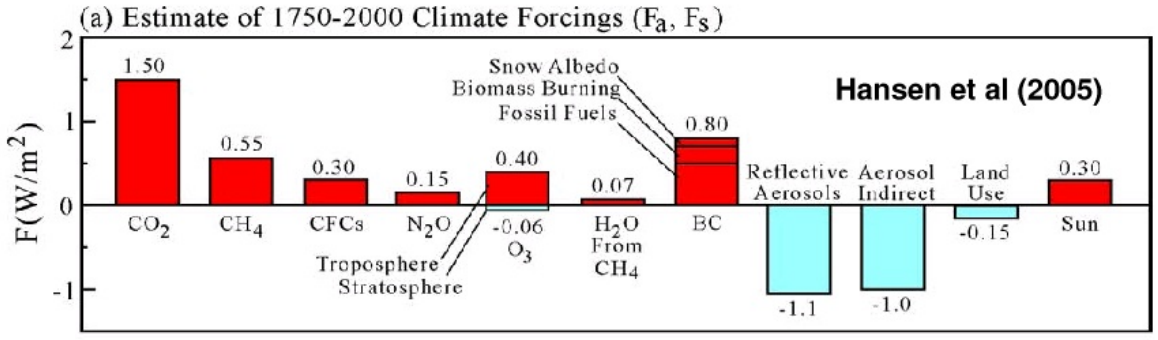
Section 2. Proposals for cooling the planet

2.1 Beyond safe levels: the climate science background

Today, the planet is absorbing considerably more heat from the sun than it is radiating back into space, resulting in the earth warming faster than ever before in recorded history. This energy imbalance is caused mainly by humans putting additional greenhouse gases into the atmosphere, mainly through fossil fuel burning, ecosystem destruction and intensive agriculture. Up to 25% of warming may be caused by black soot emissions from fossil fuel and biomass burning.[13] Carbon dioxide is responsible for about 40% of global warming, and the remaining 35% is due primarily to methane, tropospheric ozone (caused mainly by methane and NOx emissions), CFCs, nitrous oxide and other trace gases.

Right now, 55% of the global warming caused by humans is masked by other types of air pollution, sulphur aerosols, which are keeping the planet cooler than it would otherwise be. Those aerosols, the result of fossil fuel and biomass burning, persist in the atmosphere for no more than a couple of days. If air pollution were cleaned up, even if fossil fuel burning were completely halted, we would feel the full impact of warming.

Since there is a delay between increasing greenhouse gas emissions and planetary warming, at least half of the warming we have already caused, has yet to manifest itself.



www.realclimate.org/images/forcing_1750-2000-toppanel.jpg

The global warming (or radiative forcings) to which we are committed at current levels of greenhouse gases and aerosols is generally expressed in terms of CO_2 equivalents. Today, CO_2 concentrations are around 385 ppm. If we take all the greenhouse gases and the black soot which humans have added to the atmosphere into account and measure this in terms of CO_2 (known as the CO_2 equivalent or CO_2 e), we are actually at around 560 ppm Co2e. The impact of the difference between 385 and 560 ppm, however, is coincidentally almost exactly cancelled out by sulphur aerosols. This means that, in the absence of air pollution, we have nearly doubled CO_2 levels in the atmosphere from the pre-industrial levels of a little over 300ppm. We cannot be sure how much warming this will mean, but James Hansen believes that, in the long term, a doubling of CO_2 levels (or their equivalents) could mean 6°C warming, even if we could stop all GHG emissions today. This is quite clearly not a safe level: It is the same level of warming believed to have caused the end-Permian extinction event.

At the same time, fast rising levels of carbon dioxide in the oceans are already causing dangerous levels of ocean acidification and threaten to trigger a mass extinction event regardless of global warming. Ocean acidification is endangering the

survival of all shell-forming organisms, including many zooplankton species, sea shells, and corals, on which virtually all marine life depends. Marine life, including plankton, plays an essential role in regulating the planet's climate and biochemistry. The former chief scientist with the Australian Institute of Marine Science, Dr Veron, has warned that ocean acidification will cause mass extinctions once CO_2 levels go beyond a 'tipping point' and that those extinctions will become unstoppable.[14] A recent study suggests that even if carbon dioxide levels in the atmosphere could be stabilised at current levels, less than half of all coral reefs will remain in an environment with the chemical conditions to which they are adapted.[15] Clearly, there are no safe levels for any further fossil fuel burning or for other carbon dioxide emissions.

Proposals for reducing global warming fall into three categories:

- Reducing short-life greenhouse gases and black soot;
- Cooling the planet by making the earth more reflective;
- Taking CO2 out of the air.

This report focuses on the last of these categories, and in particular on the proposed use of bioenergy to reduce CO_2 levels. However, in this section we will also give a very brief overview of the other two concepts.

2.2 Reducing short-life greenhouse gases and black soot

Climate scientist David Archer has calculated from geological records of past global warming episodes that the mean atmospheric lifetime of carbon dioxide emitted today will be around for 30,000 years – an average derived from the fact that most carbon dioxide is currently dissolved in the ocean and taken up by the biosphere very quickly whilst some will remain in the atmosphere for over 100,000 years.[16] The amount of carbon dioxide absorbed by the ocean and the terrestrial carbon sink is currently declining, partly because climate change has led to the Southern oceans absorbing less CO_2, and we cannot rely on short-term carbon sequestration by oceans, terrestrial vegetation and soils to continue as the planet warms further.

Black soot, on the other hand, stays around for a few days at the most, methane for around 12 years. Hence, if anthropogenic emissions could be stopped, atmospheric concentrations would drop very quickly, provided that those reductions are not offset by methane released as a result of climate change feedbacks, such as melting permafrost. Tropospheric ozone, most of which is derived from methane, other hydrocarbons, carbon monoxide and oxides of nitrogen , should also reduce very quickly if the source emissions (fossil fuel and biomass burning and agricultural emissions) could be stopped because it only remains in the atmosphere for very short periods.

Cutting emissions of black soot, oxides of nitrogen and human-caused emissions of methane would bring down the total warming caused by humans, particularly if carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions were dramatically cut at the same time. This would require a drastic emissions reduction programme rather than geo-engineering. Provided that methane emissions from the Arctic do not accelerate, such measures would slow down climate change and they are clearly a safe option, albeit one which would require major social, political and economic change. However, if one is looking for planetary cooling, sufficient to re-freeze the Arctic sea-ice, as the authors of Climate Code Red intend, those measures are unlikely to be sufficient.

2.3 Geo-engineering to make the planet more reflective

Sub-arctic forest[17] - Cutting down those boreal forests is one geo-engineering proposal for cooling the planet.

The earth's 'heat budget' depends not just on greenhouse gases but also on how reflective the planet is. Scientists are looking at various ways of increasing the earth's albedo (reflectivity), so as to offset the warming caused by additional greenhouse gases. Proposals include injecting sulphate particles into the stratosphere, spraying a thin mist of seawater onto clouds, putting solar shades into space, or even deliberately cutting down permafrost forests because of their lower albedo.[18] All of these proposals carry extremely high risks of causing major ecosystem destruction and changing the planet's climate and biochemistry in ways that are very difficult to predict and could have very severe adverse effects. A recent study, for example, has shown that injecting sulphate into the stratosphere could further destroy stratospheric ozone, on which life depends for protection from dangerous UV radiation.[19] For a detailed discussion of geo-engineering, see: "Gambling with Gaia", ETC Group, January 2007.[20]

2.4 Taking carbon dioxide out of the air

Proposals for taking carbon dioxide out of the atmosphere include different attempts at making the biosphere more productive, as well as ideas for directly capturing carbon dioxide from the air. All of the proposals with the exception of direct air capture of carbon dioxide can be classed as 'bio-geoengineering.

1) Air capture of CO_2

Direct air capture of CO_2 involves the use of alkali materials, such as sodium or potassium, which are called sorbents and which adsorb carbon dioxide to form a stable carbonate or bicarbonate. Klaus Lackner of the company Global Research Technologies (GRT) and researchers from Colombia University have created a workable prototype which when scaled up, they estimate, could sequester 90,000 tonnes CO_2 a year. The researchers suggest that "planting" 250,000 such synthetic trees would reabsorb the 22 billion tonnes of CO_2 produced annually.

Of all proposed technologies for sequestering atmospheric CO_2, air capture would have by far the least impact on ecosystems and biodiversity. Many problems remain however. The amount of energy needed to capture and store the CO_2 would be enormous. Large amounts of energy are required to construct the units, to move the air, manufacture the sorbents, produce the oxygen, fuel and other chemicals, to

separate the CO_2 from the stable carbonate, to restore the sorbent for reuse, and to compress and transport the CO_2 to an underground repository. Howard Herzog of the Massachusetts Institute of Technology has warned that it could take more energy to capture the carbon dioxide from sorbents than would be saved from this process and that far more research was needed.[21] The problem of where and how to safely dispose of the carbon once it is captured also remains.

Proposed 'synthetic trees' to capture carbon dioxide from the atmosphere
http://sign0ff.files.wordpress. com/2007/05/grt-prototype.gif

There are proposals for making air capture more energy efficient by using thermal systems which use heat that can be generated on site. However, very few research projects looking at air capture of CO_2 exist. Klaus Lackner and his colleagues hope to build one prototype which will capture one tonne of CO_2 per day and cost £100,000. They are still researching ways to dispose of the CO_2, including possibly connecting the scrubbers to greenhouses or using the CO_2 to grow algae for food, fuel or fertilisers. This, however, would not actually remove CO_2 from the carbon cycle at all.[22]

According to the IPCC's Assessment Report Four, "no experimental data on the complete process are yet available to demonstrate the concept [or air capture of CO_2], its energy use and engineering costs." [23]

James Hansen has stressed that no large-scale technologies for CO_2 air capture exist at present and decades of strong research and development support, with large-scale pilot projects would be required. Even then, the technology is likely to remain very expensive.

Given the high energy intensity, and the fact that 80% of global energy use comes from fossil fuels, there is a high risk that any major air capture scheme would maintain or even increase fossil fuel burning.

2) Ocean Fertilisation

A number of companies have been attempting to fertilise the oceans by dumping large amounts of iron particles in the ocean in order to stimulate plankton blooms, in the hope that the plankton will sequester carbon dioxide and move it to the ocean bed, where it should theoretically remain. There is however no evidence that much of the carbon dioxide taken up by algae blooms actually makes it to the ocean floor- in natural algae blooms, only 5% of the dead algae sinks more than 300 metres deep.[24] Furthermore, there is evidence that, in most areas fertilising one part of the ocean with iron reduces ocean fertility elsewhere. Toxic algal blooms are a serious threat to marine biodiversity and raise concerns about the spread of hypoxic dead zones. There are also concerns that plankton blooms could increase methane or nitrous oxide emissions.

Planktos ship getting ready to dump iron particles in the Pacific, http://i.treehugger.com

Another ocean fertilisation proposal involves dissolving lime in marine waters in the hope that this will allow more CO_2 to be absorbed from the atmosphere and also reduce ocean acidity, impacts which have not so far been proven. The impacts on marine life are untested and could be severe. In addition, large amounts of energy would be needed to obtain the lime from heating limestone.

The London Convention, which oversees dumping of wastes at sea, has endorsed a scientific statement of concern about ocean fertilisation and declared its intention to develop international regulations to oversee such schemes.[25] The Convention for Biological Diversity has agreed on a de-facto moratorium on all ocean fertilization activities, with a very limited exception for small scale scientific research, which cannot be used for selling carbon offsets or for other commercial activities. Nonetheless, further ocean fertilisation schemes are expected in the near future, including a large project sponsored by the governments of India and Germany which is to commence in 2009.

For further information about ocean fertilization, see the different publications by the ETC Group on this topic.[26]

3) Ocean Mixing

James Lovelock and Chris Rapley, formerly director of the British Antarctic Survey, have suggested installing 10,000 to 100,000 pipes to bring cold water from the lower ocean layers to the surface in order to stimulate plankton blooms and hence increase CO_2 sequestration.[27] They suggest that further research and small-scale experiments are needed to test the feasibility of such a scheme. The impacts on marine life have not been explored and concerns have been raised that the technique could increase CO_2 emissions by bringing high-CO_2 deep ocean water to the surface where on warming, the water would discharge its excess CO2 to the atmosphere.[28]

4) Carbon capture through 'carbon negative' bioenergy and tree plantations:

Carbon 'bio'-sequestration through forestry and agriculture has long been promoted as a climate change mitigation strategy. Ecosystem restoration, if done sensitively and in a socially just way, can clearly play a role in climate change mitigation and will be discussed in Section 7, however the carbon sequestration projects supported or proposed under the UN Framework Convention on Climate Change, are by and large not related to ecosystem restoration.

However, climate change mitigation strategies that involve forests must be understood in the context of the official UN definition of forests. The definition used by the UN Food and Agriculture Organisation (FAO) and by the Convention on

Biological Diversity (CBD) includes most industrial monoculture tree plantations. The definition used under the Kyoto Protocols for the purpose of the Clean Development Mechanism (CDM) is even broader than that of the FAO and CBD, including any type of tree and shrub plantation of any height, even, potentially oil palm and jatropha monocultures.

Both 'reforestation' (meaning planting on previously forested land) and 'afforestation' (meaning planting on previously unforested land) are currently supported under the Kyoto Protocol as a means of further promoting monoculture expansion, even though monocultures are the main driver of deforestation, particularly in the tropics.

James Hansen's proposals for bioenergy and 'bio-sequestration' of carbon dioxide include:

- Ending 'net deforestation' by 2015. 'Net deforestation' is loosely defined within the massive efforts for 'reforestation' until at least 2030, sufficient to remove 1.6 billion tonnes of carbon from the air every year.
- Biochar (charcoal) from pyrolysis of biomass, which retains a portion of the carbon in the biomass and can, theoretically be useful in sequestering that carbon over a long time frame. The goal is to remove and sequester 160 million tonnes of carbon from the atmosphere every year through this method. It is suggested that this could be achieved through the use of biomass residues and the replacement of slash and burn with slash and char agriculture although, as we shall see below, the sustainability or indeed the feasibility of relying solely on those sources is highly questionable.
- Rapid expansion of liquid biofuels from a current 0.8 EJ worldwide, to 23 EJ by 2025, with biochar, a by-product of one type of second-generation biofuel production, being used on a large scale, particularly after 2025.
- Faster CO_2 reductions through burning biomass in power plants on a large scale and capture with sequestration of the carbon (Bioenergy with Carbon Capture and Storage or BECS).

[Note: Both bioenergy with carbon capture and storage, and biofuels with biochar are classed as 'carbon negative' bioenergy, based on a belief that the carbon sequestered through those technologies will be greater than the total greenhouse gas emissions linked to producing the bioenergy.]

Unfortunately, Hansen, like many other proponents of bio-geosequestration technologies, does not appear to clearly distinguish between forests and plantations or provide a clear definition of the terms 'net deforestation' and 'reforestation'.

In the context of the Kyoto Protocol's definition of forests, each of those four proposals either permits or directly encourages large-scale monoculture expansion and further destruction of natural ecosystems.

'Net deforestation' can, under the current definitions by UN agencies, be 'ended' by replacing natural biodiverse forests with industrial tree and even shrub monocultures. 'Reforestation', as we have seen is used as another term to cover the expansion of plantations. Growing large-amounts of biomass for charcoal, biofuels and bioenergy use with carbon capture and storage will require vast additional plantations, as we shall discuss in detail in Section 5. James Hansen has openly declared his support for large-scale tree monocultures in a media interview in which he advocated replacing coal with wood from tree plantations (presumably a substantial proportion rather than all) and sequestering the carbon dioxide.[29]

Although monocultures count as 'carbon sinks' under the Kyoto Protocol, in reality they speed up global warming, because they are not capable of driving key biospheric

cycles, including the carbon, nitrogen and rainfall cycles upon which a stable climate depends. Instead, they further destroy the planet's ability to regulate climate. This is discussed more fully in the later sections. For a more detailed discussion of the impact of tree monocultures, see for example www.wrm.org.uy/plantations/carbon.html.

Plantations for 'carbon negative' bioenergy are so far only a proposal, however, the reality of bioenergy monocultures can be seen from the impacts of agrofuel plantations today. Those impacts have been discussed in detail elsewhere, for example in "The real cost of agrofuels" by the Global Forest Coalition and Global Justice Ecology Project.[30]

This report will focus on bioenergy with carbon capture and storage, and biochar, i.e. the two main ideas linked to the concept of 'carbon negative' bioenergy. However, the wider issues around large-scale land-use change to allow for more intensive industrial agriculture and tree plantations apply to the debate about all types of large-scale bioenergy use for 'climate change mitigation' and to proposals for 'carbon sinks enhancement' through plantations established in the name of afforestation and reforestation. It is important to note that studies about presumed land availability for biomass, including for 'carbon negative' bioenergy draw heavily on older studies about the potential for sequestering carbon in tropical 'carbon sinks', including tree plantations. Those studies were the first to suggest that at least 500 million hectares of land, particularly in the tropics, are 'available' for climate change mitigation.[31]

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27 Lovelock and Rapley, "Ocean pipes could help the Earth to cure itself", Nature, 449,403, 27 September 2007

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29 "Phase out coal and burn trees instead, urges leading scientist", Geoffrey Lean, Independent, 14th September 2008,

http://www.independent.co.uk/environment/climate-change/phase-out-coal-and-burn-trees-instead-urges-leading-scientist-929889.html

[30] http://www.globalforestcoalition.org/img/userpics/File/publications/Therealcostofagrofuels.pdf

[31] for example "Current Land Cover in the Tropics and Its Potential for Sequestering Carbon", Richard A Houghton et al, Global Biogeochemical Cycles, Vol 7, No. 2, 1993