

Green Leaves

Quiet thoughts and prayers on green issues

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Overview

These pages cover a wide range of green issues, from how the Earth works, to how individuals can help.

The pages can be tackled at your own rate, e.g. one a day, and each ends with a personal thought or prayer.

I confess I find the issues too big to take in, and I let other people worry about them.

Learn more

The media, web pages, social media, and so on, are good at highlighting individual issues, but not always so good at showing where they fit into a bigger picture.

To make a difference as an individual, it helps to be aware of that big picture to provide some context, and build knowledge about what helps and what doesn't.

That's what these pages are about.

I promise I will find out more about green issues, here or elsewhere.

People sometimes need to make a lot of noise about green issues, to try to prompt action.

But calm contemplation is also needed. Maybe these pages will help, by taking one small step at a time.

Help me to quieten my mind, think clearly, stay sensible - and care more.

Complex

The issues are complex & interconnected like this tree.



I will try to understand green issues, one leaf at a time.

The outer links at the top right of each page take you forward and back by sections instead of pages. The sections are like branches, and the pages are like leaves.

But the sections and pages are laid out like a book, so you can know your page number and judge how far you have got.

If you go away and come back again, the web site will remember which page you were on, or you can download the PDF version.

Help me get the big picture, as well as the details.

Disclaimer

Should you trust these pages? After all, they are only a gathering together of publicly available materials.

This is mainly a matter for your own judgement, but some advice is given in the next section on how to do your own research, many links are provided, and the final section includes books to read.

I will read around if I want more depth.

Contributions

These pages are not fixed. They can, and should, be updated over time.

Contributions, suggestions, criticisms, illustrations, links and resources are welcome. Email ian@holyer.com (but please don't publish, broadcast or overuse that email address).

If I don't agree with something or I am confused about it, I will ask someone.

It is important to think about green issues from a position of knowledge and understanding, not just accept or reject things arbitrarily, and science is the main source of 'truth'.

But it takes a little practice to look for scientific truth in the right places, and to build trust in it.

I want to learn how to see things more clearly.

Who are scientists?

There is no authority which decides who can call themselves a scientist and who can't.

This is very important - science stays fiercely independent, refusing to be unduly influenced by politicians, administrators, companies, funders, academic institutions, or anyone else with an axe to grind.

I can investigate a small topic and call myself a scientist in that area.

How science works

Science is a mixture of certainty and uncertainty. It works by reaching a consensus of opinion on a topic.

That means not jumping to conclusions, and waiting for facts to survive the test of time.

I will try to cultivate patience and avoid jumping to conclusions.

Science uses the word 'theory' rather than 'fact' in recognition of the impossibility of total certainty.

Yet consensus scientific theories are far more certain than the things we ordinarily call facts.

I will try never to be too certain.

How certain?

Sometimes, science is very certain indeed.

Quantum theory, which is difficult to understand and involves fundamental uncertainties, has made predictions which have been verified within about 15 significant figures. It the most accurate theory ever.

I will try to improve my judgement about which things are certain enough to believe.

Are there pitfalls?

Although science is to be trusted, 'science news' is proto-science (science in the making) not yet verified.

And media coverage of science is often poor, without context, or misused to support spurious arguments.

And science presented by advertisers lacks objectivity.

And some self-promoting experts are really just pseudo-scientists.

I will try not to believe everything I come across in the media.

As a rule of thumb, science based on statistics is less certain and takes longer to reach consensus.

Statistics may tell us, for example, that if X increases then Y also increases, but a lot more work may be needed to find out whether X causes Y .

And statistics seems to attract bad science.

I will always take statistics with a pinch of salt.

Research papers

Most important research papers are available online. Here is [an example](#). It has not been chosen for its importance or its quality, or even its readability.

It has been chosen because it says a lot about how science works. It illustrates that scientists are only human and they make mistakes, but they are collectively self-critical and ultimately self-correcting, which is what makes consensus theories reliable.

Once I am convinced that a theory has reached consensus, I will accept it.

Full scientific research is highly specialised. But, nowadays, almost anyone can do stage 1 research.

Stage 1 research (often just called 'research' in everyday language) is finding out what's known already, and all you need is a search engine, an appetite for reading, and a reasonable level of judgement.

It is what you need to do, if you want good opinions, and it is what has been done to produce this site.

I will find out things for myself.

Your own research

Try this. Take a proposed 'fact' you want to verify. Do online searches for it, and its opposite. Cast your eye over lots of the pages you find, rather than trusting any one page. Judge the pages (e.g. less strident equals more trustworthy). See if you can detect a consensus.

Your own judgement is good enough to build up some quite sound knowledge this way. Of course, especially to build a bigger picture, it helps to read books or articles, watch documentaries, talk to people, and so on.

I will put more work in when I want more certainty.

To get some background context on various green issues, it is worth looking a bit at the Earth's history.

What important things have happened to the Earth in the past, before the human influences which worry us today?

Thank you profoundly for the Earth we inhabit. May we look after it well.

Anthropocene

We are in the geological epoch called the Holocene. That's the 10000 years since the last ice age when the human race has been developing.

Geologists are considering defining a new epoch, the Anthropocene, starting in the mid-20th century, during which human effects on nature have become significant.

Many scientists already say we are in the Anthropocene.

How far back?

The Earth has existed for about 4.5 billion years. How far back is it useful to look into that history to get a good long term point of view?

According to geologists, about 50 to 60 million years is enough (the 'recent past'). Before that, the Earth was evolving into its current stable state, so what happened was once-only and probably not relevant for explaining the present or predicting the future.

I am not used to thinking about such long time scales.

Greenhouse effect

The greenhouse effect is fairly easy to understand, because of its name. Energy from the Sun is trapped by the Earth's atmosphere as heat, making the Earth warmer.

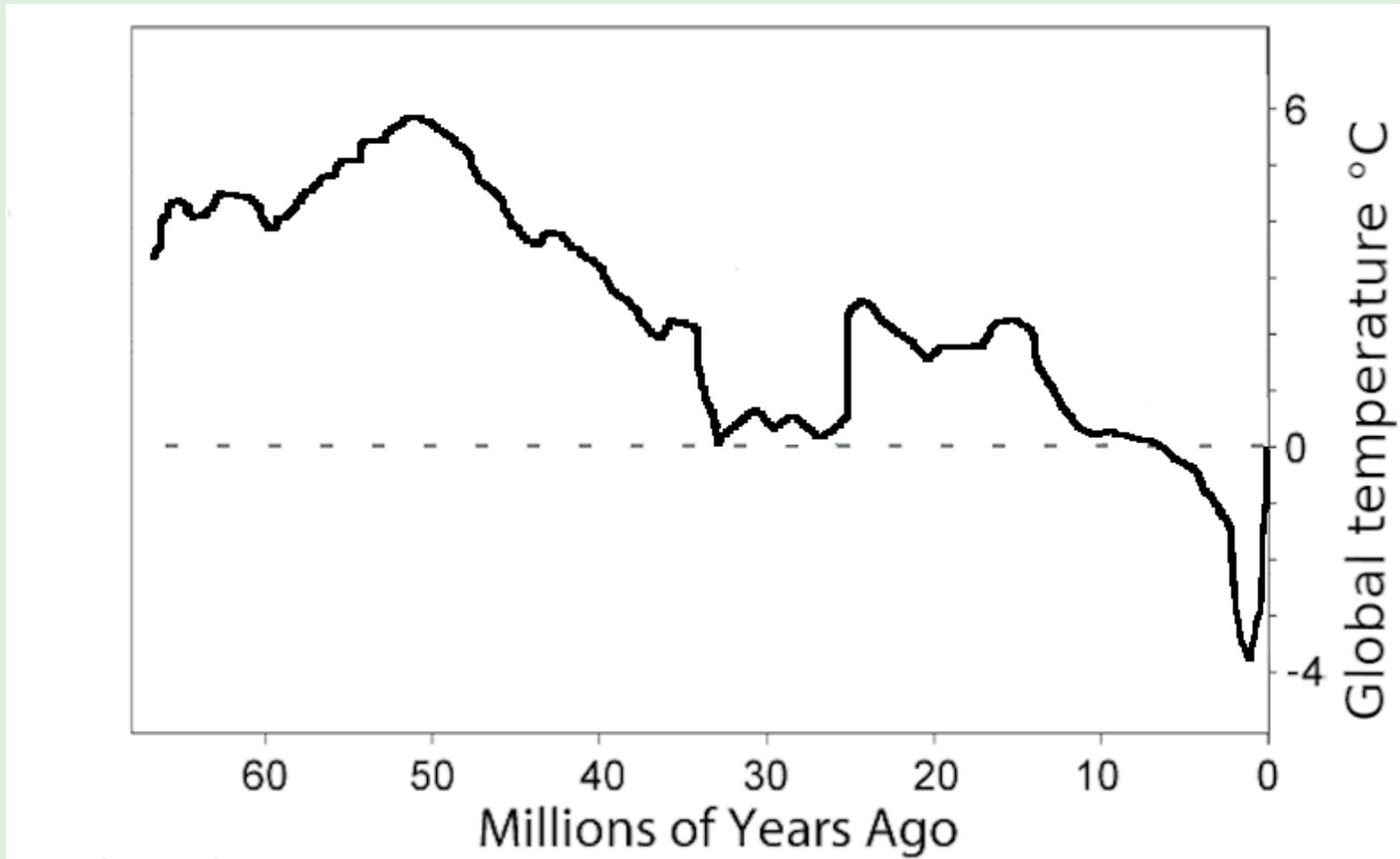
The greenhouse effect started before primitive life migrated onto land. Life (as we know it) would be impossible without it, because we would all freeze.

It keeps us warm, but the next question is how warm.

Thank you for the greenhouse effect, which keeps us alive and warm.

Graph

Here's a graph, explained in the next few pages:



Graphs are difficult to interpret.

Interpretation

The graph has been adapted from a well-known one by [Robert Rohde](#). It has been smoothed and simplified to remove the multiple sources, names of geological ages, and other information, and to combine the vertical scales into one (but not in a very accurate way).

It is still very difficult to interpret. It is an [ongoing problem](#) to produce easy-to-understand graphs of the Earth's temperature.

I confess I know little about the long term history of my own planet.

Temperature

These days, global warming is expressed as an average of land, ocean and air temperatures on the surface of the Earth. It is just called global temperature (or global surface temperature).

It is a shorthand, related to the amount of energy in the environment, which makes a lot of difference when it comes to climate, sea levels, inhabitability and so on.

Why don't scientists say what they mean? Well, they do, but only to each other. The rest of us have to make do with shorthands.

Global temperature is always quoted relative to a baseline 'pre-industrial' temperature.

Nobody says what the baseline temperature is, because it is a shorthand with no direct meaning. It is a complex measure, averaged over the globe. Wherever you live, it is whatever you think of as 'normal'.

It is not a linear scale. Doubling the rise in temperature make a lot more than twice as much difference.

Thank you for all the hard work that has been put into measurements and their interpretation.

Global temperature fluctuates in complex and seemingly random ways, on various scales, and driven by various processes. Chaos is typical of interconnected systems, making them a lot harder to study.

The scale and smoothing of the graph hide most of this complexity.

I begin to understand why scientists so often say "it's not that simple".

What to look for

We all know about ice ages. But not many of us know about the equally extreme fire ages. That's because the name 'fire age' doesn't exist - it has been invented just for these pages. There is no common, snappy, dramatic name for them. Scientists unhelpfully call them 'thermal maxima', or 'interglacials' or 'warm periods'.

The lack of a good name is probably the only reason they aren't common in popular culture.

In future when I hear about ice ages, I'll think of fire ages.

Ignoring chaotic fluctuations, the graph shows a fire age with the temperature up to about 6°C above the baseline. It is, sadly, called the Paleocene-Eocene Thermal Maximum.

And it shows an ice age starting about 2.5 million years ago with the global temperature down to about -4°C below the baseline. It is, happily, called the Last Ice Age.

We humans evolved into our current form during the last ice age, which is now ending.

Thank you for the last ice age, which allowed us to emerge.

Jumps

Between the fire age and the ice age are some sharp jumps (down, up, down).

These are where the Antarctic froze over, then unfroze, then froze again.

So it is 'normal' for the Earth to have no polar ice.

I need to expand my ideas about what is normal.

Meaning

The graph doesn't say that there is nothing to worry about, because fire and ice ages are difficult to survive. Where you live would be under water or under ice.

It tells us that we aren't going against nature. In a way, everything humans do is natural, because we are part of nature, not separate from it. But we are pushing nature along too quickly, without thinking. That's unwise.

I will try to remember that I'm part of nature.

One other feature of the past is extinctions. An extinction (or 'mass extinction' or 'extinction event') is a time, possibly a long time, over which a large percentage (say over 50%) of the species on Earth die.

We don't like thinking about them, because they involve death, but they are just another, different aspect of death. Just as individuals die to make way for new individuals, so species die to make way for new species.

I confess I find extinctions scary, and difficult to face.

Are they relevant?

Everybody knows about the most recent extinction, which got rid of the dinosaurs and allowed us to take their place. It is one of about 5 or 6 known big extinctions. The reasons for them are varied and not very well understood.

On the other hand, all of the extinctions were before the recent past, except for the dinosaur one, which was 'only' 65 million years ago. Perhaps their main importance is to warn us that they are possible.

Thank you for the dinosaurs, and for their demise.

Long term predictions

Most of us have no need to think about the long term future of the human race. But someone should.

Are there things we can say about the long-term future, using what we know about the past, and ignoring human influences on the environment?

It is amazing that so much is known, and humbling that there is so much left to know.

Speculations

The recent past gives us one example of a fire age, one example of an ice age, and one example of an extinction. That's not much to go on.

So what follows are wild speculations.

I won't take the rest of this section too seriously.

Are fire ages, ice ages, and extinctions likely in the future?

In the long term, it seems highly likely that at least one of these will happen. Unless we learn to control them.

I am not sure I like long term speculation.

Would the human race survive another fire age, ice age, or extinction?

We are very resourceful, so maybe we could.

The land area available for food would probably be very much reduced, though, so there would need to be a severe reduction in population. Unless we come up with something clever.

I am glad this sort of thing is not my concern.

An old saying is: "The human race has all its eggs in one basket". A newer one is: "There is no planet B". Can we colonise some other planet, to spread the risk?

Going to another solar system seems to need new physics and energy sources. Colonising a terraformed Mars, say, seems harder than controlling the Earth's environment. So these are extremely long term options. But space technology is worth supporting all the same (we need it to defend against some of the risks).

So we really do need to make the most of our planet.

What bad things are humans doing to planet Earth?

The simple summary is expand, consume and pollute.

It is sobering to think of humans as an infestation.

Expansion

There are lots of reasons for the expansion of the human population. There's the opening up of habitable land after the ice age, the rise of cooperative civilization, and industrial and technological development, to name a few.

Recent information about the slowing down of population growth has reduced the issue from a panic ('the population explosion') to a potentially solvable problem, though with a lot of work still to be done.

It is hard to stay up to date with information.

Population

42

This (fake) counter shows there are 7.7 billion of us:

7758413517

Many of our other problems would be far less severe if there weren't so many of us, so it is a fundamental issue.

I find it difficult to reconcile this big number with the fact that every individual matters.

Extreme Poverty

Along with the decrease in the population growth rate, there has also been a considerable reduction in extreme poverty. This is very heartening, even if there is a lot still to be done to eliminate extreme poverty completely.

Good news doesn't travel as well as bad news.

How many?

What population can the Earth sustain?

It is a very important question, but it appears to be unanswerable. Everyone you ask gives a different answer.

Perhaps a good summary is this: if we try hard, we can probably stabilize the population somewhere between 10 and 15 billion. That's probably OK, but with some changes of lifestyle that are difficult to predict.

Recent decades have seen many changes in lifestyle. Maybe more wouldn't be so bad.

Consumption

We are using up various resources: fossil fuels, minerals, metals, helium etc., that are impossible to replace.

Among many other products, a lot of traditional plastics are made from fossil fuels.

One very important limited resource is land area, which turns out to be critical in analysing how to face the future.

I will try to find out more about renewable or recyclable products.

Most pollution is easy to understand, there is relatively little controversy over what is happening or whether humans are responsible, and it is relatively easy to do your own research on individual topics. Plastic pollution has been highlighted by the media recently.

The problems are to do with the variety of different kinds of pollution, the complexity of the breakdown & interactions of chemicals, and working out how they affect the health of humans, animals and plants.

Am I responsible for any pollution?

Global warming

But there is one aspect of pollution which deserves close inspection, and that's carbon pollution, because of the global warming it is producing. And global warming causes climate change and sea level rises.

We hear about carbon footprints, carbon offsetting, carbon sequestration, and so on. So why is there all this fuss about carbon?

Sometimes, jargon gets in the way.

Carbon is another shorthand. It summarises pollution caused by emissions of gases containing carbon, which are particularly good at trapping energy from the Sun. The trouble is that they are increasing the greenhouse effect too much, and pushing up the Earth's global temperature.

The main greenhouse gases are carbon dioxide (CO_2) and methane (CH_4). Some others such as nitrous oxide (N_2O) have no carbon in them!

Shorthands are helpful and confusing at the same time.

Carbon dioxide

Carbon dioxide is the most important greenhouse gas by far. That's not because it is the most potent, but because it stays in the air for so long.

That means, while emissions continue, levels of carbon dioxide keep increasing.

Now I understand why the target should be zero emissions.

Methane is the second most important greenhouse gas. It is potent but, unlike carbon dioxide, it only remains in the air for a few years.

It needs to be monitored, and kept under control, and used to inform policy. However, the situation is far less serious than with carbon dioxide, and emissions of methane do not need to be reduced to zero. The same goes for other less important greenhouse gases.

There is more fuss about methane than necessary.

Carbon cycle

Although carbon dioxide collects in the atmosphere, there are ways in which it slowly gets extracted again. That's known as the carbon cycle.

Nature puts 150 GigaTonnes of CO₂ into the air per year, and extracts 150 GT from the air per year, creating a balance. We add 35 GT per year, upsetting the balance.

Nature can cope, eventually, if we let it.

Where it goes

Carbon dioxide dissolves out of the air into the oceans. But it makes the oceans more acidic.

Carbon dioxide is taken out of the atmosphere when rocks weather. But it takes a very long time.

Carbon dioxide is taken in by trees and other vegetation. But deforestation, caused by pressures on land use, reduces the effectiveness.

I need to know more about forests.

Forests store carbon

There are many great reasons for preserving forests, such as plant and animal habitats, and water sources.

But the most important is that they store carbon, keeping it out of the atmosphere. Then they get buried, pushing the carbon underground as fossil fuel deposits of coal, oil and gas. How do trees store carbon?

So deforestation and using fossil fuels are closely related.

Trees are made of air.

Well trees are mostly made of wood. And wood is mostly carbon. But the carbon doesn't come from the ground. It comes from carbon dioxide in the air, through photosynthesis as trees grow. And oxygen is produced.

Most plants are mostly made of air. That's amazing.

Forests breath

It is a fascinating fact that forests breath daily.

But after the discovery that forests breath out oxygen during the day, it was subsequently discovered that they breath it in again at night, with the net effect probably being around zero.

It is the long-term one-way breathing of growth, not daily breathing, that matters.

How sure are we about global warming? Early research was dogged by a lot of problems. One, not the least, was over-funding. The funders were biased in their choices of project to fund, and put too much pressure on scientists to produce particular results.

Now, despite many remaining uncertainties, the main features of the story have reached consensus. They are "not disputed by any scientific body of national or international standing".

I have noticed the certainty rising over time.

Where are we?

Since before industrialization, the rise in global temperature has been about 1°C (well, 0.8 to 1.1, depending on who you ask). That's enough to cause significant climate change.

The rise in sea levels so far is around 0.3m, not yet enough to cause a panic.

I haven't noticed much change yet. That makes it difficult to take in.

Climate change

Climate is average weather. Global warming is likely to change the climate of some countries. And the complexity of the system means some countries could get colder rather than hotter. The real worry comes when it affects food or water.

The UK climate has changed little. It could change a lot if the gulf stream or jet stream changed course. That seems unlikely, but chaotic effects can't be ruled out.

The UK could get colder? That's not intuitive.

The most worrying aspect of climate change is wild weather, caused by the increase of energy in the environment. There is a greater frequency and greater intensity of weather events. And careful statistics are no longer needed to see it.

You can't point to a weather event and blame it on global warming. There are more of them, but nobody knows which ones would have happened anyway.

I've noticed the increase in weather disasters.

Sea level rise

60

Early media reports said that melting ice caps cause sea level rises. But, at first sight, Antarctic ice is land-locked and won't melt, and Arctic ice floats, so melting makes no difference.

Later reports blamed thermal expansion. Water doesn't expand much, but expansion of a few kilometres ocean depth can cause the surface level to rise a few meters.

Recent reports blame melting ice again, from glaciers.
So which is it?

I'm confused.

Thin layer

An award winning image shows how little water is in the oceans (and how little air in the atmosphere), relative to the size of the Earth.

That makes it clear how the run-off from melting glaciers can indeed have a profound effect on sea levels.

So the answer is both. Sea level rises were initially mostly due to thermal expansion, but the contribution from melting ice at both poles is increasing over time.

We live in a very thin skin round the Earth.

Why do sea level rises matter?

The main reason is that many cities are coastal, near current sea levels, because they are or were harbours for trade ships. This is unfortunate, just as it is unfortunate that many cities are in earthquake regions, because of the presence of minerals and oil nearby.

Sea levels continue to rise, and some places will be affected a lot more than others.

It will be more important than ever for countries to help each other.

Predicting the future is a lot harder than explaining the present. Climate change predictions are based on climate models, which are a bit like long term weather forecasting programs.

These are very impressive. And there are several of them, produced by different groups, which agree with each to a remarkable degree, giving us a lot of confidence that they are programmed properly.

Without computers, we might not even be aware of the problems.

On the other hand, the climate model programs are all based on the same current science, so any current poor estimates may affect them all.

And the chaos inherent in the system means that they may be missing some chaotic effect such as going past a tipping point.

And their results don't directly tell us how our lives might change.

As the saying goes, "It is difficult to make predictions, especially about the future."

How severe?

The programs predict a global temperature rise of 1.5°C or 2°C even if we do all we can. But there was a 6°C rise in the last fire age, so how bad can it be?

The effects are not linear. A doubling of the temperature rise makes things a lot more than twice as bad. That's because temperature rises are a shorthand for energy increases. So it is best to look at examples.

That's what we all want to know, yet it is the least certain part of the science.

The worst case

If we did nothing to stop global warming, we don't know how high the temperature would go, and it is exceedingly difficult to predict the effects.

Yet it is our mental image of this possible future that tells us how urgently we should be acting. So let's take it step by step as usual.

If the worst case happens, we will only have ourselves to blame.

Will we survive?

Will the human race survive if we do nothing about global warming?

The short answer is that there is no scientific consensus which tells us the answer, one way or the other.

There are three main considerations on the next three pages.

The thought that the human race might not survive is frightening.

The last fire age

One question is whether the last fire age, with 6°C of global warming, was survivable.

There is a clear answer. Although things were tough, and many species didn't make it, many mammals, including our own ancestors, did indeed survive.

But that involved migrations across continents and, to some extent, evolutionary changes.

Thank you for the survival of our ancestors.

In the last fire age, the temperature rose over a matter of centuries.

In our case, the temperature is rising over a matter of decades.

It is this speed that puts survival in doubt.

The pace of changes, both good and bad, that we have brought about is extraordinary.

Development

Predictions of the extinction of the human race are based on nothing changing. But that's not realistic.

Although the human race can be greedy and short-sighted, it also has an insatiable appetite for scientific and technological development, so those won't stagnate.

And as the temperature rises, leaders will not be able to ignore what's under their noses, so politics won't stagnate either.

We are able to change our minds, and improve, over time.

A balanced prediction

Overall, a reasonable guess for global warming if we miss the deadlines is 4°C.

There would be flooding of coastal cities, droughts and famines especially in poor countries, and a lot more weather disasters. It would not be the end of the world, but there would be radical changes which are well worth avoiding.

Even with this muted prediction, the level of urgency is very high.

What about rises of 1.5°C or 2°C , as in the [Paris agreement](#)?

Roughly, a rise of 1.5°C is described as 'manageable'. It would be only a bit worse than what we have already experienced, and we should be able to live with it.

Roughly, a rise of 2°C is described as 'unpredictable'. We could probably live with it if we had to, but we don't really know what life would be like.

If we have reached 1°C then 1.5°C can't be far away.

The IPCC publishes reports. The best to look at is Global Warming of 1.5°C (related to the Paris agreement). It is not great bedtime reading, but parts can be skimmed.

As well as summarizing scientific consensus, with each scientific statement marked as "high confidence" or "medium confidence", it has a lot to say about practicalities, politics, economics, and ethical fairness.

Legalese is so difficult to read.

One more question about what is happening is whether or not we are witnessing another extinction event.

The Earth has maybe tens of millions of species. Perhaps tens of thousands are under threat. That means we are nowhere near to a percentage high enough to call it an extinction.

Is it an exaggeration, just for effect?

On the other hand, we don't know how much worse things may get, so it is entirely possible that we are seeing the beginning of an extinction.

These pages, like many sources, concentrate on human issues, saying little about animals and plants.

Fortunately, the things we need to do to tackle our own problems almost automatically benefit animals and plants too.

So it is an exaggeration containing a lot of truth.

This section is about what society as a whole can do about green issues. The next section is about what choices you might make as an individual.

This section affects you, because the individual choices you make, the small-talk you enjoy with family, friends and neighbours, and your support for politicians or parties or groups or causes, all matter.

I will try to do my bit, and spread the word.

What needs to be done? In one sense, the answer is simple. We need to reduce expansion, consumption and pollution to manageable levels.

Half of the problem is scientific. We need to know what might work and what won't.

And half is political. We need levels of agreement, cooperation, and effective action, especially internationally, that the world is not used to.

I would love to know what works, scientifically and politically.

What is the bottom line, from the scientific point of view?

The best guess, if not consensus, is that the problems are solvable, assuming continuing study and continuing creative and innovative development of technology.

However, we are behind schedule, and we need to be getting on with the necessary changes with great urgency.

Some say time is running out. There is some truth in that.

Technology

You may feel that technology has caused the problems. But technology itself is not bad. It has created our highly civilized and cooperative society. (Would you want to build your own house, grow your own food, make your own goods?) And it is linked to intelligence, so to reject it might be to revert to a mindless animal existence.

Technology seems to be essential in solving our problems. It just needs to be used well instead of badly.

Do I control technology, or does technology control me?

What is the bottom line, from the political point of view?

The best guess is that most of the progress made so far has been cancelled out by slippages elsewhere. It is a case of three steps forward and two steps back.

However, awareness and resolve have recently grown considerably, to the point where real and effective change feel possible.

Political reluctance just reflects our individual reluctance.

This is not about party politics, or political ideals.

Arguably, the best political systems in the world are benevolent dictatorship, enlightened communism, and smart democracy. And the worst are oppressive dictatorship, corrupt communism, and dumb democracy.

So what matters is not the system, but what it achieves and how.

Human systems have human weaknesses.

Expansion

We've seen that the population growth rate is slowing.
What does it take to stop the growth altogether?

We are used to growth, but it is a bad habit.

China's 1 child policy (or 2 then 1 then 1.5 then 2 child policy) gets a lot of attention. Surely China should at least be admired for tackling the problem head-on.

If you don't like the approach, remember that's from the perspective of our culture, not China's.

Fortunately for our culture, eradication of poverty, education, empowerment of women, family planning, financial incentives etc., work well.

We can all join in by promoting the right attitudes.

Consumption

Our appetite for goods and energy tends to keep rising.

You could blame it on 'development'. People in developed countries have a carbon footprint which is many times larger than people in under-developed countries.

But it is development which lifts countries out of poverty, so this is not something we want to reverse.

Thank you for the blessings of developed countries.

A developed lifestyle would be OK, if our demand for goods and energy didn't keep going up.

That's partly our fault as greedy consumers. But it is also due to the ingrained attitude in business, government, the media, etc. that we need continual economic growth.

This attitude needs to be challenged. Economic growth has little relevance in a well developed country.

What's the alternative to continual growth?

Quantifying happiness is odd, but the move away from GDP and towards GNH has surely got to be a good one.

The vast majority of people in developed countries would be no happier if they had more money. The most important impediments to happiness are perceived inequalities (rich/poor, minorities/majority). These aren't surprises, but it is useful to have them as established and quotable facts.

I like the idea that we can become happier at the same time as greener.

Issues of pollution are complex and detailed. But there are more and more renewable, recyclable, and bio-degradable options available to us all the time, including bio-degradable plastics.

One measure of how well we do is landfill. A landfill site represents failure, mostly. The only plus is that it is a carbon store. But it still leaks methane.

I will look out for better options, just as much as I look out for better deals.

The big pollution is carbon, mostly a side-effect of our appetite for energy.

Recent studies suggest that all the good things that have been done so far have made little discernable difference

But other studies show progress, and some commentators predict 2020 as the turn-around year when global emissions will start falling.

There are lots of reasons for both pessimism and optimism. It is difficult to maintain a balanced attitude.

The consensus view now is that there is one essential ingredient in the solution. That is to stop using fossil fuels as soon as possible (long before they run out) and leave them in the ground.

This is tough, because it means converting multi-national coal, oil and gas companies into renewable energy companies, worrying about the economic basis of whole countries, and potentially changing everyone's lives.

This is a lot to ask the world.

Replacement

Getting rid of fossil fuels is radical, but necessary. But moving to a low-energy lifestyle seems unattainable.

So an important ingredient in solving the problem, as well as curbing the growth of energy demand, is to work out what could replace all that fossil fuel energy. Is renewable energy enough?

I don't know as much as I should about renewable energy.

A lot of renewable energy is being produced. The trouble is, renewable energy is worth nothing, if its only effect is to increase energy usage. It is only useful if its effect is to reduce the use of fossil fuel energy.

Of course, it is good that renewables have been and are being developed, because they are surely essential. But the right measure of progress is not how much renewable energy is being generated, but how much less fossil fuel is being used.

Thank you for renewable energy sources.

The same goes for greater efficiency. Typically, if a product becomes more efficient, it becomes more common, and its overall energy demand goes up.

For efficiency gains to be useful, we have to find ways to make sure that their effect is to reduce energy demand, not increase it.

It is about measuring the right things, again.

Since gains can so easily be cancelled by losses and by increased demand, it is important now to use total net emissions as the measure of progress, with zero as the target.

'Net zero' means any remaining emissions need to be balanced by carbon offsetting.

The world needs to reduce net emissions to zero.

Carbon capture

Among other ways to capture carbon, it is possible to extract carbon dioxide from the air directly. Plans for limiting global warming depend on it, to offset such things as natural gas, and plane flights which can't realistically be stopped any time soon.

There is some of it going on already, and it has the advantage of using little land.

Thank you for good uses of technology.

Renewable energy sources almost all need lots of land. Land is also needed to live on, to grow food, to store carbon in forests, and so on. So a key feature in scientific studies of what things work best is how efficient they are in their use of land.

Thank you for the land we live on and off.

One example of this land-based analysis is with biofuels. That means growing renewable crops to produce a replacement for fossil fuels, and/or take carbon dioxide out of the air.

Although they have important uses, they are now seen as something to be limited, not encouraged, because they are a relatively poor way to use land.

Biofuels used to be good. Fashions change, even in science.

Animal farming can be a very inefficient use of land (including growing crops to feed animals) and is the single biggest cause of deforestation. So meat eating urgently needs to be reduced.

However, animal farming is almost the only way to use certain common types of land, and can be done well, so it is not sensible to reduce meat eating to zero. It just needs to be reduced by some reasonable fraction.

How can this be done, while being fair to farmers?

A lot is said about cows producing methane. But, because methane doesn't stick around in the atmosphere very long, it is very much a secondary issue.

Reducing meat consumption, and promoting farming methods which lead to fewer emissions, would probably be enough.

Some recent arguments about methane seem quite heated.

Solar power

All energy comes from the Sun, and the most efficient way to use it by far is to gather it directly with solar panels. It is a hugely more efficient way to use land in hot countries than other energy sources.

A lot of work is going into large-scale solar farms especially in desert areas, along with techniques for storing and transporting the energy, and ways of exporting it from one country to another.

We aren't fully aware of the potential of solar power in the UK.

Land studies even clarify the situation with bicycles. The problem is that cyclists eat more, making cycling a much less efficient form of transport than people think. In fact if everyone cycled everywhere, there wouldn't be enough land in the world to grow the extra food needed.

So, although cycles remain a good individual choice for many reasons, they are not a significant solution to the demand for transportation.

It is still very much worth cycling, for those who want to.

Electric cars and other vehicles are going to be utterly essential, because we have to stop using petrol.

Somewhat surprisingly, electric bicycles powered from solar panel energy sources turn out to be potentially the most efficient means of future transport. It remains to be seen whether they will become genuinely important.

Sooner or later, I will have to think about having an electric car, or even no car.

What about air travel?

Surprisingly, electric planes are becoming practical, which would get rid of the pollution, if the electric energy is clean.

Also, carbon-neutral aviation fuel is being developed.

However, carbon offsetting, and limiting of air flights, are likely to be a high priority for a while.

I need to think about my regular holiday abroad.

New technology

There are many new technologies on the horizon, for gathering energy, reducing pollution and so on.

I will keep a look out for new and interesting technologies, without being taken in by claims that they will solve the world's problems.

The top emitters are: China, USA, India, Russia, Japan, Germany, Iran, Saudi Arabia, South Korea, Canada, Mexico, Indonesia, Brazil, South Africa, Turkey, Australia, UK, ...

Almost all countries except the USA, plus an alliance of half the states in the USA, support the Paris agreement.

The agreement includes allowances and aid for poor countries.

Thank you for this unprecedented level of international cooperation.

About 15 countries, including the UK but not the biggest countries, have committed to zero net emissions by 2050. Success would strongly encourage other countries to follow.

It is hoped that worldwide reduction to zero emissions can be achieved before 2070 to stop global warming before 2°C.

We need the big countries to follow suit.

There are perhaps five areas in which work is needed in the UK to reach zero emissions.

They are power, farming, transport, buildings, consumption.

The UK had a huge influence in starting the industrial revolution. Perhaps it can now have an equal influence in mitigating its effects.

In the UK's National Grid, demand for electricity has actually fallen since about 2005.

And the net carbon emissions from generating electricity have also fallen, by about half. There seems to be reasonable confidence that emissions can be reduced to zero before 2050.

This is good news.

Solar power doesn't work as well in the UK as in hot countries. On the other hand, wind power works well, partly because we are surrounded by shallow seas.

The UK will always need a complex mix of energy sources. (The free book linked to is mildly out of date, but still good. Sadly, the author David Mackay died in 2016.) For now, anyway, that includes nuclear power.

Nuclear power produces dirty and dangerous waste, but in minute quantities. It still has a bad reputation because of the early false link with nuclear bombs.

Farming produces emissions, but good farming also captures carbon in soil and plants, and can make a positive contribution.

There is [a plan for UK farming](#) to be carbon neutral by 2040.

This is also good news.

UK Animal farming

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Animal farming in the UK is already done well. In fact, the plans for reaching zero emissions in farming don't require a reduction in UK meat production.

So UK reduction in meat eating should be aimed at reducing imports.

This is good news for UK carnivores.

New fossil fuel vehicles will be banned in the UK in 2035 (brought forward from 2040 to improve the chances of carbon neutrality by 2050).

The aviation industry has a plan to become carbon neutral by 2050, by a combination of using greener fuel and carbon offsetting.

This is more of a challenge, but achievable.

Buildings cause emissions when they are built (especially the use of concrete) and through energy inefficiency when they are heated.

There is a framework for zero carbon in place to promote carbon neutrality.

This is also a challenge.

For most manufacturing and industrial processes, there are now known ways to reduce emissions close to zero.

Issues to do with recycling, biodegradability and waste are ongoing.

An important move is to avoid sending food and garden waste to landfill, where it rots and produces methane, but to compost it to capture the carbon.

This is a complex issue, involving us all.

This section is about what you can do as an individual. We like to feel we are doing our bit. If we all do our bit, will that solve the problems?

The answer is yes, provided that scientists do their bit, and technologists do their bit, and governments do their bit, and companies do their bit, and people with influence do their bit, and the media do their bit, and so on. So have a think about the suggestions coming up.

I would like to get a clearer idea of what it means to do my bit.

Don't panic

The worst thing you can do is to become paralyzed by eco-anxiety and end up doing nothing.

Suggestion: Take the opposite approach: keep stress levels low, but investigate some simple actions you can take.

I would like to aim for a low-stress life.

Check your footprint

Doing your bit may be easier than you think.

Suggestion: get a very rough idea of your carbon footprint by filling in a five minute [questionnaire](#) If you can reduce it to 100, you are doing your bit. If it is below 100, you may already be doing more than your fair share.

Spread the word

People don't like being told what to do. So how can things change? It is easy. Any advertiser will tell you how easy it is to persuade people, without them even consciously realizing it.

Suggestion: spread the word. Talk to other people about green issues, or support good causes, to help build good society-wide attitudes and habits. This could easily be more important than your own individual contributions.

Maybe I have more influence than I think.

It is important to do things that are effective, not follow fashion or fall for green marketing.

Suggestion: Every time you come across a new issue that you haven't thought about before, do a little bit of research to see if you can find out the real truth or current best guess about the issue.

There are a lot of green issues.

Have fewer children

The word needs to be spread that the UK population is still growing when it probably shouldn't, and that the quota for a family is 2.1 children, not the old-fashioned 2.4 children.

Suggestion: Find gentle ways to tell people that fewer families should have three or more children. The challenge is to pass that message on, without criticising anyone after the fact, or making any parents feel guilty, or making anyone feel unwanted.

It is difficult to talk about these things.

Have fewer pets

120

A pet is another mouth to feed. The world can't afford it if everyone has a pet. Fortunately, not everyone is a pet person, so there is some wiggle room.

Suggestion: if you have a pet and are tempted to get another, think twice. If you are thinking about a replacement, consider downsizing. If you need a pet, get one, but ask yourself if it needs to be a big meat-eater.

Everyone has rights, yet between us we need to avoid going too far.

Buy less stuff

Shopping has become a pastime or therapy, instead of an essential.

Suggestion: buy more second hand things, and make things last. Try advanced window shopping: look at things, pick them up, try them, enjoy them, then put them back.

I should divert my shopping habit in healthier directions.

If world meat consumption halved, the problems caused by it would go away.

Suggestion: Aim to eat half as much meat as you used to. Perhaps the easiest approach is gradual. Add another non-meat recipe to your repertoire every now and then. Aim for one meat-free day per week. Then increase it in stages. Make sure you enjoy your food, so you can keep up good habits.

Vegetarians and vegans are doing more than their fair share, but it is we carnivores who need to change our habits.

Waste less food

123

Throwing away food because you've forgotten about it is not a good idea.

Suggestion: Get into the habit of doing a trawl through your fridge or larder for things that need using up when planning a meal.

Maybe throwing anything valuable away isn't a good idea.

Recycling is essential. The ideal is to avoid anything going into landfill. Using sustainably produced materials which are bio-degradable counts as recycling.

Suggestion: Challenge yourself to increase your recycling and reduce your landfill rubbish. Try to make sure food or garden waste gets composted to capture the carbon, rather than going into landfill which causes methane pollution. Of course, you are limited by your local recycling rules.

Eventually, everything has to be recycled except sunlight.

Use less electricity

Reducing demand is a great way to help energy producers to go green.

Suggestions: spend a short while checking how fast your meter goes round, as you switch things on and off, to get a feel for where worthwhile savings might be made. Check any device that gets warm, because it might be a giveaway. Check how well your home is insulated. Check that the devices you leave on standby genuinely use negligible amounts of energy.

Demand in the UK has gone down in recent years.

Energy loss from heating homes is considerable in the UK, even when insulation is good. The energy lost goes up drastically with the temperature difference between indoors and out.

Suggestions: Limit your maximum indoor temperature, e.g. to 20°C, wearing more layers if necessary. Make sure your heating is off or low when nobody is home and at night. Do whatever is needed to stay safe and reasonably comfortable, though.

Habits can be changed, with determination.

Travel creates a lot of demand for energy, and a lot of it is unnecessary.

Suggestions: Check whether all your journeys are really necessary. Travel more on foot or by bike, if you can. Especially take fewer plane flights. Can some of your holidays be closer to home?

It has become a national habit to fly on holiday.

The plan in the UK is for all cars to be electric by 2050. An electric car or good hybrid is worthwhile now, to reduce local pollution, start a good habit, and set a good example. There are teething problems: cost of buying, range, distribution of charging points, time to charge, and electricity not yet being fully green.

Suggestion: If you have a petrol or diesel car, start planning when you are going to go electric.

Will the national grid be able to cope? The hope is that off-peak charging will help limit peak demand.

You may not think of yourself as an investor, but if you contribute to a work pension, then you are.

Suggestion: check your investments. Divest from fossil fuel companies, or put pressure on those who invest on your behalf, or at least ask questions.

Investing in fossil fuel companies is to give them direct support.

Find more lists

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There is a lot of information out there, if we choose to go and look for it, including lots of good ideas about what to do to help.

Suggestion: find other lists of things individuals can do to help.

Maybe there aren't any new thoughts. Somebody else has always thought of them already.

Books and other resources will be collected in this section.

Many people have thought deeply about these things.

There is no Planet B

132

See [book synopsis and sample pages](#)

Find out about author [Mike Berners-Lee](#)

An expert in carbon footprints explains the science behind global warming, without too much jargon, and explores practical issues, politics, economics, culture, and ethics.

See [review by Ian](#)

I'm used to artists' impressions of the future, maybe I'll try a scientist's impression.

Review by Ian

132a

The book is presented as a series of questions, each having a short answer and a long answer, making it ideal for dipping in a bit at a time. The questions range from "Should I go veggie or vegan?" to "What new ways of thinking do we need in the twenty-first century?."

For me, each issue is tackled in a no-nonsense practical way, but with good balance. For example, self-driving cars are presented as good when they improve efficiency, and bad when people overuse them by sending them off on their own to collect the odd items that they have left behind.

Although the book is very much science-based, there is a strong philosophical and ethical theme, especially in the later parts, and there is a very short section on the question "Where is religion and spirituality in all this?".

Hell and High Water

133

See [book synopsis and sample pages](#)

Find out about author [Alastair McIntosh](#)

A Scottish ecologist and activist explores the theological, philosophical and cultural aspects of climate change.

See [review by David](#)

How do ecologists view these issues?

Review by David (a)

133a

The book deepened my understanding of Human Hubris with the Tower of Babel as it starting point;

It made an interesting contrast between people of the Old Testament and people of this current age; they saw climatic events as demonstrations of God's Wrath, where in actual fact there may have been very little direct relationship between their actions and the unfolding geological events; we (modern people) on the other hand are succeeding in catalysing an earth response (which could be understood as God's Wrath) through our irresponsible use of resources and immense greed and yet we don't see the religious dimension in the unfolding environmental events...

Review by David (b)

133b

There was a very clever chapter on death, mystical death and how advertising companies for cigarettes were able to tap into our desire for the liminal (the experience of the sacred) and replace it with the liminoid (a false mystical experience).

Finally, the book bravely considered the question of: What if we fail to save ourselves and our planet? What does palliative care mean in the context of a dying (terminal patient) planet; how do we care for each other as members of that dying planet?

See [book synopsis and sample pages](#)

Find out about author [Robin Attfield](#)

A professor of philosophy and member of the Unesco working party on environmental ethics gives a scholarly introduction to environmental ethics.

See [review by Keith](#)

I don't often stop to think about ethics.

Review by Keith

134a

The author, a former student at Regent's Park College and now a Professor Emeritus at Cardiff University, takes us concisely through some of the basic issues as we try to think ethically in response to the crisis, like:

Do we really have an obligation to future generations? How do we work out principles for right action, especially when outcomes are uncertain? What is the role of religion in all this?

The Myth Gap

135

See [book synopsis and sample pages](#)

Find out about author [Alex Evans](#)

A political adviser and Christian explores stories and truth in society.

See [review by Keith](#)

There is a clear problem with truth in the world.

Review by Keith

135a

Alex Evans writes as a Christian with wide experience of working as an advisor within the British government and at the UN on climate change and related issues.

He suggests that the Bible's account of God's covenant with the earth and humankind can be an important resource and framework for understanding how to respond positively to the crisis.

Sustainable(ish) Living

136

See [book synopsis and sample pages](#)

Find out about author [Jen Gale](#)

Or visit [her web site](#)

An 'ordinary mum' shows how you can do your bit in everyday life, without changing your lifestyle.

Review to come.

My life is busy, but I can find time to read a book like this.

Be happy and green