A Synopsis of

CLIVE PONTING'S

A GREEN HISTORY OF THE WORLD

by

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The farther backward you can look the farther forward you are likely to see.

Winston Churchill

Introduction

With an ever-increasing awareness of the effects of global warming on climate change and the pressing need to forecast — and try to ameliorate — the consequences of humankind's behaviour, many books have been written in recent years about the perils of the overpopulated, warming and post-oil world. But bearing in mind Churchill's words, I believe that it is imperative to supplement any study of our effect on the environment with this book by Clive Ponting. As my first passion is physics, with history coming a close second, I was pleased to accept, in 2005, Andrew Ferguson's invitation to write a synopsis of the 1991 edition of *A Green History of the World* (then out of print) for the *Optimum Population Trust (OPT) Journal*. The synopsis was published in nine instalments from October 2005 to April 2010.

It may seem odd to have written a synopsis of a 16 years old book. After all, with our fast-moving understanding of the environment and its link to population, perhaps one should be looking at more recent studies. Nevertheless, since the past cannot change - only our view of it - Ponting's 1991 perspective is a useful guide to the future. Indeed, in reading his book, it is instructive to recognise how the mistakes of our predecessors are being repeated today by a civilisation which should not only know better, but which ought be taking more diligent measures to prevent the catastrophe that must surely be just around the corner.

Relating to the fast-moving scene of environmental change, I was delighted when, in May 2007, halfway through writing this synopsis, Clive Ponting produced a revised and updated paperback edition entitled "*A New Green History of the World*" (ISBN 970-0-099-51668-2). The new book updates and supplements much of the first with some chapters re-worked – and renamed to reflect the events of the intervening 16 years.

The original 1991 edition has 407 pages plus a seven-page list of further reading. It is extremely well researched and is compulsory reading for anyone wanting to get to grips with a subject which is all-too-slowly gaining in importance. While politicians wax eloquently — and often ignorantly — about economic growth and better deals for all, their constituencies are for the most part blissfully unaware of the coming problems when critical resources start to run out, and of how we are trashing our environment for future generations. We owe Clive Ponting a debt of gratitude for his pioneering historical study, which provides signposts to the future, based on mankind's turbulent relationship with the environment. This book could be mistaken for a university textbook that needs detailed study to extract the full essence of its message. Not everyone has time to do that. I therefore hope that my modest synopsis will provide readers with an overview to help them to understand our ecological inheritance and to share my disquiet at the poisoned chalice we are passing to our descendants. Hopefully, it will inspire us to continue to lobby those of influence and power to take seriously the urgent problems already so evident to anyone *'who has eyes to see and ears to hear'*

I am grateful to Clive Ponting for his permission to quote passages and reproduce diagrams. My own comments have been almost entirely confined to the end notes or are made using the first person singular. I am also indebted to my wife, Karin, as well as Andrew Ferguson and Yvette Willey for their valuable suggestions and hawk-eyed proof-reading of the text of all the instalments. My typing skills have kept them busy!

Martin Desvaux - April 2010

Part 1

Chapter 1: The Lessons of Easter Island

Ponting's opening paragraph spells out the direction his book will take. "*Easter Island is one of the most remote, inhabited places on earth. Only some 150 square miles in area, it lies in the Pacific Ocean, 2,000 miles off the west coast of South America … At its peak the population was only about 7,000. Yet, despite its superficial insignificance, the history of Easter Island is a grim warning to the world*."

Easter Island was colonised by an estimated 20-30 adventurous Polynesians in the 5th century AD. They found a densely wooded island of volcanic origin with poor soil, only 30 species of vegetation, no mammals and a little water in the calderas of extinct volcanoes. Their diet was mainly restricted to chickens and sweet potatoes, which they had brought with them, along with other less successful species. When European sailors first visited the Island some 1200 years later they found 3,000 people left together with evidence of a once-flourishing society now living in *'squalor and barbarism'*, at war with each other and practising cannibalism in a desperate attempt to survive. The population continued to decline and after 1877 the island was *"taken over by Chile and turned into a giant ranch for 40,000 sheep, run by a British company, with the few remaining inhabitants confined to a single small village."*

How could this have happened? It appears that growing their simple crops was not labour intensive and the population, once developed and having little else to do, established clans and developed a culture of erecting stone monuments at *ahu* – centres for ceremonial and ancestor worship purposes. *"The Easter Islanders engaged in elaborate rituals and monument construction… The statues were carved* [in a quarry] *using only obsidian tools... which took up immense amounts of peasant labour..."* Then: *"The most challenging task was to transport the statues… weighing several tons, across the island and then erect them on top of the ahu."* Moving the statues several miles from quarry to *ahus* was done by felling trees and using the trunks as rollers. When the population peaked in about 1550, competition between the clans for making statues, and thus felling of trees, would also have peaked. As a result, the population started to collapse through *"massive environmental degradation brought on by deforestation of the whole island."*

In the closing paragraph Ponting concludes with the thought-provoking words: *"Like Easter Island the earth has only limited resources to support human society and all its demands. Like the islanders, the human population has no practical means for escape. How has the environment of the world shaped human history and how have people shaped and altered the world in which they live? … For the last two million years humans have succeeded in obtaining more food and extracting more resources on which to sustain increasing numbers of people and increasingly complex and technologically advanced societies. But have they been any more successful than the islanders in finding a way of life that does not fatally deplete the resources that are available to them and irreversibly damage their life support system?"*

Chapter 2: Foundations of History

The early history of the planet shows how it shaped the environment and, consequently, human history. *"Human history has been affected by the action of large scale geological and astronomical forces over long periods of time. Although the amount of land on the globe has remained broadly constant its distribution has altered radically*"

Starting 200 million years ago, three major processes lasting 140 million years combined to create the environment which was to be the cradle of humankind:

1) Continental drift (convection within the magma between the earth's solid core and relatively thin crust) caused flows which are still increasing the separation of continents. The original continents, Laurasia and Gondwanaland, separated by the Tethys Sea, were originally situated over the South Pole. They drifted north and broke up into the current configuration between 60 and 200 million years ago. As a result, the evolutionary changes of plants and animals were heavily influenced by the climatic conditions which varied slowly with the drift of the land masses.
2) The energy output of the sun increased.
3) A further significant influence, initially proposed by Milhankovic in 1922, was the variation of the earth's tilt and orbit around the sun. Three cycles with periods of 21,000 years (closeness of approach to the sun); 45,000 years (tilt of the axis); ~100,000 years (change in the elliptic axes of orbit) all combine to explain the major variation in global temperature as well as the regularity of the ice ages.

Ponting stresses*: "The various forms of life on earth, including humans, do not exist independently, they are part of ecosystems … There are many types of ecosystems such as tropical forest, grassland , prairie, coral reef but the foundation of all of them … is photosynthesis …*[which is] *the only way that energy is introduced into the system."* Starting from a bare-rock world, decaying primitive lichens established enough soil for grasses and other plants to evolve. These plants were subsequently broken down by decomposers to recycle their nutrients and the continuous build-up of soil over millions of years enabled trees and other vegetation to evolve. "*As the ecosystem develops and changes, so do the plants and animals that can be supported …*[the] *retreat of an ice sheet … exposes bare rock, which within a few thousand years is converted into a climax temperate forest. This development has occurred countless times during the earth's history."* In particular, rain forests: *" … are remarkable not just for the quantity of life found there but also for the diversity. A typical four square mile patch of forest will contain the following species (not individuals) — 1,500 flowering plants, 750 trees, 125 mammals, 400 birds, 100 reptiles, 60 amphibians, 150 butterflies and probably about 50,000 insects*". However: "*The soil is thin, acidic and poor quality with very little humus. If the ecosystem is destroyed by forest clearance most of the nutrients are destroyed too; there is little available in the soil to support crops and grass and the exposed ground can quickly turn into a hard baked clay.*[1]

Ponting alludes to Lovelock's Gaia theory[2] when *adding "To fully understand the individual parts of an ecosystem, it is necessary to see them as part of a bigger whole. All the parts of an ecosystem are interconnected through a complex set of self-regulating cycles, feedback loops and linkages between different parts of the food chain.*" This theory is one of the most important in the interpretation of global ecology, and really rates a more detailed mention and readers are encouraged to get hold of Lovelock's book.[3] Most species have a symbiotic relationship with their habitat, but: "*The most important task in all human history has been to find a way of extracting from the different ecosystems in which people have lived enough resources for maintaining life… Inevitably this has meant intervening in natural ecosystems. The problem for human societies has been to balance their various demands against the ability of the ecosystems to withstand the resulting pressures."*

Chapter 3: Ninety-nine Percent of Human History

Fossil records show humans progressed from early forms, one of which was known as *Homo erectus*, which survived until about 100,000 years ago *"when the first anatomically*

modern skeletons, named in a piece of immense self-flattery ***Homo sapiens****, are found in east and southern Africa. By about 30,000 years ago fully modern human types (****Homo sapiens sapiens****) were widespread throughout the world."* These stone age humans were hunter-gatherers up to about 8000 BC, by which time the population had grown to a total approaching four million.

"In nearly every case people lived in small mobile groups. It was without doubt the most successful and flexible way of life adopted by humans." While not a high productivity existence, their life was more Eden-like than Thomas Hobbes's description of: "nasty, brutish and short". Studies of the Bushmen of south-west Africa, the Hazda of east Africa, as well as the Australian Aborigines showed that, on average, gathering food only took a couple of days a week. The rest was leisure. Hunting was more precarious and less favoured as the chance of making a kill was only ten percent. Gathering was an eco-friendly activity. Bushmen knew their environment intimately and moved around to take advantage of the availability of the 'crops' of fruits, roots and nuts. In this way they did not over-stress any particular area. Sustainability at its best![3]

Tribes had to adjust the balance of gathering and hunting to suit their environment. Further north, in Canada, the: *"Netzilik Inuit … way of life depended on exploitation of every part of their environment. Houses…made from snow and ice …clothing, kayaks, sledges and tents came from skins of animals and bones provided tools and weapons*." They did the rounds of hunting salmon, salmon trout, seals, and caribou. "*In each of the phases of communal hunting there were social customs to ensure that everybody was fed and nobody was penalised because of poor luck or lack of skill."* Hunter-gatherers from the arctic to the equator had, by necessity, a nomadic existence; they were unencumbered by material goods and made no significant or lasting impact on the environment. Population control was practised out of perceived practical necessity. "*All gathering and hunting groups, both contemporary and historical, seem to have tried to control their numbers so as not to overtax the resources of their ecosystem*." In the case of the Inuit, numbers were kept in balance by "*protracted weaning of infants … infanticide … abandonment of the aged."* The development of human societies has been traced to four basic traits that distinguish humans from other primates: increase in brain size; ability to stand upright leaving the arms free to use tools and weapons; use of speech; use of technology to overcome hostile conditions. With stone and bone tools early humans managed to survive. Low sea levels in the last ice age enabled migrating groups to gain access to the Americas from eastern Siberia and to Australia from Asia. By a process of growth and fragmentation humans settled most of the world.

In the plains of northern America they hunted bison. In the north-west seal, salmon and other foods were plentiful. With the introduction of preserving (drying and smoking meat and rendering to oil for use in leaner times) and the invention of snares, nets and the bow and arrow (about 23,000 years ago), hunting became more efficient and left time for ceremony and the development of culture. Villages of about 1000 people developed socially stratified societies, many with a slave culture, until the Europeans came in the 16th century. Many groups, at this stage of evolution, would have had a limited impact on their environment by rotating hunting grounds over several years. However, many others have altered their environment considerably by tree felling, and caused other damage by the use of burning to encourage preferred plants to grow at the expense of others.

As humans spread and increased in numbers their impact began to tell: "*Gathering and hunting could even have had an impact on animal populations on a continental scale. A number of species became extinct around the end of the last glaciation … in Eurasia five large animals — the woolly mammoth, woolly rhinoceros, giant Irish elk, musk ox and steppe bison — together with a number of carnivores became extinct …* [mainly as a result

of] *the changing environment …*[but] *hunting by humans would have had a devastating impact on a population already in decline."* In the Americas, "[The] *first settlers left a trail of destruction across the continent. Two-thirds of large mammals present when humans first arrived were driven to extinction*".

Thus the early picture emerges of small groups of hunter-gatherers living in relative natural affluence in an Eden-like harmony with their environment. These conditions were amenable to the growth of human groups, which then splintered and migrated when these became too large for the territory to sustain. Over about 40,000 years, the process led to an increasing impact of humans on their environment. They developed more sophisticated and effective tools for hunting which helped them to survive as they migrated into more hostile areas. The world was very slowly becoming the kingdom of humankind.

Then, in about 8,000 BC, *"… the methods humans used to obtain their food began to change in a number of locations across the globe… Its consequences were far more radical than anything that had gone before. It brought about the most fundamental alteration in human history — and one which made possible all the subsequent developments in human society."*

It occurs to me that this could be seen as the point in time at which humans had eaten from the biblical 'tree of knowledge.

Chapter 4: The First Great Transition

Around 8000 BC, the world human population had grown to around four million. Many humans then started gradually to move out of the nomadic life and develop the means to form sustainable settled societies during what is termed the *Neolithic Revolution*. As Ponting correctly comments, this was not a revolution, but an evolution. Revolutions require foresight and drive towards a vision of the future. Ten thousand years ago, humans had no idea where they were going with the changes they were causing to happen. However, once it had occurred, this '*ratchet of evolution*' ensured there was no going back.[4] The transition occurred in three regions – South West Asia, China, and Mesoamerica over five millennia from 8000 to 3000 BC. The evidence to support this gradual progression has come primarily from detailed study of archaeological remains. Tracking progress of plant types from wild to domestic is extremely difficult, but many digs have revealed the types of animals, seeds, tools and weapons used by these early settlers.

The transformation from a nomadic to a settled society took a long time precisely because no one knew into what or how society was developing. There was no conscious 'road map' of development. It was pure trial, error and serendipitous accident, and in this sense shares the characteristic of evolution, in that the only groups to survive were those which made wise decisions based on good ideas. The drive to settlement depended on the ability to cultivate crops and to herd animals, especially those animals which did not compete with humans for food.

As humans hunted and foraged, they had become familiar with the plants and animals around them. They could study and pass on information about the benefits, dangers and habits of things animal and vegetable. However, *"Agriculture is definitely not an easier option than gathering and hunting. It requires far more effort in clearing land, sowing, tending and harvesting crops and in looking after domesticated animals."* Compare, for example, the work involved in picking wild blackberries with that of actually growing a standing crop of fruit or wheat. However, the benefit of agriculture *"is that in return for a greater degree of effort it can provide more food from a smaller area of land."* Wild plants

rarely grow in conveniently concentrated patches, but are spread extensively throughout large areas. Several theories have been propounded to explain the transition, but the one that appears to be the best fit is that of population pressure. Hunter-gatherers had ways of containing their population, helped by nature, illness and accidents. But this will not always have worked. As populations grew, they will have split up and gone their separate ways. Because cohesive social bonding is generally tighter in small groups, there will have been a sub-conscious critical size at which groups will have felt comfortable,[5] and beyond which rivalries and/or disagreements in strategy will have made groups prone to division. The splintered groups would have looked for unpopulated habitats. Eventually, as all the best habitats were used up, some groups had to accept less fruitful places to seek food, and were consequently forced to develop other methods of feeding themselves.[6] The first area to develop agriculture was south-west Asia – now Anatolia, Palestine, Syria and Iran. Wheat, barley, lentils and chickpeas were all 'domesticated' from wild '*progenitors*'. Also, *"In parallel with domestication of wild plants the relationship of humans with animals was becoming more intensive."* The wild dog was the first animal to form an alliance, possibly for protection and/or companionship.[7] Around 8000 BC, sheep, followed by goats, became the first animals to be domesticated and exploited. They did not compete with humans for food, but conveniently turned grass into milk which humans could drink, and provided hides as well as meat for a useful dietary supplement. Pigs, which do compete with humans for food, were not domesticated until around 6500 BC.

Ponting outlines the process: *"By 6000 BC the first stage of the transformation of human society in south-west Asia was complete and settled life was becoming the norm… The great transition that had occurred in south-west Asia was transferred to other regions, spreading by a combination of new groups adopting agriculture and settlers who already practised it moving into other areas … between 6000-5000 BC Greece and the southern Balkans shifted their subsistence to agriculture. Cattle were probably domesticated here at this time and spread back into south-west Asia (although they were not milked for another 3000 years)."*

China was the second area in which agriculture became established. Early settlements have been found on terraces along the tributaries of the Yellow river. Although the process would have been the same, the outcomes were different. Agriculture was based on millet (first domesticated around 6500BC) and rice which was grown as a dry land crop. Rice was also domesticated independently by people in settlements along the southern Himalayan foothills, upper Burma through northern Thailand and Vietnam to the far south of China. Native soybeans were only domesticated around 1100 BC "*and then spread rapidly, but until then Chinese agriculture was dominated by seed crop production. Pigs and poultry were…domesticated, followed much later by sheep and goats.*"

The third and last main region to develop agriculture was Mesoamerica, what we now know as Mexico, Belize, parts of Guatemala and San Salvador. This region was late in developing settled communities, and maize became the staple diet around 5000 BC with the high-yield varieties taking 3000 years longer to emerge; early varieties were no larger than the human thumb. Small villages first appeared around 2000 BC (coinciding with the appearance of the higher-yielding maize) – much later than the other regions. Cities and ceremonial centres (mainly Mayan and Aztec) did not appear until relatively recently, in about 1000 BC.

Wherever it occurred, the change from hunter gathering to farming had the same overall effect on human society. For hunter-gatherers, ownership of the land they lived off had no meaning. They could not defend it when they had moved away and, as long as they all got enough to eat, nobody was interested in ownership. Agriculture, on the other hand,

required settlement in one place for many years. Seeds had to be sown, watered and harvested, requiring a stationary population. The benefit was the production of more food from a smaller area of land; an individual could produce more than his own needs. This increased security of supply, enabling population growth. An important side effect of this was the evolution of 'ownership'. As an individual invested his family's time in cultivating crops, a sense of 'ownership of the soil and crop' developed. This will have led to disputes, requiring a strong leader to resolve them. Thus a primitive legislative function would have come into being. Surplus production of food was used to feed others who did not need to be involved in farming. *"The first non-farmers were probably craftsmen who made pottery.* [*Later on*] *ruling groups, probably religious at first and then political, rapidly took over the distribution functions. Societies emerged with large administrative, religious and military elites, able to enforce collection of food from peasant farmers and organise its distribution to other parts of society. In parallel, unequal ownership of land and therefore of food rapidly emerged …* [also] *the size of surplus available to a particular society has determined the size and extent of other functions – religious, military, industrial and cultural – that the society can support."* As more effective ways of producing surplus food were found, the pressure of population did not abate. It intensified and put more pressure on finding even better ways to produce a surplus.[8] A concurrent and important development occurred around that time, namely the development of hierarchy and authority in settlements.

The development of the south west Asia region serves as a model for the evolution of society. Initially (7000 – 6000 BC), settlements were confined to rain-dependent 'dry farming' in upland areas. As population pressure increased, all suitable sites became occupied and people migrated to the dryer areas of Mesopotamia, which necessitated the development of irrigation techniques. Archaeological remains indicate that most settlements comprised small villages as well as towns, the earliest of which *" … revealed a considerable degree of social organisation from the beginning …nearly all had temples as the focus of urban life and played a fundamental part in the redistribution of resources …by controlling food production and distributing rations to all members of the community."* By 4500 BC, large temples had been built in Uruk and 500 years later its population had grown to 50,000. By 3000 BC, eight large cites had developed in Sumer. Such dominant buildings confirm the role and power of religious elites in controlling large early societies through ceremonies and administrative organisation. One temple at Shuruppak owned 9660 donkeys and organised ploughing through labour gangs. The system created larger surpluses which supported more non-farmers and enabled the gradual emergence of social classes holding wealth and power. Such groups would have organised production, storage and distribution of food and importantly, as the cities became more prosperous, the military resources for defence against covetous neighbours. It was around 3100 BC that in Sumer the need for keeping records and accounts of food and other commodities brought about the invention of writing, the first evidence for which is inscriptions found on over 4000 baked-clay tablets in Uruk.

Egypt and the Indus Valley developed roughly in parallel with south west Asia but other regions of the world developed over markedly different time frames. China developed irrigation much later and, in the Americas, the difficulty and slowness in developing high-yielding maize varieties held back population growth and therefore the development of large cites. After describing in detail the development of human societies around the world, Ponting comments in the closing paragraph that: *"Despite the variations in cultural achievements, none of these empires and states altered the way in which humans obtained their subsistence once settled agriculture had been adopted. Nevertheless their impact on*

their immediate environment was far-reaching. They provide the first examples of intensive human alteration of the environment ... of their major destructive impact ...[and] of societies that so damaged the environment as to bring about their own collapse."

Chapter 5: Destruction and Survival.

Once settled communities took hold, destruction of the environment slowly began to increase. The early settlements were clearly successful in providing sufficient food for all. The consequence will have been a rising population since starvation and attack from aggressors will have diminished. Survival rates increased as child – and adult – mortality decreased, tipping the balance in favour of a growing population which then exerted further pressure to deliver even more food. Wherever this occurred, it resulted in deforestation to produce arable land as well as additional timber to build and heat homes as well as to cook food. The long-term consequence of this activity was the degradation and erosion of the soil. Ponting cites the evidence thus: *"Recent evidence from Jordan suggests that as early as 6000 BC, within about a thousand years of the emergence of settled communities, villages were being abandoned as soil erosion caused by deforestation resulted in badly damaged landscape, declining crop yields ..."*

Unlike hunter-gatherer communities, settled societies developed overheads in the form of:

a) rulers;
b) priests for ceremonial and spiritual needs;
c) bureaucrats for administrative purposes now that 'ownership' had evolved;
d) a resident military force for defence and maintenance of law and order;
e) craftsmen to make artefacts, utensils and weapons to serve a society with its ever-growing needs.

Communities depended on larger and larger food surpluses to maintain these functions and, when yields fell as a result of over-cultivation, societies collapsed. In Mesopotamia around the banks of the Tigris and Euphrates, the Sumerians sowed the seeds of their own destruction by overworking the land and forests. A combination of 40ºC summer temperatures (generating high evaporation rates) combined with irrigation (causing the water table to rise) led to increased salinity of arable land. This happened very slowly, but once the salinity had exceeded the tolerance level of crops (0.5% for wheat and 1% for barley), there would have been a rapid collapse of food production and, inevitably, of the population and the settlements. Desalinisation is a slow process that involves letting the land lie fallow for many years. This was probably not known at that time, or if it was people could not afford to wait and would have moved on to exploit other areas – or eventually died of starvation. In the Sumer region *"...crop yields fell 42% between 2400 and 2100BC ... 65% by 1700BC...Dating from 2000 BC there were contemporary reports of 'the earth turned white...' The later history of the region reinforces the point that all human interventions tend to degrade ecosystems and shows how easy it is to tip the balance towards destruction when the agricultural system is highly artificial, natural conditions are very difficult and the pressures for increased output are relentless. It also suggests that it is very difficult to redress the balance or reverse the process once it has started."* [9]

In the area around Baghdad, some 3000 years later, digging channels from the Tigris and Euphrates for irrigation led a burgeoning civilisation to a similar fate, followed by Mongol conquest in the 13th century. The result was a massive collapse of the population from 1.5 million to about 150,000 by 1500 AD.

The history of Indus Valley followed a similar pattern to Mesopotamia. A once richly-forested region, well stocked with wildlife, it was laid waste by a society which emerged around 2300 BC and only survived for 500 years. Some forest was cleared for arable land,

but the practice of oven-drying mud bricks (rather than leaving them out in the sun) led to rapid deforestation, followed by soil erosion and then degradation of the soil itself. In many cases, as food decreased, the weakened society was open to conquest. Large-scale deforestation had become an accepted way of building up settlements, cities and civilisations. The scars are everywhere to be seen on the earth's surface. Nowhere is it more obvious than in North Africa and the Middle East where human groups developed earliest and left behind a desertified and uninhabitable area. The Mediterranean region also bears witness to the march of Man. What was a natural habitat of deciduous forest is now covered by vines, olive trees, herb bushes, sheep on overgrazed land and silt in large deltas and river mouths. Plato, wrote in his *Critias*: "*What now remains is like the skeleton of a sick man… there are some mountains which have nothing but food for bees, but they had trees not very long ago … many lofty trees …boundless pasturage for flocks. Moreover, it was enriched by the yearly rains which were not lost to it, as now by flowing from the bare land into the sea…*"

In China, nearly all forests had disappeared by 1800 due to its need to cultivate millet. This inevitably caused severe soil erosion. The loss of trees from the uplands of China now leads to the regular flooding of the Yellow River. As a result, this river now changes course and regularly causes a heavy loss of life.[10] In the 1600s, the same trend in Japan led to strict government controls on tree felling.

By contrast, medieval Ethiopia originally had its centre of state in the north. However, following extensive deforestation and soil degradation, it moved south in 1000 AD. This process then repeated itself. Eventually, when Addis Ababa became capital in 1883, a 100-mile-radius zone became treeless by 1903, mainly through provision of charcoal for the capital. This happened in only 20 years! [11]

In Mesoamerica, the Maya died out in the 9th century AD. Originally thought to be a peaceful race, recent research shows that, at their peak, they were in fact a warmongering people with cities often only 10 miles apart. The need to support priests for ceremonial activities and to maintain armies to defend against neighbouring cities put unsustainable pressure on the surrounding land which was nothing better than cleared jungle. As already mentioned, deforested hillside and tropical soils can erode easily, and crops quickly decline once intensive arable farming begins. This was all the more rapid as there were few domesticated animals to produce manure. Rapid decline of soil fertility will only have served to increase competition between cities for the remaining land resources, leading to further warfare, exacerbating population decline through malnutrition.

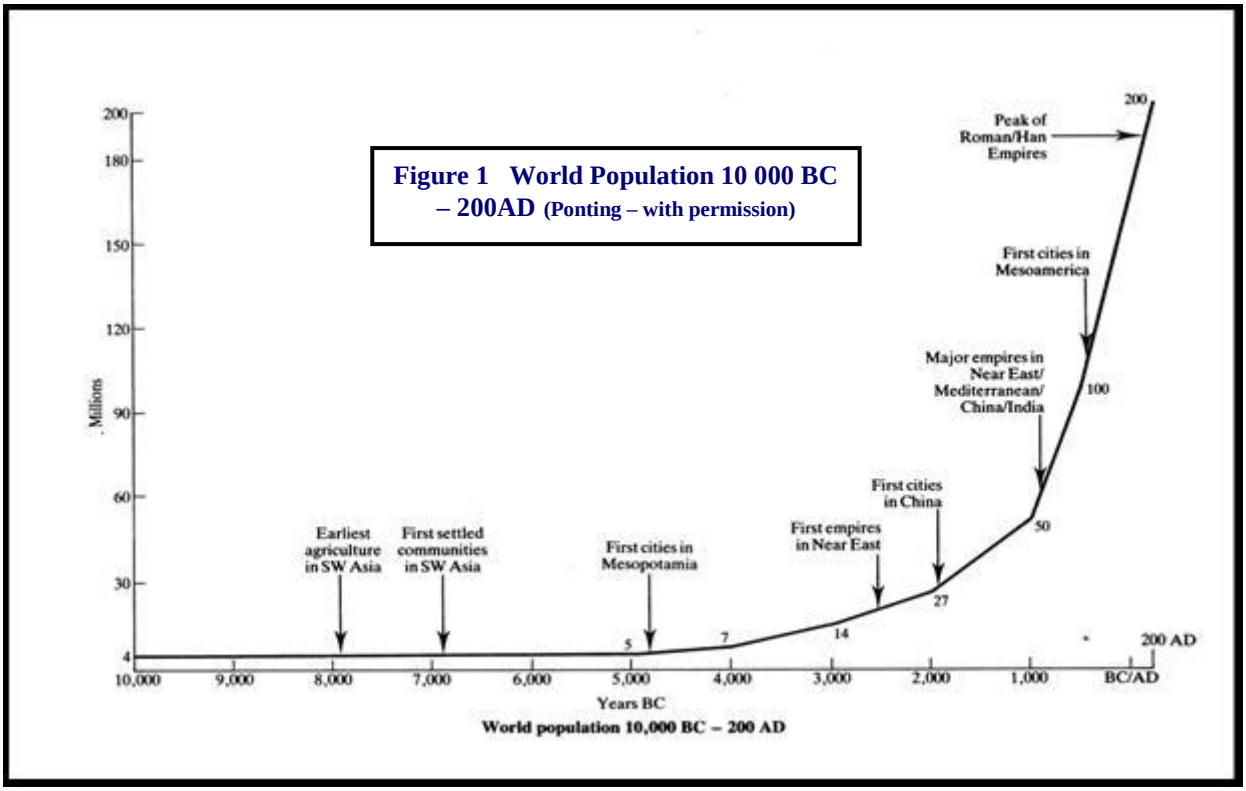

Figure 1 World Population 10 000 BC – 200AD (Ponting – with permission)

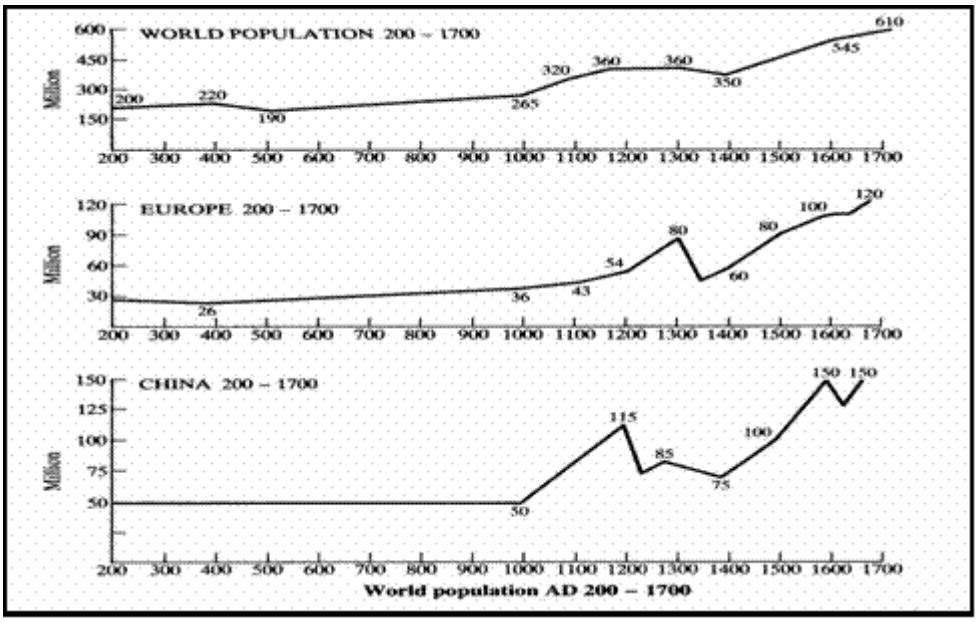

Figure 2 (Ponting – with permission)

In contrast to the Mayans, Egypt provides a classic example of a society living in sustainable balance with the environment and ecology. For 7,000 years, Egyptians used the annual flooding of the lower valley of the Nile to provide the food necessary to sustain their society. The flood brought with it nutrient-rich silt which meant that there was no need for irrigation because the water table fell to 10 feet below the surface within a month at the end of November – exactly the right time to sow. Thus no salinisation of the soil occurred, as

was evidenced by their regular wheat harvests (seen earlier as a salinity indicator). Their success was to exploit the natural process with minimal interference with the natural ecology. As testimony to the success of the Egyptian system, the 18th century Nile crop yields were double those of France. That is not to say that conditions were always so benign. Nature is intrinsically chaotic and there were periods when the floods became abnormally high or low. As a result, settlements were sometimes inundated and destroyed or crops were reduced. For example, between 2250 – 1950 BC low floods led to meagre crops and mass starvation. The resulting social unrest led to the demise of the Old Kingdom. A thousand years later, during the Middle Kingdom, another period of low flooding led to the collapse of the Ramessid dynasty. It was only when, in the 1840s, modern man installed irrigation systems to increase crop production that, by 1882, the "*British agricultural expert Mackenzie Wallace described the 'white nitrous salts covering the soil and glistening in sun like untrodden snow*". Later, between 1892 -1902, the British built the Aswan Dam on the upper Nile to try to control the water supply to the lower Valley. The final nail was put in the coffin of the Egyptian agricultural system in 1971 when the High Dam was completed in a joint Egyptian-Russian venture to provide hydroelectric power, water storage and irrigation control. This caused retention of silt in the dam, which robbed the Nile farmers of their annual delivery of soil nutrients from Mother Nature. As a result, farmers had to use expensive artificial chemical fertilizers in its place, and many went bankrupt as a result.

In summary: "*Many of the earliest settled societies were unable to strike a balance between their need for food for the populace as well as for rulers, bureaucrats, priests and soldiers and the ability of the environment to sustain agriculture over a long period … The struggle to provide enough food was to be one of the central features of nearly all of the rest of human history. It remains acute for the majority of the people in the world.*"

Chapter 6: The Long Struggle

Until about the start of the 19th century, most of the world's population lived close to starvation. This is because humans always push the envelope without realising it. No sooner does a more plentiful source of food appear – through discovery of a new supply or an advance in agriculture – than the local populace grows to absorb it, thus placing itself again close to starvation level. Then, when crops fail, the weakest and poorest people die until there is just enough food for those remaining.[12] Primitively-slow communications and transport meant that famine in one area could rarely be alleviated by a surplus from another. About ninety-five percent of the population were peasants with low life expectancy, high infant mortality and vulnerability to disease.

Priests, soldiers, rulers, etc., were a limited but privileged 'upper class'. As gradual advances in farming techniques slowly increased the food supply, populations grew until the five million inhabitants in 5000 BC (when the cities first appeared in Mesopotamia) had become 50 million in 1000 BC. This was when major empires had become established in the Mediterranean, the Near East, India and China. The world population in 1000 BC was less than that of the UK today (Figure 1). By 200 AD, there were 200 million people, but widespread social instability and warfare ensured that the world population only grew to 265 million over the next 800 years (Figure 2); it then more than doubled to 610 million by about 1700. In China, the population remained stable for about 800 years after the collapse of the Han dynasty (220 AD). *"The Chinese developed the most sophisticated agricultural system in the world (based on … crop rotation…still largely unused in Europe) … By 1200 China was the largest, most literate and most advanced country in the world."* One of the most significant advances was the transition from dry to wet rice cultivation which

increased the yields. But structural problems prevented the balance between population and food supply from improving so the *per capita* consumption remained low. Furthermore, the Mongol invasions caused 35 million deaths and two epidemics in 1586-89 and 1639-44 each caused a 20% reduction in population. However, as food production was proportionate to the peasant population, the society remained close to the brink of starvation.

In Medieval Europe agriculture fared no better than in China. The population was smaller and so was food output since soil fertility was reduced due to overuse. Poor grazing fields limited animal stocks as manure was removed to fertilise arable land. Many animals were slaughtered in the autumn because there was not enough feed for them during winter. Eventually, in about 800, France adopted a new three-field rotation system and increased crop yields. That this system only spread to England by 1250, shows how slowly innovations took to diffuse even relatively short distances. The use of improved ploughs enabled larger areas to be tilled. Growing legumes to fix nitrogen in the soil helped improved yields around 1300, but this practice was mainly limited to Flanders.

There is some evidence of population control in Europe at that time, as there is a loose correlation between population level and the number of marriages as well as with the lateness of marriages.[13]

By 1000 AD, Europe's population was 36 million and rose in the following 300 years to 80 million (Figure 2). In the next 200 years, periods of over-population were controlled by famines (1316-17) and the bubonic plague of 1348; by 1500 the population had recovered to 80 million since the heavily-reduced population entering the 15th century had become relatively prosperous. Due to labour shortages following the plague of 1348, wages rose as peasants found themselves in a sellers' market. By 1600, it was back to over 80 million and the signs of overpopulation reappeared. Famines, and the plague of 1666, held numbers in check till 1700, when the European population rose to 120 million.

The most important influence on the fate of populations in Europe during this period was the weather. As Figure 3 shows, the temperature varied by +/- 2ºC between 900 and 1900. The Medieval warm period from 900 – 1300 enabled the Vikings to settle in Iceland and Greenland and brought an extended period of good weather to Europe, improving harvests and enabling vines to grow in England as far north as the river Severn. As a result, the population more than doubled as shown in Figure 2. When that period ended and average temperatures fell, the Viking population in Greenland declined and was finally destroyed in 1350. Vines could no longer be grown profitably in England after 1400 AD. Then, from about 1550 to 1850, Europe fell into the grip of the 'Little Ice Age'. This caused several rivers including the Thames, Rhone and Guadalquivir to freeze over during several winters; the sea even froze in Marseilles in 1595 and 1684! Effects varied throughout Europe. They were particularly severe in Scandinavia leading to terrible starvation. In many areas of England, the timing of sowings changed and the duration of the growing seasons shortened; crops changed to adjust to the wetter conditions. Since the effect was worse in winter than summer, the effect on population was therefore not as adverse as might have been expected. Nevertheless, infant mortality and early death were rife from disease and starvation. Famines were never far away, particularly for the poor. In China, the two thousand years after 108 BC had 1828 years of famine in at least one province. In France, there were sixty years of famine between 970 and 1100. Europe experienced its worst food shortages in 1315-17, when the population had grown through the end of the medieval warm period of relatively bountiful and regular harvests. In 1315, four wet seasons in a row led to catastrophic crop failures. Ploughing was often impossible, seeds rotted and hay was too wet to store. What crops survived were of poor quality. The same happened again in 1316.

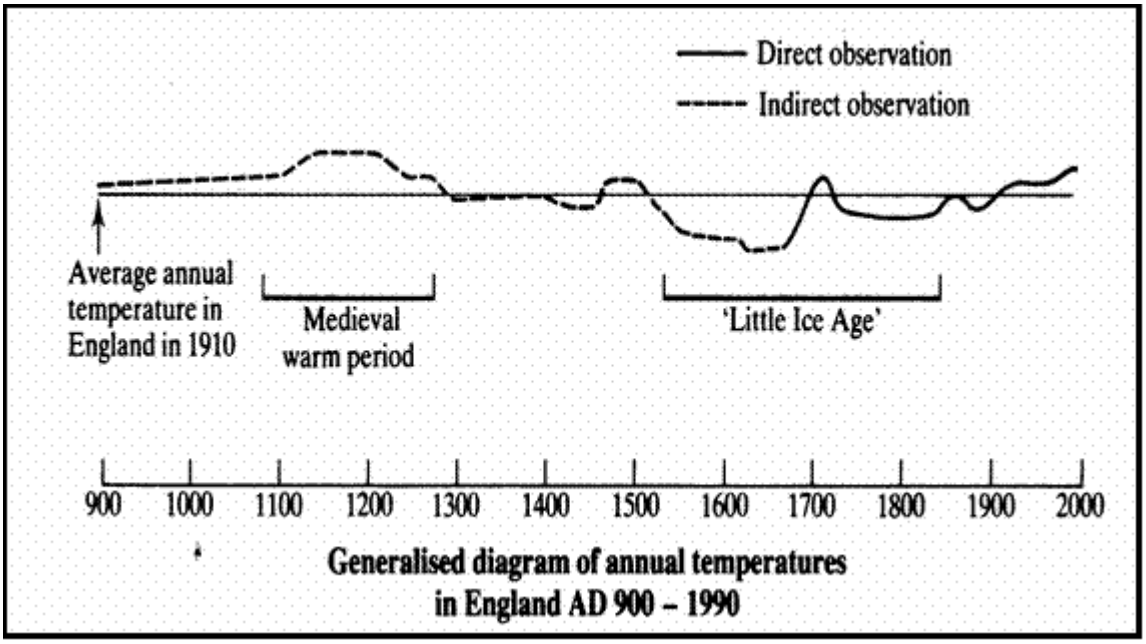

Figure 3 . (Ponting –with permission)

Crop failures in a wet year usually lasted three to four years as, in desperation, farmers ate too much of their stock of seed corn. This reduced the sowings for the succeeding year. Inevitably, as prices rose, the poor starved to death. On that inescapable slide towards death, they were driven, at best, to theft and, *in extremis*, to cannibalism.

A narrow crop base was a major part of the problem, since narrow diversity led to widespread crop failures when disease struck. The most infamous crop failure was the cause of the Irish Potato Famine of 1845-46. Ireland had 8 million people at the time (twice today's population). The majority were peasant farmers with small half acre holdings and most of them grew potatoes and little else. When blight arrived from America in 1845, part of the crop was destroyed. But when it recurred in 1846, the crop failed totally and 1 million of the poorest died. Despite the repeal of the Corn Laws, to allow import of grain, the Irish peasantry died in their tens of thousands because they could not afford to buy the grain. As always, the well-off element were least affected.

The threat of famine in Europe was very slow to subside. In 1200-1800, Europe and its colonies gradually brought famine under control. This was due to: the use of more legumes and more widespread manuring to increase soil fertility; an increased range of fodder crops; better crop diversity and rotation; increased protein output by improved breeding and cross-breeding of animals which could also be kept over winter.

Gradually, all these innovations, coupled with the introduction during the late 19th century of new types of food from around the world, rendered food production more resistant to widespread crop failures. *"The real revolution in the European food situation came about after 1850 with large scale importation of food from the rest of the world and the use of imported resources such as guano from South America and other fertilizers from colonial territories to improve domestic productivity. … One of the main reasons for Europe's success in breaking free from the long struggle to survive ... lay in its changing relationship with the rest of the world and, in particular, its ability to control an increasing share of the world's resources".*

Chapter 7: The Spread of European Settlement

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

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

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

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

**Recent data (italics)* [14] ***Population peak prior to the Black Death*

Table 1: Indicative Population Statistics for Early/Medieval Europe

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

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

The European population more than doubled between about 1080 and 1300, assisted by the Medieval Warm Period which produced high crop yields. Gradually, as the most fertile land was occupied, the remainder was less able to support the additional population. Thus, in the two decades after 1300, when the climate became wetter and cooler, food output

plummeted and the population, which now exceeded the carrying capacity of the land, declined, slowly at first and then rapidly during the Black Death (1348). This plague reduced the population of Europe by 33%. Matters were not helped by land also being lost to rising sea levels[15]. This caused the *Elizabethvloed* in Holland on the 19th November, 1421, when tens of thousands of people died and 40,000 acres of land were lost; in 1507, land at the mouth of the River Ems also had to be abandoned.

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

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

Phase 1: Between 1500 and 1750.

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

Phase 2: Between 1750 and 1850

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

Phase 3: Post 1850

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

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

a) 1552-54: Russians conquer Kazan and Astrakan opening up the South and East for settlement;
b) 1550-1850: Russians and Ukrainians move into these wooded steppes and, by 1700, 25% of the Russian population is living there;

c) 1581: Russians cross the Urals and Siberia, covering 3000 miles in 60 years and found Tomsk in 1604;
d) 1707: Kamchatka is conquered and parts of Alaska settled.
e) Between 1800 and 1850: defeat of the Turks makes the Black Sea available for further settlement and 50 million acres of new land are brought into cultivation.

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

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

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

Table 2: Impact of European Expansion on New World Populations

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

This was, and to a reduced extent still is, the way Europe exploited the resources of the world to build its civilization. Until its abolition in the early nineteenth century,

enslavement and deportation of native peoples, often with the connivance of the tribal leaders, left a huge and justifiable feeling of guilt.[16] We will let Cook have the last word in this chapter on European history. The following is a note that was written in his diary when visiting Tahiti in 1773:

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

Chapter 8: Ways of Thought

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

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

This attitude was also prevalent in the Jewish thinking in the Old Testament, which, because of its incorporation in the Bible, influenced later Christian thinking. This 'legalised' the concept that Man '*has dominion over every living thing that moves upon the earth"* and *"to be fruitful and multiply and replenish the earth and subdue it"* (Genesis Chapter 1). This thought is reinforced when God reportedly speaks to Noah after the flood: "*Every moving thing that lives will be food for you; and as I gave you the green plants I give you everything ... the fear of you and the dread of you shall be on every beast of the earth ... every fowl of the air, upon all that moveth upon the earth, and upon all the fishes of the sea; into your hand they are delivered*."[17] As a result, Man was seen as being below God but above all other earthly entities which are there for him to exploit as he thought fit, and without any preconditions. Christian writers over many centuries reinforced this view. It survived through the Reformation and the development of secular thinking since the sixteenth century. There was a minority of thinkers (among them Maimonides and St Francis of Assisi) who considered that mankind is merely the steward of the Earth, takes what is needed responsibly, nourishes it and passes it on to future generations in good shape. Eastern religious thought took a similar stance. Although wary of generalising, Ponting emphasises the basic difference between European and Eastern thought on the subject. "*The world view of the 'eastern' religious tradition, developed centuries before the rise of Christianity, does emphasise a less aggressive approach of humans to the natural world ... humans are only a small part of a much greater whole and what sets them apart – greater intellectual and spiritual capabilities – should be directed to the goal of enlightenment and enable them to act wisely towards other creatures and not take life unnecessarily.*"

During the 16th and 17th centuries, European man's actions were seen as an improvement to the world. There then emerged the powerful idea of ***progress***. This concept is so taken for granted nowadays that it appears hard to imagine a time when *progress* had no real meaning. Originally, history was a story of decay as civilisations fell from power, and the feeling was that the world had had its heyday and was in a gradual state of decline. By

1700 however, helped by the development of science and the thought that humans could *actually improve* their lot, history began to be regarded as a chronicle of progress. By the 1800s, this had developed into euphoric ideas about Man's indefinite ability to improve the world. While thinkers like *William Godwin* and *Marquis de Condorcet* propounded such ideas, *Malthus* was less enthusiastic. His view, that the human population always grows to beyond the environment's ability to feed it and then collapses through famine and disease to a lower and sustainable level, found little support in those heady days of progress[18]. Progress, supported by Saint-Simon, Comte, Marx, Spencer, Engels and others, was considered as the inevitable march of Man from primitive tribes to higher, more 'civilised' and developed societies. Today, although dented by two world wars and media exposure of a plethora of genocides, natural disasters and ecological catastrophes, human *progress* is still a strong influence in 21st century thinking. This belief in progress is reinforced by economics, which recognizes expansion as success and stasis as failure.

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

Gross National Product (GNP)[19] has become an important measure of wealth and progress in economics, and a country's success is judged by, among other factors, the annual rate of increase of the GNP. GNP has the drawback that it can only measure what is recorded. It therefore excludes a significant amount of unrecordable economic activity (barter, subsistence agriculture, voluntary work of all kinds, etc.). It also records many non-beneficial items to the economy. As an example, the fact that cars break down and have a short life means more cars can be made. Were they more durable, production would be lower and fewer jobs would exist in the industries associated insuring against and recovering/repairing breakdowns. From a resource viewpoint it is uneconomical to have unreliable cars, but from a GNP viewpoint it paradoxically represents greater 'economic' activity. I am sure the reader can think of many similar examples from personal experience where items included in GNP are non-beneficial to the economy. Ponting remarks: *"In the long term the notion of GNP takes no account of the fundamental question as to whether its*

level at any one time, let alone continual growth in the future, is in fact desirable or sustainable."

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

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

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

Chapter 9: The Rape of the World[20]

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

Modern detailed research into the destruction of habitats and species began in 1600 and traces the impact of humans on plant and animal species. In the 20th century, more detailed monitoring began. It has become clear that since the beginning of European expansion in 1500 our impact has grown at an accelerating rate[21].

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

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

Species	Population *(date)*	Date	Numbers	Location
Auroch	Common *(pre 2000 BC)*	2000 BC	Extinct	Britain
Auroch	ditto	1627	Last seen/extinct	Jactorowa Forest
European Bison	Common (*1200- 1500)*	1920	Last seen/extinct	Bialowieza Forest
Great Auk	Commonplace (*1540)*	1844	Last pair killed	Iceland
Crane	Common	16th Cent	Extinct	Britain
Great Bustard	Common	1838	Extinct	Britain[22]
Osprey	Common	19th Cent	Extinct	Britain*
Dodo	Common	1681	Extinct	Mauritius
Duck-billed Platypus	Common*(1815)*	1850	Extinct	Blue Mountains Australia
Red Kite	Common*(1500)*	1910	5 pairs left	Britain[23]
Passenger Pigeon	5 billion*(Ca 1600)*	1914	Last one died in captivity	N. America
Buffalo	40-60 billion*(1830))*	1991	Ca 5000	N America
Sea Eagle	Common*(1870s)*	2000	Extinct	Britain
Wolves	Large numbers*(Ca 1000)*	1486	Extinct	England
Ditto	Ditto	1576	Extinct	Wales
Ditto	Ditto	1743	Extinct	Scotland
Copper Butterfly	Common	1850	Extinct by collecting	England

*Now returning in small numbers

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

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

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

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

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

The reduction of wildlife in Europe was extensive. However, it bore little comparison to the impact resulting from expansion into the rest of the world. "*Explorers were stunned by*

the sheer profusion of wildlife in areas which had often seen little or no human settlement.[24]*"*

Contemporary reports paint the picture of cornucopia in bright colours:

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

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

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

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

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

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

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

The impact of man was to cause many once prolific groups of animals to be driven to, and often across the edge of extinction[25]. In parallel with all this, another type of human impact had devastating effects on indigenous wild life; the introduction of non-native species into foreign habitats.

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

In the 1420s Portuguese settlers brought rabbits to an uninhabited island. The rabbits multiplied and ravaged the flora and the settlers' crops to such an extent that the settlers had to decamp to Madeira – minus rabbits, of course! Then one day, in 1859, the year Col. Drake struck the first oil well in Texas, one Thomas Austin, a farmer near Victoria who clearly had not heard of the Portuguese experience, introduced a few bunnies into Australia (for game!) and produced his own gusher! By 1950 half a billion[26] of these furry fast breeders went rampant on the continent despite numerous attempts to exterminate them along the way. When myxomatosis was introduced from Brazil, 99.8% died. In 1991, with immunity to the disease they were on the increase again.

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

The mass slaughter of herds of bison and flocks of passenger pigeons illustrates well William Ophuls's[27] "Problem of the Commons". Because no one owned these animals, no one had an interest in killing them sustainably. Market forces ensured that people set out to bag the most in the shortest time for a 'fast buck' thereby ensuring their destruction. This principle has applied to whales and fishing and continues today despite international attempts at co-operation to prevent piracy of fishing grounds.

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

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

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

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

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

In 1946, the International Whaling Commission (IWC) was formed, and its members voted to continue the attrition despite scientific evidence to the contrary. Fifty percent of the whales slaughtered between 1900 and 1970 were killed in the period after the formation of the IWC. Eventually in 1982 the IWC allowed only 'scientific whaling' (to discover how the stocks were faring) and *"as many as 10,000 whales were being killed for scientific*

purposes although the value of the 'research' was far from clear and many of the animals ended up as meat in Japanese restaurants. ... In 1990 the IWC did not agree to end the moratorium but the pressure to resume commercial whaling remained strong."

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

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

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

Chapter 10: Creating the Third World

Prior to 1450, the world evolved in relative isolation and major continents and island groups were unknown to Europeans or each other. Their inhabitants lived predominantly as subsistence farmers, doing only limited damage to the environment. From 1500 (when the expansion began) to 1850, Europeans dominated the growth of a world economy which was largely agricultural but included increasing amounts of luxury goods, raw materials and precious metals.

"*The creation of the third world was a complex process that took many centuries, but important features can be identified in the very first decades of European expansion even before the Portuguese sailed into the Indian Ocean and the Spanish conquered Mexico and Peru."*

Starting with the Azores, Madeira, the Canary Islands and Cape Verde islands, the die was cast by Spain and Portugal, who colonized them for the production of crops and luxury foods by taking the best land. In the 1420s, the Portuguese who had settled in an unoccupied Madeira, destroyed the entire forests and woodlands by fire to gain agricultural land and introduced pigs and cattle which did further environmental damage. By 1450, these self-sufficient farming communities were well established, but by 1500 they had been transformed further into plantations growing sugar cane for export to Portugal. Slaves from North Africa were used to do all the work. In return, they were given only the poorest land for their own needs. A similar pattern followed in the Cape Verde islands to produce

cotton. Spain invaded the Canary Islands and enslaved the Guanches to grow their crops. *"The slaves suffered from the introduction of European diseases and terrible conditions on the plantations. Guanche numbers fell rapidly in the 16th century and by 1600 they were all dead – only a few half breeds remained."* This human catastrophe necessitated the import of further large numbers of slaves from Africa. The pattern emerged that territories were exploited to produce crops on large plantations of the best land by Europeans who, being only a small part of the population, made others do all the work.

Slavery was nothing new. It was commonplace in the earliest human societies, being a form of energy when wood was the only source available. Empires were built on slavery. Venice was a hub of transportation of Slavs and Greeks to Tuscany and Catalonia. From the 12th century, sugar plantations in Cyprus and Sicily were fuelled by slave labour. During the 15th century, the Portuguese transported over 150,000 slaves to their possessions and Spain issued vast allocations of slaves (encomiendas) to settlers in Mexico. England initially used native Indians on mainland America and Barbados, but by the 17th century it had become cheaper to import slaves from Africa who soon greatly outnumbered Europeans in many American and West Indian colonies.

As colonisation spread around the globe, slavery followed. Initially, the Dutch (in the East Indies) and Spanish (in America) dominated the trade, but "*by the 18th century the British shipped three-quarters of the Africans taken to the Americas."* These were mainly taken from the African west coast while Arabs dominated the slave trade from the east coast. Between 1500 and the abolition of slavery in the 19th century, Europeans had enslaved 12 million West Africans for the Americas and the Arabs had removed two million from East Africa.

Other sources of forced labour for the colonies were deported convicts and indentured servants. These were whites who had to pay for their voyage and upkeep by working a number of years for their masters – often under conditions little better than slaves. After Abolition, cheap indentured labour was obtained by recruiting people from India, China and the Pacific Islands. Thirty million Indians migrated to man the sugar plantations mainly in Fiji, Mauritius, Natal, Malaya, East Africa, Ceylon and Burma. Another thirty million Chinese were sent to South East Asia and Peru *"to replace the Hawaiians who had died there digging out the guano beds to provide fertilizer for Europe".* Another 386,000 Japanese, Chinese and Filipino labourers went to the Hawaiian sugar and pineapple plantations. This mass migration produced a *"social legacy of ethnic tension for many of the countries left with minority populations or, in the case of Fiji, with Indians outnumbering the native islanders"*

The Europeans inherited stable indigenous agricultural systems involving small plots with varied crops and cultivation techniques which caused little or no soil erosion. By comparison, their large plantations producing only a few (sometimes single) crops which were susceptible to pests, diseases, caused soil erosion and disrupted native societies. The new plantations, designed for exportable mass-produced cash crops, created a new world economy and had severe repercussions for the native peasants. These had lost much land and their meagre incomes became dependent on world prices for the crops they helped to grow. In Java, for example, when world prices for exportable cash-crops (sugar, coffee, indigo, etc.) fell, peasants turned to intensive rice production to feed themselves. Coupled with the plantation, system this action was further deleterious to the environment.

Sugar cane was the first crop to be grown in the colonies which changed the environment. It was taken from the Atlantic islands to Brazil, which became the largest producer in the world by 1700. After Brazil's temporary occupation by the Dutch, the crop was spread to the European controlled islands of the West Indies.

Tobacco became the next export crop to take hold. It required less investment in processing plant and storage facilities than sugar and it transformed the economies of Virginia and Maryland after its introduction.

Cotton became much in demand, especially by Britain which bought in the raw material to feed its thriving mills to produce cotton products for export. *"By 1807 the United States was supplying 60% of Britain's cotton and by 1820 it had become the biggest producer in the world."* As cotton spread throughout many southern US states, the overall production peaked at 30 million acres in around 1900 but later declined to about 9 million in 1990 as a result of the boll weevil pest and soil exhaustion.

In Asia, tea, rice and rubber were the dominant cash crops. Tea production was initially the preserve of China and Japan. However, once Britain developed a taste for it, production in India and Ceylon grew rapidly. Forests were cleared to grow the crop at an alarming rate typified by Ceylon where "*plantations ... increased from 1000 acres in 1875 to 373,000 acres in 1900*."

Rice, the staple food of South East Asia, was first grown for export to Britain in Burma aided by the opening of the Suez Canal (1869). As production under British and French landlords (in Burma and Indo-china respectively) expanded rapidly (1860 – 1940), peasants were reduced to being in debt to money lenders or tied as quasi-serfs to their masters. In Thailand, exports grew from 50,000 tons (1860) to 1.5 million tons (1940) at the expense of adequately feeding the indigenous population.

The discovery of vulcanisation (1840) caused a rapid increase in demand for rubber. Brazil had a natural source from wild trees in the Amazon forest, but, after the British and Dutch took seeds to Malaya and invested in large efficient plantations, the Asian exports boomed and those of Brazil declined.

Coffee – indigenous to Africa – became the major export of the Dutch East Indies which had 300 million coffee trees in 1850. When blight struck, Brazil became a major supplier, using European immigrants as cheap labour after slavery ended. Later, in the late 19th century, Britain introduced coffee to Malawi, Kenya and Uganda.

All the above crops, along with cocoa, palm oil and bananas, were grown on the plantation system, which were characterised by cheap indigenous or imported labour. Either way, "*By the early 20th century, Europe, and increasingly the United States, brought about a major transformation ...now known as the Third World."*

In addition to edible crops, Europeans also exploited the third world for its vast timber resources. Teak was in high demand. Consequently, the British stripped India's Malabar Coast, moved on into Burma in 1826 and stripped the Tenasserim province in 20 years, then on to the Irrawaddy delta which was cleared of its hardwood. The plunder continued with mahogany and sandalwood, where the latter was stripped island by island in the Pacific as each became exhausted.

Exploitation of precious metals and minerals was another part of the picture which showed how the industrialised nations created the Third World. Beginning with gold and silver in Mexico and Peru, the major bulk exportation of minerals did not take off until Africa was divided up between European powers in the 1880s. Copper and aluminium deposits were mined by companies which grew into major multinational corporations and in some cases virtually ruled the lands they exploited. Having bought the rights to mine mineral deposits for a pittance, their activities dominated the fate of the locals in the same way as plantation owners were doing with crop growing. *"The companies also exclude many Third World countries from the most profitable parts of the industry by refusing to build smelters and processing plants as both Ghana and Guinea found when even cheap energy supplies were available."* Natives could only look on as the wealth of their countries (in the form of ores containing iron, copper, aluminium, nickel) passed them by as

it was transported to ports by rail to be shipped to processing plants in other countries. Thus, the source countries lost the value added and the opportunity to increase their own wealth – which instead passed to the industrialised nations.

Fertilisers form the final part of the picture. As agricultural output grew, Europe had to turn to Morocco and Tunisia as well as to the large guano deposits off the coast of Chile. Exports of Chilean guano reached over 1 million tons per year – to the detriment of the Chinese labourers who had to dig it out under terrible conditions.

The prize for unfair exploitation, however, must go to Britain, New Zealand and Australia for the way they treated the Banabans on two small pacific islands called Ocean Island and Nauru. The total population comprised some 3800 people. They had the misfortune to live on the richest phosphate deposits in the world. The British government bought the mining rights for £50 per year and proceeded to strip the islands of eighty million tons of phosphate. This totally destroyed the fertility of the land, all top soil having been removed, and left only a narrow coastal strip on Nauru for the inhabitants to live.

Chapter 11: The Changing Face of Death

Disease affected populations in three ways: a) epidemics and plagues; b) persistent local sources of infections (e.g. sleeping sickness and river blindness); c)inadequate diet which mostly affected the poor by reducing their immunity to (a) and (b).

Hunter-gatherers were relatively free of disease because groups had infrequent contact with each other or with animals. However, this situation changed markedly as groups settled down to agriculture, domesticating animals and inevitably growing in size as a result of the more abundant food supply. "*After living for 10,000 years in close proximity with animals, humans now share 65 diseases with dogs, 50 with cattle, 46 with sheep and goats and 42 with pigs.*[28]*"* The outcome was that a whole new range of diseases affected humans, as some bacteria and viruses present in animals changed into forms that could thrive in humans. The table below lists just some of the main human diseases which are related to animals.

Human disease	**Animal**	**Animal disease**[29]
Smallpox	Cattle	Cowpox
Measles	Cattle	Rinderpest
TB	Cattle	[TB]
Diphtheria	Cattle	
Influenza	Pigs[dogs, horses]	[Influenza]
Common cold	Horses	[Common Cold]
Leprosy	Water buffalo	

The immunity of local populations evolved by the survival of the fittest, but as these expanded, they carried their infections into new areas and the consequences were disastrous. As already touched upon in chapter 7, this was nowhere more dramatic than in islands and countries invaded by the Europeans during the great expansion after 1492 when some native populations dropped by 90% or became extinct. Most especially, the peoples on the South American continent were particularly susceptible as their lack of domesticated animals meant they had no resistance to European diseases.

As communities grew from small groups into settled villages, towns and then into cities, the problems of sanitation, irrigation and close proximity provide a fertile combination for bacteria and viruses to thrive with the result that: *"Until well into the 19th century in Europe and North America … cities required a constant influx of people in order to sustain*

their numbers because of the very high death rates among their inhabitants." Within cities, immunity will have gradually built up in the population, but a proportion of newcomers will have succumbed. The pattern appears to have been "*one of a continuous low level of disease punctuated by virulent outbreaks killing large numbers.*" What caused these peaks in the death toll is not clear. Childhood diseases such as measles may have been the main culprit. Ancient records refer only to 'plagues' – a term reserved latterly for the 'bubonic' plague which first arrived in Europe in the sixth century AD.

The mutual isolation between the Far East, Europe and the Near East as well the Americas meant their diseases were self-contained. With growing populations that was all set to change. Between 160-165 AD, a virulent form of smallpox spread to China and Rome, killing 40% and 25% of their respective populations. There were many recurrences in later centuries with equally devastating results. Smallpox, leprosy and the bubonic plague were all thought to have originated in India. The bubonic plague deserves a special mention because of the speed and ferocity with which it spread. As long-distance travel developed – especially by ship – those awaiting the arrival of exotic goods from faraway lands got more than they bargained for on the quayside. Flea-carrying rats! After the first-known outbreak in the Mediterranean (542) there were further major occurrences: China in 610 and1331; Crimea 1346; Europe 1346-49.[30] Thereafter, in Europe it continued to occur at regular ten-to-fifteen-year intervals until 1670. The last outbreak of bubonic plague in Western Europe was in Marseilles in 1720-1721 and after that it remained in Eastern Europe and the Near East.

Before 1500 nothing is known of the diseases in the Americas. Because of crowded conditions in their cities, natives will have suffered from parasitic and intestinal illnesses, but major endemic Eurasian diseases had not spread to them. It began only when the Spanish conquistadors introduced smallpox. The first outbreak in Hispaniola in 1518, which spread to Peru by 1525, was followed by outbreaks of measles in 1530, typhus in 1546 and influenza in 1558. The impact was catastrophic. Overall estimates of the death toll are only vague because of unreliable information about the initial populations. As a guide, *"The most reliable figure suggest that in the Valley of Mexico, the centre of the Aztec state, the population fell from about 25 million, just before the conquest to six million by the mid-16th century and to about one million in 1600. The effect ... (together with the brutality of the military conquest and its aftermath) was to destroy the flourishing and powerful Aztec society and its culture."*

It was thought in the 15th century that, in return, the Americas "transmitted" 'Montezuma's revenge' or syphilis to the Europeans. The origins of syphilis are not certain; some propose it to be a sexually transmitted transmutation of the European *yaws* but "*the place and date of its first recorded appearance in Europe – Barcelona in 1493 (a year after the first voyage of Christopher Columbus to the Americas) – lends weight to the contemporary theory of American origins."*

Eventually, the mortality rate from such major 'plagues' declined from catastrophic epidemics to low-level infection rates due to developing immunity and other factors. But the diseases persisted in conditions of overcrowding, poor diet and inadequate sanitation such as those found in cities and armies. "*Until the present century armies nearly always lost more soldiers to disease than they did as casualties to the enemy.*" In the Crimean war, dysentery was ten times more effective than the Russians at killing the British.

During the last two hundred years, the ravages of disease have diminished markedly. Historically, up to 2/3rds of children died in early childhood; now less than 1 in 20 die before maturity[31]. Life expectancy has doubled from around 35 years to well over 70 and the death rate since the mid-19th century has fallen from 20 down to 5 per 1000 of population (England and Wales). This was because of i) the transmutation of some diseases

into less virulent forms, ii) the introduction of inoculation (possibly used against smallpox in China as long ago as the 11th century, in Turkey during the 13th century but not in England until 1721, followed by Europe in the 1790's - when it became much safer), iii) better diet, iv) more availability of food, v) cleaner water supply and improved sanitation. The last two developments may have accounted for as much as 25% of the reduction of mortality in the 19th century. A further 25% is attributed to the control of TB by the slaughter of infected cattle and the prohibition of spitting in public places.

Despite all these advances, it has only been possible to ring fence the diseases of the past. Although immunisation has virtually eradicated smallpox, other diseases have only been controlled, not eradicated; the 1918 world flu wiped out over 20 million people – possibly helped by poor diet due to lack of nutrition following WW1.

In industrialised countries, the face of death has changed. Where control of traditional diseases has enabled longevity, cancer and heart disease as well as others have become more common not just due to advancing years but also to changes in life-style especially among the more affluent. Some modern western dietary changes have been a two-edged sword. Healthier food has resulted in "*contemporary British children being 20% taller than those of mid-eighteenth century*" but less fibre intake has increased constipation and intestinal diseases. Increased sugar consumption has led to obesity and diabetes; increased fat intake – helped by modern preservation techniques and fast distribution methods to make meat widely available – has also led to the increase incidence of heart disease. Consumption of more processed – and therefore of less fresh – food has decreased the intake of nutrients and simultaneously increased the ingestion of potentially harmful additives thereby encouraging cancers and heart disease.

Ponting underlines the impact of these changes with a few *killer* comparisons:
"*Heart disease was almost unknown a hundred years ago except among the rich … It now kills forty per cent of men and twenty per cent of women in industrialised countries … one in three Americans contracts cancer compared to one in twenty-seven in 1900 … Male deaths from cancer in the western world rose by fifty-five per cent between 1960 and 1980 and female deaths rose by forty per cent. … Before 1940, Africans in Kenya and Uganda did not have rising blood pressure with increasing age, and coronary heart disease was not diagnosed at all in Uganda until 1956 and not until 1968 in Kenya and Tanzania."* And finally in 1991, "*Processing food … introduces additives such as antioxidants, emulsifiers, thickeners, dyes, sweeteners and bleaching agents. The average Briton now consumes three pounds of chemical additives every year* [and] *on average middle-aged males are now twenty pounds overweight and in the United States the figure is even bigger.*" I do not know if Clive Ponting intended the pun in the last sentence but in 2007 average 'figures' are bigger still!

Chapter 12: The Weight of Numbers

The explosion of populations[32] is the greatest change occurring in our history. The world population reached 1 billion in 1825, reaching five billion in 1988 [and 6.6 billion in 2007]. The time spans to add a further billion to the planet has shortened from 100 years (1825 to 1925) down to 12 years (1975 to 1987) but rates of growth varied by continents and by region.

In Europe, growth was initially slow but it gathered pace during the 18th and 19th

Year	1700	1900	1990	2006
World	610	1700	5000	6600
Europe	120	450	630	730
Asia	415	970	2300	2660
China	150	450	1000	1314
India	150	290	750	1095
Africa	61	110	400	910
United States	6	76	220	300
Oceania	2	--	23	33

Table 1: Some Key Population Statistics since 1700

centuries to reach 450 million by 1914.

Had it not been for the mass emigration to the New World, Europe's population would have been over 40 million higher. After 1914, the growth rate lessened to 3/7ths of the rest of the world. Regional variations were large. Ireland's population partially collapsed between 1850-1900 because of the potato famine and the subsequent flood of emigration.

In Asia, the growth was more dramatic. Already at 450 million in 1750, population doubled to 970 million by 1900 before attaining 2.3 billion by 1990. China's population – 150 million in 1700 – reached one billion in 1990 [*and 1.31 billion in 2007*]. The population increase in Africa has been one of the highest in recent times. The 60 million people in 1700 almost doubled to 110 million over the two hundred years to 1900; it then *quadrupled* to around 440 million in the next ninety years. [*It more than doubled over the next 17 years to around 910 million in 2007*]. Due to high initial immigration combined with a natural increase, the population of the United States, being only 6 million people in 1800, had grown a century later to 76 million and then to 220 million by 1990 [*300 million in 2007*]. To complete the picture, Oceania with around 2 million people in 1850 had increased to 23 million in 1990 [*33 million in 2006*]

"*The fact that the earth now supports five [2006: six] times as many people as 200 years ago seems, at first glance, to be a triumph of human ingenuity in getting round the limitations on food supply that had … restricted the growth in human numbers to very low rates. However … the impact on the environment of these changes has been profound*."

The ability to feed the rising populations was due to a number of developments[33]. In Europe and China the traditional response had been to bring less fertile land into the agricultural sphere. Due to its world influence resulting from colonial expansion,[34] Europe was able to obtain the extra food supplies from its colonies. However, these extra supplies would have remained limited, had it not been for the combined effects of four other technology-based developments. Firstly, in the mid 19th century, railways enabled more rapid access to ports from inland plantations and farmlands whilst steamships provided faster ocean transport for perishable cargoes. Secondly, the latter part of the 19th century saw innovations for chilling and refrigerating cargoes, which could retain their freshness over longer voyages. These developments caused a fifty-fold increase in international food trade from 4 million tons in 1850 to 40 million tons by 1914 after which they remained steady until 1950, before increasing five-fold to 200 million tons in 1980. The result of these changes was that, whereas prior to 1850 all Europe's imports were luxury goods, after that point they were gradually dominated by grains, meats and dairy goods. "*European countries, especially Britain, became dependent on imported food in the late nineteenth century. In the years immediately before … 1914 Britain imported 80 per cent of its wheat consumption, 65 per cent of its fruit and 40 per cent of its meat*." Thirdly, gradual improvements in crop productivity made a significant contribution to the food supply. Between the 13th and 19th centuries crop yields had doubled but, after that, the seed drill and (from the 1840s) tiled underdrainage, better animal feed (oil cake) and mechanisation resulted in significant growth. Post 1850 mechanisation – in part stimulated by labour shortages – and the use of artificial fertilisers (guano, super phosphates and nitrogenous salts) were two further factors which greatly increased production. The significant impact of these can be seen from just one example: "*Greater mechanisation made it possible to increase farm size ... in the United States the number of farms fell from 7 million in the 1930s to below 3 million in the 1980s and over half of all sales of agricultural produce came from just 5 per cent of the total number of farms. … The paradox of modern agriculture in the industrialised world … is that, as the output has soared, the number of*

people working in agriculture has plummeted, with major implications for society and the countryside."

The fourth development was improved animal productivity. Early domestic animal production was extensive and was limited by available grass and winter fodder and selective breeding. In the 20th century it became intensive, bringing animals indoors and feeding them on a diet which could include dead animals, recycled manure and growth hormones as well as antibiotics to control diseases that could emanate from such food. Increasing numbers of salmon farms became established and by 1990, 25% of British fish were being farmed. Government subsidies were used to keep prices above the market rate in the United States and in the European Community, a practice which resulted in massive surpluses of many crops. By 1990, subsidies in the UK amounted to 40% of production.

As technology influenced and changed farming methods, it had a contemporaneous impact on the food processing industry which traditionally consisted of bread, pies and jam since all produce was eaten fresh and consequently had limited availability in towns. A major development occurred in the dairy industry. Pasteurisation together with faster transportation and new ways of keeping produce cool combined to cause rapid expansion. *"In 1861, just 4 per cent of the milk sold in London came by rail but thirty years later it had risen to 83 per cent. By 1914 much of the milk sold in New York came from over 300 miles away and in the 1930s most of the milk supply for Berlin travelled more than 400 miles. ... [in 1990] milk constituted over a fifth of the total agricultural output of the United States and the European community."* Later, canning and refrigeration enabled vegetables and fruit to be consumed out of season and country of origin. The growth in the processing industry meant that farmers only got between 4 and 17 percent of the price of many of the foods sold in the shops. During the early days of food processing, many of the foods were adulterated and barely fit for consumption, resulting in a wide range of Government legislation to protect consumers against unscrupulous profiteering. Such practices still occur even today.

The development of farming in the Third World countries over the last 200 years is really a story of how self sufficiency for peasant farmers was replaced by unequal land distribution on a massive scale in order to increase crops grown almost entirely for export. For instance, in Africa 75% of the population owned only 4% of the land. This was exacerbated post WWII by the introduction of more productive varieties of wheat (in Mexico) and rice (in the Philippines). Termed the '*Green Revolution'*, this intensified the gap between rich and poor farmers since the new strains required more fertilisers and pesticides than conventional crops putting them beyond the investment capabilities of small peasant farmers. The richer farmers who could afford these inputs became wealthier and bought up more land from the bankrupt peasants.

The drive for exports meant that indigenous Third World countries became dependent on the world markets for their food. And many of them producing food for export eventually became net importers. As Ponting points out: "*The agriculture of the industrialised world is not necessarily more efficient than that of the Third World – what it is able to do is purchase more inputs and therefore ensure higher output. In energy terms it is actually less efficient. Overall there is enough food in the world to feed everybody at an adequate level – the problem is its unequal distribution… More food is sent from the Third World to the industrialised countries than in the opposite direction ... a large proportion of this trade has been to provide more variety in the diet of those who are already well fed.*"

Famine, once prevalent in Europe, died out in the 18th and 19th centuries. Not so in the Third World. "*In none of the twentieth century famines has there been an absolute*

shortage of food; the problem has been unequal access due to poverty, a problem that resort to food aid has not solved."

As a result, when world prices soared, people in countries with plenty of food have died in their hundreds of thousands. "*In Bengal in 1943-1944 about three million people died after rice prices quadrupled in two years … In Ethiopia in 1972-1974 about 200,000 people died … even though the country's food production fell by only 5 per cent … In Bangladesh in 1974 when rice prices doubled in three months after severe flooding, one and a half million people died of starvation …when production of rice in Bangladesh was the highest ever … [because] it was a problem of who had the resources to buy food at the higher prices.*"

During the last 130 years, over 800 million hectares has been put under the plough and the cow to feed a growing world population. Unsurprisingly, it has had a tremendously negative impact on the world's ecosystems through "*deforestation, ploughing up of grasslands … [*cultivation*] of marginal land and steep slopes with a consequential increase in soil erosion, degradation of land and in many areas the extension of deserts.*" In Britain we have destroyed over half of our lowland meadows, heaths and ancient woodlands, bogs and wetlands in the 45 years after WWII. Worldwide, loss of wetlands to agriculture has been a major impact, particularly in the USA where 50% have disappeared, much of that in the Florida everglades where drainage began in 1883 to house people and to clear land for sugar plantations. There, the terraforming achieved by clearing rivers and building canals extensively upset the local ecosystems: "*The water table fell by over two feet, sea water flowed in from the ocean, the main lake was affected by eutrophication (excessive plant growth resulting in the death of animal life through lack of oxygen), peat dried out and the land fell by one foot a year. Most of the wildlife including 90 per cent of the two-and-a-half million wading birds, died out."*

Table 2 summarises the extensive deforestation that has been taking place over the centuries; we can see that most of that has taken place in the last 150 years at an accelerating pace to provide agricultural land for an exploding world population. Destruction of tropical forests is only a short-term palliative for insufficient farmland. Most nutrients are held in the trees rather than the soil and they are destroyed with the tree, leaving a legacy of poor quality soil. This soil degrades quickly due to wind and rain. Settlers grew corn for a year or two after which large ranchers bought them out for pasture land; after a further five years, when soil was unfit even for that –"*nearly all the ranches established in the Amazon area before 1978 had been abandoned by the mid-1980s. It is a striking example of how quickly a highly productive natural ecosystem can be transformed into an unproductive, artificial one.*"

Country	Period	Deforestation (ha)	Comment
China	1950-1980	20 million	
Rajasthan/Punjab	2000 years	24 million	Thar desert created
New Zealand	1870 -1980	50%	To create sheep grazing
Haiti	200 years	90% cleared	Poor quality topsoil
USA	1790-1850	96 million	Eastern Seaboard
	By 1990	225 million	94% of forests
Worldwide	1980	10 million p.a.	Annual destruction rate
Africa	1980	7 million p.a.	ditto
Algeria	1890-1940	500,000	Food production
World	By 1950	50% deforested	

Table 2: Deforestation in Various Areas of the World over the Last 2000 Years

The practice of monocropping and overgrazing coupled with deforestation and ploughing-up grasslands has led to severe problems with soil erosion; an estimated 15 billion tons of topsoil are lost annually from just half of the world's croplands. Haiti has no quality topsoil left and many parts of Europe (e.g. Massif Central) suffered extensive soil erosion over the centuries. During medieval times, when land was relatively plentiful due to low population density, exhausted soil was left, and eroded, as new areas were tilled. In modern times, the loss of hedgerows on the altar of high productivity caused extensive soil loss, not only in the USA and the Soviet Union but also in Britain.[35] In the USA, because land was freely available, settlers "*paid scant attention of the need to preserve soil quality.*" After two years, tobacco and cotton crops, extremely demanding on nutrients, had to be followed by wheat which itself was viable for a further five years. Settlers then cut down more forests and started all over again, leaving the exhausted soil to be eroded by the weather. "*By 1817 in North Carolina the amount of abandoned land was equal to that under cultivation … [in] the United States area after area was ruined in the space of a few years and then abandoned but the same destructive practices continued in the newly cultivated areas*." With the development of the steel plough it became possible in the late 19th century to cultivate the Great Plains. Despite the experience of previous centuries, the US Bureau of Soils claimed … in 1909 that, "*the soil is the one indestructible, immutable asset that the nation possesses. It is the one resource that cannot be exhausted; that cannot be used up*." Famous last words! After continuous overexploitation of the land, the worst ecological disaster in history occurred in 1934 to create the 'dust bowl': "*In March 1935, five million acres of wheat were destroyed by dust storms, and by 1938, 10 million acres of land had lost the top five inches of soil and another 13.5 million acres the top two and a half inches*." The damage didn't stop there. "*By the 1970s a third of the topsoil of the United States had been lost and nearly 200 million acres of cropland had been ruined or made highly marginal for cultivation.*"

In the USSR, the 'virgin land' programme ploughed up 100 million acres of grassland between 1954 and 1960. Production peaked after two years and declined thereafter when soil erosion proceeded at catastrophic rates with up to 17 dust storms per year occurring in parts of the Ukraine. For similar reasons, soil erosion and dust storms were also prevalent in Australia and China; in the latter, 1/7th of land area is affected and Chinese dust can be detected in Hawaii!

Downstream effects of deforestation and soil erosion are silted up dams and river mouths with consequential high risks of flooding, as in Bangladesh. In many areas, soil erosion progressed to desertification (defined as the permanent loss of land for cultivation), e.g. south west United States, Africa (most notably, the Sahel and Sudan), Chile, Mexico and Australia. Pressure to produce food had also demanded irrigation; between 1800 and 1980, land area under irrigation grew from 20 million to half a billion acres – about 15 percent of the earth's arable land. This has led to waterlogging, salinisation and aquifer depletion: "*Overall, more than seventy million acres of irrigated land has been ruined and the adversely affected area is increasing by about three-and-a-half million acres per year*." The most extreme ecological consequence of irrigation has been the almost total loss of the Aral Sea in the Soviet Union by diverting 'feeder' rivers to water 18 million acres of cotton plantations. This caused salinity of the sea to treble, a lowering of the water table and collapse of the sewage system, "*…(typhoid rates rose twenty-nine fold) and 90 per cent of the children were diagnosed as being permanently ill. In 1990 an outbreak of plague led to the area being quarantined. The Aral Sea and the surrounding area is now the scene of one of the greatest of all ecological catastrophes.*"

Chapter 13: The Second Great Transition.

"*The second great transition in human history … involved the exploitation of the earth's vast (but limited) stocks of fossil fuels, a move that made possible an era of abundant energy for part of the world's population*." Put simply, energy is needed for lighting, cooking and heating, and after that, to perform tasks in agriculture, transport, construction and manufacturing. Historically, energy in the form of wood, coal, wind and water was constrained by local availability, until the development of electricity in the early 19th century. Initially, the scope of productive activity was limited to human energy and mainly to the hours of daylight. Until the late 1800s, human labour was used extensively; in the 15th century, the Great Crane of Bruges was powered by a human treadmill; in the 19th century industrialists could buy energy from human treadmills in British prisons (hmmm…!); until the 20th century the main source of household energy was servants, "*As late as the first decade of this [20th] century two-and-a-half million people (84 per cent of them women) were employed as domestic servants in Britain and they constituted the largest single occupational category."* [36]

Historically, the problem of mobilising large quantities of labour to build world wonders was solved by either subjecting large numbers of the population to forced labour or by using prisoners-of-war and other people from conquered lands as slaves. China provides us with two outstanding examples: *"… the building of the Great Wall involved about 1 million workers, of whom died half during the work. The construction of the Grand Canal, to bring food to the capital Peking and the armies in the north, used about five-and-a-half million workers guarded by 50,000 police and again about half of the workers died on the project.*"

Slavery[37] was normal in the early societies. The great states of the ancient world used them for agriculture and domestic work, while Europe later on used them on plantations to provide exportable cash crops. Most societies have used human labour for transport from carrying sedans to rowing triremes and even today in the Far East [and London!] for transportation by rickshaw.

Animals also provided a source of labour. The main downside of using animals was the need to feed them (horses require five acres each) on land which was also needed to feed humans. They were, however, useful for carrying heavy loads over long distances. Asses, onagers, mules, oxen, horses, camels, and dromedaries all found their niche the latter being particularly suited to hot desert climates. While all have been replaced in advanced countries by mechanised vehicles, many are still extensively used in the Third World where such wheeled transport is generally unaffordable.

Wheeled transport dates as far back as 3500 BC in Mesopotamia and a little later in Egypt and the Indus Valley. Horses, domesticated around 3000 BC were used predominantly for riding and did not become useful draught animals until around 800 AD when the traditional ox harness, which tended to choke them, was replaced with a more suitable design. That, and the development of horseshoes around 900 AD, transformed the horse into a ubiquitous source of energy for agriculture, transport and industry such that: "*Joseph Arkwright [developer of textile machines] used nine horses at his first factory in Nottingham to power 1000 spindles*". By the 18th century, twenty-four million oxen and 14 million horses were the main draught animals in Europe and the Near East.

The horse was also widely used for warfare. Warhorses were bred for the job. Early applications included the onager-drawn chariot, then the cavalry. Feeding them was always

a constraint. Nevertheless, "*During the First World War, the British army used 1,200,000 horses and in the Second World War the German army had mechanised Panzer divisions but it also required the logistic support of 2,700,000 horses.*"

By about 1800, horses and oxen were generally replaced by steam power in such applications, but remained vital for transport (carriages, barges, railways, etc) until well into the early part of the 20th century. As the railways became established, more traffic was generated and could only, until the development and affordability of the motor car, be satisfied by horse drawn carriages. "*In 1810 there were about 15,000 privately owned carriages. The number increased to 40,000 by 1840 and to about 120,000 in 1870. ... The number of horses kept in towns for private and business traffic rose from about 350,000 in 1830 to 1,200,000*[38] *in 1900 ... As late as 1913, 88 percent of London's goods traffic was still horse drawn. At the start of the twentieth century Britain had a horse population of about three-and-a-half million (about twenty-five times the current level).* "

Such large horse populations needed to be fed and competed with the needs of the human population. Their 'fuel' of oats and hay came from 15 million acres of cropland, which was only possible due to cheap imports.[39] (In the United States, the figure was 90 million acres!). Once motorisation of transport took hold, the horse population declined until by 1990 it was around 140,000.

Water was first used, in Egypt, to power irrigation works and a grain mill in 100 BC. These 'utilities' subsequently spread throughout Europe over the course of several centuries. The scale of their popularity was evident from the Domesday Book, which, in 1086, recorded 5,624 mills (mainly for grinding grain) in 3000 settlements in Britain. Whilst it saved labour, it was not without problems from variability of river flows, being frozen in winter, reduced during dry weather and suffering from other water wheels in their vicinity – thus weakening their supply. Water mills started to revolutionise industry from the 12th century and continued to be built until the 19th century. Their first use was for fulling cloth around 1086 in Normandy, then for tanning leather around 1138 in Paris and for papermaking in 1238 in Valencia. Additional uses included making mash for beer, sawing, operating bellows and grindstones, and later in the 16th century for milling coins and polishing precious stones. Although water mills were powered by rivers, a limited number of tidal mills were established – one notably in the Adriatic near Venice in 1044 as well as a few in Devon and Cornwall for corn grinding – but these never really caught on. The industrial revolution saw an increase in water mills in Britain particularly along the banks of northern rivers. They were also used to power London's water supply in the 19th Century; in 1900, Nuremburg had over 180 operating mills; in Japan, steam did not take over from water until the 1890s; in the United States, industries depended entirely on water power until the 1880s.

Wind provided a complementary power source to water. Although it had the advantage of being able to work when water froze over, this was partly offset by the inconstancy of the wind. Windmills were first developed in China and Tibet as prayer wheels but were used for industrial power by the late 13th century. They were developed independently in England in the 12th century and spread out from there across Europe. Their success can be seen by the fact that, in the 18th century, the Netherlands had over 8000 windmills being used for a host of applications including drainage of cultivation areas.

Until the exploitation of fossil fuels, wood was the prime source of energy. Locally available and renewable, when dried or aerobically converted into charcoal, it was used for

all the heating, building, manufacturing and transport needs of humans. Because of its abundance, the fact that it was renewable was virtually ignored; a by-product of deforestation was that another necessity – land for living and food production – was automatically increased. "*A moderate-sized house in medieval England required a dozen oaks to be cut down and … work on Windsor castle resulted in the felling of 4000 oaks in ten years … Hopewell [blast] furnace in Pennsylvania was using up as much as 750 acres a year.*" Such wasteful consumption of what was to become a diminishing resource is illustrated by the fact that, one works in Russia was using 1,000 tons of wood for each ton of potash produced and, *"By 1662 Russian potash production was using up a total of three million tons of wood per year.*"

Wood shortages first became apparent in the fifteenth century as a result of the extensive shipbuilding industry in Europe. Venetians exhausted local supplies and by 1590 they "*had to import completed hulls for their ships*." In the 16th century, Portugal had to build most of its ships in its colonies; Spain imported wood from Poland. In England during the mid-1600s, shortage of Sussex oaks for 120 ft mainmasts forced the Admiralty to replant belatedly (it would take 100 years for these trees to mature) whilst importing from Scandinavia and Russia during the interim. The Royal Navy then resorted to building its ships in North America until the American War of Independence and Napoleonic wars forced it to import from Canada.

"*A shortage of timber for naval construction was only one symptom of a major problem affecting the whole of Europe. … widespread shortage of wood meant that Europe faced an energy crisis*." This impacted on downstream industries, for example: some Slovakian iron foundries had to cut back on production; French bakers had to burn bushes in their ovens to bake their bread; the poor could no longer afford fires and a Polish salt evaporation works, which used wood as the source of heat, closed down in Wieliczka.

In Britain, the crisis deepened throughout the 16th and 17th centuries as charcoal prices rose dramatically such that "*in most areas of the country blast furnaces were only able to operate in short bursts every few years*." The result was that, begrudgingly, people gradually resorted to use what was viewed as an inferior fuel, namely coal. But when needs must, the devil drives and, starting with the poor, 'pauper coal' was used first by the poor and later by the rich so that the long reign of 'King Coal' began.

Coal had been used in small amounts in Europe for centuries, but more serious exploitation began to take off in the 16th century and marked the beginning of our dependence on non-renewable energy. First the shallow pits were mined, but later the rising price of charcoal made deeper mining economically viable. The result in terms of world output was dramatic: by 1800, 15 million tons (Mt) were being extracted; by 1860 this rose by almost an order of magnitude to 132 Mt; and then by more than five-fold to 700 Mt by 1900. *"… from a negligible contribution, coal came rapidly to account for 95 per cent of the world's energy consumption*." As a by product, waste gases from coal were used for lighting. In the United States, lower population and an abundance of forest wood meant that the transition to coal did not happen until late in the 19th century.

The most significant development of the 19th century was the production of highly convenient electrical energy, from fossil fuels. Electricity generators were first made in London in 1834, and by 1875 the first commercial lighting application was installed in the Parisian Gare du Nord. The invention of carbon filament lamps (1881) was followed by more reliable tungsten filaments in 1911, and this advance boosted the use of electricity for

lighting applications. As applications increased, industrial and domestic usage spread, leading to the development of national grids. As a result, power-plant sizes increased from 30 MW average in the 1920s to 600 MW by the 1970s. Europe's dependence on energy from coal peaked early on in the 20th century, declining from 90% at the start to 30 % by 1970, as cheap oil became increasingly attractive.

Oil had been known about for centuries. It seeped through the earth's surface at several locations, but was not commercially produced until 1859 at Drake's well in Pennsylvania. By the 1890s, 85% of oil produced was used in the form of kerosene, for lighting as a substitute for whale oil which was by then becoming scarce due to whales being hunted to near extinction in many areas of the world. In the early 20th century, furnace fuel-oil accounted for 50% of production. After the development of the internal combustion engine, gasoline then became the main refined product by 1930, followed by aviation fuel. Cheap oil did for economic growth in the 20th century what coal had done in the 19th century. Annual production, around 10 million tons in 1890, reached 2500 million tons by 1970. In America, *"...oil consumption increased at an average rate of 9 per cent from 1890 to 1922, doubled in the course of the 1920s and then continued to grow at 5 per cent a year*." Because oil had to be imported, the changeover to oil in Europe happened much later.

Natural gas was a major by-product of oil and its use quickly became widespread after suitable pipelines were developed and installed in America in the 1930s. Europe – which still used town gas – followed suit in the 1970's, when town gas in Britain was replaced with natural gas from the North Sea. Much of Europe's supply came from Soviet Union gas fields in Siberia. Overall, natural gas progressed from providing 1% of the world's energy in 1900 to 20% in the 1980s.

Apart from coal, oil and gas, only nuclear and hydroelectric power provided any realistic alternatives. In 1929, hydroelectric power was providing 40% of the world's electricity but this declined to 2% by 1990, by which time nuclear power provided a mere one per cent.

During the 20th century, the pattern of the world's energy consumption changed completely. Up until 1900, all energy had been provided by humans, animals, wind and water. *"Now, just over 90% comes from fossil fuels (40% from oil, 33% from coal, and 18 per cent from natural gas ... 4% from wood, 2% from hydroelectric and 1% from nuclear) . ... During the last two centuries, as in the past, energy supplies have been used as though they are inexhaustible. The industrialised world has encouraged consumption not conservation."*

Because energy was cheap, much of it was wasted; 90 per cent of heat from coal fires went straight up the chimney. The earliest engines were only 2% efficient but, by 1910, steam turbines were achieving 20 per cent efficiency, which almost doubled by the 1950s. Throughout the 20th century, as the natural pressure in oilfields dropped off, wells were repressurised by the injection of natural gas which was then burnt off rather than being recycled: "*In 1913 ... one Oklahoma oilfield was wasting natural gas worth more than the oil it was producing."* In the 1920s and 1930s estimates indicate that, in the US, natural gas was wasted at the annual coal equivalent of 25 million tons – amounting to 25% of the world consumption at that time.

The convenience of electricity came at the price of waste, as only 25% of the input energy ended up in the home. Inefficient lamp bulbs, refrigerators and other equipment in poorly insulated homes all add to the waste[40]. *"If individual items of energy producing and using*

equipment are not always efficient, is modern industrialised society efficient as a whole?" Crude calculations show that one can offset animal feed against time and effort savings in agricultural tasks. *"But even when the facts are known societies have found it very difficult to make the necessary adjustments to achieve more efficient use of energy"* For example, the far eastern paddy field system of growing rice reaps a return of 50 times more energy than its input, but the return on modern farming is only two-fold and getting worse! *"Overall the energy efficiency of American corn production has fallen by half since 1915 ... meat production in the industrialised world now consumes between two and three times the energy it produces ... catching and producing fish consumes ... 20 times the energy it makes available... and the processing and distribution of food takes three times as much energy as producing the food itself."* In conclusion: *"... all food production in the western world uses three times more energy than it creates."*

Chapter 14: The Rise of the City

Clive Ponting sets the scene for this chapter with the opening statement:

> One of the greatest changes in the way people live has been due to the rise of the city in the last two hundred years. Cities developed at an early stage in the growth of settled societies and have generally been regarded as one of the distinguishing characteristics of a civilized society. However for thousands of years they played a very small part in the lives of most people. Until 1800 only a tiny minority — no more than two-and-a-half per cent of the world's population — lived in cities. … With the use of fossil fuel energy sources and increasing industrialisation, truly urbanised societies began to emerge in Europe and North America. In 1900 about one in ten of the world's people lived in cities …[which] continued to increase in number, size and importance in the industrialised world.

Just eighty years later, city dwellers had grown to fifty per cent (about 2.5 billion people) of world population.

Originally, Neolithic groups lived in small settlements, but over a few thousand years there emerged several early cities, such as Uruk, Ur and Lagash in Mesopotamia and others in China, the Indus valley, Egypt, Peru and Mesoamerica. Over four thousand years, they acted predominantly as ceremonial centres and were roughly the size of small modern day towns. In Egypt, they were populated by priests and craftsmen whilst peasants lived in the rural surroundings; by contrast, in Mayan cities, peasants lived in the cities, 'commuting' to their fields. Cities gradually developed into independent administrations which distributed food, housed craft and administration centres and controlled trade. Virtually all pre-industrial towns had surrounding walls for defence as well as taxation of goods entering via the gates. In contrast to their modern derivatives, cities' streets were labyrinthine, narrow alleys leading to a centre, in the vicinity of which lived the rich in expensive houses, alongside public buildings; the poorer population lived nearer the walls. Many towns had several fields and orchards within their walls, and areas demarcating crafts and religions were carefully segregated (e.g. Jewish ghettos in Europe).

As empires grew, so also did pre-industrial imperial capitals such as Rome, Peking and Pataliputra as well as coastal trading capitals such as Athens, Venice and Genoa. Cities attracted administrators, priests, craftsmen, traders, and the rich along with their slaves and servants, with populations growing up to 800,000 in the process. However, *"Lacking a firm economic base and dependent as they were on the imperial fortunes of the great empires, these imperial cities often declined as quickly as they grew. Vijayanagar, the*

capital of the main Hindu empire in India in the thirteenth and fourteenth centuries, was virtually deserted after the Mughal conquest."

In Asia, trade networks influenced the formation and growth of cities from the first century. From the second century BC, China's cities, such as Nanking, contained around ten per cent of the population; by 1200 AD, there were many cities containing several hundred thousand people after which urbanisation then appeared to go into reverse. Ponting summarises Europe's changing fortunes at that time:

> In Europe, the Mediterranean area was the centre for all the most developed societies and empires until at least the eleventh and twelfth centuries. Even after the fall of the Roman empire in the west in the fifth century, the Mediterranean remained economically the most advanced area of Europe and the size of its cities reflected this fact… The pattern of settlement in the north and west of Europe was very different. Under the Roman empire there had been only a few towns in the area, many linked to military settlements and most containing no more than a few hundred people. After the collapse of the empire, nearly all these Roman foundations decayed drastically. For five or six centuries there was little trade and industry in north-west Europe and the scale of its agricultural surplus was generally insufficient to support more than a very small urban population.[41]

By 1000 AD, Europe had only around 100 towns, half of which were in Italy. Three centuries on, as industry developed, Europe's town count had risen to about 3500, of which about a quarter could claim populations of over 25,000. Most however had less than 2000 people who made their living from the land and traded at the weekly market alongside a limited number of craftsmen. They thus formed a predominantly agricultural society. Between 1300 and 1800, growth of the preceding three centuries was not maintained; populations, following the Black Death and the end of the Medieval Warm Period, declined rapidly and only recovered slowly: *"Between 1350 and 1550 the number of market towns in England fell by two-thirds."*

Because cities could not feed their populations without recourse to the agricultural resources around them, they evolved their wealth from manufacturing, trading, local administration and taxes. As they developed they attracted more people from the overpopulated countryside, but in many cases such people were only able to do low-paid casual work and frequently had to resort to begging.

Existing towns in European colonies of the Americas became the foundation of modern cities, e.g. Mexico City was based on the Aztec Tenochtitlan and Incan Cuzco. Where no towns previously existed – as in North America and Australia – new settlements became the seed from which the cities developed.

Up to 1800, 'city' towns containing barely 2.5 per cent of the world's population had, in the main, less than 10,000 people; America had only five cities containing over 10,000 inhabitants. In the old world, city populations ranged up to about 1 million. Then, in the eighteenth century, the fuse of population growth – lit gradually by technological development, manufacturing and fossil fuel extraction – caused city populations to rocket during the nineteenth century:

> The results of this change were first apparent in Britain – in 1851 Britain was the most urbanised country in the world but more than sixty per cent of its population still lived in the countryside.... By 1900 three-quarters ...lived in cities and one in five of the population lived in London…. The total numbers living in British cities rose from about two million in 1800 to about 30 million in 1900.

The world's city population followed suit, quadrupling during the nineteenth century and causing other changes: *"For the first time, cities, although still reliant on the countryside for their food supplies, ceased to be parasitic on the national economy and began to make a*

major contribution, primarily through increased industrial output." Just as food was the fuel of population growth in the world as a whole, industry fuelled its growth in the cities. The towns that grew were those based either on local natural resources such as salt, coal (Sheffield), wool, imported cotton (Manchester) or on the facilities needed to move them around (Swindon and Crewe – railways). London continued to be Britain's commercial and financial centre but also grew a variety of 'sweated' workshops for the clothing trade.

In Europe, similar developments followed. In Germany, the Ruhr towns developed on ports (Hamburg, for example), the coal and manufacturing industries, and "*Berlin became the hub of the railway system ...* " As population and poverty grew in Europe, emigration fuelled the growth of American cities; 23 towns in 1830 with over 10,000 people became fifty cities by 1910, with over 100,000 inhabitants. Ponting paints the big picture:

> Before 1800 most cities in the world were small in area – they were places which people could walk across to conduct their business. Rome in the second century AD was still largely contained within the Aurelian wall which enclosed an area of about five square miles. Roman colonial cities were much smaller – London covered 330 acres and Bath only 23 acres. The area of medieval London was about 700 acres. Cities in the nineteenth century began to sprawl. At ever greater distances from the centre suburbs grew up, mainly relying on new transportation systems to bring the ever greater urban population into their workplaces. Such developments significantly changed the nature of cities. Until the widespread growth of suburbs, the centres of towns had been the place where the wealthy lived. Industrialisation and the massive influx of mainly poor people seeking work led to … huge slums … in the centres of cities, such as the Covent Garden and Holborn areas of London, and many of the wealthy, together with the growing number of people working in offices and other service industries moved out to the more salubrious suburbs and surrounding countryside.

Suburbs developed with extensive housing estates to provide accommodation, and London spread out, mainly via unplanned development, to subsume nearby villages, such as Highgate and Hampstead, before marching across the countryside in all directions. Towards the south, expansion into Southwark followed thanks to new bridges and ferries.

All this development led to the parallel development of mass transport systems. After horse-drawn omnibuses were introduced in France, New York developed a 700 strong horse-drawn vehicle system along Broadway by 1853. Overall, "*Horse-drawn public transport had some effect on living patterns but the development of railways brought about major changes. In London the steady building of railway lines from the 1840s led to the growth of new, largely residential suburbs such as Camberwell, Hornsey, Kilburn, Fulham and Ealing."* This means of transport flourished in many American cities until the 1890s, by which time 5700 miles of track had been laid, before "electrified trolleys" started to replace them. To handle the rising need to move people around, London introduced the first underground railway in 1863, several decades ahead of other cities which followed suit, e.g. in Boston (1897), Paris (1900), Berlin (1902) and New York (1904).

The way that cities developed varied significantly throughout the world. In North America, where population density was low and land cheap, urban sprawl was extensive; Boston's radius grew from two to ten miles between 1850 and 1900. Overall, urbanisation grew from 2.5% in 1800 to 41% by 1985, and the number of cities with a population of over 1 million grew from 9 in 1890 to 230 by 1980.

Development was generally poorly planned, if at all. In Paris, Haussmann cleared slums in the 1850s, and in London, housing jumped the 'green belt' to extend its sprawl. In the Soviet Union, despite a highly planned economy, all attempts to constrain Moscow's population, first to 5 million (1935), then 7.5 million (1971) failed; by 1990, it reached 10 million. Japan remained predominantly rural until 1955, after which it followed the trends

of the USA and Europe. In 1920, 80% of the people lived in the country, but this all changed with the construction of the railways in 1923. In Tokyo (previously Edo), the result was a trebling in population from one to three million between 1920 and 1930; the green belt disappeared by 1960 and a fifty-mile urban sprawl became established by 1977.

In several countries, to quote Ponting: "*Concentrated industrialisation in the nineteenth century, based upon the exploitation of deposits of coal and other raw materials, brought about the formation of the first conurbations – large, formless, urban masses caused by the expansion and joining up of a number of settlements without a single urban focus*." Cases in point were: the Black Country and the Five Towns of the Potteries in Britain; the development of the *Randstad* (ring towns) in the Netherlands which now comprise eight major cities; the German *Ruhr* which grew from 0.9 million (1871) to 4.5 million (1939) and ended up with a population of 5.5 million spread across 11 cities covering four districts; Japan where one conurbation extends from Tokyo to Kobe; and in the USA where there exists *" ... a string of cities linking Boston and Washington DC and containing over fifty million people (about a quarter of the population) in just one-and-a-half per cent of the area of the country."*

Although the twentieth century saw the appearance of the large metropolis, urbanisation peaked in the second half in industrialised countries. In Britain, France, Canada, Germany and the Netherlands, many cities started to decline in population from around the 1960s. In the third world, the timing was different. In Lagos, a sixteen-fold increase took place during 1950-1985, and in Nouakcholl in Mauritania, a forty-fold increase during 1965-1985. In contrast to nineteenth-century city growth, such rapid expansions in the third world led inevitably to higher mortality rates, social inequality and unemployment, poorer housing, more slums and weaker social bonding.

In the developed world, although cities improved generally with accumulation of wealth, one downside was poorer mass transport and increased congestion as cars became the favoured mode of travel; the average speed of cars in New York declined from 11.5 m.p.h. in 1907 to 6 m.p.h. in 1970. Similar trends occurred in Paris and London. In Japan, Britain and the US, trends in the second half of the century were similar. Poor housing – often with inadequate sanitation – inadequate transport networks, increased ghetto populations, inadequate medical facilities and social degradation (*inter alia* drug abuse and crime) have led to social challenges that have yet to be effectively addressed. Ponting sums it up:

> The rise of cities is a phenomenon linked to the exploitation of fossil fuels and industrialisation in the nineteenth century, together with the development of greater trade and more complex financial transactions on a national and eventually a worldwide scale. Despite increasing wealth in the industrialised world, cities have become areas where environmental problems, in many cases specific to urban life, are concentrated. These range from air pollution from vehicles, to poor living conditions exemplified by estates consisting of large tower blocks of flats with people crowded together with often limited living space (a marked characteristic of Japan and the Soviet Union), long commuting journeys often on inadequate public transportation systems, excessive noise and the multitude of social problems that flow from growing unemployment, social inequality and urban decline in the city centres. Most of the people who live in cities – about three-quarters of the population of the industrialized world and half of the people of the world as a whole – are now subjected to such problems on a daily basis.

Chapter 15: Creating the Affluent Society

> Since the rise of settled societies some eight to ten thousand years ago the majority of the world's population has lived in conditions of grinding poverty. They have had few possessions … and have been forced to spend most of their limited resources on obtaining enough food to stay alive. Although in all societies the elite have lived at a higher standard than the overwhelming mass of population, they too only had access to a very limited range of goods and services for most of human history. However in the last two hundred years a sizeable minority of the world's population has achieved a standard of living that would have been unimaginable for previous generations. But this relatively sudden and recent improvement has been obtained at a significant price – a vast increase in the consumption of the world's limited energy resources and raw materials, widespread pollution from the industrial processes involved and a variety of social problems.

Because of their mobile lifestyle, hunter-gatherers place little value on possessions and keep them to a minimum. In settled societies it becomes necessary to own goods, and to store and process food it is necessary to collect chattels. Until 1800, societies were predominantly agricultural and most of the population lived a hand-to-mouth existence by being continually at the mercy of the climate and food supply: *"... about 80 per cent of expenditure of the mass of the population went on food but the diet was still poor ... Even in relatively prosperous times people might have no more than ten per cent to spend on clothing ... Once food and clothing had been provided for, very little money was left for housing. The average peasant hut was made out of wattle and daub, with an earth floor, no windows or chimney and cooking was on a spit or a pot over an open hearth."*

The relatively few rich spent most of their income on housing and enjoyed better clothing, education and food – usually prepared and served up by slaves/domestic servants. In rural areas, people were at the mercy of the climate, while in cities overcrowding and abject poverty were rife: *"Most people, though, lived either in a state of destitution or on the edge of it. They had no savings and so the slightest problem such as illness or unemployment would reduce them to starvation and begging…Official returns in Florence in 1457 showed that 82 per cent of the population were classified as either poor or destitute."* Elsewhere in Europe, people fared little better over the next 400 years. In England, from the mid-19th century, things improved gradually. Even so, housing and sanitation were such that 8 per cent of the population was officially designated as overcrowded in the census of 1901. These overcrowded conditions derived from need to expand industry.

Heralding the evolution of plastics, artificial fibres – mainly rayon and cellulose – were developed in the late 19th century and were being mass-produced before 1914.

> By the late nineteenth century the industries that had formed the backbone of the first wave of large-scale industrialisation were beginning to stagnate … New industries that formed the second wave, such as chemicals derived from organic materials, electrical engineering and car production …were the key to continued growth in output in the first part of the twentieth century.

Production increased during the inter-war years and, combined with the development of nylon post WWII, the plastics industry exploded: "*After 1945 ... world production of plastics has, on average, doubled every 12 years. By the 1970s it exceeded the combined production of aluminium, copper, lead and zinc, and per capita consumption had increased by over one thousand per cent since 1945."*

The latter half of the 20th century saw rapid growth of a new wave of electronics, computers and communications industries spawning *" ...an ever-increasing, indeed almost bewildering, variety of products that industry can conceive, design and persuade the public*

to buy. The technology and machinery involved have often been highly sophisticated, but the basic inputs remain what they have always been … a huge increase in energy consumption (especially coal and oil) and the use of ever greater quantities of metals."

Nowhere is the increasing use of materials and energy so clear as in mining. Early metal production started with smelting lead (6400 BC), followed by copper (3700 BC) which in turn led to tin and the alloy, bronze. Iron, much more difficult to process, eventually gained a foothold around 1200 BC, its production spreading gradually over Europe, China and the American colonies reaching around 300,000 tons by 1700. Worldwide production of iron and steel then grew to 12 million tons by 1850, increasing another one hundred-fold by 1980. Similar magnitudes of growth occurred for nickel, manganese and aluminium, but not without serious costs to the environment:

> About 70 percent of the world's ore (95 per cent in the United States) is obtained by the most environmentally damaging of all methods – open-cast mining. This keeps down the cost, but involves the digging of vast pits or the removal of whole mountain tops, the destruction of topsoil and the creation of large amounts of waste. This waste … can cause rivers to silt up and valleys to be filled in, it is often toxic and therefore creates an uncultivatable desert or leaches into water courses and poisons them.

As the richest seams became depleted, new ones were opened up. With improved extraction methods lower yield ores could be processed, generating even larger quantities of waste (slag) as previously depleted rich sites were revisited.

Downstream, energy production and wealth increased. In the market place, this took the form of the development of retail outlets; a few specialised clothing, jewellery and instrument workshops became established in major cities in the 1600's. Until the late 1800s, food was only sold at markets, but since 1900, shopkeepers, selling goods made by others, appeared and initiated the evolution of chains, department stores, supermarkets and hypermarkets. In the 1920s, the consumer durable boom started in America leading ultimately to the availability of all manner of convenience products such as refrigerators, washing machines, etc. This consumer boom eventually led to a virtual saturation of the market with products; to continue growth, manufacturers had then to develop new products, improve old ones and build in obsolescence to exploit the consumer market. The most expensive of these products was the motor car; *"Across the world the ownership of cars and light trucks rose from 50 million in 1950 to just over 400 million by the 1980s …"*

Increase in wealth brought with it spending power which entrepreneurs were eager and quick to satisfy. Sport – in particular football, boxing, cricket, etc. – became big business. Holidays became longer and more frequent, leading to world travel and tourism through a host of tour operators, hotels, caterers, holiday camps and cruises. Growth of easy credit for consumer goods fuelled evolution of multinational corporations with the power to control purchasing trends. Changes in fashion and built-in obsolescence encouraged people to throw away and buy anew with scant regard for the environment. An offshoot of this mentality has been the growth of conspicuous consumption to demonstrate wealth, noted by Adam Smith in the title quote (above). Rising expectations were a strong feature of the developing affluence as state-funded primary education, as well as insurance, housing, pension and health care schemes became established throughout the 20th century.

On the subject of cars, Ponting notes that: *"The history of the motor car in the twentieth century reveals the transition from great expectations to major environmental problems."* He highlights the power and irresponsibility of the growing corporations in the United States as they eliminated competition: *"… the car industry decided not to leave the decay of public transport to the vagaries of the market system and instead took action to close down the public transport systems and force people to use cars. In 1936 … General Motors, Standard Oil of California and the tyre company Firestone formed a new company called*

National City Lines whose purpose was to buy up alternative transport systems and close them down." Twenty years later, over one hundred rail systems in 45 cities had been removed, the largest of which was "*the Pacific Electric System, which carried 110 million passengers in fifty-six communities. ... by 1961 the whole network was closed."* The consequences for the environment are clear when one considers that, compared to rail, car transport consumes six times the energy per passenger mile and the infrastructure consumes three-and-a-half times more and uses four times the land area.

Transport spawned tourism. "*The eight-fold increase in international tourism in the last forty years has severely strained facilities and even destroyed the original attraction of the places that people came to see ...* [and Venice] *is now little more than a museum ..."*

"*The distribution of wealth in the world became increasingly unequal in the period after 1500.*" Wealth from the colonies gave a few nations substantial control over the world's resources. The commitment of international aid since 1950 has failed to improve matters:

> In 1950 the per capita wealth of the poorest countries … was about four per cent of that of the industrialized nations, by 1980 that figure had fallen to two-and-a-half per cent. … In Britain in the 1980s the proportion of national income going on aid actually fell from 0.52 to 0.32 per cent … Most aid from the United States has gone to those countries judged to be of military and strategic importance and Britain's aid programme has paid for a £7 million hospital in the Falkland Islands and an £18 million naval repair yard in Gibraltar.

Ponting illustrates how multinationals benefited from World Bank funding of major construction projects, while millions of locals suffered displacement and disease as a result. Dams, in particular, were frequently a failure due to a combination of high local evaporation rates and deforestation which, *"... produces a very high run off and siltation rate ... in China the Sanmenxia dam, which was completed in 1960, had to be abandoned four years later because the reservoir had silted up and the Laoying project even had to be abandoned before it was completed for the same reason.*"

Ponting's summary of the development of affluence up to 1990 makes the picture clear:

> For the last eight or nine millennia settled societies have produced inequalities in wealth, but the differences were essentially internal. Before the expansion of Europe and the intensification of industrial output there were no major differences in wealth between the main agricultural societies themselves. The emergence of an affluent society has not changed the persistent historical fact of internal inequality (despite major changes in the standard of living for all the inhabitants of the industrialised world), but it has brought about a huge shift in the pattern of wealth distribution worldwide. Domination of the international economic system has enabled the industrialised countries to utilise the vast majority of the world's resources and develop unprecedented, high levels of consumption. One part of the world can now be dubbed 'affluent', while the great majority of the world's population still live, as they always have done in the past, in conditions of absolute poverty. The changes that opened the way to the higher levels of consumption also involved social and environmental penalties, some of which, notably a big increase in the amount and sources of pollution, are now affecting the whole world.

Chapter 16: Polluting the World

This, the longest chapter, opens with the shortest statement in the book: "*Pollution has a long history."* With it, Ponting underlines that waste – an unavoidable consequence of life and indeed any physical process – has been taken to new heights by humans:

> The creation of wastes has been one of the distinguishing characteristics of every human society. For thousands of years the chief struggle was over sanitary arrangements and the main challenge was to obtain unpolluted water supplies. These problems became ever more acute as human

> numbers and urban life increased, but widespread industrial production and the use of new technologies introduced new pollutants and brought new risks to human health and the environment. Contamination was at first essentially localised – generally confined to a city, river, waste dump or mine. By the late twentieth century pollution had increased to an unprecedented scale – affecting industrial regions, oceans, entire continents and even global regulatory mechanisms. Human understanding of the consequences… has always tended to lag well behind the release of pollutants into the environment. In earlier societies it is possible to find evidence of many of the features which characterise the response to contemporary pollution: fatalistic acceptance of pollution as an inevitable consequence of human activities; authorities balking at prevention or control measures; lack of foresight and technical understanding; the problem of allocating responsibility; a preference for short-term local fixes rather than long-term solutions and a failure of individuals or companies to take responsibility for their actions. Attempts to control pollution are as old as the problem itself but the response has usually been belated and inadequate with a poor record of co-operation and enforcement.

The only upside to the accumulation of so much detritus was through archaeology, which has uncovered so much knowledge of human societies going back hundreds of thousands of years. Early societies only produced low-level waste such as mainly animal bones and blunt tools. Disposal of excrement without contaminating water supplies and causing human health issues was the earliest waste problem. For hunter-gatherers leading a nomadic existence, this problem will rarely have arisen, since sites were only occupied for limited periods. However, the advent of settled societies inevitably brought many instances where water supplies from local streams and rivers were contaminated by human and animal waste. These persisted in areas around small rural settlements (possibly even to the present day), but for larger conurbations the problem had to be solved by transporting water over longer distances via major underground and bridged aqueducts, as in the case of the Roman and Greek cities where "…*they were soon a familiar sight in their elevated form across the ancient Mediterranean from Spain and southern France to Carthage and Alexandria*". As cities became established in the north and west of Europe, the water supply problem followed and solutions to it developed. Lead pipes were used in London (1236). Hollow logs became the conduits of preference in e.g. Zittau (1374) and Breslau (1479). As cities grew, their water supply and effluent disposal problems outgrew local natural resources leading, after a trail of many disasters, to the use of artesian wells, the creation of reservoirs and the development of filtration plants. Water usage still remained limited up until the early 20th century: it was supplied to distribution points within the towns and cities from which it had to be carried to houses in containers. For those of us who complain if the water supply is turned off for a couple of hours, consider this:

> In eighteenth century Paris water was taken round the city by 20,000 water carriers using buckets. In mid-nineteenth-century London out of 70,000 houses in the centre of the city 17,000 depended on their own wells and the rest relied on standpipes in the street, about one for every twenty or thirty houses, which normally supplied water for about an hour a day for three days a week.

With increasing population and technical developments in water and sewage treatment, the global consumption of water quadrupled in the 50 years prior to 1990. Such a simple statistic hides the fact that, in 1990, the average American consumed 7200 litres per day – 288 times more than the average Indian. Water shortages have not been confined to the third world:

> Oklahoma and Texas had lost 18 per cent of their irrigated farmland by the 1980s and 2,300 square miles in Colorado, Kansas and Nebraska had also gone out of production due to lack of water. Using modern technology Saudi Arabia has been able to irrigate large desert areas but

this relies on underground aquifers which are being used up at a far faster rate than they are being replenished.

Today, the predominant problem of human waste disposal has taken second place to the much larger problems presented by modern industrial and agricultural pollution. The extensive use of chemicals, pesticides and fertilisers causes run-off into rivers, aquifers and the seas.

The whole history of waste management centres on the incremental approach to the solution of man's excremental issues: *"There is no doubt that someone living in the industrialised world in the twentieth century who was transported back in time to a city at any period earlier than about a century ago would be horrified and overwhelmed by the smell. This came from piles of rotting rubbish and human and animal excrement mixed with pools of urine, which often blocked the streets or were occasionally swept into the local stream or river to decompose there."* The lack of lavatories led to people using any available open spaces. *"In eighteenth century Paris a row of yew trees in the Tuileries provided an open air toilet and when the authorities drove people away they simply used the Seine instead."* Other types of waste had their problems. Some choice descriptions leave us to consider one of the upsides of 20th century life. Jacques Caille on his visit to Rabat in early nineteenth century: *"the streets of the city often show a layer of liquid mire more than ten centimetres deep. When waste matter has been removed it is thrown into the sea; or often it is simply heaped up at the gates to the city, where it forms a veritable cess pool."* Frederick Engels wrote of an area of working class Manchester in the 1840s which boasted a single, open privy serving 200 people: *"This privy is so dirty that the inhabitants can only enter or leave the court by wading through puddles of stale urine and excrement*."

After 1815, the interlaced problems of sewage and water supply began to be solved when waste flushed with water could be transferred to surface streams, thus transferring the sewage into open rivers. This only moved the problem and did not eradicate it. By the second half of the nineteenth century, the start of sewage treatment gradually led to alleviation of the problem in the industrialised world over the next century or so. The slowness of universal purification can be ascertained from these snippets: *"Dundee in 1910 only had three hotels and two private houses with water closets (and even then they only worked with buckets of water)… As late as 1960 two-thirds of urban homes in the Soviet Union were not connected to a sewer… In Paris, in 1925, half the houses had no sewage system… In 1974 over half the population [of Tokyo] did not possess mains drainage…"*

In the third world, problems of treating waste still persist. Ponting states that: *"In Manila, untreated domestic sewage now makes up seventy percent of the volume of the Pasig river. In total, eighty per cent of the people in the Third World (in other words an overwhelming majority of the world's citizens) have no sanitary facilities and therefore still suffer from the disease and squalor that this causes."*

Some pollution problems have disappeared. An example of a transient problem is that of horse droppings. Always a limited irritant, it became almost unbearable in medieval cities up to the mid 20th century as the horse was the main source of transport within cities. Once the motor car became the favoured means of transport that problem was replaced with another invisible and possible more insidious one.

The advent of coal, as wood became in short supply, brought another pollutant: coal smoke. In London, a ban imposed in 1307 was largely ignored and the west end of the city became more desirable to live in as the prevailing westerly winds tended to keep the air clean. Provincial cities such as Sheffield and Newcastle fared no better; *'Even in Oxford … classical marbles brought back to England were damaged very quickly'*. By 1880, London homes had well over three million coal-burning fireplaces which under adverse conditions

produced smog on foggy days. In February of that year over 2000 people died as a result. Only after 1952, when 4000 people died, was the clean air act introduced, in 1956. Similar developments occurred in other major cities around the world.

Industrial processes have always caused pollution, especially of waterways, the traditional conduit of industrial waste. In Roman times, mining and processing of lead and gold created noxious and deadly fumes and poisonous rivers. In Japan, pollution from the Ashio copper mine led to its closure in 1790. When opened later, the waste caused the death of fish, people and animals and left a legacy of 100,000 acres of contaminated land. Tanning of animal hides, linen bleaching, cotton dying, starch making and other processes all left their mark on the local communities and rivers: *"In the sixteenth century, the Thames near London still contained barbel, trout, bream, dace, gudgeon and flounders but by the eighteenth century they were extinct, killed by the increasing pollution.*" The industrial revolution in the late eighteenth century caused a 46-fold increase in world coal consumption and a 60-fold increase in iron production. Growing chemical industries produced large amounts of sodium carbonate and hydrogen chloride. These processes led to a massive increase in pollutants and emissions. Inspectorates, set up to control the efflux, were slow to act and mainly ineffective against the industrial lobby which often won the day in disputes. Despite the obvious damage to people and the environment, the drive for economic growth in the twentieth century produced only *regulated* pollution of rivers and waterways. The result was large areas of contaminated waters and wasteland in countries all over the world. As one mid-nineteenth-century Englishman observed*: "The sturdy hawthorn makes an attempt to look gay every spring; but its leaves… dry up like tea leaves and soon drop off. Cattle will not fatten…and sheep throw their lambs. Cows too cast their calves; and the human animals suffer from smarting eyes, disagreeable sensations in the throat, an irritating cough, and difficulties of breathing."*

During the second half of the twentieth century, conditions in the former Soviet Union, China, Japan and Brazil were significantly worse than in nineteenth century European industrialised cities. The size of the problem was much larger due to the drive for economic growth – at any price – and pollution was more deadly. In Most (Czechoslovakia) children had to carry portable respirators since sulphur dioxide (SO_2) levels were twenty times higher than WHO maximum recommended levels. Conditions in Krakow typified many growing cities in unregulated economies. There, the levels of sulphur dioxide were one hundred times the recommended maximum:

> …170 tons of lead, 7 tons of cadmium, 470 tons of zinc and 18 tons of iron are dumped from the atmosphere onto the historic city of Crakow [sic] every year. On over a third of the days in the year there are smog conditions, almost two-thirds of the food produced in the area is contaminated and unfit for human consumption and 70 per cent of the water can not be drunk. A third of the rivers are devoid of all life, the Vistula is unfit even for industrial use over two-thirds of its length because it is so corrosive and offshore an area of 100,000 square kilometres of the Baltic is biologically dead from the poisons brought down by the rivers.

The roll call of environmental destruction continues: in Tokyo (1960) fish were extinct in three-quarters of its rivers; in Chinese industrial cities sulphur dioxide levels are seven times over the WHO limit; in Cubatao (Brazil) the air pollution level is twice the WHO lethal limit and 80 per cent of plant life has been destroyed.

Pollution was often *exported* intentionally or otherwise by being carried on airstreams and in waterflows well beyond national boundaries, as exemplified by acid rain, which was first identified in Manchester as far back as the 1850s. Acid rain is produced by dissolution of SO_2 and nitrous oxides in atmospheric moisture (all generated from coal-burning power plant) to produce sulphuric and nitric acids. These ubiquitous pollutants, with which we all

grew up in the last century, were taken as a fact of life since they 'had always been there'. Unknown to almost all, it was a devastating invader on the environment with shocking statistics which was not tackled until the late 1980s.

> Global sulphur dioxide production rose from about 10 million tons a year in 1860 to 50 million tons in 1910 and to over 150 million tons by the 1970s… ninety per cent of the sulphur dioxide in the air over Europe now comes from human created sources and in just ten years the Sudbury copper and nickel smelter in Ontario, Canada emitted more sulphur dioxide than all the volcanoes (the main natural source) in the history of the earth… Highly acid rain has been noted on a number of occasions, often as low as a PH of 2.1 (vinegar is 2.4) and once at Wheeling, West Virginia, in the heart of one of the most polluted areas of the United States, a PH of 1.5 (battery acid is 1) occurred.

Acid rain affects buildings, attacking limestone, and such damage is evident in many historic buildings in Eastern Europe. It begins to affect wild life when PH falls below 6.0 (PH 6.5 is neutral) especially when combined with heavy toxic metals; *"In water with a PH of 5.5 salmon are affected and molluscs are rare. Between 5.5 and 5.0 there is severe damage to eggs and larvae and snails can not survive below a PH of 5.2. Fish can not live much below a PH of 5.0 and at a level of 4.5 even the flora is badly affected."*

Accumulation of acidified snow has devastating results in the spring melt when water courses and thus lakes receive a burst of acidity. This happened in Sweden and Norway as a result of receiving much acid rain from Britain throughout the latter half of the twentieth century. The PH of Swedish lakes, 6.0 in the 1950s, fell to below 5.0 by the 1980s – 130 years after the problem of acid rain had been noted. Only then were steps taken to mitigate the problem in some countries. In 1984, some industrialised countries agreed to cut their sulphur dioxide emissions by 30 per cent by 1993, and Austria and Switzerland actually cut theirs by 50% by the late 1980s.

From the 17th century to the mid 20th century many people died of industrial pollution. Exposure to lead (pottery glazing), antimony (glass making), mercury (hat trade), lint (cotton mills) and exposure to coal and oil caused a range of illnesses from ulcerated lungs, various types of consumption and cancers. In heavily industrialised areas, the population at large – not just the workers – were also affected by coal burning and the presence of heavy metals. This was exacerbated by poor diet and living conditions. Infant mortality in upper Silesia, for example, was 4.4 per cent; in Katowice: *"Over a third of all children in Katowice have symptoms of lead poisoning and overall cancer rates are 30 per cent higher and respiratory disease rates are 47 per cent higher than in the rest of Poland. … one in five of the Polish population face serious health hazards from high sulphur dioxide levels in the atmosphere."*

In the second half of the twentieth century, pollution from synthetic chemicals rose dramatically and disproportionately to population growth. Their toxicity and resistance to natural degradation meant they posed lasting and serious threats to the environment and biodiversity. Apart from plastics and synthetic fibres, chemical companies developed energy-hungry detergents which yield higher profit levels (50%) than the natural alternative of soap (30%). Resulting phosphate pollution levels in water supplies rose dramatically: *"The scale of these changes can be judged by the figures for US synthetic production, which has increased from one billion pounds weight in 1945 to 400 billion pounds in the 1980s."* Two of the biggest problems were generated by pesticides and polychlorinated biphenyls (PCBs). Highly toxic pesticides (DDT and organophosphates) had to be sprayed in large quantities to ensure contact with the targets. Many pests eventually became immune e.g.: "*Twenty-five out of the thirty-six pests that attack cotton are now resistant and there are twenty-four types of mosquito resistant to DDT."* But: *"The increasing use*

of pesticides has not, in practice, reduced crop losses – they rose from 32 per cent to 37 per cent in the United States between the 1940s and the 1980s."

PCBs are one of the most carcinogenic chemicals known to us. Developed in the 1930s, they were used in large oil-filled transformers and other appliances as well as an additive in products such as paints. After being banned in Japan and the USA in the 1970s, they continued to be exported to the EC until ten years later when they were banned there as well. "*By then about two million tons had been made and about sixty-five percent of the total is still in use."* The 35 per cent removed has "*…been dumped in the oceans or left to rot in toxic waste dumps, where residues have contaminated water supplies."* Their ubiquity and toxicity can not be overstated: *"They are very stable… highly dangerous… and tend to accumulate in the fatty tissues of animals. PCB contamination has been found in human milk across the industrialised world, and even small traces have resulted in birth defects. …and in the Wadden sea off the Netherlands about half of the seals are sterile because of PCB poisoning.*"

Major industrial accidents on a large scale have also exacted a toll on human and animal life and the environment. Major oil spills (e.g. Torre Canyon – 1967; Exxon Valdez – 1989) and chemical incidents (e.g. Seveso, Italy – 1976, Bhopal, India – 1984) have occurred.

The disposal of waste and obsolescent products became a growth industry, as increased amounts of packaging and non-returnable containers became standard practice. As examples, Ponting cites that in the USA when *"…beer consumption rose thirty-seven per cent … the number of non-returnable beer bottles increased by 595 per cent."* Also: "*In the 1940s the United States produced about one million tons of hazardous waste. Forty years later the total had risen to over 250 million tons a year."*

Only after the 1970s were any attempts made to control the toxic waste problem. One involved 'exporting' the problem to eastern Europe and the third world where regulations were more lax – or nonexistent. The longer term effects of dumping are manifold. Schools and homes built on landfill have had to be demolished in Holland and North America; asbestos dumped in Hebden Bridge, Yorkshire, resulted in over seventy deaths; methane leaking from the Georgswerder dump in Hamburg caused an explosion in 1984 and still releases over 100 million cubic metres of gas each year.

The medieval practice of polluting rivers, lakes and oceans continues. *"Many states such as Britain and the United States also dump untreated sewage sludge and since the 1960s incineration of toxic chemicals at sea (which produces toxic gases and residues) has become widespread – 100,000 tons are burnt in the North Sea alone."*

The advent of nuclear power since 1945, has brought with it threats associated with nuclear radiation which Ponting describes in alarming terms. The safe level of radiation dosage is unknown although, as a naturally occurring mineral ore, uranium has always been with us and is responsible for low level radiation. By contrast, the mining and processing of uranium ore to generate fuel creates highly-concentrated radioactive rods which have extremely high and dangerous radiation levels and which, when 'spent' in reactors, still have to be disposed safely, making the protection of workers and the public a major issue.

Several nuclear disasters have occurred since the inception of nuclear power. Leaving aside the use of nuclear weapons which are designed to wipe out people, several civil reactors and associated sites have caused major alerts and radioactive and problems (see table).

Nuclear Disasters

Date	Place	Reason	Outcome
1957	**Windscale, UK**	**Fire in core:**	**Major release of radioactivity – two million gallons milk destroyed.**
1957	**Kyshytm, Soviet Union**	**Waste dump explosion**	**150 square miles of land contaminated; 270k evacuated; est'd 10k deaths;**
1979	**Three Mile Island USA**	**Partial core meltdown**	**No known deaths. Reactor entombed in concrete.**
1986	**Chernobyl, Ukraine**	**Reactor explosion**	**Major radioactive contamination over Europe. 220 villages abandoned.**

The fallout of 458 nuclear explosions between 1945 and 1985 has had unknown effects on humans. Ponting states that many deaths have occurred from mining and processing uranium fuel: *" ...in the twentieth century half of all uranium miners have died of lung cancer – a rate five times higher than that of the population as a whole. ...milling of uranium ore causes about 4,000 deaths a year from lung cancer in the United States alone."*

Attempts to dispose of waste via dumping have also caused major problems: "*In 1949 the Soviet authorities started releasing liquid nuclear waste into the Techna river near Sverdlovsk. By 1952 it had reached Lake Karachai near Kyshytm, where the heat from the decaying radioactive material dried out the lake and the radioactive bed of the lake had to be covered in concrete to stop wind erosion spreading the dangerous pollution any further*."

The internal combustion engine has been an increasingly major contributor to pollution since World War II, emitting carbon dioxide, smoke, nitrous oxides, carbon monoxide as well as other toxic organic compounds. These react in the air to produce ozone and peroxides which can adversely affect photosynthesis and breathing. Burning motor fuels produced photochemical smog and vast quantities of lead until lead free fuels were introduced. Measures were taken to reduce pollution from the refineries by 90 per cent in the 1940s and 1950s but we had to wait until the 1970s for the availability of lead-free petrol and for catalytic converters to be developed and fitted to motor vehicles. The first smog occurred in Los Angeles (which has a natural inversion layer) in 1943 and by the late 1980s it affected over 100 American cities. Los Angeles itself suffered from it for over 200 days in a year. In Tokyo, 50,000 people were disabled by it in 1972 and in Mexico City there were 312 days of smog in 1988. Catalytic converters helped remove the most harmful chemical from exhausts, but they could do nothing about the major pollutant – carbon dioxide.

Photochemical smog illustrates the cocktail effect of pollutants. When the whole gamut of pollutants – exhaust fumes, CFCs, acid rain, heavy metals, excess ozone and other toxic chemicals such as tetrachloroethylene (dry cleaning fluid) and trichloroethylene (lubricant) – mix together in various combinations, there is generated a range of 'cocktails' which can adversely affect many things, in particular trees. Tetrachloroethylene, for example, reacts with ozone and UV light to produce the herbicide TCA. Consequently:

> Most of the great industrial areas were rapidly deforested… In Norway fluoride emissions from aluminium smelters have killed all pines within a four mile radius … no trees grow for twelve miles downwind of the magnesite brick factory at Satke in the Urals … In West Germany 8 per cent of the conifers were damaged in 1982, 50 per cent by 1984 and 87 per cent two years later

> ... in Poland three-quarters of all forests are affected (about 100 million trees) …Overall more than 20 million acres of forest in Europe had been damaged by the mid-1980s (an area equivalent to a third of the British Isles).

Wildlife all over the world has been affected by artificial chemicals. DDT has been a major culprit as, when sprayed, it can be carried on the wind over vast distances. *"When in 1983-4 the East Germans sprayed DDT…residues were detected over a 1,000 mile range from North of Stockholm to the south of France."* Food chains were affected, as illustrated by the attempt to use DDT at one part in 50 million to clear gnats at Clearlake, California, in 1949, 1954 and 1957:

> The level of DDT found in plankton was 250 times greater than in the water, in frogs it was 2,000 times more, in fish 12,000 times and in the grebes who fed on the fish 80,000 times greater. As a result the grebes at the top of the food chain had 1,600 parts per million of DDT in their bodies; their eggshells became so thin that they cracked under the weight of the bird and of the 1,000 pairs of grebes in the area not one hatched a chick between 1950 and 1962. It was the implications of this ecological disaster, which had been repeated elsewhere with other chemicals, that led Rachel Carson to write *Silent Spring*.

Pollution knows no bounds on earth: "*Even cores from the Antarctic ice sheet, supposedly the last wilderness on earth and even more remote from the industrial centres of the northern hemisphere, show that lead levels have quadrupled since the eighteenth century."*

Another pollutant is ozone. An enemy at ground level where it attenuates plant photosynthesis, it is an ally 18 miles into the stratosphere where it absorbs damaging ultra-violet rays from the sun. Unfortunately, it is vulnerable to CFCs which produce chlorine, one atom of which can destroy 100,000 ozone molecules. CFCs were invented in the 1920s since when they have been used in refrigerators and spray cans among other applications. When sprays were used or refrigerators scrapped, the discharged CFC gas would find its way up to the stratosphere and break down the ozone layer. Production of CFCs rose from 100 tons in 1931 to 650,000 tons over 55 years. The result was a thinning ozone layer which, by 1982, became a hole with an area of the United States which drifted around over the lower southern hemisphere. With the UV protection gone, skin cancer became rife in Australia and South America. With growing public awareness of the problem, CFCs were eventually banned by international agreement. It is likely, however, because of the long life of CFCs, that the hole will persist well into the 21st century.

Carbon dioxide, methane, nitrous oxide and CFCs are all greenhouse gases which, when present in the correct concentration, maintain a stable average temperature of the atmosphere, but when present in excess will cause it to warm. Many of these are produced when fossil fuels are burnt to provide the ever-increasing energy demands of mankind. Ponting notes that: *"Annual consumption of coal is now over one hundred times greater than it was in 1800 and annual oil consumption has increased more than two hundred-fold in the twentieth century."* The waste from these processes has been primarily carbon dioxide, about half of which is absorbed in the oceans with the remainder going into the atmosphere to be used in plant growth. *"The net result of these various human activities is that the amount of carbon dioxide in the atmosphere has risen by a third in the last two hundred years – from about 270 parts per million in 1750 to 350 parts per million in the late 1980s."* The increase in carbon dioxide emissions arising both from industrialisation and the conversion of forest to agriculture and paved areas has resulted in temperature increases: *"Meteorological observations suggest that in the course of the twentieth century global temperatures have increased by 0.5^{o}C, with the 1940s being warmer and the 1950s and 1960s cooler than the average. The 1980s were the warmest decade since records began …1990 was the warmest on record."*

Methane, generated by animals, paddy fields and decaying vegetation further promotes global warming and as the tundra melts vast quantities are released, causing positive feedback to the whole process. A report from the UN IPCC (Intergovernmental Panel on Climate Change) estimates: *'…emissions of greenhouse gases will be equivalent to a doubling in current levels of carbon dioxide in the atmosphere by 2030. This, according to the panel of experts, is likely to produce a temperature rise of between 1.4 - 4.5 ^{o}C with 2.5 ^{o}C the most likely outcome, above pre-1850 levels by 2030.'* It goes on to conclude that*: "…consequences of global warming on this scale will be profound for the whole of the world. Climatic patterns are likely to alter drastically but unevenly. … The most likely outcome is that the earth's vegetation belts will shift towards the poles, but in an uneven way.'* With areas such as the Mediterranean and the North American plains getting drier, the contrast with earlier periods of climate change "*will be not just the magnitude of the change (more than ever experienced before by settled societies) but the rate of change."*

The social effects of the change could be migration on an unprecedented scale, especially from flooding as: "*A 2.5^{o}C rise in temperature is likely to cause sea levels to rise significantly across the world, although the effects will vary from area to area. Among the areas most at risk of coastal flooding and salt water infiltration into drinking water are the Nile delta and Bangladesh, and low lying islands such as the Maldives could even disappear altogether. Ocean currents could also shift in unpredictable ways leading to further changes in temperature and rainfall across the globe."*

Ponting ends the chapter by putting our polluting activities into historical context:

> Ecosystems all over the world have now been affected to varying degrees by pollution of various types. Even Antarctica has been polluted, so far-reaching has been the spread of industrial pollutants. Evidence about how resilient plants, animals and humans are to the risks and long-term stresses associated with pollution is still accumulating. It is, however, already apparent that the effects of pollutants have become more threatening. Actions have been taken with very little thought for the consequences, particularly in the case of highly toxic chemical and CFC production. The output of greenhouse gases is likely to have the greatest and most widespread effects of all the pollutants so far produced by humans. After ten thousand years of settled societies and only two hundred years of substantial industrialisation, human activities and the pollution they generate threaten irreversible changes on an unprecedented scale to the world's climatic system.

Chapter 17: The Shadow of the Past

From the very beginning we humans, like all life, have modified our environment:

> All living things on earth, including humans, form part of these complex webs of interdependence between the different plants and animals constituting a food chain stretching from the photosynthesisers at the bottom through the herbivores to the carnivores at the top. …
>
> Human history is, at one level, the story of how [the limitations of early humans] have been circumvented and of the consequences for the environment of doing so. Overwhelmingly the most important departure from basic ecological constraints has been the increase in human numbers far beyond the level that could be supported by natural ecosystems.

This was made possible by humans' larger brain size, enabling development of speech, cooperation and technologies. This led to a steady increase in numbers to about 4 million by 10,000 BC. Pressure to find more food caused – slowly, but surely – humans to develop the means of farming and animal husbandry, whilst simultaneously destroying natural

habitats for other species, as two million years of hunter gathering was followed by 10,000 years of agriculture. In ensuring survival of our species by unabated and uncontrolled population increase, humans have come to be the dominant and most destructive species on the planet.

> By the 1980s the earth had to support about ninety million extra people every year – an increment the same size as the total population only 2,500 years ago. … As more land was needed to grow food, more natural ecosystems were destroyed.

The demand on an ever increasing scale for timber, metal ores and crops, used for housing, heating, clothing and food, drove the development of agriculture and other industries. More food and clothes could be produced, but at the cost of more effort. As an example, "The *first humans were able to clothe themselves using the skins of animals they had killed or scavenged. As numbers rose, this was no longer possible and textiles were made from natural fibres such as flax, cotton and wool. This required using land for cultivating crops or for animal grazing as well as the extra effort of spinning and weaving the raw materials."* The extensive increase in population in the 1800s placed a vast strain on natural resources: "*Only the development of ways of manufacturing artificial fibres from chemicals has enabled the world's population to be clothed in the twentieth century. But these more complex manufacturing techniques use more resources and energy."* In every aspect, the satisfaction of human needs has led to shortages. Such scarcity of resources drove the changes, e.g. from vellum (from animal hide) to paper (from wood pulp) and the use of wood to coal as a source of energy, each of which resulted in the use of even more energy: "*From one perspective this invention of new techniques and more complicated production processes and the utilisation of more resources can be viewed as <u>progress</u> ... From an ecological perspective, the process appears as a succession of more complex and environmentally damaging ways of meeting the same basic human needs."*

The first great transition affected most of the world, but the second was dominated by Europe's post-Columbian colonization of far-away lands, followed by America and Japan via trade domination. Before 1500, all countries depended on local resources, but: *"Since 1500 Europe and the industrialised countries have had access to the resources of the whole world, first to provide a wider variety of food, then important staples and second to provide a source of raw materials (and also markets) for continued industrial expansion."*

"*The process of moving from a pre-industrial society to an industrialised one has been dubbed <u>development.</u>*" The wholesale destruction of the Amazon forest is an example where in one instance the Grande Carajas project (establishment of plantations, dams, industry as well as mines for bauxite and iron ores etc.) will affect a sixth of Amazonia.

"A political, social or cultural history of the twentieth century, and particularly the last few decades of the century, might well record a growing disillusionment with the consequences of development and detect a trend towards a greater interest in the idea of conservation and protection of the environment. ... However such currents of thought have not displaced the basic philosophy engrained in western thought for the last two thousand years, that sees a separate 'natural world' for humans to exploit, and the economic approach that sees (or claims to see) continued industrialisation and further economic growth as a prerequisite for any environmental improvements." Attempts have been made to limit the worst consequences of acid rain and CFCs but "S*et against the powerful momentum induced by continued population growth, the need for more land to grow food and the in-built requirement of the world's industrial system to expand, the results of these measures on a world scale have been barely noticeable."*

Past developments subject today's societies to a range of pressures arising from inequalities and struggles in many aspects of well-being. Yet people and societies are remarkably tolerant to the point that they do not notice decline and potential collapse of their world. Even the Mayans and Easter Islanders probably did not notice the significance of the signs of their society's relatively rapid decline:

> The environmental problems now facing the world stem from a variety of pressures that have developed over long periods of time, some restricted to specific areas whilst others affect the whole world… Past experience suggests that these pressures will continue to be felt in four main areas – growing strains on resources, unequal development and distribution of food and wealth, a growing weight of numbers and the threat from the outputs of industrial society in the form of pollution. In each of these areas the shadow of the past falls across all modern societies as they try to find solutions.

Ponting considered that the projections for future supplies of energy – coal and oil - are not an immediate threat to the world, except in respect of global warming, as he believed there are adequate supplies of coal for several centuries and there is considerable scope to develop new sources. As the oil industry tends to do, he puts considerable weight on the significance of the fact of increasing reserves of oil, "*World consumption of oil is seven times higher than in 1940 but known reserves have been growing even faster, by about two per cent a year more than consumption.*"[42]

Awareness of the significance of such indicators has grown recently, but from a 1990 perspective Ponting states:

> A looming global crisis and social breakdown brought on by the world running out of raw materials and energy in the immediate future now seems less likely (although these problems, and therefore the future of industrialised societies, will have to be confronted at some point in the future). The serious and immediate pressures are now coming in the form of the degradation and destruction of some of the other vital resources on which societies depend: global environmental regulators, soil, water, air and biodiversity.

He has this to say about the inequality of nations:

> The United States contains about 5 per cent of the world's population yet it consumes 30 per cent of the world's energy and 40 per cent of its other resources. The other side of the coin is that more than 55 per cent of the world's population still live in rural areas and remain as their ancestors were, directly dependent on agriculture for their livelihood. About half the people of the world (two-and-a-half billion) are undernourished, twenty per cent (about one billion) live in absolute poverty and lack basic necessities such as clean water, sanitation and proper housing, and only slightly fewer are illiterate. Even if current European and American levels of consumption were to be stabilised, it must be extremely doubtful whether the rest of the world (over 80 per cent of the people on the earth) could ever repeat the process of industrialisation and attain these levels. The number of people in the world is expected to be six billion by the end of the twentieth century. If they were to live at current European (not American) levels of consumption, it would require a 140-fold increase in world steel production together with a similar increase in other key materials. It is unlikely that there are enough mineral or energy resources on the earth to sustain this level of production and the consequences of doing so in terms of pollution would probably be catastrophic.

And about population perspective:

> For the last ten thousand years the weight of human numbers has been a crucial factor in determining the ability of societies to feed their citizens and provide an adequate standard of

> life. The industrialised world … is having to adjust to lower birth rates and unbalanced age structures while, elsewhere, the continuation of two centuries of extremely rapid population growth is producing major strains in the Third World. The population of the world in the late 1980s was 5 billion and it will… rise to about 8 billion by 2025 and even higher later in the century. 95 per cent of this growth will occur in the Third World, where the pressure on scarce resources and limited land is already most intense. …about 11% of the world's surface[43] is now used for growing crops and there is little land left suitable for agriculture.

On the effects of industrial pollution:

> Experience suggests that societies can tolerate appalling conditions on a localised scale [as in] parts of Eastern Europe in the mid-twentieth century ... albeit at the cost of shortened lives, more illness and general environmental degradation. … However, the volume of pollution is still on the increase in these countries and will go up even more as other countries, in particular China, India and Brazil, attempt to become industrialised in turn.

And global warming:

> The greatest stresses within the global system though stem from the output of greenhouse gases as a direct consequence of the concentrated burst of industrialisation in the last two hundred years. … It is now virtually inevitable, even if strict controls are introduced quickly, that global temperatures will rise to a level never before experienced by settled societies or even in the last 100,000 years and possibly longer. The production of food will be disrupted…. Even more worrying is the rate of global warming, which will almost certainly be far above natural rates in the past and too fast for natural ecosystems to adapt, causing widespread damage. … Global warming is therefore a demonstration, for the first time on a world-wide scale, of the results of ignoring ….vital ecological constraints. The consequences for life on earth and humanity will be profound.

And finally, in grand summary:

> The world now faces a series of interrelated crises caused by past actions – deforestation, soil erosion, desertification, salinisation, increasing loss of wild life and plants, grossly unequal distribution of food, wealth and basic human amenities, increasing levels of pollution. … In this wider perspective it is clearly far too soon to judge whether modern industrialised societies, with their very high rates of energy and resource consumption and high pollution levels, and the rapidly rising human population in the rest of the world are ecologically sustainable. Past human actions have left contemporary societies with an almost insuperably difficult set of problems to solve.

THE END

1. Those permitting the destruction of the Amazon and other rain forests should take note!

2. James Lovelock: *GAIA The Practical Science of Planetary Medicine*; ISBN 1-85675-191-0. The theory postulates that the Earth acts as negative-feedback organism and reacts to remove the source of its distress, rather like antibodies do in humans. In this way the planet regulates its climate — within limits — for the good of its inhabitants. Forcing the climate beyond these limits courts catastrophe. Many scientists predict that this will be triggered by the current unprecedented rate of global warming.

3. With plenty of food around for tribes who thrived and survived, one can see how the myth of the Garden of Eden was passed down through the generations before being 'modified' by priests/leaders to end up in the book of Genesis. It is plausible to me that the banishment of Man in Genesis Ch. 1.3 occurred once he had multiplied beyond the carrying capacity of his environment, and was told "in toil you shall eat of it all the days of your life." Here 'it' refers to the tree of knowledge, i.e. the onset of agriculture around 8,000 BC. This makes an interesting, if speculative argument for 'original sin' being Man's disregard for his own environment. This analogy would place the so-called 'forbidden fruit from the tree of knowledge' firmly in the role of the knowledge of agriculture — a paradigm shift in human knowledge from which there was no going back! By starting farming, early Man had to work much harder. Ancestral memories of the 'good old hunter-gatherer days' would have been passed down by word of mouth (as is common in all primitive tribes even today); writing did not evolve until about 3000BC with the Cuneiform script of the Sumerians. The story of the great transition could then have evolved into a God-centred story to explain our existence. By 1500 BC, when the book of Genesis is estimated to have been written down by Moses, the mutation of the facts could have become encapsulated in the Genesis text.

4. The ratchet of evolution (or perhaps more precisely, *progress*) implies a major irreversible transition during the evolution of humankind's society. It could be thought that there can never be a reversal of development. But this ratchet could be questioned if we consider (as just one example) the regression of Britain's culture during the dark ages. Many of the advances, discovered and brought over by the Romans, were 'unlearnt' after 400 AD, when they abandoned our island because of trouble elsewhere in the empire. Our technology regressed. While the 'ratchet' may apply to humanity as a whole, I consider that it is reversible in 'local' areas where conditions remove the means to keep up the advanced state of society. Such regressions have been temporary up till now, but with the forthcoming depletion of fossil fuels, it should perhaps never be taken for granted. Vide: 'The Lord of the Flies'.

5. There is a critical size above which it becomes inefficient for a group to gather and hunt in a given area. The larger the group, the further it must range in its quest for food. Above the critical size, the group must continually roam and have less and less time to gather and hunt. By splitting up, one half of the group moves away to a new area and each group's subsistence is more manageable.

6. Interestingly, Stone Age market forces came into play. Where less wild food was incapable of supporting a population, the extra work involved in cultivation began to look more attractive. That is, the return on labour increased. Thus early seed sowers reaped better crops than nature could supply in the wild. True to Darwinism, groups that did not start to produce their own food or could only produce an inadequate amount, died out and those who could produce enough survived.

7. The dog is a gregarious animal with a strong territorial instinct. As one example of how its domestication might have occurred, young abandoned or orphaned pups would have been found by humans and become quickly dependent on them. Any canine descendants with nasty traits would quickly have provided extra protein for the human diet; the more amenable canines would have survived, bred and domesticated.

8. We see here that population pressure coupled with the innate human instinct for preservation and propagation of its genes is the sole driving force of innovation and technology – particularly in farming.

9. We have plenty of evidence of "*how easy it is to tip the balance towards destruction when the agricultural system is highly artificial"* today – on a massive scale. The use of pesticides (leading to the decline of bird life), sewage or artificial fertilisers (severely polluting rivers), acid rain, and the destruction of the Amazon forest, are but a few examples.

10. What had up till recently been considered a 'natural' disaster was in fact 'man-made'. This is a classic example of the type of planetary reaction propounded in Lovelock's Gaia theory – mentioned in the endnote 3 of the first instalment.

11. Sadly, Ethiopia is now a destitute country barely living at subsistence level, and this is a stark demonstration of what happens when we do not learn from past experience. National and political greed inevitably leads to the downfall of all societies and empires, of which Rome is a classic example. Even today, despite our knowledge of the shortcomings of our ancestors, we are still guilty of reckless deforestation in the Amazon and Asia to feed insatiable commercial interests. The outcome will be no different to that of earlier societies – just very much more dramatic.

12. Prior to the oil age, about 95% of people were involved in farming. Food production was therefore *dependent* on people power. The production per capita being fairly constant over many centuries ensured that populations grew and declined in phase with the variation of agricultural conditions and output at any particular time.

13. Interestingly, this trend exists today in Europe, where marriages are later and many do not marry at all, preferring to live alone. That, coupled with birth control and a falling fertility rate in men, has led to a negative growth rate in the birth rate of the UK and several other European countries – a welcome trend which is more than eliminated by increased immigration levels.

14. Data found at www.ukagriculture.com/countryside/history of countryside.

15. An example of what is now happening all over again but this time due to man-made causes!

16. This has within just the last few decades motivated the developed nations to give aid to the third world with the culmination in 2005 of G8 resolutions to cancel the debt of several African nations.

17. Seen from today's perspective, this is nothing more than a recipe for environmental disaster and has largely come to pass. I personally find it incredible that any God would entrust *carte blanche* the resources of His earthly warehouse to a race which had no idea of how to care for it.

18. There is reason to believe that Malthus's ideas are a fundamental social law, and still valid. Many scientists think that the current population explosion will lead to famine, wars and civil unrest and populations will collapse as a result of the imbalance created by a cheap source of energy, namely fossil fuels. Many 'Peak Oilers' as they are known predict dire catastrophes once oil production declines and prices rise. Others calculate that we are already exceeding our ecological footprint by a factor of three, and without a warehouse of stored energy, a rebalancing of demand to supply is overdue.

19. GNP or Gross National Product is defined as Gross Domestic Product (GDP) plus the net inflow of labour and property incomes from abroad. For a region or country, the GDP is the market value of all the goods and services produced by labour and property located in the region or country.

20. I found this chapter the most difficult one to précis. It is packed with distressing accounts of Man's crimes against nature, and delivers a poor image of our race and ancestors. Nevertheless, one must bear in mind that their actions were a consequence of ways of thought so aptly laid out in the previous chapter. It is tempting to take solace in the thought that now, as the destruction of our environment is better understood, the changes in the way we think about our environment may pull us back from the brink – but I doubt it.

21. The damage has been more than just proportional to the rate of population growth because of the greater destructive power put into human hands by new technologies, such as those which enable us to locate fish by electronic devices.

22. In June 2006, *The Times* reported that a pair of great bustards were breeding again on Salisbury Plains in Britain following an absence of over 170 years.

23. Another example of success is the red kite which ten years after being released in Britain is now breeding again in parts of the Chilterns, East Midlands and in the South.

24. It was almost as though *Homo Sapiens Sapiens* was being given a second chance to visit the 'Garden of Eden', i.e. the world before the first great transition into agriculture (Ch. 4).
25. When we bear in mind that much of this happened in the first half of the 19th century, when the world population was around ¾ billion (Australia ca. 2 million, US < 15million), the carnage must have been conspicuous by its magnitude and wastefulness!
26. Only humans could exceed this level of reproduction in the mammal world, increasing *their* numbers by 3 billion over the same 91 year period!
27. William Ophuls is visiting associate professor of Political Science and Urban Affairs at Northwestern University. He has written *Ecology and the Politics of Scarcity* (1977), which won the American Political Science Association's Kammerer award in 1978.
28. Ponting doesn't mention birds; bird flu is a modern threat.
29. Ponting only mentions the animal diseases for the first two entries in this table.
30. The timing and geography clearly trace its progress from the Far East to Europe.
31. Readers should note that these figures – as all others in this essay – apply at the time of writing, 1991.
32. Some statistics used here are updates of those given by Ponting in 1990; it is sobering to realise that, since the book was published, the world's population has increased by over 1.5 billion. The 2006 figures in this paragraph have been taken from the United States Census International Programs Center.
33. A recent book by John Bligh, 'The Fatal Inheritance' (ISBN1-844-1-336-7) provides excellent further reading on this point concerning the changes that have made it possible to feed so many people.
34. The effects of colonial expansion are covered in detail in Chapter ten of the book/synopsis.
35. When travelling in East Anglia earlier this year during a four week period of no rain, I experienced a vast dust storm rising off the fields as the wind blew the topsoil away just after the seeds had been sown.. Locals told me later this is a common occurrence and farmers often have to re-seed after such an event.
36. Since the UK population was around 42 million in 1910, this amounted to six percent (or one seventeenth) of the population being in domestic service. When children are excluded from the figure of 42 million, then the percentage of the working population would have been much higher – perhaps as much as 10 percent of the working population.
37. Slavery has been dealt with in chapters 7 and 10.
38. During this period, 1830-1900, when the horses kept in towns increased by a factor of 3.4, the population of the UK rose from 16 to 38 million, a factor of 2.4.
39. As fossil fuels are becoming scarcer, the '21st century horse' is already using biodiesel and ethanol from corn, once again setting the use of land for food production in competition with energy production.
40. Things have improved significantly since 1990 and for the greater part energy efficiency is rising, but only because present and anticipated scarcity of fossil fuels has driven up energy prices.
41. Following the Romans' invasion of Britain, London's population grew to 45,000 by 300 AD. It then declined to 10,000 by 350 AD before collapsing to only fifty people after the Romans departed in the early fifth century.
42. Ponting does not draw attention to the insight of M. King Hubbert that the peak of production is likely to occur about forty years after the peak of discovery, and that the peak of oil discovery was in the 1960s, and that at that time the rate of discovery was about seven times as much as it was in the 1990s.
43. More precisely 11% of the area of ice-free land