How Many Lightbulbs Does It Take to Change a Planet?

95 Ways to Save Planet Earth

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Extract

PART 1

Interesting Times

Kathleen Elliston was my maternal grandmother. She was born in the same month that the first powered aeroplane took to the air. As a young teenager growing up in the East End of London she worked in a sugar factory. It was attacked by a Zeppelin airship and burnt to the ground in one of the first ever air raids on a city. As an old woman she told me how burning molten sugar ran in the gutters of the streets near where she lived and how she saw a tiny British biplane destroy the gas-filled giant in a massive aerial explosion. The flying machines fighting above London were at the cutting edge of modern technology.

When she was sixty-six, people landed on the Moon. By the time she died in 1998 the Internet was growing exponentially, mobile phones were even owned by children, and you could buy a ticket to fly to Australia for less than a week's wages. The shops were full of produce from all over the world. Her many great-grandchildren had little knowledge of seasonal foods. For them, endless dietary choice was normal.

When she was a small child at the start of the 20th century, the distant world she left at the end of it would have seemed quite impossible. When she was very old, she would sit and shake her head in disbelief.

Change continues, and at an ever-accelerating pace. We are now living through social and technological transformations more rapid and profound than any to have occurred in human history. The

increase in human numbers to over 6 billion people (three times that of that a century ago), the expansion of the global economy, the emergence of an elite consumerist class around the world, and the mass production of high-tech products are among the major trends now shaping the present and future.

Change can be positive, of course. My grandmother often said to me how much better life was for my sisters and me compared to how it was for her as a child. When she was young she faced deprivations and hazards that we find hard to believe today. Poverty, disease and ignorance made many people's lives a grindingly miserable experience. Most agree that development and technology have provided benefits and comforts, at least for some. Perhaps it is because of this comfort and convenience that we find it hard to take a wider view of where we are going, to appreciate the logical destination of the course we are on, let alone what alternatives might exist.

For centuries people expected little change in the structure of society or the way they lived. They expected that life would remain largely as they found it, and to leave the world pretty much as it was when they came into it. Today we anticipate that things will change on an almost daily basis: a new cure for heart disease one day, a new form of genetically engineered corn that can resist insect pests the next. Rapid change is now very much the norm.

Our species has not been here before, nor has it been where we are going – wherever that might be. Who would dare speculate as to the state of our world and the nature of our society in 2100? No matter what the world might look like less than a century away, it is clear that the state of the Earth's natural environment will play a crucial part in the outcome.

Since the beginning, human progress has relied on the exploitation of nature. Natural systems have been the basis of our wealth and security. In the cause of survival, welfare and quality of life, we have sought new ways to get more value from the environmental resources and services provided free by our planet. This remains a fundamental force in our modern world too.

There is massive momentum behind our demands on nature.

Seeking out new natural resources was one of the principal motive forces behind the process of globalization initiated by Europeans in the 16th century. Expeditions were sent out from the technologically advanced European societies to determine what could be taken from newly discovered lands. The pioneering expeditions brought back both the spoils of conquest and products exchanged in trade, setting in motion economic links that remain with us today, only on a very much larger scale.

Europeans established new societies in the places they conquered, some of which took on characteristics of the mother civilizations – the USA, Australia and New Zealand among them. The colonial period was followed by a phase of further globalization of trade and commerce. This replaced the political control of natural resources by colonial governments with a market-based system increasingly run by transnational corporations.

The process of economic globalization has until now had some clear winners – the rich minority who happen to live in the Western countries. Predictably, some of those who have been left behind, such as China and India, are now trying to catch up – and doing rather well in terms of mimicking those countries that are already industrialized. Rampant economic growth built on high-tech manufacturing, booming services sectors, Western-style business administration and the emergence of a consumer class are leading to huge new demands for energy and natural resources, from oil and water to fish and timber.

Perhaps it is not surprising then that many see recent history and present circumstances as fully vindicating the recent high consumption- and growth-led pattern of development that is now being copied by countries everywhere, especially in Asia. It worked in the West and now it is working in Asia – so it can work everywhere. Or at least that is the assumption that lies behind some of the most important political decisions of our times. Considering the implications of this point of view, it is rather surprising how rarely, if ever, it is the subject of mainstream political debate. Can we really carry on as we have in recent decades, and extend the Western path all around the world. Is it really feasible to have all 6 billion of us con-

suming as 1 billion Westerners presently do, let alone the 9 billion people expected to live on Earth by 2050? Can we really accommodate that much demand on the planet?

Without thinking too much, people generally answer the question by putting their faith in technology. After all, from anti-cancer drugs to 800-seat airliners, from the Internet to missions to Saturn, we have achieved what until recently would have seemed like miracles.

Many in the developed industrialized countries feel we can sit back in triumph. Our system of government, our style of development, our technology, comfort and culture are all expressions of progress that have succeeded in improving many people's lives. Many Western societies now see themselves as the gold standard for development, an example that others can emulate.

Because of our achievements, the popular assumption is that in order to render ourselves more secure and wealthy, we should carry on as before, growing the economy, unleashing new technology, and finding new ways to exploit natural resources.

But there is a problem. The simple fact is that the demands we are making on nature cannot be sustained.

That we have some serious ecological problems to deal with is not news. What is novel, however, is the scale of the environmental change now underway. While once we faced challenges that could be managed by local or national action, the trends we must now address are global in nature. The situation is also different because of the growing public and political acceptance of the need to do something about it. But what?

In some ways my own awareness of environmental issues mirrors that of society as a whole. I have a childhood memory of walking with my grandfather near our home in Oxford. I was about four years old and fascinated by animals and plants. We had found some spiky black caterpillars on nettles growing on a rough verge by the side of some allotments. I knew that the plants could sting and was intrigued as to how the creatures could not only sit on the nettle leaves, but also eat them. This was baffling enough, but the news that the caterpillars would soon turn into brightly coloured

peacock butterflies I found quite amazing. I still do.

Some days later, we passed by the nettle patch again. Now it was brown and withered. It had been sprayed with herbicide. The nettles and everything on them was dead. It was explained to me that the allotment keeper wanted to get rid of the weeds and had used plant poison. Had they not thought about the caterpillars, I asked. The nettles weren't even on the allotments, so why spray them, I demanded. I don't remember the answers, but I have repeated the sentiment of these questions a million times since. The caterpillars have provided an enduring paradigm.

I didn't know it at the time, but a couple of years before the spraying incident left such an impression on me Rachel Carson had published *Silent Spring*, one of the most important environmental books ever published. This pioneering American author put the world on notice about the deteriorating state of nature and in so doing is credited with helping to give birth to the modern age of environmental awareness.

Her book was one of those shocks to the system that make people aware that things are not as they seem. It was thought until then that pesticides – whose use had greatly expanded in the postwar years – were unambiguously good: they increased food production, made groceries cheaper, and would end poverty. But the downsides were not widely appreciated, until Carson pointed them out.

The caterpillar incident was just one in a long line of environmental experiences that shaped my views during childhood. As I got older I spent much of my time riding my bicycle in search of wildlife. I became obsessed first with birds, then reptiles and then insects. I wanted to know more about plants and how they formed different communities, and what part they played in different habitats. I was a fossil hunter, and through this interest became aware of the huge timescales spanned by evolutionary processes.

My passion for nature brought me into contact with filled-in ponds, drained marshes, polluted streams, new buildings covering little bits of wild green space, hedgerows and trees grubbed up to increase the size of fields. I saw birds of prey that had been poisoned, and watched new roads destroying the homes of wild

creatures. When I was about 13 years old, I took my first action as a campaigner – against some bulldozers being used to clear a patch of swamp where reed warblers were nesting. The bulldozers won that time. But if anything it made me more determined.

As I have seen more and more aspects of the challenges that face us, it has become clear to me that we are confronted by far more than a series of disconnected battles over particular bits of wildlife habitat. It is also obvious to me that the days when the environmental debate seemed to pivot on a presumed conflict between environmental and human goals are long since departed. The issues are now far bigger than in the 1970s, and are more urgent too.

We must now face the challenge of meeting expanding human needs while simultaneously maintaining the relatively stable and productive planetary conditions that have sustained our welfare. It is not a matter of whether we protect the environment *or* promote increased human well-being: the simple fact is that if we do not do *both*, then we will not succeed with either one. If we are to achieve this goal of sustainability, maintaining functioning environmental systems while ending poverty and delivering a good quality of life for people, then we must make some radical changes, and make them quickly.

We have come a long way since *Silent Spring*. Today the environmental challenges are global. They are deeply embedded in economic questions. They are also fundamentally matters of justice, human rights and democracy. If we are to build sustainable societies we will need to address some urgent and large-scale interlocking trends, namely, climate change, the impending global mass extinction of species, and the depletion of resources.

To be effective in rising to this challenge we need to re-examine the process of development and growth, and make sure that we embed justice at the core of solutions.

Many others have reached the same conclusion. The question is, what to do about it. This book will, I hope, provide at least part of an answer. Before going to the solutions, in the rest of this chapter I will set out what I see as the main dimensions of the

environmental situation. This is important, for if we do not understand the scale and scope of the ecological challenge, we are unlikely to succeed in delivering effective solutions in time.

Bristol Zoological Gardens is a delightful place. I came to know it as a student in that city in the early 1980s. Some years later I was there again, with my wife and children for a family day out. It was a glorious sunny afternoon, and the children chased about on the lawns in t-shirts. At over 20 degrees centigrade it was wonderfully warm. Very pleasant indeed – but for one thing: it was early February. While we should have expected conditions typical of the depths of winter, daffodils were in bloom, and a chiffchaff sang in the high bare branches of an oak tree. It was quite spooky I thought – really not right.

Unusual weather is not necessarily a cause for alarm. Indeed, like all other inhabitants of the British Isles I regard changeable weather as the norm. That day turned out not to be an isolated occurrence, however. The year in which it occurred, 1999, turned out to be one of the warmest on record, and that was not just in Bristol, it was a global average. The next year, 2000, was reported by meteorologists as probably the warmest ever in southern England for at least the last 1000 years. In 2006 that record was broken again.

It is not only in England that temperature records have tumbled. At the global level the top warmest ten years were all recorded in the 12 years up to 2006.

There is no longer any scientific doubt that the climate is changing, and after a great many years of campaigning on environmental issues, it is without hesitation that I can tell you that this stands above all others as the most dangerous, pervasive and alarming ecological challenge that confronts us. Paradoxically, however, it seems that the scale and urgency of this issue has had the opposite effect to what might be expected: instead of galvanizing action, the scope and pressing nature of the threat appears to have generated paralysis.

It is too easy for us to take the climate for granted. Over the course of our short lives we get used to predictable conditions. In temperate western Europe we expect spring to follow winter at a certain time of year, for sufficient rain to fall, and for there to be a tolerable range of temperatures. Any talk of climate change or global warming can be dismissed on the back of a short cold snap. A lazy glance skywards gives the impression of limitless space, a vastness that seems beyond human influence. It appears that we humans could not possibly alter something as fundamental as the seasonal cycles that have dictated our lives since before writing was invented. But we are.

The sky is not as big as it looks, and it is only in a thin veneer of atmosphere that our climate and weather are born. From ground level it looks limitless: but in reality the atmosphere is no thicker than the equivalent of a coat of paint on a football. Most of the greenhouse gases that are causing our world to warm are trapped in a layer of air about 10 km (6 miles) thick, a distance that most people could walk in a couple of hours. The diameter of the Earth is about 13,000 km (8000 miles).

The climatic dynamics of our planet are finely poised, and the unintentional interventions of humans are leading to rapid and potentially dangerous changes. Because of alterations in the composition of that thin layer of atmosphere, serious climatic disruption is already taking place – and is expected in the coming decades, if we do nothing about it, to take on very damaging proportions.

The mechanism causing these changes is called the enhanced greenhouse effect. Certain gases act like the glass on a greenhouse. They freely let light through, but then trap the heat energy that radiates back from the ground. The result is an increase in temperature. There is a milder natural greenhouse warming that makes the Earth a pleasant place to live. It is the increase in the greenhouse effect that is a major problem. This extra heating is popularly known as 'global warming', and is driving changes to the Earth's climate.

The changes to the composition of the atmosphere that are

already causing global warming have occurred very quickly. For millions of years the atmospheric concentration of carbon dioxide has mostly remained below 300 parts per million (ppm). That is 0.03 per cent of our air, making carbon dioxide effectively no more than a trace gas. But even quite modest changes in the levels of carbon dioxide, we are now learning, have a major bearing on how the Earth's climate system functions.

In the pre-industrial period, up until about AD 1800, the concentration of carbon dioxide in the atmosphere was about 280 ppm. Since then the level of carbon dioxide has rocketed to over 380 ppm, and is continuing to increase at about 2 ppm per year. Carbon dioxide is the most important agent of climate change resulting from human activity, but it is not the only one. Methane levels have risen too, and so have nitrous oxide concentrations. A group of industrial gases, including the chlorinated fluorocarbons (CFCs) – which have additionally dug a 'hole' in the ozone layer – are also implicated.

We have known all this for some time. And there has been some modest action. For example, the European Union has introduced rules to discourage landfill because of the methane released from rotting organic matter buried in the ground. There has been some focus on the industrial gases (such as CFCs) as well. The main problem, however, and the one that is also the most difficult to deal with, is in relation to carbon dioxide.

Deforestation has for millennia been changing the Earth's carbon cycle. When trees are cut down and replaced with crops, for example, there is a net release of carbon dioxide. This has had some influence on the Earth's climate, and deforestation is still responsible for about one-fifth of carbon dioxide releases due to human activity. The rapid recent upswing in concentrations of carbon dioxide is, however, due to large-scale combustion of fossil fuels, starting with coal burning during the Industrial Revolution. That was later joined by the use of oil, mainly as a transport fuel, and then by natural gas, which is mainly being used for power generation, domestic heating and cooking. Natural gas is the cleanest and least damaging of the three main fossil fuels from a climatic point

of view, but the huge quantity now being burned is not compatible with long-term climatic stability.

The climatic changes that we have already initiated will continue, and if left unchecked are expected to lead to a wide range of mostly unpleasant consequences. One is a global mass extinction of species. Recent projections suggest that even on the basis of a mid-range warming scenario we can expect a million or so terrestrial species to disappear[1]. This will be caused by large-scale habitat change, as for example rainforests desiccate into savannah owing to drier conditions. Changes to seasonal patterns will disrupt the life cycles of animals and plants, while alterations in precipitation will play a part too. Already several species have been lost because of recent climate change, the golden toad from the cloud forests of Costa Rica among them[2].

An increasing frequency of extreme weather events, attributable to climate change, will inflict increasing levels of damage to buildings, roads and other structures. This is already happening – there has been a sharp increase in damage payouts by insurance companies in recent decades[3]. Even with the modest levels of recent warming insured losses are approximately doubling every decade as extreme events take their toll on people and property – from hail storms in southeast Australia to floods in southern England and hurricanes in the USA. 2004 broke all the records. That year alone saw economic damage of about 200 billion dollars and about 75 billion dollars in insured losses[4]. Rising sea levels will eventually cause trillions of dollars worth of damage, inundating some of the world's major cities and depriving us of vast areas of productive agricultural land. No wonder the insurance companies are getting edgy about their future prospects.

There will also be impacts that more directly undermine people's welfare. Depending on how much climate change occurs, billions of people could face water shortages. Water availability will also hit food production. Diseases will spread to new lands. The World Health Organization estimates that over 150,000 people are already dying each year because of existing levels of climate change – mainly through the spread of disease[5]. Impacts on water and food

and the increase in disease will impact on economic development – especially in the poorest countries.

A combination of these consequences of climate change working in concert could lead to social instability, mass migrations of people and even the rise of authoritarian regimes. That in turn could lead to new sources of international tension and conflict.

This kind of prognosis used to sound like science fiction. It now sounds to some experts more like an inevitability. In reality, however, neither is necessarily the case. It could happen, but there is still time to avoid the worst effects of climatic upheaval. However, we need to act now.

Today, the dark reality of human-generated climate change is very widely accepted, but getting anything done about it is still agonizingly difficult. The world presently runs on fossil fuels, and there is a vast economic momentum that keeps us reliant on these energy sources. However, if we are to pass on to our descendants the kind of world that has enabled human civilizations to be born, grow and thrive, then we have to change the way we supply and use energy. But what scale of change is needed, and by when?

It is impossible for anyone to make detailed predictions about the future, or to model a system as complex as the Earth's climate to the point where we can be certain of the consequences of different pollution loads. Having said that, however, the climate-change scientists are becoming ever more convinced that we need to limit the eventual warming to below 2 degrees centigrade compared with the average global temperature in the pre-industrial period.

If we are to limit the warming to below that level we don't have much time to act. We have already exceeded a 'safe' level of greenhouse-gas concentration (this is estimated at about the equivalent of 400 ppm carbon dioxide, including the warming effect of the other greenhouse gases). To stand a 50/50 chance, more or less, of remaining below 2 degrees, then the best estimate we have at present says that we must avoid concentrations going above about 450ppm, and then quickly come down from that level during the course of the 21st century. On the basis of present trends, we will hit the 450ppm level (calculated at the carbon-dioxide equivalent)

in about a decade. We are already at about 430ppm carbon dioxide equivalent, and are going up at over 2 ppm per year.

Recent events underline the urgency of the situation. In 2003 an unprecedented heat wave killed more than 20,000 people in Europe. The heat and dryness also wiped about 20 billion euros from farm incomes. Climate-change scientists concluded that the event was so off the scale of natural variability that it was likely caused by human-induced global warming. Recent modelling suggests that by 2050 a 2003-type summer might occur every other year. If the warming gets that severe, then an exceptional summer under those new climatic conditions would be hugely damaging.

Human impact on the climate has also been linked to the devastation wrought by Hurricane Katrina, which hit New Orleans in 2005. Although in that case it was not possible to say that the specific storm was caused by human-induced climate change, storm researchers could relate this intense event to a longer-term trend towards more powerful hurricanes caused by increasing sea-surface temperatures[6]. This in turn is a result of global warming. The damage caused by the recent intense drought in the Horn of Africa, threatening the lives of millions of people, is a further case in point, again linked to increasing sea-surface temperatures – this time in the northern Indian Ocean. The situation in Africa is especially grave, not least because some 70 per cent of the population rely directly on rain-fed agriculture for their livelihood[7].

We are thus already living with the consequences of elevated levels of greenhouse gases. What makes the climate-change situation more complicated, and in some ways more difficult to deal with, is the inertia that is in the climate system. Even if we stopped the accumulation of greenhouse gases tomorrow, there would still be further warming because of the delay between today's pollution and the warming effect it will generate. Carbon dioxide also remains as an active warming agent for a long time. Molecules of this gas being released today – from our cars, aeroplanes and power stations – will remain in the atmosphere for about a hundred years.

Already we have generated about 0.7 degrees of warming compared to pre-industrial global average temperatures, and a further

0.7 degrees or so is already in the Earth's climatic system, no matter what we do now. The longer we leave serious action to cut the emissions, the bigger the warming we will generate. The bigger the warming, the more serious the climatic change that we will bequeath to future generations. At some point, perhaps at around 2 degrees' increase, the warming may take on a momentum that becomes unstoppable, no matter what we do.

This could occur because of a series of 'positive feedbacks' that at some point are likely to be activated on a large scale by the human-induced warming. Several are already kicking in, such as the loss of white surfaces that reflect a lot of the Sun's energy back into space. Arctic ice has melted to record low levels in recent years, exposing dark sea and land surfaces that absorb more heat, thereby further fuelling the warming. This is part of a wider trend that has seen an average 10 per cent reduction in global snow and ice cover since the 1960s. The frozen subsoil of the tundra in the Arctic regions of North America and Siberia is also thawing, and this is releasing methane and carbon dioxide from bogs that were previously locked tight with permanent frost. The more it thaws, the more greenhouse gases will be released. In 2005 Russian researchers confirmed that this feedback has actually begun[8].

British climate modellers have set out scenarios that could plausibly see the dieback of the Amazon rainforests to savannah or even treeless grassland as a result of a long-term reduction in rainfall across much of northern South America[9]. The great Amazonian drought of 2005 could in this respect be a portent of things to come. If it did become a long-term trend, then billions of tonnes of carbon dioxide would be released as the biomass of dense forest was reduced to sparse woodland. Soils are another growing source of atmospheric carbon: as conditions become warmer micro-organisms in the soil become more active and degrade organic matter more quickly. The world's reservoir of carbon in the soil would thus fall while the atmospheric loading goes up[10].

A 25-year UK soil survey by the National Soil Resource Institute found that soil is losing carbon 'on an enormous scale'[11]. The survey estimates that 13 million tonnes of carbon is lost from UK soils

each year. The carbon is going from the soil and into the atmosphere at a rate equivalent to about 8 per cent of the UK's 1990 total emissions.

At the same time as the feedbacks become activated, some of the present 'sinks' for carbon dioxide (that is those elements of the global system that suck in and hold carbon dioxide) may become less effective. The biggest sink of all is in the oceans. Marine organisms absorb carbon as they grow. When they die they sink and take the carbon that was previously in the air to the sea bed. As carbon levels in the atmosphere rise, however, carbonic-acid concentrations in sea water are rising. Basically, the oceans are becoming more acidic because of fossil-fuel combustion. This not only has serious implications for the functioning of marine biological systems (including fisheries), but means that the ability of the oceans to absorb carbon could decrease too, in part because the more acidic conditions make shell formation problematic for sea creatures[12]. This could happen as the feedbacks increase, thus dealing a double whammy.

While 2 degrees of warming is now widely regarded as a key danger threshold, the Fourth Assessment Report of the Intergovernmental Panel on Climate Change[13] presents modelling that shows how a rise of more than 6 degrees is a plausible outcome by the end of the present century. The modelling used to reach this potential level of estimated warming is based largely on assumptions about emissions, and does not fully embrace the effects of the feedbacks. In short, the science shows that we are creating very serious future risks and committing the world to grave danger.

The other environmental trend that is working at a similar scale alongside climate change, and in important ways in synergy with it, is the massive decrease in biodiversity. This poses similarly fundamental challenges.

The Earth, as far as we know, is the only place to support life. A mind-boggling diversity of living organisms shares the planet with us. A recent estimate suggests that there are in the order of 13 million species living today[14]. From strange fish and worms inhabiting the ocean depths, to spotted cats and tough little flowering plants

on the tops of high mountains, our world's myriad ecosystems have spawned and sustain a staggering variety of life.

The Earth's amazing biodiversity is the pinnacle of more than 3.5 billion years of evolution. Hundreds of millions of species have come and gone over this vast period. Today it is likely that less than 1 per cent of all the species that have ever lived are presently with us. The rest have gone, quietly slipping into oblivion after a gentle and slow decline as conditions gradually changed, or lost with countless others in some global catastrophe, such as the collision with the asteroid or comet that wiped out the dinosaurs 65 million years ago.

Although only a tiny fraction of the life forms that have ever lived on Earth remain today, until recently the array was probably more varied than at any time in the Earth's history. A substantial number of species have already been lost through human activities. For tens of thousands of years we have been burning forests, hunting game and moving animals and plants to new lands to which they were not native. All of this has taken a heavy toll. For example, the so-called Pleistocene megafauna, including large mammals such as mammoths, woolly rhinos, giant ground sloths, huge armadillos and giant marsupials were most likely wiped out by prehistoric humans who colonized the lands where these animals once lived, in the Americas, Australia and northern Eurasia[15]. The place where the large Pleistocene animals mainly survived is Africa. This is where humans first evolved, and the large animals there had a uniquely long opportunity to get used to us.

While the impact of humans on the Earth's biodiversity has already been very considerable, we can in the coming few decades anticipate a sharp escalation of the damage. Recent assessments show that biodiversity loss is accelerating[16] and if left unchecked could soon reach the point where a global mass extinction is initiated.

A number of factors are responsible for the current rapid loss of natural diversity: the extension and intensification of agriculture; the impact of logging and fishing; the release of species into lands where they did not previously occur; various forms of pollution; and

the direct exploitation of wildlife through such activities as collecting and hunting. Add climate change to this series of pressures and a very serious situation is laid bare.

The geological record is punctuated with five major mass extinctions and a number of smaller ones. The last one, the fifth, was caused by the impact of the comet or asteroid that came down in the Gulf of Mexico 65 million years ago. The sixth, it is believed, is now getting underway. This time the rapid loss of natural diversity is because of human activity.

This loss of biodiversity is irreversible. Once various evolutionary pathways are closed by extinction, they cannot be reopened. Extinction is forever. The finality of what we are doing has as yet proved insufficient to stir the necessary action, however. But perhaps some practical considerations might still prod us into doing what is needed.

The most practical consideration of all is the fact that all the food we eat ultimately derives from wild species. Chickens, wheat, cattle, potatoes and all the other animals and plants that we now rely on for sustenance are without exception derived from wild species. Only when our ancestors discovered their value did the process of domestication begin. How many species might provide the foundations for future nutritional needs, let alone industrial purposes, we can never know. Allowing them to die out before we have had a chance to identify their potential would be the height of folly.

Another practical consideration concerns our health. A high proportion of the medicines we rely on today, from treatments for minor ailments to cures for cancer, are ultimately derived from wild species[17]. Rainforests have been an especially rich source of such drugs. In these complex ecosystems evolutionary arms races are constantly waged between plants and herbivores and between predators and prey, and have led to various 'chemical weapons' that have turned out to have great value to humans.

Natural ecosystems are also sources of great quantities of raw materials and food. Forests, for example, provide timber. Mangroves and coral reefs act as the nursery grounds for a significant proportion of the fish that we eat. Natural systems also help to

maintain regional climatic stability and to provide and protect supplies of fresh water. We also must not underestimate the importance of intact ecosystems in the regulation of global climate – forests in particular are important sinks of carbon dioxide. The annual contribution of carbon dioxide from deforestation is about one-fifth of the total caused by human action, and is more than the total global emissions from transport. Protecting intact forests is thus a priority if we are to avoid the worst impacts of climate change.

Wild ecosystems are also a core asset for tourism, the number-one industry in many countries and the fastest-growing economic sector in terms of foreign-exchange earnings and job creation. International tourism is the world's largest export earner. A high proportion of this economic activity is driven by people wishing to spend time with nature, to see wild species and to experience wilderness. The destruction of these assets is therefore very likely to lead to a decline in this vital sector.

Despite all of these considerations the destruction continues. A common justification is that it is part of the price of 'progress', and that we need to strike a 'balance' between the needs of people and conserving wildlife. Sometimes the point is put even more starkly, by senior political figures and others, who claim that it is more important to end poverty than it is to protect species and habitats. Political leaders sometimes even argue that protection of the environment will make poverty worse.

The March 2005 publication of the Millennium Ecosystem Assessment[18] helped to put things into perspective. The Assessment – the most thorough and authoritative to date, and prepared by 1300 scientists from 95 countries – is essentially a global stocktake of the state of nature. It reached some remarkable conclusions: including the fact that humans have changed the environment more rapidly over the last 50 years than in any other time in history. It found that more land has been converted to cropland since 1945 than during the whole of the 18th and 19th centuries combined. It said that approximately one-quarter of the world's coral reefs and about 35 per cent of the mangroves, in coun-

tries surveyed, were destroyed or badly degraded in the last decades of the 20th century. It estimated that more than half of all the synthetic nitrogen fertilizer ever produced has been used since 1985, causing problems of nutrient pollution around the world.

The survey revealed how overall nearly two-thirds (fifteen out of twenty-four) of the 'ecosystem services' that were assessed were found to be undergoing long-term degradation or were being used unsustainably. For example, a high proportion of commercially important fish stocks are over-harvested, and between 15 and 35 per cent of water withdrawn for irrigation exceeds replenishment rates. Pressures on ecosystems may be increasing the chance of sudden changes that could harm human well-being, the Assessment said. Examples include new diseases, so-called coastal dead zones, collapsing fisheries, invasive species and regional climate change.

Crucially, the Millennium Ecosystem Assessment noted that – despite the huge wealth and material benefits derived from the exploitation of nature – billions of people remain poor. It further concluded that the destruction of the natural world was an increasingly significant barrier to the reduction of poverty. It said that United Nations goals to halve poverty and hunger by 2015 will not be met, and hunger and malnutrition will remain problems even in 2050, unless governments pay greater attention to what nature does for humanity.

In short, the Assessment said that the excessive exploitation of nature would be a *cause* of future poverty and hunger – and *not*, as some would have us believe, a solution[19].

It is much the same with climate change. Already the impacts are hitting the poorest hardest. One statistic that sticks in my mind is the fact that of the 600,000 or so people who died in extreme weather events during the 1990s, some 99 per cent were in the poor countries[20]. It is true that this is where most people live, but still the impact is hugely disproportionate. Since the people worst affected are by and large not the ones who released the greenhouse gases, a terrible injustice is clearly being perpetrated.

All this leaves me with the conclusion that the protection of the environment is not only an economic, scientific, technical and prac-

tical question, it is at heart a moral issue. The degradation of nature is already causing disproportionate harm to the poorest and most vulnerable people; and this will get worse as the process becomes more advanced and acute.

Aside from questions of poverty today, is it really morally acceptable for us to meet our needs now in a manner that will most likely be to the cost of future generations?

If we are to surmount the challenges posed by the worsening ecological situation, then not only must we treat the protection of the Earth and its resources as an environmental issue of pressing urgency, we must also take up questions of environmental justice. Our relationship with the Earth is a deeply moral matter and we are obliged to act accordingly. In an age of deep and in some cases worsening injustice, and with few sources of moral leadership, the challenge is, to put it mildly, very considerable.

There is no longer any doubt as to the scale or likely ramifications of human impacts on the Earth. Indeed, so profound has humanity's role become in shaping the conditions on this planet that scientists now speak about a new geological epoch – it is called the Anthropocene (from Greek *anthropos*, 'human'), and it is generally agreed to have started with the commencement of the Industrial Revolution.

The fact that humans are now the most important ecological and evolutionary force on the planet is clear. The more important question is: can that influence be harnessed to ensure the wise management of our resources, for ourselves and the rest of the life forms that share this small planet?

At the start of this new epoch in the history of life on Earth, there is an opportunity for us to use our knowledge, technological capability and influence to shape the future, not only to reduce the risks, but to help increase comfort and security for people everywhere. The start of a new geological age is not a common occurrence, and at this time of intense and rapid change the future

could develop in many different directions. Given the enormous power and creativity of humankind, however, it seems that the future is in large part up to us.

We should embrace the future and the very considerable ecological challenges we face with optimism. A blend of scientific research, public demand, political action and technological innovation has already led to some important improvements. In the 1980s, acid rain and ozone depletion were issues at the front line of environmental campaigning. Since then very significant progress has been achieved in reducing the pollution causing these problems. The quality of river water and urban air are now much better in the UK than twenty years ago, not least because of laws passed to require various industries to clean up. Many of the world's most important wildlife areas now enjoy at least some basic protection, and this has undoubtedly helped to improve the fortunes of some declining species.

The work that must be done now, however, is bigger than all of this. The question is, will we rise to this challenge, the challenge that is most likely to define our century?

We live in very interesting times.