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EUAN G. NISBET

‘Speak to the Earth and it will teach you’

In the garden of Eden, the monarchs were Adam and Eve: Hebrew monarchs were shepherds, and the task of the shepherd monarchs was to guard and protect their flock. Humanity has been given the skills and the challenge to set a measuring line to the Earth, to draw out Leviathan with a hook, even to reach the Pleiades if we can: but with this ability we now also face the challenge and responsibility to care for the garden. The geological record shows that catastrophes and sudden changes have taken place in the past, and illustrates the likely consequences of humanity’s present behaviour, while also giving us the evidence to understand the complexity of our planet. Creation groans: our actions across the planet are now on a scale that can radically change the operation of the whole biosphere in a way that is comparable to the sudden past catastrophes. Simultaneously, we are discovering new scientific knowledge, and growing in our understanding of the natural world. This is giving us the ability to manage the Earth, just as our unplanned actions impose change on the planet. Managing the atmosphere, determining climate and environment, sustaining the biosphere, are all tasks we can no longer avoid, as we already control the planet. Creation is not to be worshipped—creation spirituality is dangerous doctrine—but it is to be respected, for in understanding and maintaining the biosphere, humanity itself grows as an heir, jointly with the rest of life, of Noah’s covenant.

Key words: environment; Eden; creation; Gaia; extinction; ecosystem

Introduction

‘The global environment does not matter. We in the western nations can adapt easily to any effects of environmental change. Perhaps the poorer people in the poorer nations may suffer, but what does that matter to us.’ So say the harder voices in the corridors of Washington and Brussels. Some voices are different: ‘Looking after the global environment is our responsibility, and the only people with the skill to do it are the technological societies of the G7 nations: we need to act’.

Do we need to act? Do any other voices deserve to be heard? For instance, what about African street kids, who are likely to be among the chief sufferers of global environmental change. Can they have a voice? Surely they do not have much time to think of anything except themselves, especially if they are not even local nationals, but the children of poor refugees. Yet they can be environmentally important people. The rubbish

dumps of the African cities are recycled by these kids. Zimbabwe's most substantial writer, apart from Doris Lessing, was a rubbish dump kid called Dambudzo Marechera, who learned his craft from a copy of Arthur Mee's children's encyclopaedia and a child's typewriter, both found on a tip among the rotting vegetables and bones. Such children occur in all poor tropical nations. Twenty-five years ago, shortly before an Arab-Israeli war, I visited Old Cairo. The old synagogue was still respected, despite the impending war, but most of the people had gone: I chatted with the custodian, who tried to sell me the scrolls. Shocked, I refused. Years later, I realised that he may have genuinely been trying to get me to take them somewhere safer. Fortunately, scrolls and the truths they bear last longer than wars. Nearby was the church where the Holy Family was said to have rested after the flight into Egypt. Christian street kids scrabbled for a living by sifting the rubbish of the city, just as the Zimbabwean writer had. This brings me to my point—that we should consider the world from the viewpoint of the poor African child. Imagine the small son of political refugees, his father 'in the informal sector of the economy' (i.e. desperately trying to scrape a living by making things), his mother pregnant before marriage. There must be millions of these children among the refugees who have run from Rwanda or Mozambique or Somalia. They are hopeless cases. Or perhaps not so hopeless: one of these, that refugee child whom strong legend suggests was a Cairo street kid, one of the millions Africa has hosted, grew up to tell us to 'love one another'. It was two millennia ago, but the truth still holds.

If we follow those teachings, that we should love one another, should we also love the natural environment? Do we really need to act altruistically to protect the common good, so threatened by greed and neglect[1]? Surely it is possible to love humanity without also needing to go to the extra effort of loving the environment? Do we listen to the harder voices that argue the environment does not matter? Do we instead listen to the responsible but patronising voices that the global environment is the sole burden of the advanced nations? Or do the voices of the street kids matter also? Can we somehow use our advanced knowledge without also ignoring the voices of the unskilled? The answers to this are immediate: we cannot love our neighbour without also caring for the 'Nature' that we and our neighbour have in common—the two are linked (Hosea 4. 2–3); furthermore, if we attempted to ignore or exploit our common heritage, not only would we corrupt our love, but we would all, rich and poor, eventually have trouble filling our bellies also. There are thus both ethical and pragmatic reasons to make us care for the environment. However, just as Christ showed that ethical questions often have counter-intuitive answers, so too do environmental problems often need unexpected solutions. Not everyone who cries 'Lord, Lord' gains salvation, and neither does simplistic feel-good greenery (support 'green' causes loudly, but do not act oneself) always shape good policy in saving the environment.

1 Hardin, G. (1968) The tragedy of the Commons. Science, 162, 1243–8.

It is best to start with the biblical guidance. This begins in Eden: humanity, Adam and Eve, is given dominion over the garden. This is a monarchy, not a dictatorship. The Hebrew monarch is a shepherd king—the monarch cares for the sheep, guards them, and cherishes them. Yes, the sheep are sacrificed to feed the shepherd, but if the monarch fails, the kingdom is taken away and given to another. The message is reinforced after the Flood, with the covenant between the Creator and, here below, all creation (Genesis 9. 15–16). This covenant is specifically inclusive: it applies not only to humans, but explicitly to all living things. There is an immediate and powerful corollary: humans must worship the Creator, but not the fellow creation, which is with us on our side of the covenant. God is not to be seen in the creation, but apart from it, the creator of the ends of the earth (Isaiah 40. 12–13, 28). As Epimenides knew (Acts 17.28; Titus 1.12), the paradox of humanity is that we may be liars (the consequence of our freedom), but it is in God we live and move and have our being. It is not the other way around.

That is not to mean we should ignore the beauty of the creation. We cannot discover God in the creation, and so it is wrong to worship the creation. Nor can we prove God's existence by studying the creation—Kant's fourth antinomy. But once we have found God by faith, we can then see the hand that made us is divine:[2] we must then cherish God's work. The heavens are telling the glory of God, but only if first we have the faith. Like Job (38–41), we cannot yet understand the mystery of the universe, nor yet measure it out, though we learn more every generation. The more we learn about it, the more we who believe can wonder at its creator. We are told to find wisdom (Proverbs 4. 5), and it was wisdom that was the master workman when the foundations of the Earth were laid (Proverbs 8. 30): natural science is surely among the seven pillars of wisdom's house. God specifically challenges us to take a measuring line to the universe. There is no injunction against doing so, and we are encouraged both to see the beauty and to discover the science of the natural environment.

There is more yet. In the garden we are monarchs; after the Flood we share the Earth; with Job we are given the task of seeing and understanding the wonder of Nature. With God's covenant with Noah comes a terrifying command: 'Everything that lives and moves will be food for you' (Genesis 9.3). We are put in control of our fellow beings. They are our responsibility. We may eat them, but as joint heirs of Noah's covenant, our burden now is to sustain the garden. Even worse, we then discover that all Creation is groaning to see us gain our full stature, which is surely in natural knowledge as well as spiritual (Romans 8. 22; Ephesians 4. 13). We are set a task of faith, but along with that task of faith is the need to work to increase our knowledge and understanding of Nature. Setting the measuring line to the universe is not only a challenge, perhaps it is a duty.

2 Addison. *Spectator* 465.

Discovering the Biosphere

In the last century, Ruskin complained of the terrible geologists and their clinking hammers. The late Georgian savants, in destroying the security of time's comfortable fabric, unleashed Tennyson's terrifying vision of 'Nature red in tooth and claw' (In Memoriam, LV), powerfully fuelling the Darwin-Huxley synthesis of a savage, competitive natural environment, in which all creatures must kill or be killed.

And so it is, up to a point. But the story is more complex. Today, we recognise three 'domains' of life[3]. These are:- 1) the Eucarya or Eukaryotes, which include the plants and animals as well as simple single celled organisms; 2) the Bacteria or Eubacteria, which include many common bacterial organisms; and 3) the Archaea or Archaebacteria, including a wide variety of organisms such as the methanogens, which make methane, and also many single celled organisms in hot or acid settings. Darwinian survival of the fittest applies most satisfactorily to the Eucarya—plants or animals which fail to compete do not have offspring and become extinct. But in the bacteria the story is more complex. In them, genetic information can sometimes be transferred between living individuals—it is as if a mythical 'giraffe-bacterium' could gain a longer neck simply by a chance encounter with another bacterium that had a longer neck. It is, arguably, the genetic material that survives competitively, not simply the organism, which can learn by a process analogous to the way humans learn from each other when they live together in a tribe or society. Perhaps we can call it the 'underpants' method of development. Let us assume that all readers of this article wear undergarments when in society; and that their parents did so: indeed, perhaps a majority of the world's population does so now. But fifty years ago, was this true? Or a century ago? And in 1700? There has been no decree that all the world should wear underpants: the sensible idea has simply spread by example and transfer of idea from person to person, across cultural and social boundaries. Likewise, bacteria can exchange genetic assets: natural selection operates, but it can apply as much to the community as a whole as to the individual.

Patterning human behaviour on some ideological interpretation of nature is always highly dangerous, but the complexities of bacterial evolution show up yet more fully the bankruptcy of arguments, such as those of Eugenics, or Social Darwinism, that draw on natural examples to dragoon humanity. These ideas, by using half-truth, are false prophecies, clouds without rain, wandering stars: deepest evil (Jude 13). From the 'scientific socialism' of Stalin's state to the race theories of the Nazis, the application of Darwinian ideas to human behaviour has led consistently to evil. Humans are capable of ethical decision, eaters of the Tree, able to

3 Woese, C. R., Kandler, O., and Wheeler, M.L. (1990) Towards a natural system of organisms: proposal for the domains Archaea, Bacteria and Eucarya. Proceedings of the National Academy of Sciences, USA, 87, 4576–9.

choose good or evil whatever their genes, all able to attain the measure of the stature of Christ (Ephesians 4,13).

Gaia

The matter becomes yet more complex when Gaian views of Nature are considered. Here the trap is set the other way. The Gaian, hypothesis, as proposed by James Lovelock[4] and colleagues such as Lynn Margulis[5], is that the natural world is self-regulating: it is a cybernetically self-controlling system that regulates variables such as climate and chemical composition of the atmosphere to maximise the survival of life. In other words, there are feedback systems that act to maintain conditions conducive to life. If volcanoes erupt carbon dioxide, trees grow, carbon is taken up, the atmosphere returns to its prior state. This example is over-simplistic (carbon regulation is in fact extremely complex), but illustrates the type of cybernetic feedback loops that can exist.

Stated as an explanation of the way the natural world behaves, there is an enormous amount of support for the Gaian view. It is good natural science. The atmosphere, for instance, is almost entirely a biological construct (nitrogen, oxygen, carbon dioxide, water content are all biologically managed, directly or indirectly: only the argon and rare gases are not biologically sustained), and this atmosphere maintains a surface temperature of about 15°C on average on Earth, about 33°C warmer than the temperature on a similar but 'dead' planet. Moreover, over the past 4,000 million years this equable temperature has been continuously sustained with only minor blips of possibly less than 10–20 degrees, certainly not hundreds of degrees. Imagine any human machine that could keep a steady temperature over such a time. The puzzle is even greater, as there is clear reason to believe that the Sun has warmed up substantially in this period. Not only has the house stayed at a steady temperature, but this has been accomplished while Nature has been turning up the heating. Venus, in contrast, gave up: from possible watery, Perelandrian beginnings, it has become a true inferno, with a surface at 500°C and almost all its water lost. Mars has had rare warm events over the aeons, but is now permafrost, with temperatures of 0°C on the hottest equatorial days (for a discussion of planetary atmospheres, see Refs 6 & 7).

In the Gaian view, life cooperates on a planetary scale. Nature is not entirely red in tooth and claw. Such cooperation is easily understood

4 Lovelock, J. E (1979) Gaia—a new look at life on Earth. Oxford: Oxford University Press. Lovelock, J. E. (1988) Ages of Gaia. New York: W. W. Norton. Lovelock, J. E (1989) Geophysiology: the science of Gaia. Reviews of Geophysics, 27, 215–22.

5 Lovelock, J. E. and L. Margulis, 1974. Homeostatic tendencies of the earth's atmosphere. Origins of life, 5, 93–103.

6 Lewis, J. S. and Prinn, R. G. (1984) Planets and their atmospheres. Oxford: Oxford University Press.

7 Henderson-Sellars, A. (1983) The origin and evolution of planetary atmospheres. Philadelphia: A. Hilger; Bristol: Heyden and Son.

when one looks at a Canadian forest growing after a fire has cleared the land[8]. Initially, brambles and berries grow in the debris after the fire, and tree seedlings under their shade. Bears forage, and open-land animals flourish. The trees rise, and slowly the brambles lose light and die. In their place come ferns and mushrooms, and shade-loving plants. Later generations of trees seed under the canopy of the pioneers, and woodland animals replace the earlier community. Beavers block streams with cut hardwood, and create new wetland areas in which grow plants sustaining moose and smaller water-loving mammals, insects and other creatures. More widely, the green coniferous forest influences the colour of the land in winter, changing the climate. The emissions, photosynthesis and eventual burning of the forest exert a control on the entire global atmosphere. The forest is a 'biome', containing an array of living organisms which individually compete but collectively cooperate[9], just as fast-food shops and video outlets compete in a human town, but pay city taxes and collectively help to maintain the services that make society.

On a global scale, it can be argued that biomes have coevolved, each influencing the others. The transfer of water vapour into the air above tropical rainforest globally cools the tropics and helps to warm the extratropical areas, perhaps even helping to induce the pattern of jet stream flows that create the Sahara; Saharan dust helps provide nutrient to Amazonia; in the north, dust from the dry grasslands of the prairie and steppe help fertilise the northern forest and Chinese fields. In the Gaian system, each biome depends on the others, and all collectively sustain the atmosphere that sets the global temperature and hence global rainfall. The cooperation grows out of local competition, but mutually maintains the system in a set of feedback loops—cybernetics. To take another simplistic example, should the Sun suddenly warm and the planet become warmer in consequence, more water will evaporate globally, plants will grow, capture carbon dioxide, and reduce the global greenhouse: consequently the planet will cool back to its former temperature. Of course, matters are much more complex than this, and there seems to be more than one stable state.

Just as Darwinian competition leads to the bitter and false ideologies that humans should compete racially (Nazism), or on the basis of intelligence (eugenics), or collaborate as worker ants ('scientific socialism'), so the Gaian view can be yanked from its natural context and improperly applied to humanity. It is easy to see deity in the machinery of Nature. Gaia was the Earth Goddess. Lovelock adopted this splendid, but dangerous name, which was given to the hypothesis on the suggestion of his neighbour, the author William Golding. From this, creation spirituality easily and falsely grows. The idea of Gaia is lovely, but risky unless kept in the context of empirical enquiry into Nature. To ascribe deity to Gaia is as

8 Holling, C. S. (1992) Cross-scale morphology, geometry and dynamics of ecosystems. Ecological monographs, 62, 447–502.
9 Colinvaux, P. (1993) Ecology 2. New York: J. Wiley and Sons.

false, and perhaps in the long term as dangerous, as the misuse of Darwin: the idea has a seductive beauty, but ultimately can lead to ecofascism and destructive intolerance. Both Darwinian selection and Gaian cooperation are valid hypotheses in explaining Nature; but neither should be applied as guides to human behaviour, their misuse going against that Cairo refugee child's command to love one another, against the even greater first command, and against the individual promise that even the hairs on each head are numbered.

Learning from the Earth

Biblical teaching (Job 38–41) is that God is neither found in Darwin nor Gaia. 'Hear, O Israel', God transcends all, creates all. Natural selection may be the way evolution takes place, it may provide the fishhook that draws out Leviathan, and the process that gives the horse his might and the raven his prey. Gaia may be the father of the rain, and may provide the control that shuts in the seas with doors, but behind the machinery is deeper reality. Humanity can now measure the Earth, though we are far from understanding it. In our submersibles, we can walk in the recesses of the deep. One day, perhaps, we may even reach the Pleiades and Orion, but even there the creation will still not be God. Creation worship and creation spirituality are dangerous bypaths, attempts to bring down God into the narrowness of what we can see, measure, and attempt to understand. The Greek Orthodox church, which has a fine theology of the environment, and the Book of Common Prayer point to the deuterocanonical Song of the Three Young Men (Daniel 3: Apocrypha)—'O all ye works of the Lord, praise ye the Lord': the creation is not the creator. Creation too must praise God. Creation is not God.

Job tells us 'Speak to the Earth, and it will teach you' (Job 12.8). The Earth gives us a perspective of time and complexity in time. As Augustine pointed out (Confessions, XI.24), time is not the movement of a heavenly body: it is a created character of the universe. God exists outside the created dimensions. This gives us an important and interesting change of perspective. When we read a Donald Duck cartoon, we can see the buttons on Donald's jacket. But Donald, who is two dimensional, cannot see those buttons. He cannot see past his outline. Nor can Daisy, who can only see the line of Donald's profile. We, who are three dimensional, can see right across Donald, looking through his entire two dimensional being at one glance. Time is the fourth dimension: a four dimensional being could see our entire time history in one inspection, from birth to death, as a coherent whole. And the one who created all dimensions and exists outside them, can see all.

This sense of looking from outside the dimensions is strongest in the epistle to the Hebrews, where we are told that the history of the Earth since the foundation of the world is that of the seventh day. 'Today' is not ended: through Christ we are called to enter into the sabbath rest (Hebrews 4.

4–11). The days of creation in Genesis are clearly seen in this context. Unlike days defined by the movement of a heavenly body (in our modern understanding, the rotation of the planet), the days of creation have evening and morning, not 24 hour cycles of light and dark: how could they be solar, especially in the early 'days' of Genesis before the separation of day and night and making of the lights?

The Possibility of Catastrophe

Using theories about natural history, drawn either from natural science or from a perverse interpretation of biblical teaching, in order to shape human ideology, may lead us to create seductively dangerous distortions. But are there true lessons that we should draw from the perspective of Earth history that natural science gives us? One of the most striking features of relatively recent geological time is the insecurity of the modern environment[10]. Fifteen thousand years ago the Earth was in the late Glacial maximum, with icesheets covering nearly all of Canada and the Baltic states, large parts of Russia, and extensive sheets also in South America and even Southern Africa and Australia. The climatic end of the last glaciation came astonishingly quickly, about 13–14 thousand years ago. Sudden shifts in climate occurred, then a very rapid global change in temperature, and water vapour, carbon dioxide and methane (the greenhouse gases) in the air[11]. This change, Termination 1a, probably took place within a few decades, possibly in a single year. Over the next millennium or so, the ice was still present, though melting, but the climate was essentially modern. Then, strangely, the climate slipped back into near-glacial conditions for some centuries, a period ended by a second sudden warming, Termination 1b, that brought about the final melting of the ice and the modern climate. These terminations were sudden, and massive, shifting global climate into a completely different regime.

The history of the Terminations at the end of the last ice age immediately raises the question whether similar events could occur again. The warmings at the end of the ice age greatly increased the biological productivity of the planet. Could another equally sudden warming event occur? Possibly—we do not know. Warming, by increasing evaporation and rainfall, and associated with increased carbon dioxide, will in the most general terms make the planet more habitable. But we have strong evidence that different climates can exist. A well-known example is the Southern Oscillation or El Nino/La Nina events. When parts of the Pacific warm, and currents change off Peru around Christmas (El Nino), millions of people can die from drought in Africa. Could this become the stable state? Another example, perhaps potentially even more serious, is the

10 Lorius, C. J. Jouzel, D. R over the past 160,000 years. Nature, 345, 127–31.
11 Chappellaz, J., J. M. Barnola, D. Raynaud, Y. S. Korotkevich and C. Lorius (1990) Ice-core record of atmospheric methane over the past 160,000 years. Nature, 345, 127–31.

movement of ocean water known as the 'Atlantic Conveyor'[12]. This is a massively important part of the global heat exchange system that we call the climate. It involves the movement of North Atlantic Deep Water around the planet, and this movement system is very precariously balanced. It could be switched off or on easily, with major global implications.

What if it suddenly begins to rain in the Sahara and Australia, but the interiors of North America and Russia, and parts of China and India become hotter and drier, with crop failures. Will the Indians and Chinese migrate to Australia and Morocco? Humanity, locked behind national borders, cannot quickly adapt to sudden climatic change: the misery and conflict may be immense.

Noble savages?—was the dreamtime innocent?

At the terminations of glaciation, with the climatic changes also came sudden changes in plants and animals. Changes of this sort may have occurred on many occasions in the geological record, and similar sudden events clearly took place at the end of older glacial intervals. But what is unusual about the shifts at the end of the last glaciation is that the increase in biological productivity and extension of plant life was accompanied not by the spread of large animals, but by mass extinction of large animals in all the major continents[13]. Furthermore, these extinctions were synchronous with the colonisation of the planet by our ancestors, humanity. In Africa, which may have been our first home, about two-fifths of the large mammals have become extinct since 100,000 years ago. Apart from the modern KhoiSan people ('Bushmen' and 'Hottentots'), it can be argued that none of us is 'aboriginal'—we are colonists, all of us, not dating 'from the origin' in our occupation of the land on which we live, either in the continents outside Africa, or in much of Africa. Even most of the people of modern Africa have immigrated to their present localities in relatively recent time, displacing the San. As late as 1800AD, the spread of maize cultivation in the aftermath of Columbus allowed the multiplying Xhosa people to remove the San from the hills of the eastern Cape in South Africa.

In Eurasia, as modern humans arrived, roughly three-quarters of the large mammals disappeared in the same period. Whether the humans drove the animals to extinction is unproven, but the association of the arrival of humanity with the disappearance of large animals (which had

12 Broecker, W. S. and Denton, G. H (1989) The role of ocean-atmosphere reorganization in glacial cycles. Geochimica et Cosmochimica Acta, 53, 2465–502. Street-Perrot, F. A. and Perrot, R. A. (1990) Abrupt climate fluctuations in the tropics: the influence of Atlantic Ocean circulation. Nature 343, 607–12.
13 Martin, P. S. and R. G. Klein, (eds.). Quaternary extinctions: a prehistoric revolution. Tucson: University of Arizona Press.

not happened in previous interglacials) is compellingly powerful circumstantial evidence. Humans arrived in Australia some time between 50,000 and 30,000 years ago. It was a continent of astonishing creatures—giant kangaroos, marsupial lions, huge wombats. Here too, three quarters of the large animals disappeared, and a grossly impoverished fauna was left by the time westerners arrived, bringing cats and rabbits to endanger the rest. In the Americas, the main wave of human settlement arrived 11,000 years ago: very quickly, three quarters of the large animals disappeared. The sabre-toothed tigers, mammoths, giant musk-oxen, giant beavers, all went as humans appeared. Most recently, New Zealand and Madagascar were colonised, both about 1000 years ago. The same pattern of extinction took place. In New Zealand, the Maoris eliminated the moa and burned the forests; in Madagascar, the giant birds (Sindbad's roc) also went.

Humans are omnivores. When they eliminate their prey, unlike other animals, they do not also become extinct from lack of food. Most probably, the first humans to arrive were destroyers, with little thought to a future of scarce resources: they killed what they could. Once the first wave of extinction had happened, humanity in each continent, from Australia to the Americas, developed methods of living that co-existed with the surviving animals, those which were more wary, faster, or better hidden. This coexistence is perhaps best illustrated by the KhoiSan of Southern Africa. But new technology could easily disrupt the new balance. The reintroduction of horses to the Americas (where they had evolved prior to humanity's arrival) and the spread of guns initiated a new wave of hunting. Westerners almost eliminated the bison at the end of the last century, but arguably the American Indian with firearms and horses would have done the same job very quickly, had not the Europeans preempted them.

The point of this discussion is not to blame our prehistoric ancestors, of whatever race. They were in Eden, not knowing the right or wrong of their actions 'ere the base laws of servitude began, where wild in woods the noble savage ran' as Dryden put it. But the argument of the 'noble savage', living in deliberately maintained harmony with the biosphere, is fallacious: a creation of western intellectuals. All have fallen short of the glory of the natural ecosystem. The difference, though, is that our early ancestors were acting without knowledge of the consequences of their actions. For the last few centuries, however, technological societies have appreciated the fragility of nature, and bear responsibility for their behaviour. One cannot condemn the Amerindian hunters of the last century, whose response to the arrival of the horse and gun was to hunt bison. In contrast, their European counterparts in North America were on the verge of understanding the larger impact of their assault on the bison (and, luckily, did understand, just in time). They did have knowledge, and thus can be judged guilty of ecocide in large areas (and, to be fair, also commended for ultimately saving the bison).

Is the Biosphere Worth Preserving?

The arguments in support of protecting the natural environment are, surprisingly, not immediately strong. Perhaps this is a test of our culture. Consider first the ethical arguments. There is a strong view that it is ethical to hand on the next generation a planet as rich and diverse as the one we were given. This is an almost universally accepted point of inter-generational equity. Or is it?—leaders of many non-western societies (e.g. in south-east Asia) argue that it is better to create wealth for this generation, for instance by cutting forest, so that the next generation can grow up in an environment that, although poorer in natural quality, is materially richer. Is it not better to use taxes raised by cutting trees to create jobs and to pay for schools and health care? Is it not more important to build houses and to pasture cattle on formerly forested land than to preserve useless uninhabited natural ecosystems? Although this type of reasoning is strongest in non-Christian societies, especially in south-east Asia, many Brazilian leaders in the 1980s expressed the same views, and, conversely, many non-Christian leaders have deep reverence for the natural environment. African Christians vary—for instance, in Zimbabwe there is a wide sense that it is indeed unethical to damage the natural environment, but there is the equally strong feeling that there is no option for the poor peasant living off the land. 'Burn and cut, or starve' is the harsh, but understood choice[14]. On occasion, there is more insight in the conversation of a peasant teenager over an evening cooking-fire in southern Zimbabwe than there is in the erudite words of a don at a Cambridge high table discussing the same subject.

If the ethical argument for preserving the biosphere is seen by some as lacking conviction, is there not a scientific argument? Surely it is apparent that the whole fabric of nature is in peril. If we cut the forest and eliminate the animals, will not famine and mass extinction of humans immediately follow?

Perhaps, but perhaps not. We simply do not understand the complexity of the natural system well enough. Complexity may add stability to a natural ecosystem, but it can be argued that simpler systems are more stable. At the base of the biosphere are the bacteria, and they are unlikely to be much affected by what humans do, in the long term, over millions of years (although in the short term we have massive impact on bacterial populations).

A better answer to the puzzle is to look at analogies. Consider a tropical island, populated over the millennia by a variety of immigrant plants and animals, that over time adapt to coexist. Each new species that immigrates competes with the existing collection. In many cases, eventually, a richer and more diverse system results. But this can take time. And in some cases, the new species is so competitive that there is 'overkill'—the whole

14 Campbell, B. M., R. F. du Toit, and C. A. M. Maxwell (eds.) (1989) The Save Study. Harare: University of Zimbabwe Press.

system crashes. Rats have done this in many places, destroying both animal life—bats and birds in particular—and plant life. On some offshore islands in southern New Zealand, the introduction of rats has led to massive ecological collapse. The rats arrive, breed profusely, and eat everything available: the best food species rapidly become extinct (as do other animals that used to eat the food), and the omnivorous rats simply switch to other edibles. Then, the food runs out, and the population crashes. A million years hence, a new and diverse ecology, including rats, will have established itself. But in the meantime, the ecology is impoverished, and less productive than before. Humans, like rats, are immensely advantaged, and the Earth is an island in space: we too can produce an impoverished system, less diverse and less productive. But can we wait for new species to evolve and adapt to the changed conditions. Or will we simply breed them?

Most likely, however, the reduction in biodiversity will indeed cause major problems to humanity. For instance, the Irish and Scottish populations early last century increased rapidly, helped by the increase in food supply when potatoes were introduced. But the genetic basis of the potatoes was very slight and when, inevitably, potato blight struck, mass famine followed. The government in London was not inhumane, and helped millions with emergency aid, but it was slow to act and we live today with the long-term political consequences in Ireland, America and Australia. If a famine like that in Ireland were to happen today, we would search through the genetic heritage of Andean potatoes to find varieties resistant to blight. The celebrated Phylloxera plague that destroyed the vineyards of nineteenth century France was overcome in this way by grafting onto vines of a separate but related American species. But what if environmental despoliation in the Americas has reduced the wild stock of potatoes or vines? Other foods—especially maize and coffee, are today based on a very slender genetic heritage, and our society runs the risk of major crop catastrophes. The losses of elms and America's chestnuts may have been minor disasters—losses to the beauty but not food of the world—but loss of a major food grain would be catastrophic. And academia and the computer industry, the basis of western wealth, would collapse if we lost coffee. . . . Of course, international agencies keep large seed stocks, for exactly this reason, but the risks of losing the wild stock are great.

Moreover, there is clearly much yet to discover in the undergrowth of Eden. Pacific yews (relatively uncommon) yield important drugs, Radiata pines (a species of pine naturally restricted to a small part of California) form the basis of much of the Southern hemisphere's forestry, innumerable fruits await discovery. There is even a kosher pig, the Babirusa, a very rare and slow-breeding Indonesian forest animal, that could put bacon rashers on the Israeli breakfast table. More generally, rain forest plants from rice to sugar have shaped our modern civilisation and our history: there are more to come.

The Atmosphere

The winds carry no passports, as Sir Crispin Tickell pointed out (see Ref. 15 for a wider discussion). They are part of the common good of humanity. The atmosphere is a biological construction, the memory of the aeons.

A non-biological atmosphere that had existed from the dawn of the planet, like that of Venus, would probably be largely carbon dioxide. This would be air in equilibrium, sustainable, not demanding maintenance. But it would not sustain life, and the surface would be an inferno. Instead, we have air that is out of equilibrium with the rocks, unsustainable without constant action by the biosphere. Were all life suddenly to perish, the air would slowly lose oxygen and nitrogen over the next tens of millions of years, eventually either becoming a runaway greenhouse like Venus, or an icebox like Mars (the modern Earth is precariously between the two states, though probably closer now to Mars's condition, with its non-biological surface temperature of –18°C[16]. So the atmosphere that is 'sustainable' over the very long term is not for us.

When rich western humans realise they are overweight, they tend to go on a diet. At first, they resent and deny the need; later they try with varying degrees of effect to reduce food intake. A few simply try to ignore the problem and expand, hoping to escape the medical problems that may result. But once on a diet, forever on a diet: there is no escape. For the rest of that person's life, every bite of food will be taken in the conscious or subconscious knowledge of the calorie content. The atmosphere, too, cannot ever again be taken for granted. Aeschylus held that the air was heaven's protectorate, but it is so no longer. We have left behind our youth.

Every molecule of gas that humanity and its activities emit, every plant or tree that processes the air, is under our control, whether or not we accept the responsibility. Our industrial processes and the emissions from our transport have directly changed the atmospheric burden of carbon dioxide and methane, the two most important greenhouse gases after water, and the fine controls on global temperature. In addition, we have radically altered the concentrations of many of the trace gases. One amusing calculation is to work out the concentration of humanity in the air. At any one moment there may be several hundred thousand people airborne, with a typical atmospheric lifetime of a few hours—similar in atmospheric burden and life to many trace gases. Planetary warming, which is probably now well under way[17], may be beneficial to the

15 Tickell, Sir Crispin (1986) Climate change and world affairs. Lanham, MD: University Press.

16 Lewis, J. S. and Prinn, R. G. (1984) Planets and their atmospheres. Oxford: Oxford University Press. Henderson-Sellars, A. (1983) The origin and evolution of planetary atmospheres. Philadelphia: A. Hilger; Bristol: Heyden and Son.

17 Intergovernmental Panel on Climate Change (1990 and subsequent years) Climate Change: the IPCC scientific assessment (and also a series of annual updates). Cambridge: Cambridge University Press.

generality of humanity; but it is also possible that it may be harmful. Our models so far are not good enough to give us more than tantalising hints of the world that awaits our personal old age and the maturity of our children. The processes that may induce atmospheric and climatic change will continue, at least until human society massively rearranges its use of energy and its transport systems. We must await developments, with hope and prayer. We have so have sown the wind (Hosea 8, 7)—will we now reap the whirlwind?

On the land, the planet is now a garden. Except in the core of the forest, no plant grows free of our influence. The photosynthetic air conditioner is now under our control. For humanity the challenge of the reduction in biodiversity is immense, in many ways much more urgent than the challenge of atmospheric alteration, to which it is linked. Do we ignore the killing of the biosphere, as creation groans? Will each nation go its own way, the rich West zealously guarding its residual fragments while the poorer nations slash and burn? Or do we attempt to maintain the common good, even while we understand it so poorly, and while nation distrusts the motive of nation? The seas, too, are under attack, with some fish ecologies already in what may be permanent collapse. Here even the wealthy nations like Canada and the US cannot easily agree. But the Earth is already our cabbage patch: we do cultivate or neglect it all. Nothing grows unless we permit it, or plant it, or have not yet come around to cutting it, or it is a weed too costly to eradicate. And we do already manage the air: it is our protectorate now, even if we have not yet recognised the responsibility. There is no going back.

The Precautionary Principle

The argument above leads directly to the precautionary principle. We do not know what we might lose if we reduce biodiversity, or if we change climate with greenhouse emissions, so a wise and cautious society is obliged to preserve, at least until it understands the consequences of its actions. We are grossly negligent if we cut down nature before we comprehend it, and the consequences of this negligence may not only affect the next generations, but ourselves too. 'If in doubt, be cautious'. The lessons of Terminations 1a and 1b, are too fearful to do otherwise.

It is a curious coincidence that, just as our actions become important on a planetary scale and we become capable of changing the air, so at the same time we are discovering the skills to understand the complexity of the atmosphere. The need collectively to manage the common air has arrived at exactly the same time as our computers and data gathering have equipped us technically to meet the challenge. Whether we have the ethical ability to cooperate on this scale remains to be discovered. But the technical ability is there, or soon will be. It will not be long before we can calculate how much to reduce methane emissions to attain a chosen level of radiative forcing. Soon we shall be able to halt an incipient ice age

simply by releasing calculated quantities of methane or carbon dioxide. More immediately, we shall very soon be able to give good advance notice to peasant farmers in southern Africa, telling them the week the rains will arrive, and how strong they will be—the farmers can then plant maize seeds, of chosen drought resistance, in the knowledge that they will not sprout with the first shower and then die when the main rain does not come for weeks. It is perhaps not long before we can advise also India and the monsoon nations when and what seed variety to plant. The step from prediction to management is not too great to imagine.

Mansfield Park?

During the early 1700s, Christian baptism conferred freedom on slaves. Few nations allowed their inhabitants freedom from some degree of coerced labour—even Scotland had bondsmen—but a baptised black slave became free. Not surprisingly, slave masters tried to prevent the baptism of their slaves. In 1772, Lord Mansfield, crusty and in many ways a reactionary, laid the foundations of the modern western idea of human rights in his judgment that every slave, as soon as he touched English ground, acquired his freedom. Britain was free, and thus so were all who lived in it. More than half a century passed before, at fabulous cost, Parliament voted to abolish slavery in all the empire by compulsory purchase (and in so spending helped perhaps to buttress the foundation of the modern financial system), and even longer before David Livingstone's efforts helped finally to stamp out the slave trade in eastern Africa.

Mansfield's judgment was linked to his development of the law of contract[18]. Slavery existed without contract, and so had no validity in England. The judgment had commercial implications, and Mansfield, conservative and wealthy, limited the scope of his decision, disallowing claims for back wages. If the slave had worked for no contract, that was his problem. In America, the judgment did not immediately take root—to quote Dr. Johnson's sour remark: 'how is it that we hear the loudest yelps for liberty among the drivers of the Negroes?' But despite this, the judgment doomed slavery across the globe and has shaped all subsequent views of civil rights in the western nations: other nations, especially in Asia, still argue that food, health and security are more important rights than liberty.

The Mansfield judgment was made in the richest society on Earth, and indirectly helped to sustain and increase that wealth. This was no accident, just as today it is no accident that the richest skilled nation on Earth, Switzerland, is also arguably the nation most concerned, with profit, about the maintenance of its own local environment. Wealth may corrupt, but it also brings opportunity. In the seventeenth and eighteenth centuries, Britain and Holland had invented a new way of doing things, that was able

18 Drescher, S. (1987) Capitalism and antislavery. New York, Oxford: Oxford University Press.

to create wealth without slavery. Only in prosperity could liberty become secure. Only with liberty could prosperity stably continue. And so, in part growing out of the profits of slavery, began the age of Mansfield Park, our elegant wealthy society capable of all that is highest and yet at each moment forever threatened by the corruption of its own greed and immorality. Poverty is limiting, as Zimbabwean peasant teenagers are well aware. Only when we have the wealth to escape out of the gutter can we lift our minds to the stars. But if we ever become arrogant and uncaring in the enjoyment of our wealth, that wealth will destroy us. Jane Austen, who knew well that the basis of much aristocratic wealth lay in slavery, reflected on the danger . . . 'had he been more in the habit of examining his own motives, and of reflecting to what the indulgence of his idle vanity was tending: but, thoughtless and selfish from prosperity and bad example, he would not look beyond the present moment.' It is very easy to slip from the golden age of Mansfield Park across the boundary to the ruin of Samaria. The prophet Amos (5,11) saw the fragility of wealth: however technically able we are, however skilled, we can be rapidly ruined by internal dissension, by external competition, or simply by nature. The examples of fall from wealth are all around. It is not long since Argentina was one of the half-dozen wealthiest countries on Earth, on a par with Canada. Even in Africa, it is only a few decades since Ghana was comparable in per capita wealth to some southern European states; the jet fighters that advanced Zimbabwe used 35 years ago to help in the defence of the ill-equipped Kuwaitis from Iraqi aggression are still flying.

Sustained wealth, that does not collapse, allows the build-up of skill, through education and investment in learning. It is this skill that will allow us eventually to maintain the integrity of the planetary ecology, if we can agree to do so. The task of managing the planet will be immensely difficult technically, requiring much new knowledge both in the field and in satellite vision, and in the computer. Do we have the right to manage the planet? Or do we have the right to avoid the task, given that we already act on a global scale, but chaotically? Even if we agree, the implementation is immensely difficult, both technically and politically. Western nations can do much to reduce their atmospheric emissions, but ultimately there will be no success until the poorer nations have their chance at wealth too. Yet this is dangerous: if the most populous nation, China, electrifies, depending on coal, the global increase in carbon dioxide emissions will far outweigh reductions imposed by western control measures. Clearly, we need to help China move away from coal, or to develop carbon recapture by reforestation.

In Africa, will not an increase in total wealth simply be countered by increased birth rates, reducing per capita income, devastating vegetation, destroying the environmental air conditioner? Can the devastation of the African biosphere, which has major importance in the global atmosphere, be stopped? Yes is the answer to both questions, but only if the lot of women is changed. A large part of the solution is technical. Electricity, as

Lenin knew and Nelson Mandela after him, builds a new state. Electrification has had a massive role in changing the status of women in the rich nations, and in Africa it is now a prime goal of the new South African state. Rural electrification frees women from the burden of gathering wood, allows reforestation, and promotes reading and learning at night. Urban electrification allows quick cooking and cleaning, and reading and education. There are other factors. Clean pumped water and drains improve health. Eliminating the bride-price system (which provides financial security to parents in south-central Africa) and replacing it with a pensions system will remove the pressure on women to bear innumerable children. Many Africans are Roman Catholic, but the Billings method of contraception[19] is free, effective, works within a family unit, and is supported by Rome. Rather than facilitating the behaviour that spreads AIDS (up to 30% of young adults are HIV positive in many parts of south-central Africa), the method works in marriage. Its impact is widespread. Many rural African women know more about their reproductive cycle than European inner city teenagers. When population growth is slowed, and wealth and skill can build up, then societies can afford to care for their environment, to protect the global air conditioning system.

Seen from the viewpoint of the African peasant, wealth does bring benefits if its arrival does not also corrupt. No African peasant chooses to be poor and unskilled. With skills—true wealth—life ceases to be a daily struggle for food: in peaceful and wealthy Mansfield Park, the higher qualities can at last be addressed.

The path of economic ascent can be entered, the environment can be nursed even in Africa, but the first steps are the most difficult.

Stewardship

Nature has never been particularly interested in sustainability (if interest is a feeling that can be ascribed to nature!). Early Bacteria and Archaea used all available resources. Whenever and wherever a resource was available, it was exploited. Other bacteria evolved the ability to recycle the waste products. Some waste accumulated, like oxygen, becoming the substrate of the next generation. Waste—including the atmosphere— is the memory of the system, creating the environment of the next generation, and in each generation all resources are used until some resource-limitation or waste poisoning crops up.

The early geologist James Hutton used the term 'the oeconomy of the Earth' to describe something much wider than the flow of little green pieces of paper. Oikos, oeconomy, is a term rich in the idea of family. This family is wide: 'All people that on Earth do dwell' (Psalm 100). And this economy should not be dismal: 'Sing to the Lord with cheerful voice. Him serve with mirth, his praise forth tell'. The BBC and many Anglican hymn

19 Billings, E. L. and A. Westmore (1981) The Billings method. New York: Random House.

books invariably have it wrong: they enjoin us here to serve the Lord with 'fear'. This is unfair to the Hebrew—we must indeed fear the Lord, but the psalmist tells us to serve with gladness, 'mirth'. Our stewardship should be a cheerful business, a family economy. 'Mirth' and 'Earth' go together—our home is a place of gladness. The lesson is important, if we are not to revert to dour ecofascism.

But can we design a system of stewardship? A small example illustrates the problem. Not long ago, a holly tree in our front garden died, for no obvious reason, but possibly honey fungus. The tree had probably bolted years ago from a hedge. The dead trunk began to tilt, and crack. We were about to cut it down, when we discovered to our horror that it was 'listed' (as are all the shrubs and trees along our street frontage of about 25 yards), presumably some years before we bought the house. It is not permitted even to cut down a non-existent lilac in the front garden, because it is listed (perhaps the council misidentified another plant). Finally, after many weeks and much pleading that it was a safety risk, and an inspection, we obtained permission to cut the trunk. Moreover, we received a stern warning that if we did not cut it down immediately we would be in trouble for allowing an unsafe tree to stand. Furthermore, there were also orders about what to plant as a replacement, mostly either fungus-susceptible, or else perhaps the official idea of 'native plants' (a dangerous notion: even the much maligned *Rhododendron ponticum* was a native prior to the last glaciation). Flowering plants except laurel were mostly verboten: the preferred choice was an evergreen. Yet the same local council that was so concerned about our dead holly authorised a large and wholly unnecessary car park in the recently-abandoned University of London Botanic Gardens, destroying a place of aetherial beauty. It is possible that the entire gardens will eventually be built over.

The management lesson from this little example is perhaps that if we find it difficult fairly to order the land under a borough council, how can we aspire to manage a planet? Our council is attempting to manage the local environment, but lacks skill to deal with tiny detail and simultaneously lacks will to deal with major problems. Would it not be better if each individual landowner was given back individual rights, and the council busied itself by a more rigorous and better informed supervision of corporate landowners? No North American would put up with, or pay for, such use of state power to manage the garden lilacs. This illustration is trivial—all British property owners must surely at some time come up against the excessive power of the U.K. state—but the point is profound. In a small and crowded environment, we use state power to moderate individual action, so all can live together. But in doing so we risk creating a bossy monster that terrorises the small while fearing the big. Just as a council may allow large corporate bodies to do profound ill, so in a global management system, small nations will inevitably be forced around by badly-behaving large states. There seems to be only limited choice: either we carry on as at present, with untold consequences; or we construct some

sort of ponderous, committee-dominated global management system, that will inevitably be partly ineffectual; or we give in to some sort of eco-fascism, that may briefly much improve matters, but inevitably will fall apart or lead to conflict. It seems we must depend on the committees:—the elephantine bureaucracies of the UN, supplemented by the negotiated realpolitik of the G-7, GATT and WTO. But in all this, where will the mirth go? Will we lose the gladness of the Earth?

Committees have little imagination. They typically go for the safe option—that is, if they are not corrupt. Our science councils in the UK are superb examples of this: they fund safe, predictable science, without spark. If we turn over the management of the planet to committees, will we not do too little, too late, and slowly let crumble what Lucretius called the proud ramparts of Earth? Perhaps, but is not managing ourselves the core of the challenge? If we manage to manage ourselves, we can sustain the biosphere.

One possible strategy is a minimalist option—decision-making at the lowest informed level. This could be called the '1950 Earth' model[20]. In 1950, the Earth was biologically and climatically in reasonable shape. The 1949–51 period was average for the conditions in which the presently ruling generation of adults grew up. More than that, it was a period that was adequately documented scientifically. Nearly everywhere, we have a reasonable record of the broad state of the biosphere at the time. Obviously, there had been massive anthropogenic change prior to 1950, especially in China, Russia, Europe and North America, but the biologically important and most productive parts of the biosphere were still in reasonable shape. Obviously also, the state of knowledge in 1950 was only broad, not detailed: even now we are only beginning to count the biodiversity of the creation. The 1950-Earth model simply states that management policies should be designed to move towards, not away from, conditions in 1950. This allows a local scale of decision. Instead of some grand plan to manage the environment of a planet or a nation, the 1950-Earth model simply allows local decision making, and local approach to a common standard.

Every sparrow is counted; every lily clothed (Luke 12.6, 27). Can humanity achieve such a census, or provide such garments? Should humanity attempt to? Or is it blasphemy even to think of the task? God gives breath to all life; in him we live and move and have our being. He did give us the ability to discover, and perhaps to know our home. Our knowledge of the natural world is still very trivial, and we barely understand the gross structure of the workings of the atmosphere; we are many many years away from a detailed knowledge of the intricacy of the biosphere. But as we blunder and slash our path through nature, we inflict upon ourselves the need to count those sparrows; to clothe those lilies. Perhaps our task now, as we grow in technical skill, is to hear creation

20 Nisbet, E. G. (1991) Leaving Eden. Cambridge: Cambridge University Press.

groaning, and to take on a small part of the labour of maintaining the garden. Who hath known the mind of God? Is it our predestiny, as we come so haltingly to the measure of the stature of Christ, to learn collectively this task? Noah's rainbow still shines, though dulled by air pollution in many lands; hand in hand, with wandering steps and slow, Adam and Eve take their solitary way through Eden. We have been given the computing tools to begin to understand the complexity of the Garden, we have the biological skills to start deciphering the diversity of the flora, fauna and bacteria. And is it accident that this has come about in the decades when our rickety world order is just gaining the ability to discuss these problems on a global scale, and perhaps even to act on them?

Professor E. G. Nisbet is at the Department of Geology, Royal Holloway, University of London, Egham, Surrey TW20 OEX.