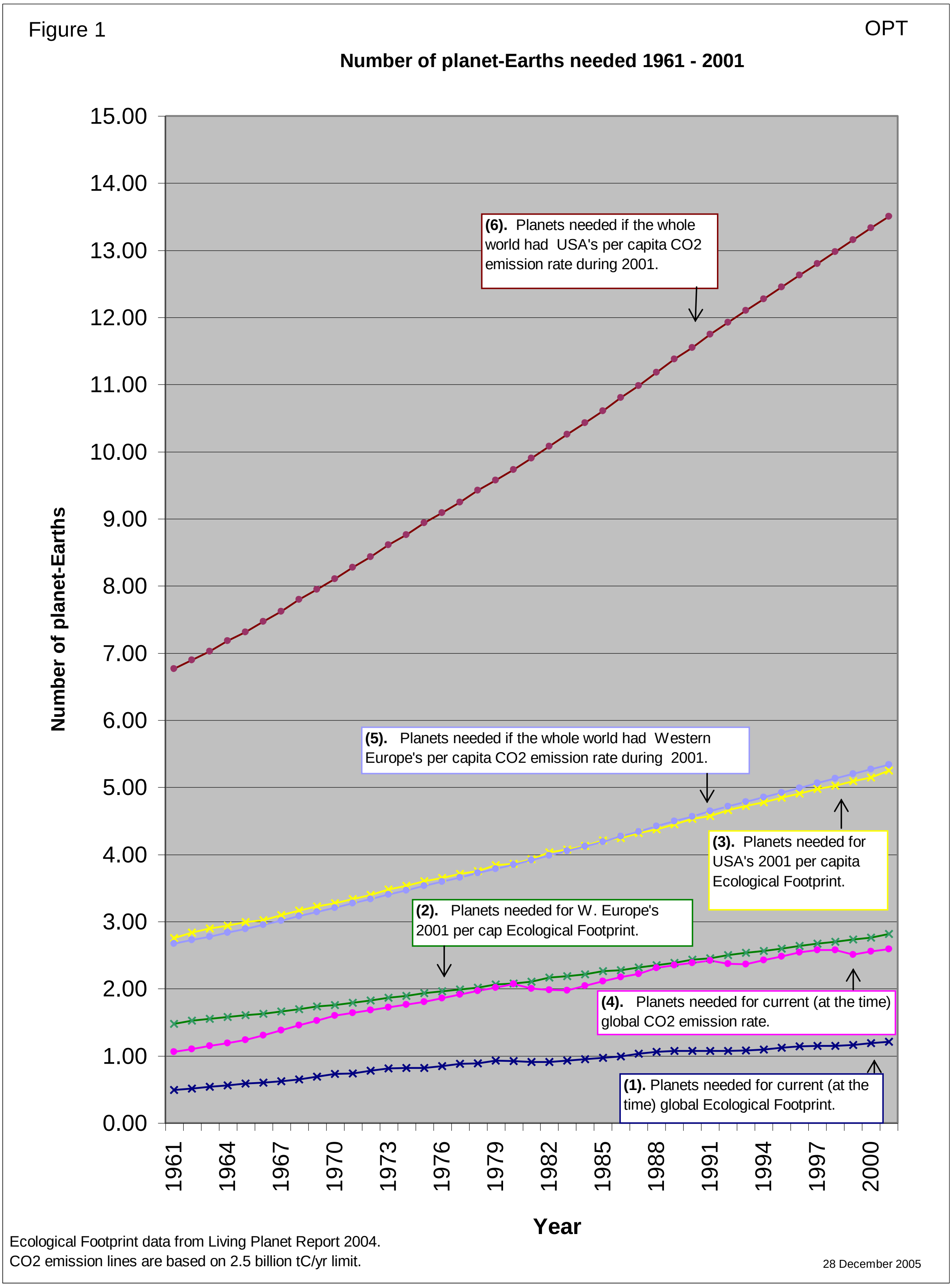
Figure 1
OPT
Number of planet-Earths needed 1961 - 2001
Number of planet-Earths
Year
(6). Planets needed if the whole world had USA's per capita CO2 emission rate during 2001.
(5). Planets needed if the whole world had Western Europe's per capita CO2 emission rate during 2001.
(3). Planets needed for USA's 2001 per capita Ecological Footprint.
(2). Planets needed for W. Europe's 2001 per cap Ecological Footprint.
(4). Planets needed for current (at the time) global CO2 emission rate.
(1). Planets needed for current (at the time) global Ecological Footprint.
Ecological Footprint data from Living Planet Report 2004.
CO2 emission lines are based on 2.5 billion tC/yr limit.
28 December 2005

PLANETS FOR ECOLOGICAL FOOTPRINTS AND CARBON ABSORPTION

by Andrew R.B. Ferguson

In 1865, William Stanley Jevons, a Victorian economist, wrote thus about the basis of English material prosperity:

> The plains of North America and Russia are our cornfields; Chicago and Odessa our granaries; Canada and the Baltic are our timber forests; Australia contains our sheep farms, and in South America are our herds of oxen,… our coffee, sugar, and spice plantations are in all the Indies. Spain and France are our vineyards, and the Mediterranean our fruit garden. (*The Coal Question*)

So a century and a half ago, the essence of the idea of Ecological Footprints was understood; namely that each person requires ecological space, wherever it may be located.

The Ecological Footprint concept added to this an awareness that ecological space is also required to provide energy on a sustainable basis. That is an important addition, as we are entering the phase of human existence when fossil fuels are becoming scarce.

In Figure 1, the concept of each person needing an Ecological Footprint is presented as the number of planet-Earths that would be needed to support the existing population *sustainably*. The most usual exposition of the data, namely line 1 on the graph, is misleading in that the Footprints being considered include those of some 860 million people who are hungry, plus all those who suffer from malnutrition (about half the world), and many suffering from shortages which are too well known to need rehearsing.

Thus a better guide to the number of planets required to sustain humans is line 2, which relates to the Footprints of western Europeans. It is apparent that, by 2001, it would require 2.8 planets to support the existing population of 6.2 billion in western European comfort. Thus the actual population which could be supported would be 1 / 2.8 = 36% of 6.2 billion, namely, 2.2 billion.

It could sensibly be argued that western Europeans are consuming more than they need to. That could certainly be said about the Americans. Line 3 shows that for everyone to sustainably follow the American lifestyle, 5.2 planets would be needed.

An aspect that William Stanley Jevons did not consider, and which is not reflected in the methodology of assessing Ecological Footprints, is the problem of excess carbon emissions, related to the limit of the Earth's absorption capacity, 9 billion tonnes of carbon dioxide a year (as per the IPCC's long-standing statement on the matter). Lines 4, 5 and 6 show the sustainable population constraints which would result were all of the 'current' world population to be emitting at the rates of (a) annual world average emissions, (b) Western European 2001 emissions, and (c) USA 2001 emission rates, respectively.

Most dramatic is line (6). Were the whole world to be emitting at the American 2001 per capita rate, then 13.5 planets would be needed, or conversely — as planets are not easy to come by — 1 / 13.5 = 7% of the 2001 population could be sustained.

A particularly alarming aspect of this is that with the US population standing at 4.6% of world population in 2001, and its population expanding at 1.06% per year, in only 40 years from now the USA will need *one planet all to itself* in order to absorb its emissions.

Figure 1 encapsulates many of the problems facing humanity. It does not show everything. It is arguable that western Europeans could live acceptably with only two-fifths of their present energy use. Altering the spreadsheet to reflect that, causes line 2 to move down, so that in 2001 the number of planets needed would be 1.8. But we must remember that, in a reduced-energy world, it will be virtually impossible to maintain current high agricultural yields. A sustainable world population is likely to be around that suggested long ago by David and Marcia Pimentel, in *Food, Energy, and Society*, 2 billion.

PLANET EARTH: USERS AND LOSERS

by Sangeeta Sonak (The Energy and Resources Institute), India. sangeeta.sonak@gmail.com

In *Steady-state Economics* (1992), Herman Daly encapsulated humanity's problems thus:

> The starting point in development economics should be the "impossibility theorem" mentioned in Chapter 1: that a U.S.-style high mass consumption economy for a world of 4 billion people is impossible, and even if by some miracle it could be achieved, it would certainly be short lived.

In 1977, when the first edition of Daly's book was published, the truth of that assertion was already evident, as Figure 1 makes clear. By 2001, the truth of the assertion was amplified to the extent that 13.5 planet-Earths would then be required to provide adequate carbon absorption were everyone to emit carbon dioxide at the rate of Americans in 2001.

Excessive carbon dioxide emission is just one way that a nation may impose an excessive burden on the Earth's biological capacities. It is evident that the carbon cycle of the Earth system is out of balance today. The major source of increase in CO_2 concentration is emissions from burning of fossil fuels. While much of these emissions originate from countries in the North, it is well accepted that their impacts are largely felt by the countries in the South. Several studies have shown that climate change associated with increasing levels of carbon dioxide is likely to affect developed and developing countries differentially, with major vulnerabilities occurring in low-latitude regions (Darwin and Kennedy, 2000; Reilly et al., 2001). Developing countries are more vulnerable to the effects of climate change than those that are more developed (Thomas and Twyman, 2005). In other words, unfortunately, communities that have contributed least to the carbon emissions are likely to bear the most severe impacts of these in the form of loss of livelihood, challenges of extreme events and impacts on human health. Increase in carbonates absorbed by the world's oceans also changes ocean chemistry leading to degradation of coral reefs (Steffen et al, 2004) and subsequent impacts on fishery.

Within this context, the ecological footprint serves as an important yardstick in measuring global sustainability, as it combines both the consumption patterns (per capita) and the population pressure (the national footprint). It is clear that there is a vast difference in per capita resource consumption between different countries. In order to demonstrate this difference, Rees and Wackernagel (1994) developed the concept of the 'ecological footprint' (EF). EF analysis carried out by Rees and Wackernagel (1994) reveals that a number of developed countries survive by importing surplus carrying capacity of developing countries. However the ecological footprint has some limitations. These are apparent from line 3 of Fig. 1, which shows that, in 2001, 5.2 planets were needed for all 6200 million people to live in US style. 5.2 is a lot less than 13.5. The reason is that a substantial part of an ecological footprint comprises the energy component. That energy component is no guide to carbon absorption, but it is a good estimate of the ecologically productive land needed to provide energy from renewable resources. Thus we can say that for all to live *sustainably* in an American lifestyle, 5.2 planets would be needed.

With some intimations of fossil fuels becoming scarce, perhaps everyone is ready to accept that the whole world will not be attempting to live an American lifestyle. So a more useful line to look at is line 2, which shows that by 2001 the number of planets needed for all 6200 million to enjoy a western European lifestyle would be 2.8. Conversely, the indication is that only 6200 / 2.8 = 2200 million people could sustain that lifestyle.

In 1990, the transportation sector was responsible for about 25% of the world's primary energy use and for 22% of CO_2 emissions from fossil fuel use (IPCC, 1996). Of this, leisure related travel in the North accounted for about 50%. Gossling (2002) suggests that industrial countries of the North with a population of 900 million undertake leisure travel of 6570 billion passenger kilometres (pkm) per day, whereas, developing countries with a population of 4750 million undertake leisure travel of only 867 pkm per day. The industrialized countries, which constitute only 15% of the world's population, account for 82% of the global leisure-related transport (Gossling, 2002).

There are arguments for the possibility of reducing the use of energy to only 40% of current western European energy use (the assumption applies only to an average climate). That adjustment indicates that a population of 3400 million is sustainable. But world population is already 6500 million So what is to be done?

The ecological footprint of each Indian is, on average, so small that it would require only 0.7 planets to accommodate all 6200 million people who were alive in 2001 in average Indian lifestyle. But there are political realities that cannot be avoided. The South is no more willing to continue to live in poverty than the North is to become impoverished. It is clear that the North needs to listen to the South when told that their oversize footprints are taking too large a share of the Earth's ecological capacity, and the South needs to listen to the North when implored to remember Herman Daly's "impossibility theorem."

For the South, the 13.5 planets needed for everyone to emit carbon dioxide at the rates of the USA is critical. 13.5 planets indicates that only 6200 / 13.5 = 460 million people could be sustained at that rate of emission. As mentioned earlier, the IPCC (The Intergovernmental Panel on Climate Change) has stated that it is likely to be the South rather than the North that will suffer worst from climate change, so it makes sense for the South to urge the North to reduce both their population and their per capita emissions. **The global per capita ecological footprint is being subsidised by the South.**

The South, on the other hand, needs to heed the problems that it is bringing on itself. There are many problems which make it difficult to assess the size of ecological footprints accurately, e.g. (a) tourism (Sonak, 2004), (b) wastage, and (c) energy spent in mining energy resources that are then exported. It is somewhat more reliable to assess the biocapacity that is available to nations (Ferguson, 1999). When biocapacity is displayed alongside rates of population growth, the future of some countries becomes only too clear. Any nation is in an unsafe position if it has approximately — or might soon have— less than 0.5 global hectares of ecologically productive land per person. Using figures from the Population Reference Bureau data sheet (PRB, 2001), and the *Living Planet Report 2004* (WWF, 2004), figures for 2001 can be tabulated thus:

	Natural pop. incr. % per yr	So doubling time in yrs	Biocapacity in global ha/cap
Pakistan	2.8	25	0.4
Bangladesh	2.0	35	0.3
Rwanda	1.8	39	0.5
India	1.7	41	0.4
China	0.9	78	0.8

Contrast these figures with the USA. The natural rate of population increase in 2001 was 0.6% per year. Because of inward migration, the actual rate during the last three decades of the past century was 1.06% per year. Note that this US rate is higher than that of China. But where the United States differs from all of the above is the biocapacity available per person. Americans have 4.9 gha per capita. While that is about ten times the size of the above countries, it is not excessive compared to Finland, Sweden, and Norway, which have 12.4, 9.8, and 6.9 gha/cap respectively. All three nations should manage to sustain their populations in tolerable comfort without fossil fuels. With less biocapacity, but similar hard winters in much of the United States, the US is beyond the point at which sustainability — at an acceptable standard of life — seems likely. For every US citizen to enjoy an adequate supply of food and fuel *without the benefit of fossil fuels*, the US needs to reduce its population to about 200 million (Pimentel et al., 1996, 1998).

For the South, or indeed anywhere that biocapacity is around 0.5 gha per person, it is impossible to see anything but a temporary move — and only for an elite — toward western European affluence, because of the approaching demise of fossil fuels combined with excessive population density (as related to ecological capacity).

However, an important point that is being missed in the debate is that the biocapacity of the South is being reduced by the affluent lifestyles of the North. The ecological footprint not only underestimates carbon emissions, but also fails to incorporate reduction in biocapacity that will occur as a result of these emissions. Carbon emissions associated with increased global temperature and sea level rise result in changes in precipitation patterns and monsoon cycles ultimately leading to land degradation and reduced productivity. These impacts are largely felt in the low latitude countries, where majority population depends on climate sensitive sectors such as agriculture, forestry and fishery. In overview, while population of the North uses Earth capacity beyond sustainability limits, marginal population of the South loses benefits from biocapacity of the Earth system.

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POPULATION LIMITS AND ENVIRONMENTAL RESOURCES

by David Pimentel (College of Agriculture and Life Sciences) and Marcia Pimentel (Division of Nutritional Sciences), Cornell University, Ithaca, NY 14853. USA

Are the earth's resources vast enough to support ever increasing human numbers? Even if a policy of 2 children per couple were to be adopted tomorrow instead of the current 2.7 children, the world population would continue to increase for approximately 70 years. The 'population momentum', based on the current young age distribution in many countries, would power this continued population growth. In the event of the current rate of population growth,1.2% a year, slowing to zero during the next 70 years, by the end of the period world population would be about 10 billion.

Significantly more people inhabiting the earth will require more food, more water, more shelter, more energy, and more jobs. Signaling the serious impact population numbers are having on human health is the recent World Health Organization report that indicates more than 3.7 billion people now are malnourished. This is the largest number and proportion of malnourished ever in history. Malnourishment is a serious disease, for it increases the human susceptibility to other major diseases, like malaria, diarrhea, and AIDS. Furthermore the sick and diseased find it difficult to work productively and even enjoy their daily existence.

Per capita shortages of basic food resources are responsible for much of this malnutrition. Poverty, political unrest, as well as inadequate or unfair distribution of food supplies also contribute to inadequate food supplies.

Cereal crops are the mainstay of human diets, comprising about 80% of the world food supply. Yet food availability per capita as measured by cereals has been declining for more than 20 years. This is true despite all the advances in biotechnology and improved agricultural production.

As population numbers expand, human life activities spread ever farther over the land with houses, roads, and industries. For example, each additional person added to the U.S. population requires 1 acre (0.4 ha) of land just for urbanization and highways. With these changes, prime cropland, pure water, and other life-supporting environmental resources are diminished. Currently in the world there is only 0.23 ha of cropland per person compared to the level of 0.5 ha needed for a food system similar to that in the United States.

About 99% of world and U.S. food (calories) is produced on land while 1% is wildcatch from oceans and other aquatic ecosystems. Productive agriculture requires ample supplies of fertile cropland, sunlight, and water. Worldwide soil erosion is diminishing the productivity of soils and causing the loss of vital cropland, at a time when food production should be increasing. Crop production also requires both renewable and fossil energy for cultivation, fertilizers, pesticides, and irrigation.

Without water, neither humans nor crops survive. Growing crops require large amounts of water. One hectare of corn uses 5 million liters (500,000 gallons/acre) of water just during its growing season. In arid regions like Arizona, water is being pumped from aquifers 10 times faster than the recharge rate by rainfall. Further problems exist because water resources are shared within and between countries and disputes over water resources are increasing.

Perhaps the most serious threat to world and U.S. food production are emerging shortages of finite oil and natural gas supplies. Worldwide, the projections are that oil and natural gas resources will be mostly depleted within the next 40 to 50 years.

With only 4% of the world population, the U.S. consumes 25% of the world's fossil fuel. Approximately 1,900 liters (500 gallons) of oil equivalents are used to feed each person in the U.S. An estimated 6% of total U.S. fossil energy is utilized directly as agricultural inputs to food production, with a further 7% used in processing and packaging, plus 6% in distribution and preparation.

The U.S. is importing 63% of its oil and more than 25% of its natural gas, both vital to the food system. Americans must begin to seriously reduce their energy consumption for food, as well as for other purposes, by more than one half in the future, since oil and natural gas supplies are projected to be reduced significantly in the near future. Fortunately, the U.S. has 50 to 100 years of coal resources, but the use of coal has serious pollution risks and technologies must be implemented to reduce these risks.

Energy conservation, combined with the development and use of renewable energy sources, should receive high priority. Moving to renewable energy systems (including biomass, hydropower, wind power, photovoltaics, solar thermal, and a few other systems) for the U.S. will require nearly 20% of the total land area. Although the use of such land will impact some pasture and forest land, it should not cause any loss in cropland. However, even being optimistic and using 20% of American land for renewable energy, only about 46% of current energy consumption can be realized. Furthermore, the cost of renewable energy is projected to be 2 to 3 times higher than current fossil fuel costs, and the problem of producing liquid fuels in sufficient quantity remains unresolved.

Simply put, the earth cannot supply adequate quantities of energy, land, and water resources to meet human needs based on the current rapid human population growth. Not understood is the fact that the U.S. population, powered by immense numbers of illegal and legal immigrants, is growing twice as fast as China! The U.S. now has nearly 300 million people, whereas its ideal population, based on the availability of its natural resources, is only 200 million.[1] For the world, instead of the current 6.5 billion, the ideal population is estimated to be 2 billion.[2]

With rapidly declining oil and natural gas supplies worldwide, the current serious food shortages, and the increasing water shortages, plus overall destruction of the natural environment, humans must recognize this critical situation.

Whether humans have sufficient knowledge, wisdom, and courage to make the necessary adjustment in their numbers is not predictable. Without action to conserve vital environmental resources and to begin the reduction of the human population growth rate, devastation of the earth's resources is inevitable.

Endnotes

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This is a contribution to the Forum pages in *Renew*, the newsletter of the Network for Alternative Technology and Technology Assessment. I sent it together with the calculations as background information; it is introduced here without them, as it is mainly to set the scene for the *Lagoons of Silence* piece that follows.

The 20% "Uncontrollables" Limit

David Milborrow of the BWEA wrote a short piece in your pages (*Renew* 154) saying that he thought that "variable" was a better adjective to describe the output of wind turbines than "intermittent." Spain now has some 10,000 MW of installed wind power. Its recent experience provides a good example of why an appropriate description of the output of wind is "uncontrollable." The same is true of some other renewables.

Daily graphs of power output from wind turbines are available from the Spanish utility REE at <http://www.ree.es/>. The wind profile for the 19th June 2006 is instructive, particularly if we examine how it would apply to the UK, were the UK to have 20% of its electricity supplied by wind turbines.

On that basis, there would be the occasional day, such as 19 June in Spain, when all the wind turbines in the UK would produce only an average of 750 MW from midnight until 1300 hours (dropping to 125 MW at 9:35 in the morning). Over the next six hours this would increase fairly steadily to 5700 MW and be maintained from 1900 to midnight. Thereafter is open to speculation, but of course there is a possibility of this being followed, on occasions, by a few days of windy weather over a wide area, leading to the wind turbines producing their collective peak infeed, amounting to 24,000 MW. That output would be only slightly less than the figure for the UK low demand for electricity.

David Milborrow wrote an article musing on why the effects of wind variability were so contentious (*Renew* 157). Perhaps you could persuade him, or someone else in BWEA, to explain how they think that such uncontrollable power input, varying from less than that of a 1000 MW power plant, to 30 such plants operating at 80% capacity, can be handled without considerably impairing the efficiency of the controllable (conventional) plant, and without having such plant both available for use when the wind is producing only 750 MW and standing more or less idle when it is producing 24,000 MW.

Perhaps, too, the BWEA would like to go on to explain what is to be done with the proposed additional 30,000 MW of uncontrollable power — proposed to be coming from Wave, Tidal currents, and PV — at times of low electrical demand, when the wind is already supplying 24,000 MW. The proposal was on the cover page of Renew 155, with the DTI / Carbon Trust given as the source.

There are occasions when the BWEA deems that silence is their best defence, so I won't count on hearing from them. But I was impressed by Bob Everett's thoughts on the difficulties of dealing with variability in Renew 161. Maybe we will hear from him as to whether he agrees that the key division within "renewables" is between "controllables" and "uncontrollables;" that wind, wave, tidal stream, and photovoltaics are all "uncontrollables;" and that all uncontrollables combined are limited to supplying about 20% of total electrical supply, due to their uncontrollable nature.

Andrew R.B. Ferguson

LAGOONS OF SILENCE WITHIN THE RENEWABLES LOBBY

by Andrew R.B. Ferguson

Abstract: Many awkward problems arise when introducing "uncontrollables" into the electrical power system. They are problems which the renewables lobby would rather not talk about. This paper draws attention to the problems of: a) variability, b) the clash with nuclear power, c) the additive effect of uncontrollables, d) the need for curtailment of uncontrollables even at a fairly low penetration, and e) the unknown inefficiencies that are imposed on the rest of the system by uncontrollables.

When I submitted the preceding piece for possible publication in the Forum section of the NATTA newsletter, *Renew*, Dave Elliott, the editor, commented that I had adopted a somewhat hectoring tone towards the British Wind Energy Association (BWEA), and suggested that I needed to justify my assertion that the organization tends to remain silent whenever inconvenient matters are raised. I am very ready to do that.

First, I should say that I was trying to keep the mooted Forum piece as brief as possible, so the BWEA stood surrogate for Friends of the Earth, Greenpeace, the Sustainable Development Commission, UKERC, and other organizations which, for one reason or another (often just wishful thinking), want to bolster support for renewables. They all appear to avoid awkward realities. Let us now look at exactly what those realities are.

The German utility E.ON Netz made it amply clear in their Wind Report 2004, that there needs to be controllable power plant available *in addition* to the peak capacity of the wind turbines, and not *in substitution* for it. They were referring to wind turbines, and what they were stating is the rather obvious fact that controllable plant is needed which has a capacity equal to the likely peak output from all the wind turbines operating together.. This is how they put it in that report:

> In order to cover electricity demands, traditional power station capacities must be maintained as so-called "shadow power stations" at a total level of more than 80 % of the installed wind energy capacity

These are hard things to write about clearly, and in their subsequent Wind Report 2005, they said essentially the same, although unfortunately there was a mistranslation of the German into English; but the error was obvious, and this is the corrected translation:

> Consequently, in order to guarantee power supply at all times, there must always be sufficient capacity available from traditional power stations to cover at least 90% of the rated capacity of the installed wind turbines.*

David Milborrow, technical consultant retained by the BWEA, wrote a two-page feature article titled *Wind — Why so contentious?*, which appeared on pages 20-21 of *Renew* 157. He referred to the E.ON statement, but instead of accepting it as a fairly obvious fact, he confused the issue by quoting from the Sustainable Development Report to the effect that, "*With wind supplying 10% of electricity, estimates of the additional reserve capacity are in the range of 3 to 6% of the rated capacity of the wind plant. With 20% wind, the range is approximately 4 to 8%.*"

Milborrow is there addressing an entirely different matter, namely the amount of *online* reserve that is needed. There, and in the rest of the article, he simply ignores the point that, as noted by E.ON Netz in both their reports, wind capacity is in *addition* to and not *in substitution* for the power output of controllable plant.

Another point arises from the same article. He quotes an "early analysis" as saying, *"... there is no operational necessity of associating storage plant with wind-power* *generation, up to a wind output capacity of at least 20% of system peak demand*." But he is silent about how that statement can mislead the uninitiated. Since wind capacity factors in the UK are about 30%, his 20% is an actual wind power production of 0.30 x 20 = 6%. 6% of peak demand is about 9% of mean demand. So what the quoted "early analysis" is actually saying is that storage is not necessary when wind is providing 9% of electricity. Could the silence about capacity factors arise from the hope that the reader will interpret the quotation as being more encouraging than it is?

It is not only the BWEA, but all the renewable lobbies, that want to keep quiet when it comes to discussing one particular aspect of nuclear power. When nuclear power is suggested, the renewable lobby only complains that investors will choose to invest in nuclear power rather than renewables, thus making life difficult for the renewables sector. What they keep silent about, presumably thinking that the argument would only draw attention to the problem of uncontrollables, is that the use of uncontrollables has to be *diminished* in proportion to the extent to which nuclear power is *increased*. Taking the matter to the extreme clarifies the point. If nuclear power generated *all* the electricity needed to satisfy minimum system demand, then there would be no room at all for uncontrollables. For example, if one introduced some tidal stream power into that mooted nuclear energy situation, then one would need someone with powers exceeding those of King Canute in order to stop the tide from rolling in!

I am willing to be corrected on this, but it appears to me that *all* the renewable lobbies are keeping quiet about the fact that each uncontrollable power source compounds problems introduced by a preceding uncontrollable. Thus, for example, if wind and PV are capable, at their combined peak output, of meeting low system demand, then adding wave capacity would produce power *in excess* of low system demand. Of course the extent to which one is prepared to waste renewable energy in order to cope with uncontrollables is open to debate. Both Australia and Germany (at their still fairly low wind penetration) have spoken about the need to have some control over wind power by being able to let it go to waste on occasions. Energy consultant Hugh Sharman, in a paper for *Civil Engineering*, "Why UK wind power should not exceed 10 GW," said:

> It is clear that 5 GW, just two-thirds of what is already operating and planned [in Scotland], will be unmanageable unless turbines are shut down. Such 'wind curtailment' is already widely used by German utilities, which have great difficulty coping with a level of wind penetration that is only 0.2 kW per capita. Curtailment of output, as a policy, is a curious solution when wind power is already three to four times more expensive than conventionally produced energy. Furthermore, when its output is curtailed, no thermal MWh are displaced, so its value is further eroded. Although the words 'wind curtailment' appear in unofficial remarks about the UK's energy planning, no official acknowledgement is made that in the absence of very expensive technical solutions, such as storage or the construction of large inter-connectors, it is the all-but inevitable solution.

If someone can show me that the BWEA has not only addressed Sharman's point, but has also drawn attention to the facts that, (a) other uncontrollables would exacerbate the problem, (b) the introduction of nuclear power would diminish the role of uncontrollables, and (c) no one knows how much the introduction of uncontrollables diminishes the efficiency of the rest of the system, then I will withdraw my assertion that there are many things about which the BWEA deems it expedient to remain silent.

* The original German reads: "Dementsprechend müssen herkömmliche Kraftwerkskapazitäten in der Größenordnung von über 90 % der installierten Windkraftleistung weiterhin dauerhaft vorgehalten werden, um jederzeit die Stromversorgung sicherzustellen."

WHY POPULATION CONCERNS ARE NOT 'POLITICALLY CORRECT'

by James P. Duguid. Oaklands, Merlewood Road, Inverness, IV2 4NL, Scotland.

The great American ecologist Garrett Hardin noted the harmful tendency of Western politicians and media to avoid considering the role of population pressure in causing, enhancing and multiplying many of the troubles of mankind. This Hardinian taboo became most severe in Britain after about 1980, when heavy net immigration began to contribute largely to the overgrowth of the already crowded population.

In his recent book, *The Treason of the BBC*, Jack Parsons describes how in forty years of correspondence with the BBC, he failed to get it to include a mention or discussion of the probable role of overpopulation in exacerbating many of the political, economic, social and environmental troubles it was vividly portraying in its documentary programmes.

How and why did the ban come about? The studies of Malthus and Darwin showed that all living creatures, including man, evolved to produce far more offspring than needed to replace the adults dying at maturity. Populations therefore press over the limits of the resources of their territories, and so have to struggle violently to defend their territories and resources, or to seize those of others. Inevitably, under such natural conditions, human communities suffer a heavy death rate, and much want and suffering in children and innocent people.

This grim picture of reality is wholly incompatible with a mistaken conception of Christian doctrine increasingly held by comfortable members of Western societies. The 'new age' Christians believe that the world and its creatures were designed and created by an all-wise, all-powerful, benevolent and fatherly God for the enjoyment of mankind. To support their belief, and explain why the innocent are allowed to suffer, they are forced to assume that suffering is caused by human greed and sin. Latterly, they commonly blame capitalism, political corruption, and European and American imperialism. In effect, they teach that *if everyone cared enough and shared enough, everyone would have enough.*

Their mistaken view has spilled over into secular socialism. Marxists and socialists brushed aside Malthus's findings as "discredited," in order to put all the blame for want and suffering on capitalist greed and oppression. An example is seen in the influential work of Lancelot Hogben, Professor of Social Biology in the London School of Economics. In 1938, his 1100-page book, *Science for the Citizen*, dismissed Malthus's work in a few lines, and then devoted a long chapter to 'The Laws of Increasing Returns', suggesting that science applied on socialist principles would provide enough for everyone.

Those religious and socialistic views were altogether incompatible with the realities described by Malthus and Darwin, *which were therefore ignored and suppressed*. Further misplaced reluctance to recognise the harmful roles of overpopulation arose from the justified horror at the NAZI genocidal policies and drive to seize 'Lebensraum' in the 1939-45 war.

In the UK, the 'pro-life' lobbyists have succeeded in getting restrictive legal limits imposed on the use of induced abortion of unwanted babies and that of embryos found to have serious genetic defects. They oppose promoting the sterilisation of carriers with genetic defects, and suicide by those whose life has become intolerable.

But the worst outcome of pro-life attitudes is their effect in persuading governments and charities to give financial and food aid to poor countries with high birth rates in order to save the lives of starving children and malnourished mothers, and to give that aid without tying it to the acceptance of a rigorous policy of birth control. Such aid increases the population faster than its wealth, and thus the number of the poor.

SCIENTIFIC AND JOURNALISTIC GOOFS II.

by Andrew R.B. Ferguson

The scientific and journalistic goofs which are under consideration here stem from a failure to see the wood for the trees. The scientific paper that we will look at is *Ethanol Can Contribute to Energy and Environmental Goals*, published in *Science* in 2006. John Nunn kindly sent it to me, noting in general terms the shortcoming that I am about to analyse. The lead author was Alexander Farrell. For short I will refer to the paper as being authored by Farrell et al. [1]

The paper correctly observed that the calculation of *net* energy is always somewhat speculative, and that different assessments are often based on different criteria. The paper made a good job of producing what was called "commensurate" *net* energy values, so as to make it possible to compare the six studies on which it reported. The *net* energy results, which the paper shows in its Figure 1, are in terms of MJ/L (megajoules per litre of ethanol). For the different studies, the results varied between minus 4 and plus 8 MJ/L. The last was produced by Hosein Shapouri of the United States Department of Agriculture. The 'wood' that escaped the notice of Farrell et al, was the effect of the very low *net* power density that is achieved even with Shapouri's *net* 8 MJ per litre of ethanol.

Based on this most optimistic of the six figures, in order to produce just 10% of the *net* energy supplied by gasoline would require 62 Mha (million hectares) to be devoted to growing corn (maize).[2] Everyone regards the use of such a large area to grow corn for ethanol as absurd; the absurdity is even more obvious when one considers that at the present rate of US population growth, in only nine years population would expand by 10%, using up the 62 million hectares. In short, the goof is the failure to see the effect of low power density. Were that to have been appreciated, then the paper might better have been titled, *Why Ethanol from Corn Can Contribute Only a Trivial Amount to US Gasoline Consumption, and could do so only at an Unacceptable Environmental Cost.* This is the message that has been spelt out for many years by David Pimentel of Cornell University, but those who wish to believe otherwise continue to cloud the issue with irrelevant analyses.

Another way of looking at the usefulness of ethanol is to overlook the problems of *net* energy, and ask only how much ethanol liquid is left after providing the relatively small proportion (about 17%) of the total inputs that needs to be in liquid form. I did such a calculation in a previous paper, and concluded that "50 million hectares of cropland would supply about 11% of the liquid fuel used by U.S. transport."[3] While that calculation ignores the problem that other forms of energy are also in short supply, especially natural gas, it again shows the limitations of ethanol due to low power density. Low power density is the very thing that Farrell et al's paper ignores.

Worldwatch paper 169 *Mainstreaming Renewable Energy in the 21st Century*

Let us now turn from a scientific paper to a journalistic effort, for the Worldwatch Institute, by Janet L. Sawin. Again the mistake is to see the wood for the trees. This time it is manifested in a failure to address the most vital problem of renewable energy, namely intermittency as reflected in capacity factors (also known as load factors or infeed factors) and peak infeed factors.[4] There are only two passing references in the endnotes to "capacity factor," and no mention at all of peak infeed factors. The latter is nearly as important as the capacity factor, because if wind turbines, for example, could be connected up all around the world, then the capacity factor and peak infeed factor would be virtually the same (unless there are times when it is windy around the whole world and other times when it is less windy), and then wind would provide a nice steady baseload. What happens in real situations is that the capacity factor, say over a nation wide area, is typically 25% with a peak infeed factor of 80%, meaning that 25 / 80 = 31% of the work can be done by wind, but the other 69% has to be done by a highly flexible power source, which can work in harness with wind. Needless to say, since there is no mention in the main text of capacity factors or peak infeed factors, Sawin's 39 page screed fails to give any intimation of this type of problem, but instead is filled out with irrelevant statistics about rates of expansion of the various types of renewable energy.

She is equally remiss in failing to mention another problem with uncontrollable variable power inputs, namely the problem of combining them. This problem is most easily seen by considering photovoltaics. Because of the very low capacity factor of photovoltaics, for example, at the very most 11% in the UK, and since photovoltaics can deliver a peak infeed — when there is sunshine over the whole country — of 100%, if photovoltaics are given the task of providing *only 7%* of the total electricity supply, then when there is wall to wall sunshine they will produce 7 / 0.11 = 64% of the mean power demand in the country. That is about the low level of demand, so installing 7% of photovoltaics leaves no room for any other form of uncontrollable input, such as from wind and tides, or for any slow reacting input, such as from nuclear power. That is a bit of a simplification, because photovoltaics deliver their best at midday, which means that their peak output is unlikely to coincide with points of lowest demand, but the example serves to explain the general problem.

While there are many misleading implications in Sawin's paper, there is no point in going through them when the booklet is totally flawed by the huge goof of failing to recognize either of the fundamental problems that plague renewable energy, namely (1) uncontrollable variability and (2) the low power density of those renewable sources which *are* controllable, e.g. hydropower and biomass.

Endnotes

1. The paper *Ethanol Can Contribute to Energy and Environmental Goals*, was published in Vol 311, 27 January 2006, of *Science*. The authors were, Alexander E. Farrell, Richard J. Plevin, Brian T. Turner, Andrew D. Jones, Michael O'Hare, Daniel M. Kammen.

2. The calculation stems mainly from data in Farrell et al's paper, except that a figure is taken from one of Shapouri's papers for gross ethanol yield per hectare, 3108 litres/ha. This is the calculation.

At 8 MJ/L, *net* energy density is 8 x 3108 = 24.9 GJ/ha/yr (which as a matter of interest is a *net* power density of 24.9 / 31.5 =0.79 kW/ha, or 0.079 W/m^2).

10% of the gross energy provided by gasoline = 2.5 x 10^{17} x (10 / 1.3) = 1.923 x 10^{18} J.

19% of the energy in gasoline is needed to produce and supply it, i.e. as input, so to provide 10% of the *net* energy in gasoline requires 1.923 x 10^{18} x 0.81 = 1.557 x 10^{18} J of *net* energy.

At a *net* energy density of 24.9 GJ/ha/yr, the area needed would be 1.557 x 10^{18} / 24.9 x 10^9 = 62 Mha.

3. *Implications of the USDA 2002 Update on Ethanol from Corn*, pages 11-14 of OPTJ 3/1. 2003. *Optimum Population Trust Journal*, Vol. 3, No 1, April 2003. Manchester (U.K.): Optimum Population Trust. 32 pp. Archived on the web at www.members.aol.com/optjournal2/optj31.doc

4. If records are kept of the power fed into the grid from wind turbines (or another variable device) over the period of a year, then the "peak infeed" is the maximum power infeed which ever occurs.