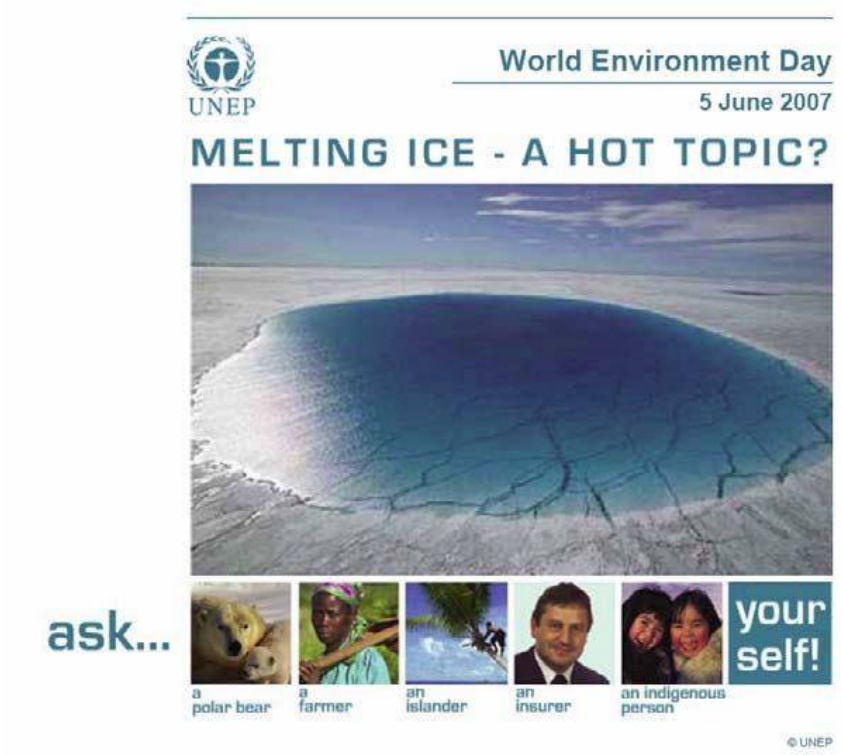
OIL SEARCH LIMITED



Climate Change: A Biologists Perspective

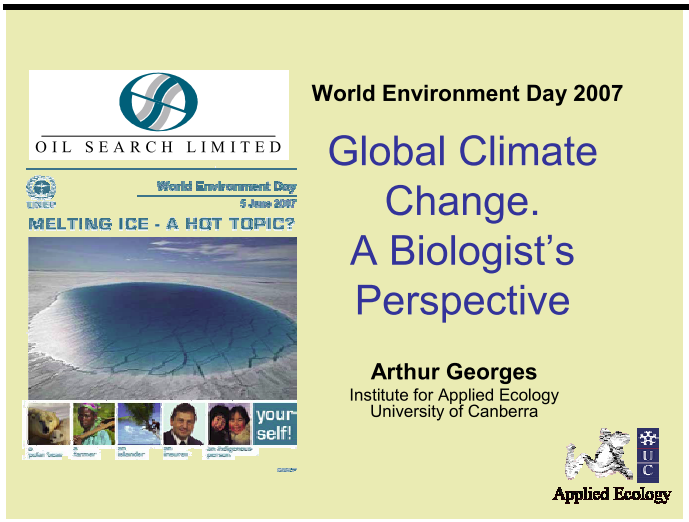
A World Environment Day Presentation

Climate change is in the news almost every other day. It is a hot topic. Is the climate indeed changing, and how fast? Are we humans responsible or are natural forces at play? What will it mean for us, our agriculture and our economy, and for some island peoples, the very land upon which they live? These are questions brought into sharp focus for Australians by the combined effects of increased diversion of our scarce freshwaters to meet production goals and the current drought. Many people are very worried about the future. Should we be concerned? And what about our native wildlife? How will they respond? They have seen it before, and those species with us today have persisted. But is the rate of change too fast, or perhaps more importantly, as we strive to protect our interests -- our economy and standard of living -- are we ignoring the needs of the native flora and fauna in these times of change?

Our Speaker: Professor Arthur Georges, University of Canberra
When: Tuesday 5th June 07
Where: L27 Conference Room
Time: 1130 – 1300hrs

Nibbles and soft drinks available.

Sydney Green Office Group



It is great to be here at Oil Search on World Environment Day, and I thank Dr Yaru for inviting me here to speak today.

It is a very important day in the calendar. It is important because it takes our minds off the busy work of corporate life (in my case academic life), and provides some time to reflect on the broader picture of how what we do can influence the environment in which we live and work.

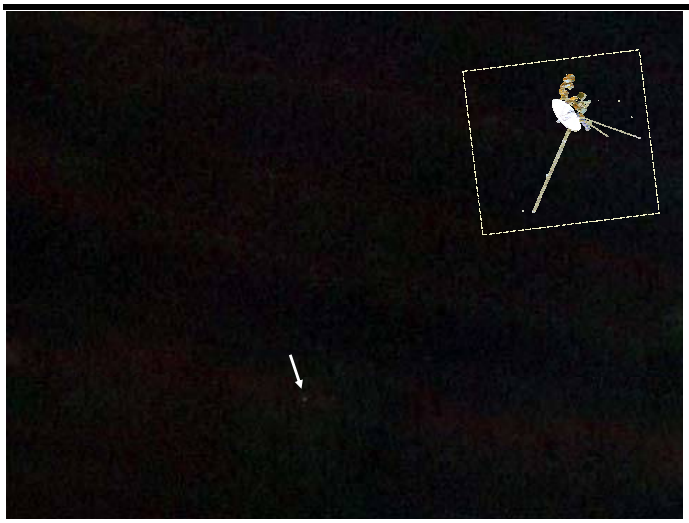
Today I am going to talk on one facet of this subject, on global climate change, and indeed, I will narrow it further. Ben has asked me to focus in particular on sea level change.

I am not a climate change specialist. I am a biologist, so you will see climate change and its impact through a biologists eyes.

I will however talk about the changes we are bringing about to our atmosphere through industrialization, the changes we are bringing about through global warming, melting of ice sheets and thermal expansion of the oceans, what this will mean for human societies.

I will then move on to more familiar ground for me, and talk of what global climate change will mean for our native flora and fauna. They have coped with climate change in the past, will they be able to do it this time around?

I will then move to less familiar ground for me, and finish by presenting what I see as a climate change triumvirate – each presenting differing views on how we should proceed. I believe there is a special role for large corporations in meeting the challenges we face from global warming.



I would like to begin with a very famous picture. Does anyone recognize it? *[Arrow and probe not visible]*

What about now? *[Show arrow].*

It is a photograph of Earth taken by the voyager space probe as it moved at 66,000 km per hour from the solar system into interstellar space. It was taken at a distance 100 times that of the distance between the earth and the sun. *[Bring in Voyager Probe]*

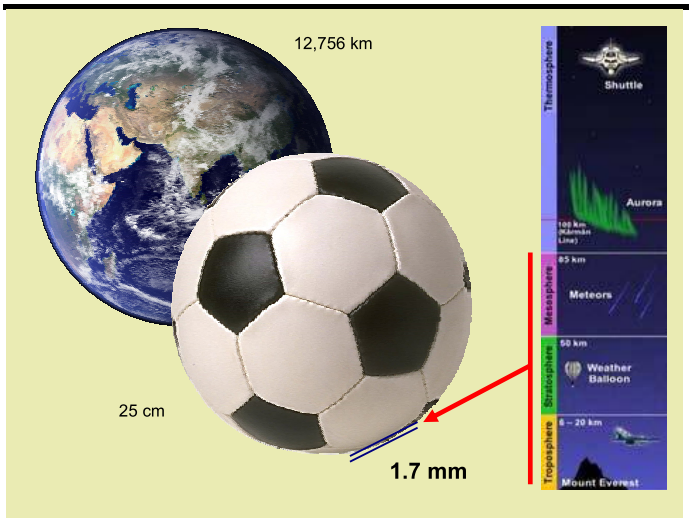
How insignificant do we appear? And how much more insignificant when we learn from the explorations of Hubble that not only are there 200 million stars in our galaxy, the Milky Way, but there are billions of galaxies in the visible universe, each with billions upon billions of stars.

A photograph from Mars does little to boost our egos (That is us on the left).

It is not until we get very close that we recognise our planet as something special – the blue oceans, the green and brown continents. Wonderful images such as these have come to be associated with what we call home.

There is clear evidence also of an atmosphere and weather patterns. Satellite images of weather patterns, major storms and cyclones are now common place.

It is to this atmosphere that I want to draw your attention.



The Earth has a diameter of 12,756 km. It is a big ball.

I would like you for the moment to imagine it scaled down to the size of a soccerball, that is, 25 cm in diameter.

How thick would be the atmosphere?

Well, its 1.7 mm, less than 2 mm. It is a tiny film of gas surrounding our planet.

Yet in that tiny space we are all born, we breathe, we endure storms and cyclones and raging seas, engage in wars. We participate in sports, climb Mount Everest, conduct our commerce, fly from Sydney to London. In fact, all of these activities occur within a fraction of a millimetre from the surface of our soccerball (20 km translates to 0.4 mm). I find that quite remarkable.

Yet it is into this finite space we call our atmosphere that we pump all manner of gaseous and particulate wastes, and we have done so since the beginning of the industrial age. We have treated our atmosphere as an infinite sink, or as if there were no tomorrow.

There has been pollution from our factories and power stations, from agricultural practices, and from the transport industry. I show land clearing here also, as it is a major contributor to CO_2 to the atmosphere, through the release of CO_2 from felled forests, exceeding that of the transport industry.

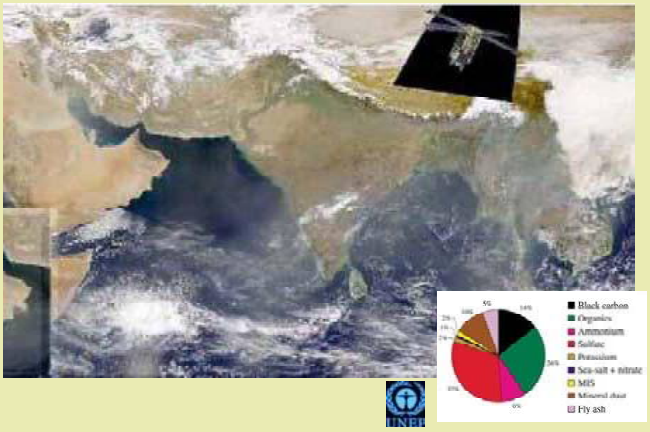
To be fair, we have long known of the local affects of air pollution in our industrial cities. Shown here is Bejing on a day after rain, and again on a sunny day. I could have shown you Los Angeles or Mexico City or any number of industrialized cities.

We have addressed these issues by reigning in the excesses of major industrial polluters, and by the addition of catalytic converters to our cars. Our major cities are cleaner today than they were in the 60's.

But largely, these problems have been viewed as local issues.

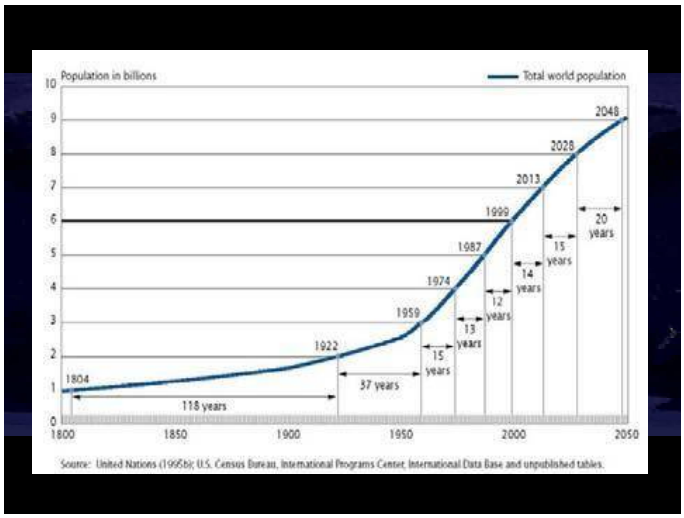
Or as a temporary issue, as in the case of the great Asian fires in the late 1990's.

Air Pollution Goes Global



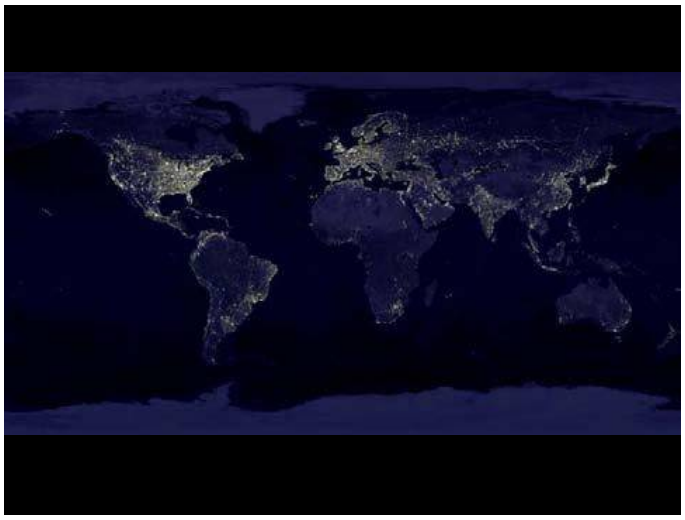
But atmospheric pollution is no longer a local problem. Air pollution has gone global.

These dramatic images from space show the so-called Asian Brown Cloud – a vast plume of pollutants wafting off the Asian continent. This photograph was taken over South Asia by NASA in 1999 and graphically illustrates the extent to which we are having an influence on our atmosphere.

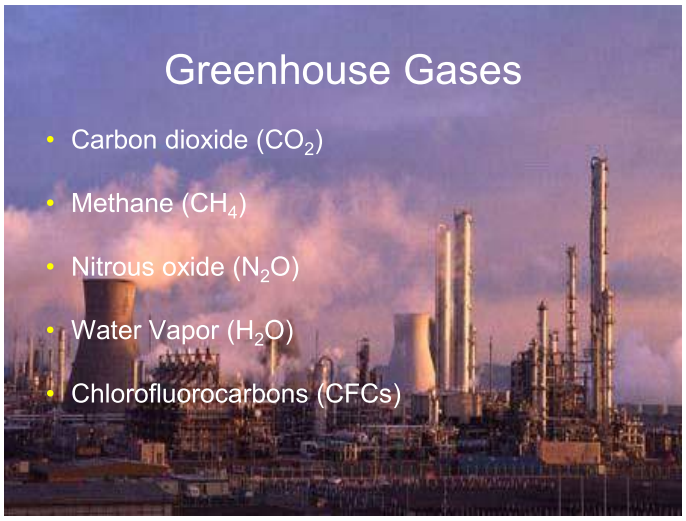


The reason of course lies in our population growth, coupled with the rate in which we have brought societies into the industrial age. When I was a child (and I am not as old as I look), there were 3 billion people on the planet. There are now 6 billion.

If Ben and I lose a bit of weight, do a bit of exercise, reign in some of our more outrageous recreational activities, we might well live to see the human population rise to 9 billion in 2038.



Human populations and associated industrialization are now global in extent, as can be seen from yet another famous NASA photograph – earth lights at night.



I would like to turn your attention now to the greenhouse gasses. They are called greenhouse gasses because of their role in trapping heat from the sun at the planet's surface.

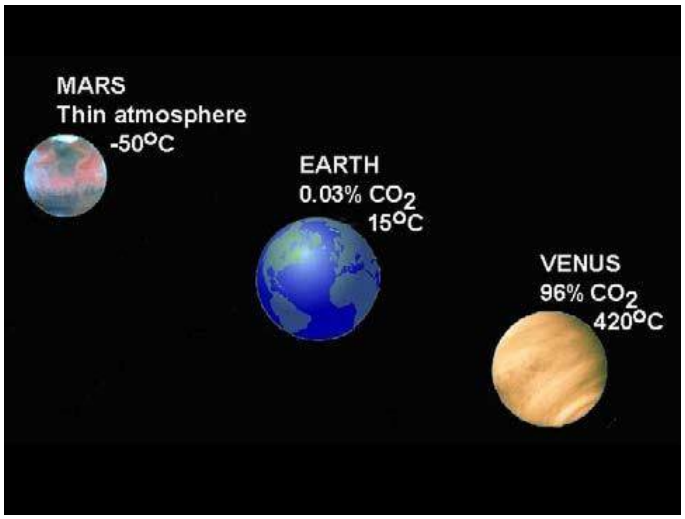
I won't go into these in great detail.

Carbon Dioxide is the best known, as it is the one most commonly featured in the press. It is released when fossil fuels burn, when forests are cleared, from wildfires and agriculture.

Methane is produced by bacterial degradation of organics, in rice paddies and landfills. Methane traps 33 times more heat per molecule than carbon dioxide.

CFCs are found in refrigerants and aerosol cans. They trap hundreds of times more heat per molecule than CO_2 and therefore contribute disproportionately to global warming. Government regulation has brought CFC emissions under control.

And we must not forget that water vapor is a greenhouse gas.



We know that atmosphere, and greenhouse gasses in particular, are important in determining surface temperatures of our planet because

- **Mars, with hardly any atmosphere has a surface temperature of -50C,**
- **Venus is of similar size to Earth but has an atmosphere that is 96% carbon dioxide. It has a temperature of 420C.**
- **Our temperature averages about 15C.**

Early predictions

Svante Arrhenius, 1896

The basics of the greenhouse effect have been understood since 1827, and a quantative estimate of climate sensitivity was first given in 1896.

Few results in any science go back as far or rely on such fundamentally understood principles.

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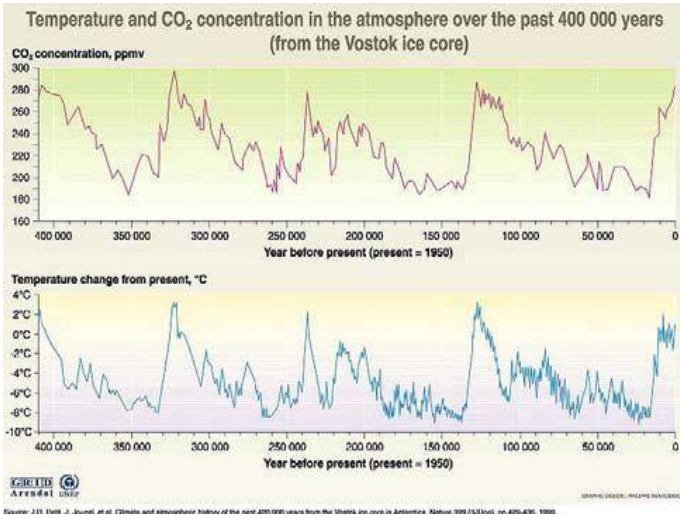
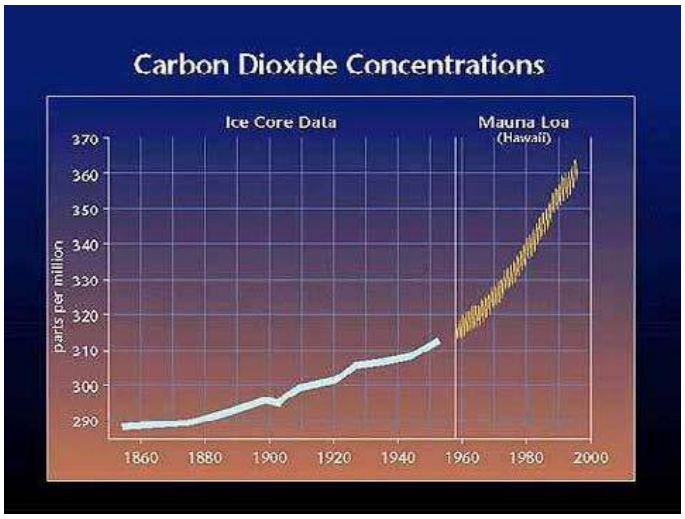


Closer to home, studies of gases in bubbles in ice cores show a strong correlation between atmospheric carbon dioxide and global temperatures. Temperatures have gone up and down by about 8°C over the last 400,000 years, closely tracking CO2 levels.

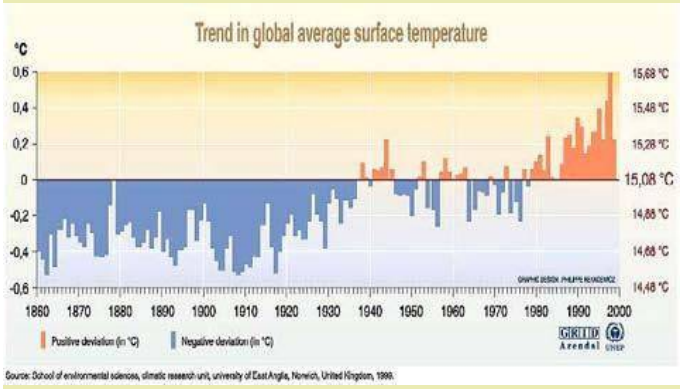
There is a strong relationship between the two.

There is a positive feedback loop involving the oceans. As the planet warms, CO_2 is released from the oceans, reinforcing the warming trend. Indeed, warming caused by other influences (our orbit) may precede rises in CO_2 levels.



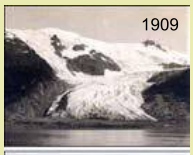
The ice core data show a progressive increase in CO_2 since industrialization, an accelerating trend that is evident since we began seriously measuring it in 1959. Here you can see the rise in atmospheric CO_2 on Mauna Loa, Hawaii, with such sensitivity that the annual cycles of growth are evident in the CO_2 levels.

The current level of CO2 in the atmosphere is around 430 ppm, compared with only 280ppm before the Industrial Revolution.



Source: School of environmental sciences, climatic research unit, university of East Anglia, Norwich, United Kingdom, 1999.

These concentrations have already caused the world to warm by more than half a degree Celsius and will lead to at least a further half degree warming over the next few decades, because of the inertia in the climate system.



Toboggan Glacier (Alaska)

Muir Glacier, Alaska

Glaciers are retreating

Alpine glacier, Austria

There are a number of dramatic indications of this rise in global temperature. A number of glaciers are on the retreat.

- **The Toboggan Glacier shown here in 1909 and again in 2000.**
- **The Muir Glacier, again of Alaska, shown here in 1941 and again in 2004.**
- **The Alpine Glacier of Austria, shown here in 1900 and again in 2003.**

We would all be aware of the retreating ice cap of Mount Kilimanjaro in Africa.

Hansen, Scientific American, March 2004

MELT

Greenland Ice Sheet Melting

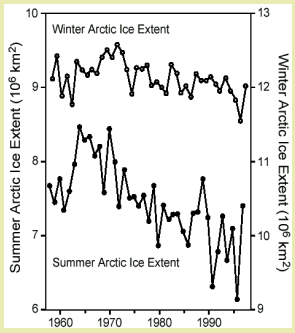
Conrad Steffen & Russell Huff, University of Colorado

Greenland, our smallest continent, is capped in ice, but it too is melting, and scientists keep revising their estimates of the rates. If it all melted, and this is unlikely in our lifetimes or that of our children or grandchildren (it will take 1,000 years), the sea would rise by about 7 metres. The graph to the right shows the summer melt in 1992 and again in 2002 – a disturbing trend.

Arctic Sea Ice is Melting

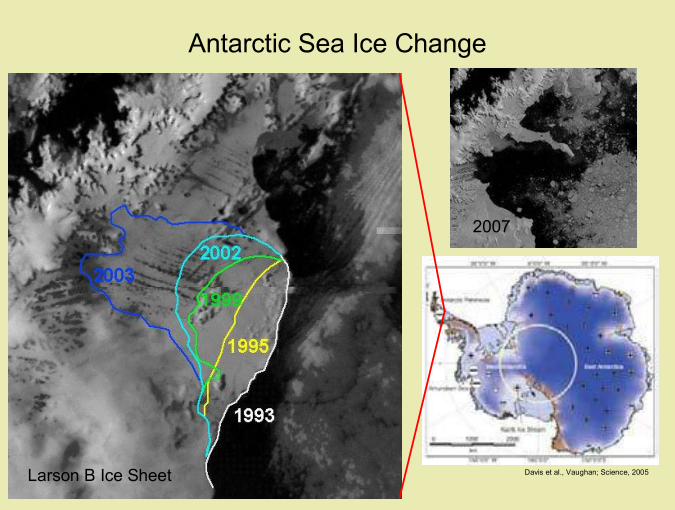
1990

2000



10% decrease per decade

Although less critical because here we are talking here of sea ice, the Arctic Sea Ice is retreating. The extent of summer sea ice has clearly decreased between 1990 and 2000. It is decreasing at a rate of about 10% per decade since measurements began in 1959.



Antarctica is interesting because precipitation rates there are actually increasing, but all the same there have been some catastrophic collapses of ice sheets in the west in recent decades.

Here I have pulled down some images and added the shifting boundary of the Larson B Ice Sheet before it collapsed in March of 2002. The sea remains clear of summer ice to this day (picture, upper right).

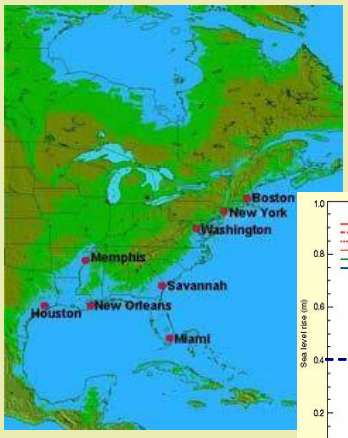
Its collapse is an indication of warming, but because it is sea ice, sea levels will not rise. There is concern however that the rate of discharge of adjacent glaciers has increased as a result of the collapse, and this will contribute to sea level rise.

[*Credit: Scripps Oceanographic Institute*]

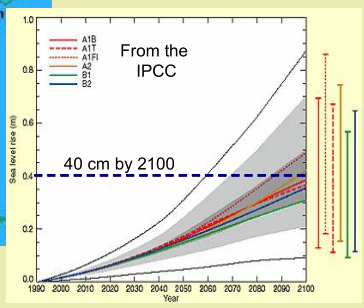
But by How Much?

Here is a prediction from the Lunatic Fringe

But by how much can we expect them to rise? The loonies have jumped on the band wagon and published dire consequences of a rise in sea level. Memphis & Washington would be coastal cities; Boston, New York, Miami and Houston would be lost. This would require a 100 m rise in sea level. No-one believes this to be likely.



But by How Much?



The IPCC, the Intergovernmental Panel on Climate Change, has weighed up the evidence and drawn upon the best available modeling to estimate sea rises over the next century, with a most likely estimate of 40 cm, 60 cm at worst.

I like to look back at the last interglacial period, when sea level was about 5-8 m higher than it is now, even though temperatures were only 1-2°C higher. History is a good teacher.

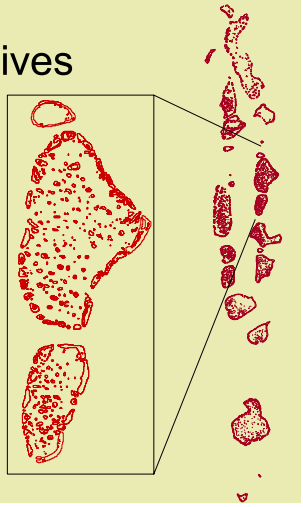
Three (3) million years ago when global temperature was 2-3°C higher, sea level was 25 m higher. The IPCC thinks this will take many centuries, but it could happen much sooner if there is a catastrophic collapse of ice sheets.

As with all risk assessments, we simply do not know for sure.

[Source of historical sea level data: New Scientist, May 2007]

The Maldives

- A chain of coral atolls 860 km long, 80 -120 km wide
- 1,192 islands, 199 inhabited, 143,000 people



It is very difficult for us to appreciate here in Australia that if the sea level rises a few tens of cm, say 40 cm, whole nations will disappear. Take the for example the Maldives.

- **A chain of coral atolls 860 km long, 80 -120 km wide**
- **1,192 islands, 199 inhabited, 143,000 people**

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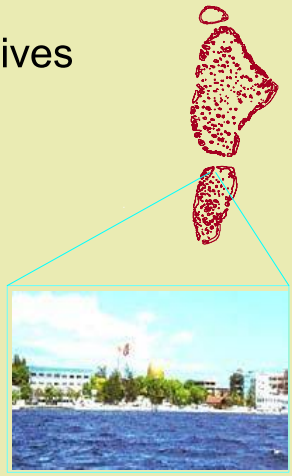
- 1,192 islands, 199 inhabited, 143,000 people
- Average height 1.5 m, 80% less than 1m above mean sea level
- 86 resorts, 5 airports



- **86 resorts and 5 airports.**

A thriving tourist economy supporting 143,000 residents.

The Maldives

- Inundation by the rising sea
- Erosion, aggravated by storm surges
- Salinization of ground and surface water supplies
- Increased depth of lagoons with loss of fish breeding and crash of seafood harvests

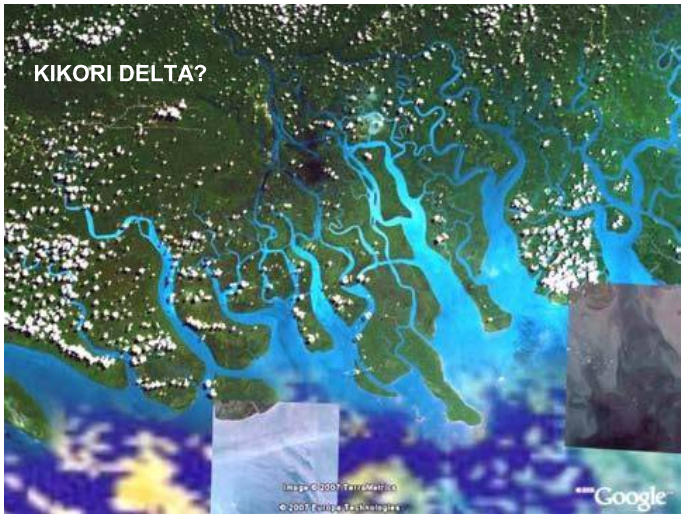
They are obviously very concerned.

They fear inundation by the rising seas. Before that occurs they anticipate massive loss of land and crops from erosion under the effect of heavy seas and storm surges.

They anticipate salinization of ground water and surface water supplies upon which they depend.

And they anticipate major changes to coral lagoon ecosystems as the water deepens, with loss of important fish and mollusk breeding areas.

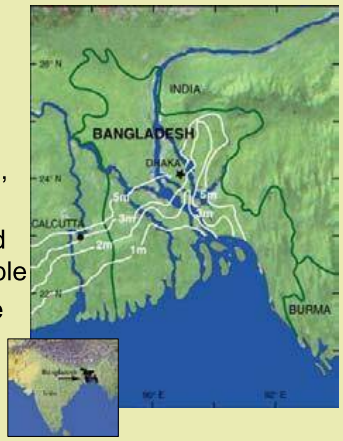
Basically they fear a collapse of their economy through loss of land, water supplies and local food supplies. Not a rosy picture, but it is one repeated in the Bahamas, the Marshall Islands and other island states.



Other low lying coastal regions are also likely to be affected. I am not sure what the consequences of sea level rise would be for the Kikori, which is an area of special interest to Oil Search, because I do not believe that there has been any modeling done. But there has been such modeling for a number of more populated river deltas.

Bangladesh

- 138.4 million people
- 134,000 km^2
- High monsoonal rainfall, flood-prone
- 1 m sea level rise would displace 15 million people
- Would we cope with the social and political disruption that would ensue?

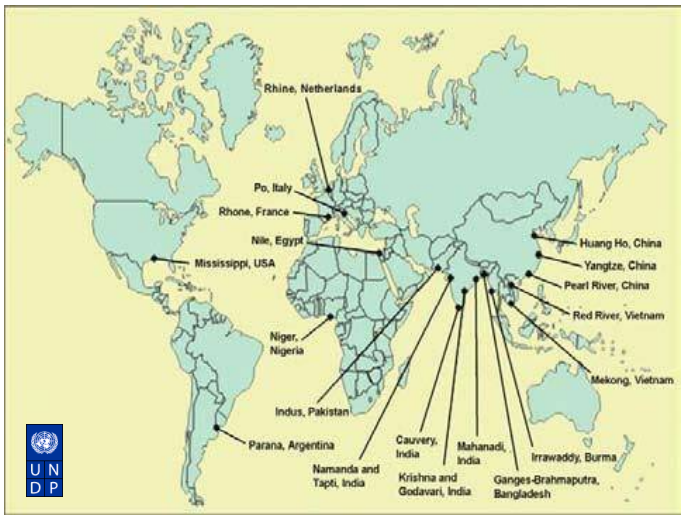


Adapted from Milliman *et al.* (1989 .

Bangladesh has a population of 138 million living in a land area of 134,000 km2, much of it river delta.

It is a country with a high monsoonal rainfall and is exceptionally flood--prone. A 1 m sea level rise would displace 15 million people.

Think about that. Would we cope with the social and political disruption that would ensue?



Bangladesh is but one example. There are similar delta areas scattered around the globe, on all populated continents – in China, Vietnam, India, Africa, Europe, North and South America.

Environmental Refugees in a Globally Warmed World
Norman Myers
BioScience 43:752-761

	Refugees (millions)
Bangladesh	15
Egypt	14
China	30
India	30
Other delta/coastal	10
Island States	1
Agricultural dislocation	50
TOTAL	**150 million**

In 1993, Norman Meyers published a paper in BioScience outlining what he saw as an emerging problem of environmental refugees in a globally warming world. The figures are truly disturbing. 100 million people would be permanently displaced from their homes by a sea rise of 1 m, and a further 50 million would be displaced by agricultural failure as rainfall patterns altered.

143,000, 15 million, 150 million. How would the world cope with this?

HIGH ROAD or the LOW ROAD

Report to the Pentagon

"Abrupt climate change could bring the planet to the edge of anarchy. Disruption and conflict will be endemic features of life. Once again, warfare would define human life. Climate change should be elevated beyond a scientific debate to a US national security concern".

Peter Schwartz, CIA consultant & former head of planning at Royal Dutch/Shell Group
Doug Randall of the California-based Global Business Network

The Observer, ***February 22, 2004***

What is the High Road?
Are we mature enough as a global community to devise one?

Probably not very well.

There is a high road, and there is a low road. Governments are very aware of this problem. I point you to advice given to the Pentagon by Peter Schwartz, former head of planning at Royal Dutch/Shell Group.

He and his co-author believe that

> ***"Abrupt climate change could bring the planet to the edge of anarchy. Disruption and conflict will be endemic features of life. Once again, warfare would define human life. Climate change should be elevated beyond a scientific debate to a US national security concern."***

I put it to you that this is the low road.

But what is the high road, and if it has not yet been charted, is the global community mature enough to devise one?

"The developed world will be far from immune"

Sir Nicholas Stern, 2007

Copyright: R.J.T. Klein

- Loss of infrastructure
- Reduction in available water (Europe, West USA, Australia)
- Disruption of agriculture
- Downturn in global GDP

Although the developing world will wear the brunt of the cost of global climate change, the developed world will be far from immune.

Loss of infrastructure in the USA alone will mount up to hundreds of billions of dollars according to an EPA report to Congress commissioned in the 1990's.

Preston and Jones in their 2006 report to the Business Roundtable on Climate Change estimate that river flows in New South Wales, including those supplying Sydney, will drop by 15% for a 1 – 2°C rise in temperature.

According to Sir Nicholas Stern, climate change may initially have small positive effects for agriculture in a few developed countries, but is likely to be very damaging if the much higher temperature increases expected by mid- to late-century materialize.

According to Stern, existing models that include the risk of abrupt and large-scale climate change estimate an average 5-10% loss in global GDP, with poor countries suffering costs in excess of 10% of GDP.


THE INDEPENDENT

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Climate change: What MPs think

Published: 15 November 2006

* What MPs think - introduction
* What MPs think - D to F
* What MPs think - G to H
* What MPs think - I to L
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* What MPs think - T to Y

Climate Change
is shaping up as the
greatest challenge
faced by our generation

The bottom line is that climate change is shaping up as the greatest challenge faced by our generation.

This is now widely recognized.

While shifting range or range expansion is a likely scenario for the more mobile of species, range contraction is a likely outcome of climate change for many others.

Here on our doorstep, we have the spectacular Corroboree frog which inhabits the subalpine regions of Kosciusco National Park.

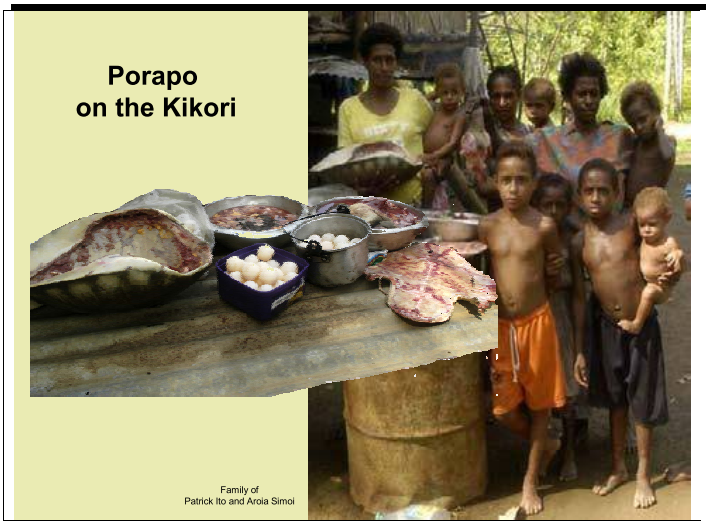
My colleague, Will Osborne, has been studying them for over 30 years and has seen their range progressively contract as the climate has warmed.

In 1989, there were 2,500 breeding pairs, in 1998 this had dropped to 500. There are now only an estimated 80-100 breeding adults remaining, and they risk contracting their range right off the top of the mountain, to extinction within 6 years.

This will be the plight of many montane species [*Burramys parvus*].

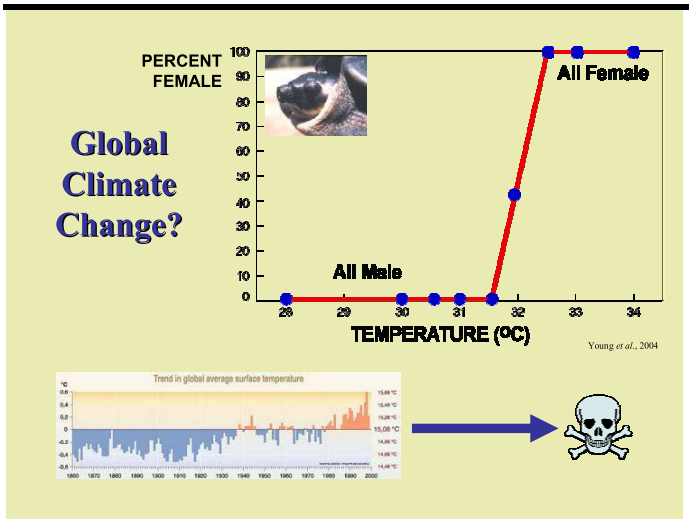
Other species have peculiar biological traits that on first glance, look to make them appallingly vulnerable to global warming. One such species is the pig nosed turtle of northern Australia and southern Papua New Guinea.

It is an important source of protein for villagers in the Kikori region. They catch the animals when they come ashore to nest in large numbers in the months of October to December. Both the nesting adults and the eggs are taken.



Everything is used. The eggs are boiled as snacks. Their contents are added to flour and sago to make cakes and patties. It is added to rice to add consistency and flavour. The meat is used in all manner of recipes.

What has this got to do with climate change?

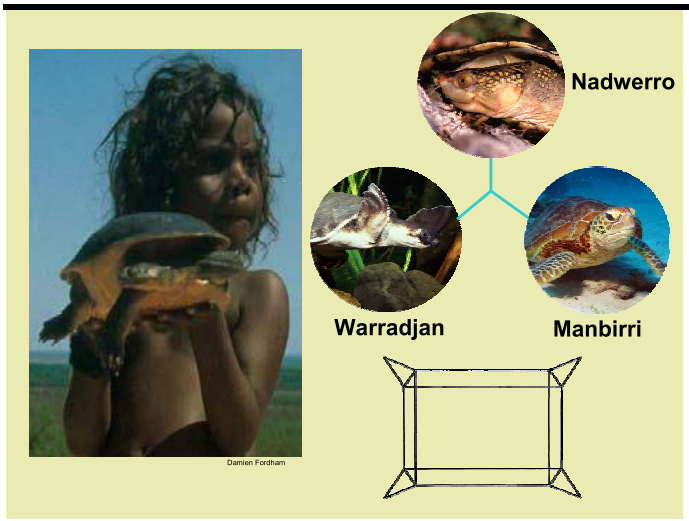


Well the sex of the offspring of this species depends entirely on their incubation temperature. It is something I and my students have been working on for many years.

Nests that incubate below 32°C produce no females, only males. Nests at higher temperatures produce only females, no males. A very narrow range of temperatures produces both sexes. Half a degree in either direction can mean all the difference.

I think you can see the potential for a shift in environmental temperatures to totally disrupt their population structure, and potentially threaten them with extinction.

Males are already hard to locate in the Kikori. Where are the male producing beaches, and how does their distribution relate to patterns of intensive harvest? Is the combination of harvest dynamics and shifts in climate likely to bring about a population crash?



Our native flora and fauna have seen climate change before, and they have coped. Why not again now?

Indeed they have seen it before, and the graph I showed earlier had the climate varying by 8°C over the last 400,000 years. The sea has been 5-8 m higher, and 120 m lower in that time. Climate change and sea level change have even been experienced by human populations.

The Aborigines of northern Australia refer to sea level change in their traditional legends.

In Kakadu, it is believed that Warradjan and Manbirri, the green sea turtle, are sisters (Manbirri being the younger). A long time ago when the saltwater was "going away", Manbirri decided to go with the salt water while Warradjan decided to stay in the freshwater with Naderrwo (Elseya dentata).

Stories about Warradjan are told with the aid of a "string figure". is made from two lengths of string manipulated by two people. This was shown to Aboriginal people by ancestral entities involved in some way in Warradjan's coming into being.

What is remarkable is that a story passed by word of mouth down the generations can contain references to sea level change that occurred at least 1000 years ago.

So our flora and fauna have coped in the past, but what we need to realize is that the speed with which global warming is occurring may be unprecedented, and the highly modified environment in which many species now find themselves (60% of Australian biodiversity lies outside reserves), presents our native flora and fauna with very great challenges.

It is estimated that warming of 2°C could leave 15-40% species facing extinction.

Challenge

What are we doing to interfere with the scope of our native flora and fauna to accommodate climate change as they have done in the past?

Sean Doody

The challenge for us is not how the biota will cope with climate change, but what we are doing to interfere with their scope to adjust as they have done in the past. This is a major challenge for biologists.

So climate change is a major risk for human society.

- **All countries will be affected by climate change, but the poorest countries will suffer earliest and most.**
- **Warming of 3-4°C will result in many millions of people being permanently displaced by rising sea levels, heavier floods and drought.**
- **There are economic downsides to action (1% of GDP if we act now) but the possibility of much greater losses of economic activity if we fail to act.**
- **We face great challenges if we are to conserve our native flora and fauna, with estimates of 15-40% facing extinction following even a modest rise in temperature of 2°C.**

A CLIMATE CHANGE TRIUMVIRATE

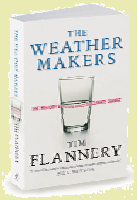
Voluntary action by well-meaning consumers is the only way to save the planet.

The world did not eliminate ozone-depleting substances by relying on the good sense of consumers. Governments banned CFCs.

Climate change is shaping up as the greatest market failure ever seen. Effective action NOW makes good economic sense.

What I see emerging from debate on this issue is a climate change triumvirate – three camps each with their own strong views on how to tackle climate change. I would like to close by elaborating a little on these.

A CLIMATE CHANGE TRIUMVIRATE



Voluntary action by well-meaning consumers is the only way to save the planet.

Climate change is the most serious long-term threat facing our planet. . . . . Personally, I have already turned down the Downing St thermostat by 1 degree . . . .

***Tony Blair**, British Prime Minister*

A major thrust of Flannery's book is that voluntary action by well-meaning consumers is the only way to save the planet. We should change our shower-heads, use energy efficient light bulbs, use public transport or cycle to work, and install solar panels on our roofs.

Tony Blair in a survey of what MP's think by the Independent Newspaper stated that "Climate change is the most serious long-term threat facing our planet. . . . . Personally, I have already turned down the Downing St thermostat by 1 degree . . . .". Flannery's call is clearly being adopted by some politicians.

A CLIMATE CHANGE TRIUMVIRATE

The most effective way for individuals to make a difference is to pressure governments to take collective action . . . .

The world did not eliminate ozone-depleting substances by relying on the good sense of consumers. Governments banned CFCs.

Hamilton is renowned for his broadsides on government, and more recently on Flannery. He argues that the world did not eliminate ozone depleting substances by relying of the good sense of consumers. Governments banned CFCs.

We did not address pollution issues in our major cities by relying on concerned citizens electing to add catalytic converters to their cars. Governments made them mandatory.

Hamilton argues that the most effective way for individuals to make a difference is to pressure governments to take collective action.

The challenge here is that climate change is not a national problem, it is a global problem, and we do not have a global government. This will require unprecedented inter-governmental cooperation. Kyoto was an attempt at this. It failed. Today we learned that India announced at the G8 Meeting that it will not come to the table.

An international emissions trading and carbon credits scheme will be a good start, as it will provide a level playing field for industry to engage constructively to bring about solutions.

But the real decision is how much carbon in total is to be traded. There is little environmental benefit in having a water trading system in the Murray Darling if you over-allocate the water.

You will be seen to be doing something, but will achieve nothing.

Ultimately we will have to reign in the carbon. Governments are very reluctant to do that because of what they see as immediate negative effects on the economy and their parliamentary terms. Governments do not look far beyond their parliamentary terms.

The STERN review is the first serious attempt to look at the economic costs of climate change, and in particular, the economic costs of inaction.

It is an economic assessment by a leading economist, Sir Nicholas Stern, former Chief Economist and Senior Vice-President of the World Bank.

He describes climate change as potentially the greatest and widest-ranging market failure ever seen. The economic benefits of strong, early action considerably outweigh the economic costs. The annual costs of achieving stabilisation between 500 and 550ppm CO_2e are around 1% of global GDP, if we start to take strong action now.

What we do in the next 10-20 years can have a profound effect on the climate in the second half of this century.

Change brings with it opportunity, and Stern estimates a burgeoning industry in clean technologies.

According to Stern, effective action NOW makes good economic sense.

All large corporations need to inform themselves of the key issues, evaluate their long term economic prospects under climate change, and the opportunities it might bring, and act now. If Stern is right, this will be in the interests of their bottom line and the environment.

If large global corporations come to share this view, change practices, and put pressure on governments to ensure no disadvantage for those that do, we will see some real changes.

I see great hope emerging from the Stern Review.

I recommend that you all read at least the full executive summary.

The evidence of global warming is mounting, and it is strong. The picture the IPCC have painted may well not come to pass. However we need to look at climate change as a risk management problem.

When I got in my car to come here today, I did so knowing that I might have an accident and be seriously injured or killed. I did not turn around and go back into my house (we will not be leaving coal in the ground). Nor did I drive with gay abandon throwing caution to the wind (the do nothing option).

When we drive, we acknowledge these risks and take action. Most if not all of us would have life insurance and medical insurance, we choose cars with safety features even though it might cost a little more, we wear our seat belts.

These actions in the face of risk are at a substantial personal cost to protect us against something that might not happen, indeed in this case, that is unlikely to happen.

Yet to do so makes sense to all of us. I think you can see the parallel.

I finish with a photograph of Lake Kutubu, below Oil Search's Ridge Camp that I took on my last trip. Looking at that tranquillity, who could believe that not far beyond is a beehive of activity, concerns and fears that surround the issue of global climate change.

Thank you.