Part 3 — Gravity Rules, OK?

Heating in the Earth

In Chapter 9 we looked at the question of the heat which flows from the Earth, and concluded (Proposition 9G) that it was mainly derived from the frictional heat of domain rubbing. We will now look at this area again, a bit more closely.

Proposition 9G is all right as it stands, but it does not explain everything. Heat flows up from beneath the Earth's surface even in places where the domains are not apparently active, where it is tectonically quiet. Of course the average sub-ground temperatures are higher in places where the domains are currently shifting — in fact close studies of these temperatures would be a good way to trace domain boundaries — but we still need a mechanism for the spread of the frictional heat throughout the rest of the Earth's surface.

This mechanism is to be found in earthquake waves. We already know that these travel throughout the body of the Earth — our knowledge of the Earth's interior is based on a sudy of these waves. And we have seen, in Chapter 14, that around a million earthquakes occur on our planet each year. This number is fairly arbitrary; if we took into account weaker and weaker earth-twitches, the number would be two, ten, or a hundred million.

It seems obvious that it is these vibrational waves which carry the heat energy derived from domainographic processes throughout the Earth.

> *Proposition 16M*
> *Heat derived from domain movements in the Domainosphere is distributed around the Earth by earthquake waves*

Heat is itself a form of vibrational energy, so the transfer of this energy from the earthquake waves would be quite normal. Where, in the Earth's upper layers, is the energy originally produced? This must be in the area of active domains, in what I have called the Domainosphere. This is the same as the area in which earthquakes are active, from the surface down to about 700*km* below.

Here is another area where the current treatment gives an improved explanation of observed facts. In the old tectonic-plate idea, these plates were assumed to be about 100*km* thick, and floating at this depth on a mushy or semi-liquid layer called the Aesthenosphere (Fig. 9.1). Movement of these plates has been suggested as the cause of shallower earthquakes, but till now there has been no accepted cause of origin for the deeper ones.

As the Earth expands, the effects will be most apparent near to the surface, where most of the volume lies. Setting the Domainosphere to 700*km* deep is arbitrary, that is just the level where domainographic activities have faded away close to nothing.

We can, however, try to identify a band in the Domainosphere where activity, and hence temperature, is highest. We have good information on the depths and strengths of larger earthquakes which have occurred over many years. If we assume as a first approximation that the Domainosphere's maximum activity band lies at the same depth over the whole Earth, its position can be found by summing together the energies of these earthquakes at the different depths, and seeing where the energy level is highest.

> *Proposition 16N*
> *The Domainosphere has a maximum activity band, with a position derivable from measurements of earthquake depths and energies*

It seems that the position of this band must be more than 10*km* down, because measured temperatures from oilwells increase to this sort of depth. Presumably underneath the band, and right down to the centre of the Earth, the temperature should be fairly uniform and close to that of the activity band — there is nowhere for the heat to escape to — at least in parts where the concept of temperature still has meaning.

Ultimately, all the domainographic energy stems from gravitational forces. A simple mind model of Earth Expansion is that the crust splits apart under the expansionist forces and top material falls down the split to fill it, with the potential energy given up by the falling material providing the source of heat. However, there are other models, for processes which are not quite as simple. We will pass on now to one of these.

The Moon Masseur

In Chapter 15 we looked at the Earth-Moon system, and saw that the double-planet situation which existed or was approached there may have led to the loss of much atmosphere (Proposition 15D). This close coupling between our planet and our moon has a further implication.

We saw that the centre of gravity of the system formed by our planet and its moon lies some 1400*km* below the surface, or around 5000*km* above the actual centre, of the Earth. Now this point is obviously not fixed in the Earth. Instead, it moves around the Earth as the planet rotates, staying always on the line joining the centres of gravity of the two bodies.

The gravitational attraction of the Moon has a very noticeable effect on our lives. Together with the attraction of the Sun, it controls the tides. The Moon is both much closer to the Earth and much lighter than the Sun, and the outcome of these two opposing influences is that the Moon has a little more than twice the effect of the Sun on tides. Tides have greatly influenced biological matters on Earth, as well as physical ones, and have set 'biological clocks' which are still ticking millions of years later, as in the menstrual periods of women.

There is a lot of energy in tidal movements, and commercial tide-power stations have been built in some parts of the world. Ultimately this energy is mostly derived from the rotational energy of the Earth, which is tending to slow down to present the same face to the Moon, as the Moon now does to the Earth.

Tidal energy, like most forms of energy, ends up as heat, so one effect of the tides is to heat up the oceans. But there are other tides. One is the tide of the atmosphere, the reason why weather patterns tend to move from west to east, and this also must result in some heating of the atmosphere.

But a far greater tide is the tide of the solid Earth. Every day, the Earth-Moon centre of gravity travels more than 30,000*km* round inside the Earth, at that depth of 1400*km* below the surface. The gravitational forces act like a giant fist, massaging the ball of the Earth. Because the solid Earth is hugely more massive than its oceans or atmosphere, even a small effect will release a lot of energy from this massage, and this energy will also appear as heat.

> *Proposition 16O*
> *The Earth is being continually heated up by gravitational massage exerted on its mass by the Moon*

It should be possible to calculate the amount of heat released in this way. It may or may not be significant compared to the energy released by Earth expansion. However, the forces involved are by no means minor, we know that they have been able to stop the rotations of planets and moons in their tracks.

As far as the Earth is concerned, the heating happens because its rotating gravitational system with the Moon is 'lopsided'. This point is true for when the rest of the Universe is considered, too.

The Lopsided Universe

As already mentioned, the Sun also has an effect on tidal processes in the Earth, if a lesser one than that due to the moon. As the Earth rotates each day, the Sun attempts to raise tides, not only in the seas and the atmosphere, but also in the solid Earth. The straining of the Earth's inner substance towards the direction of the Sun may be very small, but will still add up, and again contribute to 'tidal heating'.

Gravity reaches right throughout the Universe. As the Solar System is not at the centre of our local galaxy, but out towards the rim, the sum of the gravitational pulls of all the stars in this galaxy will also be lopsided, and have its effect on the Earth. The effect may be extremely tiny, but even so, over periods of billions of years, it may produce a measurable result.

Killed by an Apple

Another matter which will be affected by changes in the Earth's radius is its surface gravity. If the Earth had half its present radius but still the same mass, the gravitational force at its surface would be about four times as great as it is now, other things being equal. This is because gravitational forces decrease as the square of the distance.

A variation of this sort would have many effects on the Earth, for example erosion would be more active, stable mountain slopes would not be as steep (that is why Mars has a mountain twice as high as Earth, its surface gravity is lower), and taller plants and animals would be less feasible. Against this, the atmosphere would be drawn in closer to the surface, making it much denser and able to buoy up tall plants. Here is a further reason for assuming a much denser atmosphere on the early Earth.

According to legend, Isaac Newton first developed the theory of gravitation when he thought about what had caused an apple on a tree he was sitting under to fall on his head. If

gravity was four times higher, he might not have been in any condition to think afterwards.

When the rule for the variation of gravity with distance was mentioned above, the rider 'other things being equal' was added. It is possible that they weren't equal.

The Gravitational Constant and the Nuclear Strong Force

Just over 50 years ago, the Nobel Prize-winning physicist P.A.M. Dirac published a paper [Dirac, 1938] which suggested a number of basic relationships existed between the fundamental physical constants of the Universe. In particular, he suggested that these 'constants' were not actually fixed, but varied with the age of the Universe. Among these constants was included the gravitational constant, G, which defines the amount of gravitational attraction between two bodies of given mass and separation.

The effect of Dirac's Proposition was that G was decreasing in size with time, and so the gravitational forces holding together a body such as the Earth were also decreasing as time went on. Dirac was active at a time when the currently-accepted ideas of an expanding Universe were being worked out. Whether the relationships and numbers suggested by Dirac are 'true' or not, it does seem at least feasible that, in a Universe held together by gravity, the fundamental forces of gravity might alter as the Universe expanded.

Variation in the gravitational constant would also have many other effects, for example the planets would be expected to move out further from the Sun under weaker gravity. This would make them receive much less radiation from the Sun, unless there was some compensating effect, and get much colder. I know of no evidence to support such an occurrence.

Another, possibly more likely, cause concerns the Nuclear Strong Force, or some other force responsible for holding atoms together. A reduction in the strength of one of these forces, which are of relatively recent discovery and were not known when Dirac was active, might cause atoms to expand in average size. This need have no connection with gravity, and could explain planetary expansion without any changes in planetary orbits.

Here then is a possible root cause for the expansion observed in the Earth and our neighbouring planets.

> *Proposition 16P*
> *Planetary expansion has occurred because the nuclear forces acting between the components of the planet have become weaker as time progressed*

Of course, making such a bold assumption as that the fundamental constants of the Universe may vary with time really is opening a huge can of worms. So much of modern science depends on the assumption that some things really are permanently fixed. Once one starts questioning whether the rate of decay of a given radioactive substance, or the speed of light in a vacuum, or the rate of progression of time, are fixed quantities, the resulting chaos is more one of philosophy than of science. We will not venture further into these heavily mined areas, but instead will now sit back and review the ground already covered.

CHAPTER 17

LOOKING BACK: THE FINAL SYNTHESIS

Entia non sunt multiplicanda praeter necessitatem (Don't make a Big Deal out of it)
— William of Occam (died 1347)

And so, at the end of a long and perhaps tortuous journey, we look back down on the landscape travelled through, and try and view it as a whole. This may be difficult; the ground we have covered has been very diverse.

A possible criticism of this book is that it is too discursive, too rambling, covering too many unconnected topics. I would have to accept, with Propositions ranging everywhere from control of weeds to changes in the constants of the Universe, that the matters dealt with have been exceptionally varied. But that is the nature of the beast.

This book is a work of synthesis. At the head of Chapter 7, I quoted Sharr's call for us to move from an Age of Analysis to an Age of Synthesis. I have heeded this call, and this book is the result.

The essence of synthesis is that it draws from a number of disparate areas. In doing this, I have not hesitated to use written and other sources of every nature, whether learned periodicals, popular encyclopedias, newspaper articles, phone calls to local companies, television programmes, or science fiction magazines. Everything is grist to the mill, and that includes one thing especially — personal observation of what is going on in the world.

It may be appropriate for a work of analysis to be erected purely on carefully verified results published in refereed professional journals, but synthesis requires a wider range. Most important of all, it must not just put facts and opinions from different areas together, it must question the underlying, unquestioned, and even unrealized assumptions propping up those analytical edifices.

In this final chapter I will summarize what has gone before, in three parts. The first will deal with the physical nature of the Earth, and the second with its biological nature. These are the two great branches of the 'hard sciences', and cover the bulk of the material in this book.

The third part covers the interaction of Man and other intelligences with the first two parts, falling into the branch of 'soft' or social sciences. Some of the Propositions I have put forward may cause a degree of upheaval in the hard sciences, and it is a purpose of this book to do so. Not for the sake of upheaval in itself, but because we should always examine new propositions in the hard sciences, with a critical but unbiased approach, and let them stand or fall on their merits.

If the technique of synthesis works in the hard sciences, one may ask whether it will work also in the soft ones. I believe it could. While there are many fallacies and false assumptions rife in the hard sciences, there are probably far more in the soft ones. In the third part I will put a toe into the shark-packed sea of economics, politics, law, and psychology, but no more than a toe — any more would need a book of its own.

In what follows, to save repeating cautions at every stage, it will be assumed that the Propositions referred to at any given point are 'true'. All are, in fact, only working hypotheses to be picked apart, and it would be astonishing if all were accepted. But this is a case where the reader can decide.

Many scientific theories need a specialist knowledge of the field in order for them to be judged; the ones presented here do not. This book does not contain a single equation or complex formula; any intelligent reader can decide for themselves whether the Propositions I have put forward make sense or not. The synthesis has been built on a broad foundation of the sort of information available in any public library, and is not hard to check. Here goes.

Summary 1
What's Happening: The Physical Earth

We have seen that the Earth has been in a state of continual flux ever since it first existed. Formed from a mass of material at the same time as the rest of the planets of the Solar System, that material separated into three parts — solid, liquid, and gas.

The solid Earth has remained uniform and unchanged in composition except at its surface, but has been subject to regular expansion, which has caused at least a doubling in its radius. This expansion has been a basic factor in the changes which have occurred on the Earth's surface and above and below this surface.

The Atmosphere

The atmosphere has been subjected to complete reworking during the Earth's history. Most of its original hydrogen was lost into space, only that combined with other elements being retained. The early atmosphere included no free oxygen, but did include large amounts of the carbon-containing gases methane and carbon dioxide. Almost all of these have since been withdrawn from the atmosphere to make organic-based fossil fuel rocks or carbonate rocks, mostly in two great sequences of deposition.

The early atmosphere was much denser than the modern one, resulting in much more humid and more uniform conditions over the whole Earth. The surface may have been shielded from space by a thick permanent cloud cover until around the beginning of the Cenozoic.

The Oceans

Oceans have existed since the early history of the Earth, but their nature and extent has altered considerably. Most of their water has been derived from the rocks under the surface, and has been continually released by domainographic processes. This water has more than replaced the water lost to space.

Originally, in the early days of limited expansion and a smaller Earth, the waters covered most of the Earth and substantial land did not emerge until the Paleozoic. Sea areas were relatively shallow and modern deep ocean beds did not begin to be formed until the Mesozoic.

The early seas contained fresher water than modern ones. While water has been released from the rocks exposed as expansion has proceeded, this release has not quite been enough to keep pace with filling the new low areas formed, and hence both the total area and the proportional area of land to sea on the planet have increased with time.

Domainographic processes have continually raised and lowered individual areas of the surface, and current sea-land boundaries have no relationship with those in the past. All the modern deep ocean beds are new surface, while most current land and continental-shelf areas consist of much older surface.

The Land

The Earth's current land surfaces are all remnant 'mesas' of older surface. As the Earth has expanded, creating first the continental shelves and then the modern deep ocean beds, these mesas have become separated in the expansion.

The whole of the upper 700*km* or so of the Earth's surface, the Domainosphere, consists of a complex aggregate of lumps of rock of every size, from close to subcontinental size downwards. These 'domains' exist with varying thicknesses and at varying levels from the surface down, similar to a drystone wall.

Continuing expansion has resulted in continual movement and fracture of these domains. The heat generated by these movements is the principal source of the Earth's heat. This heat is responsible for the local formation of igneous rocks, for volcanoes, and for all 'geothermal' processes.

Domains are also subject to movement away from the equator in an effort to conserve momentum on an expanding Earth. This domain flight is most marked with smaller domains, but it is modified by blocking with other domains and by the gravitational attraction of nearby large domain aggregates.

Domain movements and adjustments, recognized as earthquakes, are responsible for the formation of mountains of two main types. 'Fat' mountains are formed by impact between domains. 'Long' mountains are formed by rubbing domains, which slide against each other's edges.

The energy released by domain movements is distributed throughout the Earth by earthquake waves, and eventually ends up as heat. Temperatures inside the Earth do not increase continuously as the core is approached, but only up to the 'maximum activity band' in the Domainosphere, the level where domainographic processes are most active. The Earth is also subject to gravitational massage by the Moon and other parts of the Universe, which also releases energy which ends up as heat.

The Surface of the Land

The original composition of the rocks at the Earth's surface was the same as that throughout the Earth. Forces of erosion and chemical and biological change have redistributed and sorted this surface material to create differentiated rocks and mineral ores, some of which include material withdrawn from the atmosphere.

These differentiating forces have 'leached' certain of the heavier metals from the original

upper-level rocks, and some of these rocks have been reworked by domainographic processes to give Sial-type igneous rocks. Domain movements have also been responsible for the creation of precious-metal and gemstone ores through natural 'zone-refining' processes.

SUMMARY 2
What's Happening: The Living Earth

As with the physical Earth, the complex of living creatures and their interactions with the Earth which we call the Biosphere has been in a state of continual flux ever since life first evolved. Life itself has been responsible for major changes in the physical conditions on our planet. It has been responsible for the development of the free-oxygen atmosphere upon which all higher life depends. It has withdrawn much of the carbon from the atmosphere, and deposited quite a lot of it in the rocks as fossil fuels and shell beds.

The pace of change as regards individual species has been enormously faster than generally recognized, with a continual turnover and change such that species half-lives are only of the order of one million years. The 'isocon envelopes' or ecological-condition niche boundaries within which individual species live are being continually shifted as a result of domainographic processes. These shifts have promoted the rapid changes in species.

The Isocons

On the other hand, the rates of natural spread of species have been far slower than usually assumed, averaging not more than one metre per year. In most cases, natural extension of the isocons has been limited by physical boundaries such as the change from land to sea.

Isocon boundaries frequently coincide with domain edges, as the physical changes associated with the edges are often the strongest factors in setting the limits to the associated ecological-conditions niche. Movement of domains has therefore often caused movement of isocon envelopes, and hence an apparent 'spread' of a species. Usually the apparent spread caused by domain movement has far exceeded the 'natural' spread caused by seed dispersion processes.

This feature has been particularly the case in more recent geological history, during the Cenozoic, when the increasing proportion of sea on the surface of the Earth has meant that land domains have become increasingly isolated. It has also become more important as the Earth has expanded and increased its surface, allowing more scope for greater domain flight as blocking factors decrease.

Fragmentation of the land in this way, plus a decrease in the uniformity of climatic conditions because of atmospheric changes, has led to a great increase in the number and range of available isocon envelopes. This is turn has resulted in a large increase in the number of extant species at any given time during the Cenozoic, especially on land.

Biological Dependence of Isocons

While the positions of isocon envelopes are strongly dependent on physical conditions, they are also dependent on biological ones, on other forms of life. This is demonstrated most clearly in the animal kingdom. Animals are dependent on plant-controlled aspects of their environment to a much greater extent than plants are dependent on animals.

The two major control aspects are food and habitat. The majority of animals eat plants as their major food source. Those that do not, the carnivores, are only one or possibly two steps away — their prey is usually a herbivore. Obviously a herbivore isocon must be contained within the isocons of plant species providing suitable food for the herbivore species.

Like plants, animal species have become adapted to the physical conditions of their isocons, but often these physical conditions are themselves strongly modified by plants. Many jungle animals could not survive in the open plains without trees, while a plains-adapted animal such as the bison could not survive in the jungle.

There is also a reverse dependence, but a less obvious one. It is not usually one of nutrition — although some plant species are dependent on animal droppings for this — but more often one of reproduction and of species continuance.

In particular, many plant species are dependent on insects or other animal vectors for pollination, and of course without pollination, there are no more seeds and the species may die out. Some flowers are utterly dependent for pollination on a single animal species, for example a moth with an especially long tongue, or a bird with a very long, thin beak. The incredible variety and complexity of plant-animal interactions in pollination is well covered in Bristow [1978].

The Birds and the Bees — and the Cassowaries

The development of pollination mechanisms is a fascinating and complex study which can yield inferences about the general history of the Earth. The flower-insect mechanism with which we are most familiar is of middle age, and developed largely during the earlier part of the Cenozoic.

Earlier plants, especially the more lowly ones, were usually dependent on pollen transportation by localised, non-animal means, such as in drops of water falling from leaves and splashing. Later plants developed the use of wind for pollination, and this mechanism is mostly restricted to the more recently-evolved species. It does suggest that winds of the type we now regard as normal were not common in the earlier days of the Earth.

Generally speaking, domains with a preponderance of insect-pollinated flowering plants among their flora became separated during the Cenozoic. This is true of Australia, which has the largest flowering plants of the world in its eucalypts, and which possesses an exceptionally rich flora of this type.

On the other hand, the great grasslands of the world, and their cereal derivatives such as wheat and rice, are more typical of the great Laurasian continents of the Northern Hemisphere. The same is true of the great pine forests of the world. Both these ‘mega-isocon envelopes’ are representative of wind-pollinated species.

Animals are also very important in the dispersal of the seeds of plants, especially plants which we regard as fruit or nut producers. In fact, the most common reason why plants have evolved to yield attractive edible fruits or nuts is so that they can take advantage of seed

dispersal by animals.

As with pollination, each fruit species distributed by animals has a target group which it relies on for this purpose, and the nature of the target group determines the nature of the fruit. Small fruits, especially berries, ‘expect’ to be distributed by birds. They have evolved to be small enough for birds to handle, and usually have tiny seeds which ‘expect’ to pass through the bird unharmed and be deposited in the fertilizer-pack bird droppings.

Larger fruits and nuts depend on larger animals. Sapucaia nuts, from South America, are produced in huge ready-made pots with lids (Figure 17.1); they are distributed by monkeys, who grab handfuls of nuts from the pots, and invariably lose some as they move back to base. Oak forests are partly regenerated from the acorn caches of squirrels, buried or hidden near the ground and then forgotten.

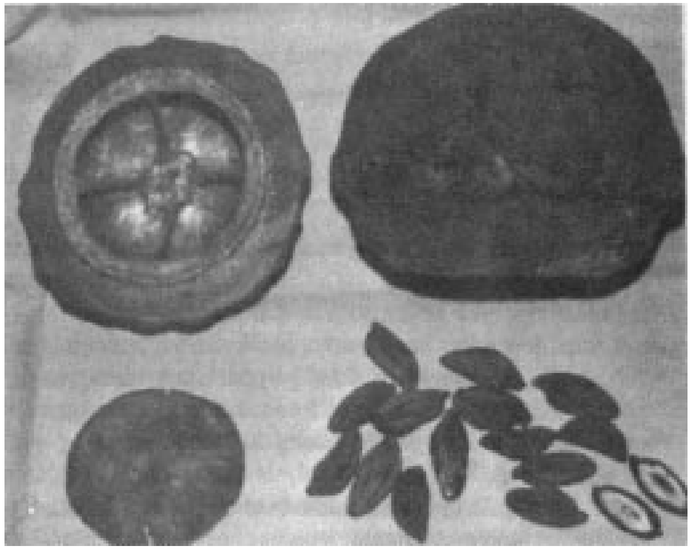


Fig. 17.1. Sapucaia pots and nuts (Lecythis species)

Fruits with large seeds depend on large animals for their distribution, especially if the seed is likely to be passed whole through the animal’s digestive tract. Elephants are noted fruit lovers, devouring the sweet marula fruits of southern Africa, and voiding the large edible nuts. Gorillas are also noted fruit eaters. In Australia, the attractive red quandong fruits have round stones which pass easily through the emu — that is one recommended germination method! And the huge Davidson plum of the Queensland rainforests (*Davidsonia pruriens*) is believed distributed by cassowaries.

There are some deductions to be made here. Most of the large fruit-loving animals are of Gondwanan origin. This is probably because most of the tropics are also Gondwanan, and it is these areas which provide the dense tree cover which is optimum to support communities of large animals. Hence large fruits evolved mostly in Gondwanaland, where they could find distributing animals. This appears to be the reason why the Asimina is the largest native fruit in North America (Chapter 7); it is a Gondwanan migrant.

Of course, as well as plants being dependent on animals, and animals on plants, species in each of these groups are also dependent on other species within the group. The more complicated the ecology, the greater the number of species interacting — we are only at the earliest stages of beginning to understand all the interconnecting factors, all the overlapping isocons.

Another deduction concerns the establishment or introduction of a 'new' crop — one which is not native to the area of cultivation. All too often, the crop is considered in isolation, without regard to the complex of other-species isocons which it needs for good growth and ability to survive in the presence of pests. Elsewhere [Noël, 1988] I have dealt with this area in more detail. In the present context, it will be apparent that the need to move other, 'symbiotic' isocons at the same time is a basic reason for the slow natural spread of plants (Proposition 2A).

So far we have looked at the effect on the isocons of physical factors, such as domain movement, and of biological factors, such as food cycles and pollination and seed dispersal mechanisms. Now we move on to the last and most complicated group of factors — those based on intelligence.

Summary 3
What's Happening: The Intelligent Earth

We have seen that the physical changes in the Earth represented by domainographic processes have had a very strong influence on the isocons, the ecological-niche boundaries of living creatures. We have also seen that these isocons are also very much interrelated, with one species dependent upon many others. So the biological influence is also large.

We have also seen that these physical and biological influences have been hugely overshadowed, negated, or made irrelevant by the third great factor — the actions of man. These actions have changed the face of the Earth beyond recognition, in many cases wreaking great devastation. In the final analysis, the physical and biological factors have stood by helpless, or been swept aside, in the face of the intelligence factor.

Using his power of thought, Man has become master of the planet. But it cannot be said that this mastery has been a very benevolent one, as each day passes the planet moves closer to self-destruction; with increasing power has come the ability to inflict greater and greater harm. But there is increasing hope, hope that the species *Homo sapiens* is maturing. This is not a physical or a biological maturing, but one of the mind. And so we stand today in the Age of Decision, within which the race will stand or fall, and with it the Earth.

Man and the Environment

Evidence already given in this book has shown how Man has caused huge changes in the environment ever since he evolved as an intelligent being. We are accustomed to the idea that modern technological civilization has caused such changes, but the idea that these changes began perhaps 100,000 years ago may be something of a jolt.

Of course these early changes were not intended — most of the harmful changes in the environment made by Man have been quite unintentional — but they have been nonetheless profound. It seems that our huge deserts and vast savannahs and grasslands were actually

caused by Man's actions. It is lucky that that the great mutability of species has allowed plants and animals to rapidly evolve and partially adapt to and compensate for these changes.

Degradation or elimination of habitat is the most obvious sign of environmental decline — the forests are changed into fields, the forest-based isocons vanish, and with them their associated species. Other changes are less obvious, but no less destructive in the long term. Quandongs still grow throughout Western Australia, but their distribution agent, the emu, is banished to the back blocks. Will the quandong survive? Will the Davidson Plum survive in Queensland, even in its preserved rainforest environment, once tourist pressures restrict the movement of cassowaries, or cause their numbers to tail off altogether?

Ironically enough, this degradation of the land had as its basic cause the urge to make the land fruitful, through the development of agriculture. Of the three great branches of agriculture, two of them, stock raising and field crops, are very often destructive of the environment. They need not be, but they both require careful monitoring and holding back if the damage is to be avoided. And even when farmers are aware of this, economic competition and the realities of the marketplace — and, ultimately, land degradation itself — often force their hand or force them, or their children, off the land.

Trees and the Environment

Only the third great branch of agriculture, that of tree cropping, is essentially beneficial to the environment. As I have described elsewhere [Noël, 1985b], this can be explained logically and reasonably in terms of the efficiencies of the different approaches in the use of light, land, water, and people. There are also some philosophical grounds.

Trees — and this word is used here to mean the whole class of perennial woody plants — are by their nature equalizers. They have evolved to live through all the seasons and through all the cycles of years, through years of high rainfall and drought, through hot years and cold. When the grass is gone, the cattleman may need to move his stock to other pastures, but the trees withstand. When the rains do not come, the wheat farmer will not plant, but the trees grow on. They smooth the benefits of land use out through the years, trimming off the peaks and using them to fill the troughs. They are essential for sustainable, long-term agriculture.

Such agriculture should not be based on trees alone, but on a thoughtfully integrated combination of tree crops, field crops, and stock raising, a sort of planned synthetic ecology. People whose traditions stem from Europe are accustomed to the idea that their food comes from the wheatfields and the cattle pastures, and need to look back before the two centuries of industrial development to realize how important tree crops were to their ancestors. In these two centuries, a huge hole developed in their tradition of land use, a hole which was largely filled by importation of goods from other 'less-developed' countries.

In some of these 'less-developed' countries, the traditional tree-based economies have disappeared under the influence of western ideas, in others they have hung on and may well prove to be the superior system in the end. When examined closely, an 'unsophisticated' swidden or slash-and-burn system such as that used in New Guinea is revealed to have astonishing complexity, subtlety, efficiency, and durability — no wonder it has been used with success for more than a thousand years.

Such systems are good 'natural' examples of integrated tree-field-animal ecologies in which man participates as a vital fourth factor. We are only just beginning to appreciate the interlocking of the isocons and microecologies involved. In another place [Noël, 1988], I have tried to show how biennial bearing in fruit trees can be explained by study of just such a system, involving the wild pigs, nut trees, and people of Borneo. It is vital that we attain not just a knowledge, but also an understanding, of the workings of such systems if life on our planet is to continue.

The Greenhouse Effect — Reality or Hoax?

The Greenhouse effect is currently a matter of worldwide public concern. The fact that people everywhere are now vitally concerned with matters such as this is a very desirable thing. But I will attempt to show that our knowledge of this matter is limited, our understanding is very small, our proposals are timid and restrained, and our concern is misplaced. The current near-panic has all the hallmarks of a 'manufactured' crisis.

> *Proposition 17A*
> *Concern over the 'Greenhouse Effect' is misplaced, and represents a 'manufactured' crisis*

What are the facts behind the Greenhouse Effect? The main feature is that the amount of carbon dioxide in the Earth's atmosphere has increased over the last two hundred years or so, almost certainly as a result of industrial and agricultural activities, and appears to be increasing still. In fact, it appears to be as high now as it has ever been in the last 100,000 years or so. More recently the concentrations of the natural gases methane and nitrous oxide, and of manufactured gases called chlorofluorocarbons, have also increased. That is pretty well the extent of the facts.

The carbon dioxide data is mostly derived from studies of the composition of air bubbles trapped in glaciers of different ages, and I would not argue with these results. It is the conclusions and deductions made from the data which should be questioned.

Some dire predictions have certainly been made about the effects of the Effect. Foremost among these is that the increasing level of carbon dioxide in the atmosphere will trap more of the Earth's heat (whether generated here or received from the Sun), causing world-wide increases in temperature. This will lead to partial melting of the polar icecaps, and hence increases in sealevels and flooding of coastal areas. Widespread changes in weather patterns have also been predicted, sometimes with increased frequency of storms.

Proposed actions to counteract these predicted bad effects have ranged from the sensible down to the trivial and ludicrous. Sensible ones have included the widespread planting of more trees, to tie up more of the carbon dioxide in the atmosphere — we have seen that that is a good idea anyway, from both environmental and economic viewpoints.

Trivial recommendations I have seen in print include such gems as "switch off lights when not in use". Perhaps the most ludicrous one, stemming from the W.A. Greenhouse '88 Conference supported by our State Government, was to "Identity and proscribe Greenhouse

activities in light of existing laws". Such an action, if carried through literally, would mean the immediate end of all life on Earth.

Some Carbon Dioxide Background

The carbon dioxide position is at once far worse and far better than is generally appreciated. The main sources identified for the Earth's increasing atmospheric carbon dioxide content are the burning of fossil fuels and the clearing of forests.

Both these sources are very significant. As we have seen from Chapter 13, the use of fossil fuels is putting back into the atmosphere carbon which has been 'frozen' for millions of years, many deposits dating back to Paleozoic times. The amount of carbon 'frozen' in standing forests is also very large, but while it can be treated as being transferred continously from one plant to the next in a 'steady-state' forest, it does not matter. It is only when standing forests are cleared that it becomes a factor.

Table 17. Carbon on the Earth

Position	Mass*
Atmosphere	
Pre-industrial (1860)	1.0
Modern (1987)	1.3
Biosphere	
Above ground	0.9
Soil organic matter	2.8
In seas	
Dissolved in seas	65
Dead in seas	1.8
In sedimentary rocks	
Carbonate rocks	67 000
Fossil organic matter	27 000
Potential 'fossil fuel'	14

*In units of 575 billion tonnes carbon equivalent

Let us put some figures to this picture. A dense, tall forested area will contain around 500 tonnes of plant material per hectare above ground. Obviously this figure will vary according to the nature of the forest, and scrubby open forests will contain less, but this gives us some sort of handle to work from. A field crop will typically hold only a few tonnes of plant material above ground when fully grown, and nothing at all outside the growing season. A pasture cover will typically have less than a tonne per hectare.

Both the field and the pasture plants will have much more water and less carbon in them than the woody plants of the forests, so as a rough figure we can assume that replacing forests by field crops or pasture reduces the carbon held to under 1% of the original figure. At the accuracy we are working at, we can assume it has all gone.

> *Proposition 17B*
> *Changing land use from forest to field crop or pasture reduces the amount of 'frozen' carbon to negligible levels*

In Table 17, mostly taken from Beckmann [1988], there is a figure for the carbon contained in the total estimated deposits of fossil fuel on the Earth. If this figure is divided by the total land area of the Earth, it gives a result which, coincidentally, is about the same as the forest — 500 tonnes per hectare. This figure takes no account of such factors as the extensive fossil fuel reserves under the sea, the many geological areas where fossil fuel deposits are lacking, or the fact that forest plant material is not all carbon, but it is another handle to use on the problem.

> *Proposition 17C*
> *Fossil fuel deposits in the ground have the same magnitude of 'frozen' carbon per hectare as a dense forest, on an Earth-wide average*

There are lessons to be learned from this comparison. First, it is much quicker, easier, and cheaper to clear forest than to extract fossil fuels from beneath the Earth, and so this forest clearance has had a much more immediate effect on the environment than burning fossil fuels. Most of our forests are already gone, but we are a still a long way from using up all our fossil fuels, in spite of widespread gloomy predictions to the contrary.

In the 1970's we had the Oil Crisis, and I was surprised at the antagonistic response from some quarters at that time when I went on public record with a contrary-to-usual view. I pointed out that similar gloomy predictions, of the Earth running out of fossil fuels or other mineral resources within 20, 10, or five years had been made many times before in the past, dating back to the mid 1800's. All such predictions had proved false.

In hindsight, we can see that the Oil Crisis was also a 'manufactured' crisis, and current worries relate to oil gluts instead of shortages. The paradoxic reality appears to be that mineral resources are not, in practice, finite; what happens when one 'standard' resource runs thin is that another is found to substitute for it, often one quite unappreciated at the time. For example, if there is X amount of fossil fuel deposits on Earth, there is some 2000X of other fossilized organic matter which is still untapped (Table 17).

The relevance of all this is that it is the forests, not the fossil fuels, which are both the danger and the potential salvation. Most of our forests are already gone. The position is seen to be even worse when it is remembered that Man has been clearing the world's forests, intentionally and accidentally, not for one or two centuries but for tens of thousands of years. Primitive man changed whole landscapes, whole climates. Even so, we can still restore the health of the Earth, with the use of ecologies and economies in which tree crops are no longer the forgotten Third Component of agricultural land use.

Salinity and Trees

There is another aspect of land degradation which is the subject of increasing public concern, especially in Western Australia, and that is loss of useful land through salinization. Salt is regarded as the Great Enemy at the moment.

Nowhere is that more true than in Australia, particularly Western Australia. In a recent article entitled "White Death: How Salt is Decimating the Country", Julian Cribb [1989b] reports how this State is losing the use of a massive 20,000*ha* of agricultural land each year through soil salinization.

Tree planting has been widely promoted as a means to combat soil salinization here. The basis of this measure is said to be that trees use up water and keep the water table, which is often saline, low. If the trees are cleared, the water table rises, and salt comes to the surface, eventually in sufficient amounts to kill most vegetation.

The fact that tree clearing can cause soil salinization has been well documented. However, most analyses of the situation ignore a basic factor — the salt content of the trees.

Far from being a poison, salt is in fact an essential component of the blood of most animals, and the sap of most plants. In animals, the right concentration of salts in the blood is essential for many bodily functions. In plants, the basic mechanism by which plants take up water through their roots, osmosis, is dependent on having a higher concentration of salt in the cells than that outside.

Different plants are able to function with different salt contents, but a rough working figure can be taken as 1%. One percent of the 500*t/ha* of forest growth is 5*t/ha* of salt. Spread 5 tonnes of salt over a hectare of field crop or pasture, and you are sure to kill it. Yet the same amount is a normal feature of a hectare of forest. The forest 'freezes' the salt, just as it does carbon.

> *Proposition 17D*
> *In contrast to field crops and pastures, permanent tree-based ecologies handle high per-hectare amounts of salt without difficulty*

Industrial Carbon Dioxide

We have seen that forest clearing and the burning of fossil fuels, much of it in industry, are the main activities responsible for the increase in atmospheric carbon dioxide. But there are many other industrial activities which may also make a significant contribution.

One of these areas is the use of cement, concrete, and mortar. Calcareous mortars based on lime produced by burning limestone have been used at least since Roman times. Burning the limestone releases carbon dioxide. However, as the older types of mortar harden, they do this mostly by absorption of carbon dioxide from the air.

This is not the case with modern cements, produced by burning limestone together with clay. Carbon dioxide is released in the burning, but the resulting cements harden by chemical reactions to produce complex calcium silicates. Only a little carbon dioxide is subsequently absorbed. The now widespread use of cement and concrete is relatively new, much less than a hundred years old. It may figure significantly in the overall carbon dioxide cycle.

Many industrial and mineral refining processes release large amounts of acid gases into the air. The phenomenon of 'Acid Rains' is another pressing matter of environmental concern, particularly in Europe, where natural vegetation has suffered or been killed over large areas. These acid rains attack the carbonates in building limestones and cements, or in exposed natural limestone outcrops, again releasing carbon dioxide.

Manufacturers can be forced to neutralize acidic flue gases before release into the atmosphere, and this does eliminate damage to buildings. But the neutralization process is invariably based on using limestone materials, which therefore releases carbon dioxide sooner rather than later.

The very widespread practice in farming, of adding ground limestone to acid soils to improve their pH, also causes significant release. Every 100*t* of limestone used in this way gives out 44*t* of carbon dioxide.

The position looks grimmer and grimmer. But before shooting ourselves, let us look and see whether it really matters, or whether what we would actually be doing is to shoot ourselves in the foot.

Carbon Dioxide — Killer or Nutrient?

The first thing to look at is whether the higher concentration of carbon dioxide is, in itself, good or bad, or indeed of any relevance. The background is this. We saw in Chapter 11 that in earlier geological times, the amount of carbon dioxide in the atmosphere was enormously greater than now, when it it is really only at trace level (Proposition 11J).

We also saw (e.g. Beckmann [1988]) that modern plants are CO_2-hungry, chasing ever-decreasing amounts of the gas in the atmosphere. In fact, a relatively recent event in plant evolution appears to be the development of species able to use a photosynthesis path called the C4 cycle, which improves the efficency of photosynthesis in low-CO_2 situations. Plants with this C4 ability have a strong advantage in many environments, and have become known both for their high biomass conversion abilities (as with sugar cane) and their ability to outgrow non-C4 species and become powerful weeds.

Whether or not plants use the C4 mechanism, increasing CO_2 availability is now accepted as benefitting plant growth. In fact, Julian Cribb [1989], in an article headed “Farm Bonanza on the Horizon”, reports a prediction that Australia’s agricultural production levels could rise by up to one-third — a very significant amount — just because of the stimulus to plant growth from increased carbon dioxide levels (both Cribb’s and Beckmann’s articles are mostly based on work done by Roger Gifford of CSIRO). Usefully enough, the improvement is likely to be most marked in some of our hottest and most arid areas (Figure 17.2).

So there appears little doubt that increasing CO_2 levels in the atmosphere will, in fact, be of benefit to us. Let us now go on to see whether we can expect to continue to enjoy these benefits.

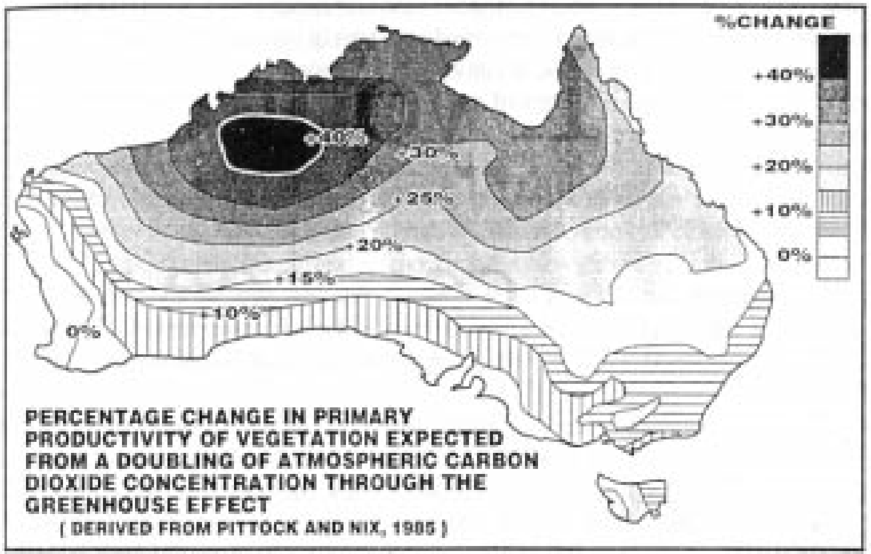
Balancing the Books: Gains and Losses

So far we have only looked at where the carbon dioxide in the atmosphere is coming from. If we are to get a balanced view of the position, it is vital that we also see where it is going to.

We already know that our plant cover contains a lot of carbon. Plants give out CO_2 as well as taking it in — they do this mostly at night, which is why trees grow mostly at night — but if the plant cover is at a steady state then decay and growth within the biosphere cancels out changes in carbon dioxide content.

If we plant more trees, and we have good reasons why we should do this anyway, we can expect to take some extra of the CO_2 out of the atmosphere and ‘freeze’ it in plant carbon. How far could we take this process, how much could we take out?

We saw above that a complete dense forest cover over the whole of the Earth’s surface would represent a similar amount of ‘frozen’ carbon as that in all fossil fuel deposits. Let us assume for the sake of calculation that these amounts are the same.



PERCENTAGE CHANGE IN PRIMARY PRODUCTIVITY OF VEGETATION EXPECTED FROM A DOUBLING OF ATMOSPHERIC CARBON DIOXIDE CONCENTRATION THROUGH THE GREENHOUSE EFFECT
(DERIVED FROM PITTOCK AND NIX, 1985)

Figure 17.2 [Cribb, 1989]

If we again look at Table 17, we can see that the atmosphere currently holds 1.3 units, while the fossil fuel stands at 14 units. Above-ground carbon in plants and other living matter amounts to 0.9 units. To cover the world with trees, we would need to find another 13.1 units, much more than the total in the atmosphere! Where could it come from?

There is another way of looking at all this. Forests are the normal ‘climax’ vegetation of an area left undisturbed by man, and perhaps also by grazing animals. This is because a forest ecology is, as we have seen, more efficient than any other. There are good grounds, historical and otherwise, for granting that the Earth’s forest cover was once far more extensive than it is now. If it once averaged out at even half a full cover, that is 7 units, where has it all gone to now?

With 0.9 units in the current above-ground biosphere, there is an extra 6.1 units to account for. We know that the atmosphere has gained 0.3 units since 1860, but even if the whole of the 1.3 units in the atmosphere had come from early tree clearing (which is obviously impossible since plants could not have functioned with *no* carbon dioxide in the atmosphere), that still leaves a massive 4.8 units to find. Clearly there is something wrong.

The explanation lies in a simple and obvious fact. Carbon dioxide is being withdrawn from the atmosphere continuously by other agencies apart from plant growth. When we look at it more closely, we find that these agencies may far outstrip the plant factor. Most involve the freezing of carbon as carbonates.

> *Proposition 17E*
> *Removal of carbon dioxide from the air as carbonates has had a greater impact than its removal as plant organic matter*

From Table 17 we can see the importance of the carbonate issue. Instead of talking about one, two, or 20 carbon units, we are concerned with tens of thousands of them. There are two main routes by which CO_2 in the air is converted to carbonates.

One is in the shells and skeletons of animals, particularly marine animals. Some quite massive limestone beds are known to consist almost entirely of mollusc shells, so the cumulative effect is quite powerful. Even more important are the coral reefs, again consisting mostly of carbonates. Australia's Great Barrier Reef has *grown* into position, and in so doing has frozen uncountable billions of tonnes of carbon into solid rock.

The second route is by direct precipitation from carbon dioxide dissolved in the sea. Many limestones contain some obvious shell remains, but the bulk of the material is fairly amorphous rock which could have been formed without any involvement of life processes. It has been said that limestone is currently being deposited on the bed of the Caribbean today, in this way.

What it comes down to is that carbon trapping by plants above ground is competing against carbon trapping under the sea by marine creatures and direct chemical processes, and the latter usually win. Once formed under the sea, carbonate rocks are subject to little attack, whereas plant material — whether still alive, as standing trees, or preserved as timber buildings or great libraries on paper — is continually liable to decay and burning.

So the wheel has come full circle. Instead of the perceived excess of carbon dioxide in the air, we have a shortage. There isn't enough in the air to restore our forests. If we frantically pump some more in by burning up our fossil fuels, the molluscs and corals will grab most of it, and never give it back.

> *Proposition 17F*
> *The Earth is suffering from a carbon dioxide shortage in the air, not an excess*

It seems that the most accessible source for the carbon dioxide we need is the carbonate deposits, whether on land or under the sea. But all this arose from concern about another matter, about the Earth heating up due to the Greenhouse Effect. Where do we stand on the heat balance?

Heat Trapping in the Earth

It seems to me that a quite unnecessarily alarmist attitude is being taken in regard to possible heating up of the Earth. It is a good thing that the matter should be looked at in detail, but that certainly does not mean throwing logic and reasoning to the winds.

What are the facts in this matter? It is claimed that the Earth has heated up by an average of about half a degree during the present century, or perhaps the last fifty years. It is claimed that this heating is due to the accumulation of carbon dioxide and other 'Greenhouse' gases, due to Man's activities over the last century or so. Are these claims fact?

There does seem to be little doubt that increasing CO_2 content in the air will tend to heighten its ability to trap heat. As to the half-degree rise in the Earth's temperature, that is really not too much above the degree of accuracy of measurement, but we may as well assume that it is true too. Now we can look at the conclusions which have been drawn from these assumptions, but first we should look at the balance sheet of the Heat Budget of the Earth.

Sources of Heat in the Biosphere

We have already seen that domainographic and gravitational processes within the Earth have contributed to the heat we experience in the biosphere. We know also that most of our heat comes, and has always come, from the Sun. In considering the importance of the Greenhouse Effect, what we are most concerned with is things we think we can influence, in particular heat generated by the activities of Man.

Man has always used artificial heat generation, ever since he first found out how to make fire — that is nothing new. However, since the development of modern technology the amounts of heat produced have increased. Concern with the Greenhouse Effect has caused people to look at ways in which Man's output of heat into the biosphere could be limited or reduced.

Most of the energy we use ends up as heat, but we need to distinguish between energy sources which are neutral as far as the Earth's energy budget is concerned, and ones which add to the heat of the biosphere above the level which would occur if we had not intervened. Budget-neutral sources include hydroelectricity, wind power, tidal power, and direct use of solar energy. In all these we are only temporarily diverting energy which would have turned into heat anyway; how long the diversion lasts depends on the use which we make of the energy source.

There are other 'benign' energy sources, some of which have never been tapped. In an earlier article [Noël, 1983] I have suggested a more efficient technique for trapping solar energy, and also pointed out ways of using two untapped sources. These are the electrical energy of thunderstorms, and the potential energy of rain.

Both these sources could be very major — one good thunderstorm is said to release as much energy as many atomic bombs. As far as I know, no-one has even estimated the energy available from rainfall potential energy, but with a fall of around 1000*m* available, compared to the 10 or so metres in a conventional hydroelectric plant, the amount must be huge.

Budget-negative sources are the ones we are currently worried about, ones which add extra heat to the biosphere rather than borrow it temporarily. Of course this group includes burning of fossil fuels (provided our budget runs over a hundred years or so, rather than many millions). Interestingly enough, it also includes at least the greater part of nuclear power generation.

Early nuclear power generators used a naturally-radioactive isotope of uranium, uranium-235, as their power source. To some degree this is a 'neutral' source, since some of the uranium-235 would decay anyway and give off heat, even if it were still in its original deposit in the Earth. But most of the power in modern nuclear reactors comes from the conversion of naturally non-fissionable forms of uranium and thorium into fissionable isotopes, and this is energy which would not be released except for our actions. This applies to current fission methods of nuclear power generation; the hoped-for 'clean' power from hydrogen fusion is entirely budget-negative.