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Global warming: the human costs
(Fingerprints and footprints)

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Abstract:

The accumulation of greenhouse gases is leading to global warming, sea level rise, and more frequent extreme weather events. It is anticipated that human health will be adversely affected in several ways. These include (1) direct physical effects such as heat, floods and droughts. (2) Physicochemical processes intensified by global warming will promote temperature-dependent ozone generation, resulting in an increase in respiratory disease. (3) The potential for increased exposure to infectious diseases engenders concern and controversy. Vector-borne diseases (carried by mosquitoes and ticks) such as malaria and viral diseases (dengue, encephalitis, yellow fever, epidemic polyarthritis) will at least be provided with an expanded geographic range. Similarly, waterborne pathogens (*Giardia*, *Cryptosporidium*, and paradigmatically *Vibrio cholerae*) are expected to flourish under warmer or more variable climatic conditions. (4) In sociodemographic terms, forced relocation of populations (from expanding deserts or inundated coastal cities) represents dislocation on a colossal scale.

The accumulation of greenhouse gases reflects excessive consumption of resources, far in excess of the carrying capacity of the planet, and (theologically, one must conclude) far in excess of that intended by the Creator. In addition, consumption is concentrated in the hands of the wealthiest populations. For the Christian this represents both an idolatrous pursuit of material gain, and an unjust disregard of the needs of other people. This untenable situation is compellingly expressed in the concept of the 'eco(logical)-footprint'. If the members of the Christian church cannot seriously address the implications of their lifestyle, then their claims to represent the God revealed in Christ, and to be concerned with the Kingdom of God, are manifestly fatuous. Both the ability of the planet to support the lives of future generations, and the credibility of the Church's proclamation require radical reorientation of the loyalties of those wanton consumers who claim to follow Christ.

The long-term prospects for maintaining the American lifestyle – or extending it to the nearly six billion people now on Earth – are grim. ... To bring the developing world up to the living standard of Canada, assuming available technology, would require two more planet Earths (1).

An ecological ethic recognises that the earth cannot sustain the consumer society of the 'developed' nations. Moreover it is not possible to extend this lifestyle to all the inhabitants of the earth. All human beings bear the image of God and therefore all have an equal right to the earth's resources and a sustainable lifestyle. The present inequalities are a violation of the creator's mandate (2).

Three related physical processes constitute and accompany climate change (3).

- Temperature increase: Global mean temperature has increased by 0.5°C (range 0.3-0.6 °C) in the century to 2000 (with reductions in snow cover, glacier mass, and sea-ice extent), and will increase by 2°C (range 1–3.5 °C) over the next. Warming may be greater over land and at high latitudes, leading to marked local differences. Small changes in mean climate trigger large changes in heat wave frequency and severity.
- Sea level rise: Sea level rose by 10-25 cm over the last century; and is anticipated to rise by 49 (20-86) cm over the next.
- Extremes in the hydrologic cycle: An increased percentage of the rainfall is delivered in extreme 1-day events. Hurricanes form only where sea-surface temperatures are >26°C. Warming of slightly more than 2°C would increase hurricane strength by 5-12%.

1. *Human health costs of climate change (identifying 'fingerprints')*

Global warming is profoundly affecting the distribution, phenology, and well-being of many species (4). Health effects on humans include direct physical consequences, physicochemical effects on air pollutants, biological effects, and sociodemographic effects (3).

1.1 *Thermal stress*

A heat wave in Europe in 2003 caused 22-35,000 deaths. Modelling suggests that heat waves will become more frequent, protracted, and intense in the 21st century (5). The body adjusts to higher temperatures by perspiration and cutaneous vasodilation. The ability to cope with heat stress requires the capacity to increase maximum cardiac output for increased cutaneous blood flow. Mortality from all causes increases during heat waves. Specific effects include cardiopulmonary failure and various form of heat stress (6)

- heat rash: sweat gland dysfunction, which may be associated with infections;
- heat syncope (fainting): blood pooling in the lower extremities with decreased flow to the brain;

- heat cramps: electrolyte imbalances (especially Na⁺), with cramping of the abdomen and extremities;
- heat exhaustion: dehydration, loss of effective blood volume (hypovolaemia) leading to nausea, dizziness, shortness of breath, headache, and shock (circulatory failure with hypoperfusion of vital organs) or arterial occlusion by thrombosis;
- heat stroke: impairment in body temperature to >45°C, with absence of sweat, tachycardia (excessively rapid heart rate), changes in mental state and death.

People most at risk are those with a limited physiological capacity to adapt, who are old or very young, who have pre-existing cardiovascular disease, who have heavy workloads (especially in high temperature and humidity), and who abuse alcohol.

1.2 *Physicochemical effects on atmospheric pollutants*

Increases in the temperature of the troposphere enhance photochemical (UV-mediated) reactions that generate oxidants such as ozone. High-pressure systems may create temperature inversions that trap pollutants in the boundary layer at the earth's surface. Global warming is expected to promote ozone pollution, and hence

- increases in airway reactivity, bronchitis and chronic cough;
- increased sensitivity of asthmatics to allergens;
- impaired lung function;
- mortality (exacerbated with hot weather).

Modeling for the New York metropolitan area indicates that adverse effects of ozone will intensify in the next few decades (7).

1.3 *Biological factors*

Aerial allergens (pollens, spores) increase with CO₂ concentrations and temperature, and contribute to increased frequencies of rhinitis and asthma. Warmer temperatures and weather extremes may contribute to increasing contamination by toxin-producing fungi (*Aspergillus* and *Fusarium* spp). Mycotoxins have carcinogenic and teratogenic effects (8).

Warming of fresh water (with excess run-off from heavy rain leading to eutrophication) can cause cyanobacterial blooms. These agents produce highly potent hepatotoxins, the microcystins. Warming of seawater may be related to the increased frequency of toxic algal (dinoflagellate, diatom) blooms, with their associated burden of neuro- and gastrointestinal toxicity (9).

A direct relationship between temperature elevation and the potential of infectious diseases to expand their geographic range has been suggested. More problematical is the issue of whether climate will prove to be as important as behavioural or social factors in determining actual disease incidence. Wealthy countries should have the infrastructure to control disease spread (9), although the spread of West Nile virus across North America (between 1999 and 2004) leaves no room for complacency (10). More generally, factors such as deforestation, irrigation, population growth and migration, urbanisation, and housing conditions may be dominant factors (11).

Evidence is accumulating that climatic features such as *El Nino* are linked to outbreaks of disease.

- *El Nino* and waterborne disease: Warming of seawater favours growth of *Vibrio cholerae* in zooplankton. Warming of the Indian Ocean has increased the frequency and intensity of *El Nino* events, and since 1980 has strengthened its relationship with the incidence of cholera in Bangladesh. Patz has concluded that this finding ‘likely represents the first piece of evidence that warming trends over the last century are affecting human disease’ (12).
- *El Nino* and vector-borne disease: Hantavirus was first isolated in the SW USA in the early 1990s. Drought reduced predator populations (owls, snakes, foxes) that prey on the mouse vector and led to mice entering human dwellings searching for food. Subsequent heavy rains increased numbers of grasshoppers and pinon nuts, leading to 10x increases in rodent populations. Mouse urine contains large numbers of shed virus. Human infection may arise from inhalation of aerosols or dust (13).

A number of other diseases have been shown to reflect *El Nino* conditions (table below; see Patz *et al*, ref.3).

Potential for interaction between *El Nino* and global warming

<i>Area</i>	<i>effect of El Nino</i>	<i>disease</i>
E Africa	more rain	malaria, plague, Rift Valley fever
SW USA	flooding	rodent borne hantavirus pneumonia
Caribbean, Brazil	flooding	leptospirosis
Bangladesh	sea surface temp	cholera

From these findings, long-term climate change is a candidate for increasing the range or incidence of infections disease.

- Waterborne diseases that may be intensified by climate change (in addition to cholera) include *Giardia* and *Cryptosporidium*. Increased contamination of water follows heavy rainfall. An increased geographic range of snails may lead to concomitant expansion of the range of the trematode *Schistosoma* spp and its affects on humans (schistosomiasis/bilharzia; ref.14).
- Vector-borne diseases feature malaria, which kills >1 x 10⁶ people/y (mainly children). It flourishes when the environment is wet (provides breeding sites; prolongs mosquito life) and warm (accelerates mosquito development to adults; increases frequency of blood feeding and parasite acquisition, and reduces the ‘extrinsic incubation period’ of the parasite in the vector). *Plasmodium falciparum* takes 26 days to incubate at 20°C, but half this time at 25°C. The lower limit for development of *P falciparum* is ~18°C, and of *P vivax* is ~15°C. Many species of mosquitoes stop biting at low temperatures. For these reasons, malaria has been eliminated only in temperate regions (Europe, 1975; N. America, late 1950’s) but not in other wealthy countries with high year-round temperatures (Oman, United Arab Emirates)(15).

Flaviviruses are major pathogens. The effects of climate change remain controversial, but expanded range or incidence has been proposed for a number of agents (16). Tick-borne (*Ixodes ricinus*) encephalitis (TBE) has shown an expanded range both in latitude and in altitude in parts of Europe. This is probably because tick survival and embryological development are limited by protracted cold. The incidence of TBE may be related to the growing abundance of deer populations (principal tick hosts), which may also be promoted by milder winters (17).

Candidate vector-borne diseases that may respond to global warming

<i>Vector</i>	<i>parasite type</i>	<i>disease</i>	<i>possible climate effect</i>
Mosquito	<i>Plasmodium</i>	malaria	increased range
Mosquito	flavivirus	dengue	increased range
		Yellow fever	higher transmission; wet, warm
		St Louis encephalitis	increased range; wet, warm
		West Nile Fever	
Tick		encephalitis	increased range
Mosquito	togavirus	Ross River virus	increased range; incidence
		polyarthritis	with increased rain, min temp

1.4 Sociodemographic impacts

Sea level rise and perturbation of the hydrologic cycle with flooding may lead to forced migration and dislocation (environmental refugees). Of the world's 20 megacities, 13 are at sea level, and would be susceptible to disruption of stormwater drainage and sewage disposal from rising seas. A rise of 100 cm would inundate low-lying areas in China (19 million people affected), Bangladesh (13 million), and Egypt (3.5 million).

Overall, the impacts of progressive climate change may not be adequately expressed by 'itemized tallying'. Global warming will interrupt 'regional food and water supplies and thereby social and economic conditions – particularly in already poor and vulnerable populations. Conflicts would arise, migration flows would increase, and a mix of violence, injury, infectious diseases, malnutrition, mental health disorders, and other health problems would result' (18).

2. Human costs of addressing climate change (addressing footprints)

'Adverse health consequences of climate change may be yet another example of the observation that often the adverse consequences of the lifestyles of the wealthy are felt, not by those enjoying the benefits of those lifestyles but by the poor. ... The West has a moral responsibility towards the poorest nations for the potential adverse impacts that they are likely to experience as a result of our inability to control our own excess energy consumption' (9).

A primary question of human ecology is 'How much of the Earth's resources supports my current lifestyle?' This issue can be approached by considering the 'ecological footprint', a term which reflects the area of land required to support a

particular population. It may be defined as ‘the area of productive ecosystems required on a continuous basis to produce the resources that the population consumes and to assimilate its waste (19).’ In the context of this review, energy is a key resource and CO₂ is a key waste.

Ecological footprints (ref.19)

<u>Population</u>	<u>eco-footprint (hectares per person)</u>
USA	12.2
wealthy countries	5 to >10
poorest countries	0.5
current actual world average	2.3
current available world average	1.9
anticipated available world average, 2050	1.3

Striking conclusions emerge.

- There are huge disparities between the most and least affluent countries. This is unjust. New Zealand has an eco-footprint of 8.35 (ref. 20), which places it in the small group of the most consumptive nations (21). Surprisingly, some countries (Canada, France, Hong Kong, Germany, UK, Japan) have a higher per capita income than New Zealand’s, but a lower ecological footprint. This indicates that New Zealand has a particularly ‘resource intensive lifestyle’.
- The richest countries have eco-footprints larger than their domestic area. These countries effectively operate by appropriating the resources of other (poorer) countries, and dumping their wastes into them. Rich countries are shielded from ecosystems degradation and resource depletion, creating the illusion that limits to material consumption have not been exceeded.
- The actual world average footprint is greater than the available parcel of land per person. The excess represents consumption of not merely the productivity of the biosphere, but of the very structure of the biosphere. In fiscal terms, humanity is not living off the interest but off the principle itself, and has exceeded the sustainable carrying capacity of the planet. This will become more pronounced in the next few decades.
- The long-term integrity of the ecosphere, allowing ecological space for poor countries to develop, requires that the richest countries reduce their consumption to 20% (22).

In his highly instructive paper, Rees severely criticized the controlling myth of modern society. This ‘expansionist vision’ or ‘gospel of growth’ has equated global sustainable development and poverty alleviation with ‘ever-increasing material well-being’. He laments the pervasive belief that human ingenuity has displaced nature as the great provider, and the mythology that transforms citizens into ‘gluttonous single minded consuming machines’. *Homo economicus* is unresponsive to any factor that is not expressed in terms of market activity, and is oblivious to others’ sufferings or satisfactions, to family or society, and to moral arguments for wealth distribution. The net result has been to deepen the poverty of the poorest. In 1998, Hurricane Mitch, *El*

Nino conditions, declining soil fertility and deforestation, drove 25 million people from the countryside into cities. For the first time, environmental refugees exceeded political refugees (23).

Rees concludes that we must transcend our genetic predisposition, deconstruct our materialist world-view, forsake our self-delusions, and acknowledge that our reason is unreliable (24). *'It is not just the environment that needs to be fixed, but humans ourselves – the environmental crisis is the product of gross human ecological dysfunction'* (19). But Rees is not explicit about the provenance of the necessary new cultural myth.

2.1 *The role of 'Enlightenment' anthropocentrism*

The Christian response is that the world belongs to God (25) and exists for God (26). The basis of Christian ethics is profoundly theocentric, not (as has often been asserted) anthropocentric (27). The modern anthropocentric controlling myth finds rather its metaphysical basis in the Enlightenment of the eighteenth century. McGrath writes:

Lying behind this desire to dominate nature is the belief that humanity is of central and defining importance. Humanity is the creator and arbiter of values and is free to interpret and manipulate nature as it pleases ...

The roots of this thought are found in the Enlightenment, which was marked by a 'deliberate and principled rejection of the authority of anything and anyone other than individual human reason' (28).

Similarly, Gunton states that the Enlightenment was the time when Reason was elevated to the status of being the supreme arbiter of truth. Reason became 'the source of control, absolute or otherwise'. Enlightenment man claimed for himself omnipresence and omnipotence. 'Human self-divination is to be seen in the sometimes conscious attempt to transfer to man the attributes of divinity'. The Enlightenment was characterised by 'the idolatrous worship of human capacity'. This gave rise to the 'mechanisation and technologisation of reality', which is precisely 'the form in which the ecological crisis meets us today' (29).

2.2 *Anthropocentrism transmogrifies dominion into domination*

According to Genesis, humans were given dominion over the other organisms (30), but they transmogrified that into domination. Unfortunately, some authors have failed to distinguish between these words. According to White (31), the Bible taught that humanity was given 'dominance' over other living things. This misconception has been compounded into widespread confusion. 'Dominion' and 'domination' are radically opposed. For 'dominion' is authority under God, whereas 'domination' represents the will to power.

Thus Osborn criticises White for regarding 'dominion' as being synonymous with 'domination'. Whereas 'domination' implies exploitation, the 'dominion' (kingly rule) envisaged in the Old Testament was one of a ruler existing for the wellbeing of his subjects. The Hebrew idea of kingly 'dominion' is very different from the European understanding of the absolute monarch. The Hebrew king was intended to be one who worked for the blessing of his subjects. 'The king existed *for* his subjects' (32). Humanity in its dominion was intended to work devotedly on God's behalf for the good of creation.

Indeed, humans have dominion over nature only to the extent that they receive it as a gift from God, and that they are involved in the service of God (33). There is a close connection between mankind's dominion, and its possession of the very image of God (34). 'It follows that appropriate human dominion will be modelled upon the divine sovereignty.' There must be a correlation between the way in which God is sovereign over his creation, and the manner in which human dominion is expressed. The biblical teaching about the Fall of mankind, then, arises from the 'the denial of creation's character as a divine gift.' Human dominion is transmogrified to the 'assertion of human autonomy and absolute lordship over the world' (35).

To David Given, properly exercised kingship and dominion are not intended to be 'rule by tyranny', or 'the accumulation of great wealth for oneself or the exercise of despotic power. The key issue is that kings and rulers are answerable to God.' Given cites God's tender care for Israel, his rebellious son, as the model of righteous rule (36).

Rae takes the biblical concept of 'dominion' further, categorically distinguishing between 'dominion' and 'domination'. The authentically Christian concept of 'dominion' or 'Lordship' is defined by the person who is addressed as Lord in the New Testament. The eternal Son of God, the Lord of Creation, 'exercises his lordship by becoming a servant in the midst of creation, by directing his ministry towards the reconciliation of all things to God, and by offering his own life as a sacrifice of atonement for all that mars God's good creation. This is what dominion means when it is exercised by the Lord himself'. If we are to be influenced by the God of the Bible, then for us, 'dominion is not the imposition of our own rule on creation but a faithful following after the order that is established by Christ'. The pattern of 'dominion' for us is thus servanthood, reconciliation, self-sacrifice (37).

2.3 *Domination is idolatry*

The result has been displaced loyalty in which humans have pursued the unrestrained materialist dream of which Rees has so compellingly written. King has stated that by sequestering more than their rightful share of the Earth's resources, the rich countries have forsaken God and turned the material world into a god. The roots of the ecological crisis are to be located in idolatry (38). Gunton has also said that 'The ecological crisis results from the worship of that which is not God', which is in fact idolatry, 'giving to anything created the value of God' (39).

The ethicist Northcott has the last say in a highly erudite book, *The Care of Creation*, in which Christian scholars discuss the 'Evangelical Declaration on the Care of Creation'. Of all the contributors, he seems to come closest to the essence of the problem. He identifies worship as being at the heart of the ecological crisis, and continues.

It is precisely the modern devotion to the cult of consumerism which is driving the horrific global scale of environmental destruction. The modern Western appetite for a constant and changing flow of consumer goods represents a spiritual disease, and is indicative that Western civilisation has at its heart a devotion to that which is not God. 'Idolatry' is the word used in the Old Testament to describe the worship of created things in the place of God (40).

He points out that idolatry leads to further evils – justice and oppression. Idolatrous Christians are faced with a stark choice. They can either continue in their worship of the idols of consumerism (which so belies and makes a mockery of their claim to worship God), or they can (re-)discover the life-changing reality of authentic adoration of the God revealed in Christ, who tolerates no compromise with Mammon. The latter requires radical reductions in the consumption of materials and energy by Christians. Only thus can they provide the paradigm by which humanity may address the ecological crisis.

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33. *ibid*, p.90, citing Bonhoeffer; cf Hebrew 2:8: 'we do not see man ruling over all things now'. Dominion is lost when man turned to grasping domination.
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