25 February 2008.

To: Ross Garnaut, contactus@garnautreview.org.au

From: G. J. Brunskill
Alligator Creek, Queensland

This document results from an invitation to review item A below. These comments below are made in reference to

A) The Queensland Coalition "Sustainable Future for Queensland: Minimising Our Impact on the Environment and the Changing Climate" (23 May 2007).

B) Queensland Government (Mines & Energy) document "Carbon dioxide geosequestration tenure administration, Discussion Paper" 2007.

C) Queensland Government "ClimateSmart 2050: Queensland Climate Change Strategy", Executive Summary

D) http://www.pmc.gov.au/energy_future, John Howard's White Paper "Securing Australia"s Energy Future" as of May 2004. An update on this plan is at http://www.pmc.gov.au/energy_reform/docs/energy_update_july2006.pdf.

E) http://www.engineeraustralia.org.au/policy/submissions_by_year1.html a response to the above White Paper from Australian engineers, who acknowledge that the White Paper is not good enough for a lucky country.

F) http://www.abare.gov.au/publications_html/climate/climate_07/apec_security.pdf, A September 07 ABARE Report on "Energy security, clean technology development and climate change: Addressing the future challenges in APEC." Predictions for energy sources to 2050 show only small increases in non-carbon energy sources, with coal, oil, gas, and biomass fuel being dominant.

G) http://www.businessandclimate.com/report.htm, The Australian Business & Climate Group comprises nine major organisations that have come together during 2007 to look at how Australia can accelerate the development and deployment of low emission technologies. The participating organisations are Anglo Coal, BP Australia, Deloitte, Mirvac, Rio Tinto, Santos, Swiss Re, VicSuper and Westpac. The Australian Business & Climate Group released a report in August 2007 entitled Stepping Up: Accelerating the Deployment of Low Emission Technology in Australia. The report calls for the urgent development of a National Low Emission Technology Strategy to complement an Australian emissions trading scheme, in order to reduce Australia's greenhouse gas emissions.

H) http://www.dpmc.gov.au/umpner/reports.cfm, "Uranium Mining, Processing and Nuclear Energy – Opportunities for Australia?" and other reports about energy sources for the future. The main report is the "Switkowski Report on Uranium Mining, Processing, and Nuclear Energy".

I) http://www.unep.org/geo/, gives sources and information about the Nov07 UNEP Geo4 Report (Oct07)… The United Nations Environment Programme says that major threats to the planet such as climate change, the rate of extinction of species, and the challenge of feeding a growing population are among the many that remain unresolved, and all of them put humanity at risk. The warning comes in UNEP's

Global Environment Outlook: environment for development (GEO-4) report published 20 years after the World Commission on Environment and Development (the Brundtland Commission) produced its seminal report, Our Common Future. GEO-4, the latest in UNEP's series of flagship reports, assesses the current state of the global atmosphere, land, water and biodiversity, describes the changes since 1987, and identifies priorities for action. GEO-4 is the most comprehensive UN report on the environment, prepared by about 390 experts and reviewed by more than 1 000 others across the world. See also

http://www.unep.org/geo/geo4/media/, where you can download chapters and summaries, fact sheets, graphics, individual chapters and special summaries in 6 languages.

http://www.unep.org/geo/geo4/media/GEO4%20SDM_launch.pdf, Geo4 Summary for Decision Makers, which is copied to my References folder. Lots of good graphics can be downloaded.

J) http://www.liberal.org.au/about/documents/CleanEnergy.pdf, the Coalition "Clean Energy Plan" for the future of Australia, 21Nov07.

I understand that it is the concern of politicians to promote economic growth, the accumulation of wealth, protection of jobs and industries, and the general well-being of the population. Some of these aspirations and concerns lead to unsustainable use of the environment and world resources.

It is the job of scientists to provide to the public complex information and conceptual views of how the world really works, or at least as best as we can discover from peer-reviewed published scientific research, and our own observations and experience. Some of my views are given below, based upon over 40 years of research activities in aspects of freshwater and oceanography, and chemical and biological aspects of ecology in the Arctic, Temperate, and Tropical regions of the world. From this viewpoint, it is not reasonable or socially responsible to support continued human population growth, economic growth, and the accumulation of excessive wealth, if you want to provide a good quality of life and well being for Australian citizens and other people in the world. In my view, a good government would make it easy (and cheaper) to do the right thing, and make it difficult (and more expensive) to do the wrong thing, concerning these issues.

I have no allegiance to any political party, and I am surely naive and cynical about how politics and economics operate in the artificial business world. I am not a "tree-hugger" extreme environmentalist, having worked my entire career within national government scientific institutions in USA, Canada, and Australia. I have worked on physical and ecological aspects of energy related developments (oil pipelines, uranium mining, nuclear power plant radionuclides, acid rain, metal and pesticide contamination, sediment and nutrient budgets for the Great Barrier Reef shelf, climate warming and ocean acidification from greenhouse gases). I generally avoid references to most industrial trade or conservation NGO organizations and publications, as these are often less firmly based upon scientific evidence and experimental methods. I am now retired from a position of Principal Research Scientist (Chemical Oceanographer) at the Australian Institute of Marine Science near Townsville. I would be happy to provide more documentation that supports my opinions below, or to meet with you to discuss these suggestions.

1. Never before in the history of western civilization has there been more of a consensus on the threat of global climate change caused by anthropogenic greenhouse gas accumulation in the atmosphere & oceans. It is unusual for scientists from so many different disciplines to agree with the Intergovernmental Panel on Climate Change (IPCC) about the magnitude and consequences of the threat from anthropogenic climate change. It is normal to have some critical negative comments from scientists who find other explanations for our observed increase in atmospheric and oceanic CO_2 and melting of the ice caps. It is significant that there are many global change scientists who think that the IPCC is too conservative in its predictions, and they worry about rapid/abrupt changes in temperature & sea level rise over the next decade. Climate change models improve and change as new information appears, so you should expect changes in the predictions of climate change scientists. The acidification of the surface ocean from greenhouse CO_2 is now occurring, and is a threat to the Great Barrier Reef coral communities. [See Appendix A for references]

2. Population growth is the root cause of the anthropogenic global change problem. A sensible policy of limitation of population growth and immigration is required for Australia to maintain its quality of life. Population growth = increased energy, food, water and shelter requirements. There needs to be an education program directed to economists and politicians about the rational and humane basis of zero population and economic growth. It is feasible to promote a form of economic & social growth that is based upon a reduction in earth resource use, sustainable life styles, recycling of many mineral and organic resources, and knowledge-based enterprise. [See Appendix B for references]

3. The bottom line is to reduce greatly the emission of greenhouse gases (CO_2, methane, N_2O, etc) by accelerating the use of non-carbon energy sources. This means we need to gradually but firmly put the coal, oil, and gas industries out of business. Protecting jobs and markets for the coal industry is the worst thing that could be done. Expansion of coal gas, natural gas, tar sand, and oil shale use for energy production will greatly increase greenhouse gas emissions and environmental pollution. It is also very probable that global energy needs in the next century cannot be supplied by existing reserves of coal, oil, gas, and biomass. [See Appendix C for references]

4. For large cities and heavy industry, there is no present feasible alternate clean energy source to nuclear energy. Nuclear power plants and the uranium mining industry are safer and cleaner than the coal/oil/gas industry. Australia has about 30% of world reserves of U ore, and we should be keeping it for our own use, not selling it to India, China, Russia and France. Unfortunately, Australia does not have experience or expertise in building or operating nuclear power plants, due to post-war fear and the lack of public education/promotion by Commonwealth agencies such as ANSTO and ARL. If we follow the nuclear power path, there needs to be an urgent and immediate priority on education and training of nuclear power plant engineers and scientists, and importation of expertise from France, Germany, Canada and USA. There are small nuclear reactors (the Canadian “Slowpoke”) available for small industries, and remote industrial outposts, such as mining communities that have high power requirements. Nuclear power plants should be the first choice energy source for desalination plants. [See Appendix D for references]

5. Cap & Trade, Geosequestration, Carbon Capture & Storage, Emissions Trading, Carbon Credits and Carbon taxes are an economic evasion of responsibility, not a solution to the greenhouse gas problem. The market and economic measures are not

likely the best methods to put the brakes on greenhouse gas emissions. It is more likely that lack of action to directly & quickly reduce greenhouse gas emissions will lead to economic depressions, market crashes, and world wars. In my view, it is a waste of the taxpayers money and public faith in technology to invest in geosequestration and carbon trading systems, whereas it would be more beneficial to proceed directly to support the technology for non-carbon sources of energy. [See Appendix E for references]

6. We have all the tools, methods, and technology necessary for abundant power production from non-carbon energy sources, but we lack the political and cultural will to develop and promote this new technology. These new developments will provide new industries, jobs, and a healthier life style in Australia, and will set an example for the rest of SE Asia. [See Appendix F for references]

7. For small cities and rural properties of northern tropical parts of Australia, it is feasible to harvest abundant energy from solar, geothermal, wind, tide & wave sources. These ancient and new technologies would need encouragement and assistance from state and national governments, both in the research and practical engineering phases, but working examples are in place in this country and around the world. [See Appendix G for references]

8. There is no such thing as a “clean coal industry”. Coal may be useful for other products formed from advanced chemistry, but should not be burned to CO_2 greenhouse gas, if we want to avoid global warming. Burning natural gas (methane) is cleaner than burning coal, but this is not a solution to the problem, as burning methane gas also generates CO_2. [See Appendix H for references]

9. The world’s largest solar photovoltaic power plant planned by technology and project developer Solar Systems for Mildura will be the model for another 10 to be built around Australia. The Mildura plant will use large scale solar concentrators to generate the equivalent annual power consumption requirement of 45,000 homes a year, about 270,000MWh, with zero greenhouse emissions. [See Appendix I for references]

10. Intensive agriculture, irrigation, and land-clearing for cattle pasture grasses usually results in a loss of soil organic matter to oxidation and CO_2 emission to the atmosphere, as well as a loss of soil fertility, water retention capacity, and biological diversity. Encouragement and assistance in maintaining or increasing soil organic matter, fertility, and biological diversity should be a priority in agricultural education. Despite the wild extremes of our North Queensland weather, the climate here and worldwide has been relatively steady and consistent over the past 6,000 to 8,000 years. Plant and animal communities have depended upon this climate stability during their evolution, and agriculture absolutely depends upon a consistent climate. It seems likely that we are moving into an anthropogenically warmed climate, where extreme events will be more frequent. Some agricultural crops will be disadvantaged, and wild fire frequency will increase. Food production methods, crops, and locations will likely change (here & around the world) in the next decades, and this will cause unpleasant disruptions in economic and social systems. The climate change parameters now observed are larger than those observed in the known ancient history of agriculture & civilization, which probably caused the collapse of the Fertile Crescent culture in Mesopotamia, and the prosperous Mayan cultures in Central (tropical) America. [See Appendix J for references]

11. Current management of water supplies will be affected by greenhouse gas warming. Too much attention is paid to domestic water use, when agricultural and industrial water use is over 80% of national water use. Regulations on city people

watering their gardens will not improve water use efficiency, but modification of water use by agriculture and industry would greatly improve the situation. Export of north Queensland water to southern regions will likely disadvantage tropical ecosystems and local domestic and industrial water supplies. Building dams and river diversions is not likely to be a useful or wise action. Marine productivity, seafood and fish harvest in tropical estuaries depend upon seasonal floods, which are often greatly changed or reduced by dams and water diversions. [See Appendix K for references]

12. State and national governments should encourage coastal communities to move essential services and industries toward the safety of inland, higher elevation locations. New port and resort construction at sea level locations should prepare for rising sea levels and increased frequency of cyclones, storm surges and floods. Although the science of abrupt sea level rise is highly uncertain, accelerated melting of polar ice masses is considered to be a real possibility in the next decades. It is likely that surface river and subsurface (groundwater) salinity in the near-coastal zone will increase in the next decades, due to sea level rise, which will affect community water supplies and floodplain agricultural productivity. [See Appendix L for references]

13. If reduction in emissions of greenhouse gases is a good thing to do in this country, then it is counterproductive to build more and more roads for automobile and truck traffic. Fuel efficient human and freight transport by rail, bus, and ships should be encouraged, and disincentives should be heavy on automobile and truck transport systems. Government should move to make rail and bus transport cheaper and easier than private cars and trucks. [See Appendix M for references]

14. Production of hydrocarbon fuels from cultivated crops (biomass, biofuels, ethanol) is not likely to be practical or feasible on a large scale, as this would remove large areas of prime land from food & fibre production. Oil Palm plantations (for biomass fuels) in SE Asia are a threat to the large & unusual biodiversity of microbes, plants and animals in the tropical rainforests, and will decrease food production for indigenous people. [See Appendix N for references]

15. Planting trees is good for soil health and soil-water retention, but this is not a solution for sequestration of greenhouse gases. Tree plantations take up atmospheric carbon for maybe 20-50 years, and then, at forest maturity, they are null flux ecosystems (only if they are not harvested). Stopping deforestation, intentional forest burning, and land clearing would be an important action to reduce greenhouse emissions (from soil organic carbon oxidation) and to improve terrestrial freshwater cycles. [See Appendix O for references]

Appendix A.

www.ipcc-wg2.org, the 4th Report (2007) of the Intergovernmental Panel of Climate Change.

Baettig, M. B., M. Wild, and D. M. Imboden (2007), A climate change index: Where climate change may be most prominent in the 21st century, *Geophys. Res. Lett.*, *34*, L01705, doi:10.1029/2006GL028159. A Climate Change Index (CCI) is developed that is composed of annual and seasonal temperature and precipitation indicators. These indicators are aggregated to a single index that is a measure for the strength of future climate change relative to today's natural variability. The CCI does not represent climate impacts. Its aim is to comply with the increasing need of policy makers to gain a quick overview of complex scientific findings by means of summarized information. The index is calculated on the basis of three GCM simulations of the 21st century under the IPCC emission scenarios A2 and B2. The results indicate that the strongest climate changes by the end of the 21st century, relative to today's natural variability, will occur in the tropics and in high latitudes (especially in the northern hemisphere). The CCI is also calculated on a country basis, allowing for comparison with social and economic country indicators.

Day, J. W., J. D. Gunn, W. J. Folan, A. Yanez-Arancibia, and B. P. Horton. 2007. Emergence of complex societies after sea level stabilized. Eos, Transactions, American Geophysical Union 88(15):169-170. They make the case that most complex city-states originated near estuaries/floodplains after sea level stabilized 8-6 kys ago. During sea level rise and fall times in the Quaternary, there were few periods of extended millennia with stable sea level. The 10 X higher productivity of estuaries, wetlands, and shallow coastal shelves, compared to the steep slope & deep ocean, would have provided food and safe navigation.

Haug, G., D. Gunther, L. Peterson, D. Sigman, K. Hughen, and B. Aeschlimann. 2003. Climate and the collapse of Maya civilization. Science 299:1731-1735.

Linden, Eugene. 2006. The Winds of Change: Climate, Weather, and the Destruction of Civilizations. Simon & Schuster, NY, 320 pp. Amongst other stories, this book gives the chronicle of the fall of the Akkadian Empire and the collapse of the Mesopotamian cultures in 2200 BC. Linden is a journalist, but a good writer.

Pittock, A. B., and M. J. Salinger. 1990. Southern hemisphere climate scenarios. Climate Change 18:205-222.

Pittock, A. B. (ed.) 2003. Climate Change: An Australian Guide to the Science and Potential Impacts. (1.4Mb): http://greenhouse.gov.au/science/guide/pubs/science-guide.pdf

Pittock, A. B. 2005. Climate Change: Turning up the Heat. Earthscan, London/CSIRO Publishing, Collingwood, Victoria, Australia, 316 pp. Barrie was one of the CSIRO scientist that was gagged by Canberra, and appeared on the ABC TV program about the "Greenhouse Mafia of Australia".
http://www.publish.csiro.au/pid/4992.htm

Pittock, Barrie. 2006. Are Scientists underestimating climate change? Eos, Transactions, American Geophysical Union 87(34):340. See also http://www.agu.org/eos_elec/climatechange_refs.html for all the references to this paper. Barrie claims we are not paying attention to the upper limits of the ICPP model predictions, where large effects could be happening soon. While we don't want to "cry wolf", we are also responsible to warn the public of big danger ahead. His list of suspected (faster than expected) operators are: 1) Global dimming by pollution aerosols is declining, enhancing greenhouse warming, 2) Permafrost is melting faster

than predicted, 3) biomass feedbacks appear to be mostly carbon sources (from soil, deforestation, and hot/dry effects on respiration) and fewer sinks, 4) Polar sea ice is melting fast, 5) ocean circulation appears to be slowing, 6) tropical cyclones may be coming more intense and frequent, and 7) atmospheric circulation and ENSO/PDO are changing. Abrupt climate change and rapid sea level rise is the worst case scenario for the next few decades, not centuries in the future.

Hansen, J. E. 2007. Scientific reticence and sea level rise. Environ. Res. Lett. 2 024002 (6pp) doi:10.1088/1748-9326/2/2/024002. I suggest that a 'scientific reticence' is inhibiting the communication of a threat of a potentially large sea level rise. Delay is dangerous because of system inertias that could create a situation with future sea level changes out of our control. I argue for calling together a panel of scientific leaders to hear evidence and issue a prompt plain-written report on current understanding of the sea level change issue. See also plain language version of this in New Scientist, 28 July 07.

Royal Society (UK). 2005. Ocean acidification due to increasing atmospheric carbon dioxide. Science Policy Section, The Royal Society, 6-9 Carlton House Terrace, London SW1Y 5AG, published by The Clyvedon Press Ltd. Cardiff, UK, 60 pp. Science.advice@royalsoc.ac.uk. Full copy of this report is on their website at http://royalsoc.ac.uk.

http://www.unep.org/geo/, gives sources and information about the Nov07 UNEP Geo4 Report (Oct07)… The United Nations Environment Programme says that major threats to the planet such as climate change, the rate of extinction of species, and the challenge of feeding a growing population are among the many that remain unresolved, and all of them put humanity at risk. The warning comes in UNEP's Global Environment Outlook: environment for development (GEO-4) report published 20 years after the World Commission on Environment and Development (the Brundtland Commission) produced its seminal report, Our Common Future. GEO-4, the latest in UNEP's series of flagship reports, assesses the current state of the global atmosphere, land, water and biodiversity, describes the changes since 1987, and identifies priorities for action. GEO-4 is the most comprehensive UN report on the environment, prepared by about 390 experts and reviewed by more than 1 000 others across the world. See also

http://www.unep.org/geo/geo4/media/, where you can download chapters and summaries, fact sheets, graphics, individual chapters and special summaries in 6 languages.

http://www.unep.org/geo/geo4/media/GEO4%20SDM_launch.pdf, Geo4 Summary for Decision Makers, which is copied to my References folder. Lots of good graphics can be downloaded.

Appendix B.

Bartlett, A. A. 2004. Thoughts on long-term energy supplies: scientists and the silent lie. Physics Today 57(7):53-55. The exponential rise in energy and food consumption, resource exhaustion, and global pollution is due to unrestrained human population growth. None of the technological fixes on energy supply can keep up with population growth.

Appendix C.

Caldeira, K., A. K. Jain, and M. I. Hoffert. 2003. Climate sensitivity uncertainty and the need for energy without CO_2 emission. Science 299(5615):2052-2054. Models of global mean temperature increase per unit CO_2 increase in the atmosphere are much more uncertain than global CO_2 budgets. This means that there is no good way to select target atmospheric CO_2 levels for emission reduction schemes. The best way to avoid severe climate change consequences is to find non-carbon energy sources, and stop burning coal, oil, gas, and biomass fuels.

Brandt, Adam R., and Alexander E. Farrell. 2007. Scraping the bottom of the barrel: greenhouse gas emission consequences of a transition to low-quality and synthetic petroleum resources. Climatic Change 84(3-4):241-263. We investigate uncertainties about conventional petroleum resources and substitutes for conventional petroleum, focusing on the impact of these uncertainties on future greenhouse gas (GHG) emissions. We use examples from the IPCC Special Report on Emissions Scenarios as a baseline for comparison. The studied uncertainties include, (1) uncertainty in emissions factors for petroleum substitutes, (2) uncertainties resulting from poor knowledge of the amount of remaining conventional petroleum, and (3) uncertainties about the amount of production of petroleum substitutes from natural gas and coal feedstocks. We find that the potential effects of a transition to petroleum substitutes on GHG emissions are significant. A transition to low-quality and synthetic petroleum resources such as tar sands or coal-to-liquids synfuels could raise upstream GHG emissions by several gigatonnes of carbon (GtC) per year by mid-century unless mitigation steps are taken.

Doniger, David D., Antonia Herezog, and Daniel A. Lashof. 2006. An ambitious, centrist approach to global warming legislation. Science 314(5800):764-765. These Washington DC think-tankers suggest that a delayed (decadal) action for reducing CO_2 emissions (to allow technology and the economic system to get ready) is not a good idea. Emission caps, reduction in emissions now, subsidies & tax breaks for non-carbon energy sources should be started now.

Edenhofer, O., Michael Grubb, and others. 2006. The Innovation Modelling Comparison Project. The Energy Journal, special issue. This includes an economic and business model that estimates the cost and loss of GDP for developing non-carbon energy options, and large reductions in carbon emissions. The outcome is that the decrease in GDP is <1% for this century, with possibilities of stimulating economic growth. The hard part is to get industry to go in this direction. This report is at...
https://www.iaee.org/en/publications/ejsearch.aspx?entireIssue=true&id=2132

Flues, M., I. M. C. Camargo, P. S. C. Silva, and B. P. Mazzilli. 2006. Radioactivity of coal and ashes from Figueira coal power plant in Brazil. 270 Number 3 of Journal of Radioanalytical and Nuclear Chemistry 270(3):597-602. The Figueira coal-fired power plant (CFPP) is among the Brazilian CFPP which presents higher uranium concentration. Gamma-ray spectrometry was used to determine ^{238}U, ^{226}Ra, ^{210}Pb, ^{232} Th and ^{40}K contents in pulverized coal, furnace bottom ash and fly ash samples. The natural radionuclide concentrations in pulverized coal ranged from 813 to 2609 $Bq \cdot kg^{-1}$ for U series and from 22 to 40 $Bq \cdot kg^{-1}$ for ^{232} Th. The fly ash fraction gave concentrations ranging from 1442 to 14641 $Bq \cdot kg^{-1}$, for uranium series. The same enrichment factor was observed for ^{238}U, ^{226}Ra and ^{232} Th. Only ^{210}Pb and stable Pb presented a high enrichment factor for the last stage filter fly ash. The concentration of the uranium series found in the ashes is close to the limit adopted by the Brazilian guideline (CNEN-NN-4.01). Therefore, it is advisable to evaluate the environmental impact of the installation.

Gerlagh, R., B. van der Zwaan, M. W. Hofkes, and G. Klaassen. 2004. Impacts of CO_2 taxes in an economy with niche markets and learning by doing. Environmental and Resource Economics 28 (3): 367-394.

Giere, R., and P. Stille (eds.). 2004. Energy, Waste and the Environment: a Geochemical Perspective. Geological Society of London, Special Publication 236, 688 pp. Energy needs will be 18 GTep in 2050 and 23 GTep in 2100. Present technological energy consumption was 9.3 GTep in 2000. These future energy needs cannot be supported by presently known coal, oil, and gas supplies, so many other energy sources will be used in the near future. The exponential rise in energy use almost surely will deliver exponential rises in waste materials from the energy industry, and they will (in some cases, already do) rival and exceed natural geochemical fluxes. Nuclear power (fission, fusion) will be essential for large cities. Hopefully it will soon occur to politicians and industry and economists that wastes contain valuable resources of metals and energy.
This book includes 35 papers that document geochemical approaches for immobilizing, isolating, and neutralizing waste from nuclear, fossil fuel, and geothermal energy production and consumption. These papers are divided into five parts dealing with The Nuclear Fuel Cycle (nine papers, 145 pages), The Fossil Fuel Cycle (seven papers, 133 pages), The Geothermal Energy Cycle (four papers, 84 pages), The Waste-to-Energy Cycle (six papers, 133 pages), and Water–Waste Interaction (nine papers, 144 pages). In addition, this book contains an index of 12 pages composed of about 1100 entries.

Giles, J. 2006. Economists claim carbon cuts won't break the world's bank. Nature 441(7091):264-265. Pro-active business models suggest that alternate energy source development could stimulate the economy, with <1% reduction in GDP over this century. This is a review of Edenhofer, O., Michael Grubb, and others. 2006. The Innovation Modelling Comparison Project. The Energy Journal, special issue.

Harvey, L. D. Danny. 2007. Dangerous anthropogenic interference, dangerous climatic change, and harmful climatic change: non-trivial distinctions with significant policy implications. Climatic Change 82(1-2):1-25. Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC) calls for stabilization of greenhouse gas (GHG) concentrations at levels that prevent dangerous anthropogenic interference (DAI) in the climate system. However, some of the recent policy literature has focused on dangerous climatic change (DCC) rather than on DAI. DAI is a set of increases in GHGs concentrations that has a non-negligible possibility of provoking changes in climate that in turn have a non-negligible possibility of causing unacceptable harm, including harm to one or more of ecosystems, food production systems, and sustainable socio-economic systems, whereas DCC is a change of climate that has actually occurred or is assumed to occur and that has a non-negligible possibility of causing unacceptable harm. If the goal of climate policy is to prevent DAI, then the determination of allowable GHG concentrations requires three inputs: the probability distribution function (pdf) for climate sensitivity, the pdf for the temperature change at which significant harm occurs, and the allowed probability ("risk") of incurring harm previously deemed to be unacceptable. If the goal of climate policy is to prevent DCC, then one must know what the correct climate sensitivity is (along with the harm pdf and risk tolerance) in order to determine allowable GHG concentrations. DAI from elevated atmospheric CO_2 also arises through its impact on ocean chemistry as the ocean absorbs CO_2. The primary chemical impact is a reduction in the degree of supersaturation of ocean water with respect to calcium carbonate, the structural building material for coral and for calcareous phytoplankton at the base of the marine food chain. Here, the probability of significant harm (in particular, impacts violating the subsidiary conditions in Article 2 of the UNFCCC) is computed as a function of the ratio of total GHG radiative forcing to the radiative forcing for a CO_2 doubling, using two alternative pdfs for climate sensitivity and three alternative pdfs for the harm temperature threshold. The allowable radiative forcing ratio depends on the probability of significant harm that is tolerated, and can be translated into allowable CO_2 concentrations given some assumption concerning the future change in total non-CO_2 GHG radiative forcing. If future non-CO_2 GHG forcing is reduced to half of the present non-CO_2 GHG forcing, then the allowable CO_2 concentration is 290–

430 ppmv for a 10% risk tolerance (depending on the chosen pdfs) and 300–500 ppmv for a 25% risk tolerance (assuming a pre-industrial CO_2 concentration of 280 ppmv). For future non-CO_2 GHG forcing frozen at the present value, and for a 10% risk threshold, the allowable CO_2 concentration is 257–384 ppmv. The implications of these results are that (1) emissions of GHGs need to be reduced as quickly as possible, not in order to comply with the UNFCCC, but in order to minimize the extent and duration of non-compliance; (2) we do not have the luxury of trading off reductions in emissions of non-CO_2 GHGs against smaller reductions in CO_2 emissions, and (3) preparations should begin soon for the creation of negative CO_2 emissions through the sequestration of biomass carbon.

Hubbert, M. K. 1967. Oil , Gas, & Coal Reserves. American Association of Petroleum Geology Bulletin 51:2207-XXXX. He correctly predicted that oil production in the 48 states of USA would peak and begin to diminish in the 1970s.

Hubbert, M. K. 1982. Techniques of prediction as applied to the production of oil and gas. Oil & Gas Supply Modeling, Special Publication 632, S. I Gass (ed.), pp. 16-141, National Institute of Standards and Technology, Gaithersburg, Maryland.

Kallbekken, Steffen, and Nathan Rive. 2007. Why delaying emission reductions is a gamble. Climatic Change 82(1-2):27-45. In the debate on the timing of greenhouse gas emissions reductions the aspect of political feasibility has often been missing. We introduce this aspect and show that, if we decide to delay emissions reductions, and the environmental effectiveness of global mitigation efforts is to remain the same in terms of temperature change, we must be willing and able to undertake much more substantial emission reductions than with early action. Even under conservative assumptions on initial political feasibility (maximum 0.25% year-on-year reductions), a 20-year delay means that we must reduce emissions at an annual rate that is 5 to 11 times greater than with early climate action. Our capacity for technological progress, political change and the inertia of the socio-economic system gives us reason to be concerned about our ability to achieve such higher rates of emission reductions. If we are not able to achieve such higher rates, delaying action will inevitably result in higher temperatures in 2100. Unless we are willing to accept higher temperatures, choosing to delay climate action is a gamble that political feasibility will increase over time as a result of the delay itself.

Kaplan, Karen H. 2007. EU hammers out pact to cut greenhouse emissions. Physics Today 60(5):26-28. This is a news article about German chancellor Angela Merkel (currently head of EU as well), who pushed through significant future cuts in greenhouse gas emissions in Europe. They plan to reduce emissions by 1/5 of 1990 levels, and increase non-carbon energy sources by one fifth by 2020. They also supported the production of biofuels to reduce dependence upon petroleum.

Whole issue of **Scientific American 295(3) for September 2006** is about “Energy Future beyond Carbon”, with articles on global warming, greenhouse gas emission control, transportation fuels, energy efficiency, Coal and CO2 sequestration, Nuclear power options, renewable energy sources, solar cells, wind turbines, biofuels, tidal and wave energy, hydrogen fuel cycles, fusion, space-based solar collectors, designer microbes, and water tower engines.

Appendix D.

Butler, D. 2004. Nuclear power’s new dawn. Nature 429(6989):238-240. Nuclear power can generate electricity and hydrogen gas without putting CO_2 in the atmosphere, but it can also be made cheaper, cleaner, and safer. Most new reactors can be delivered on line by 2025.

Dawson, J. 2003. MIT study sees nuclear power as green weapon against global warming. Physics Today 56(12):34-35. For high output of industrial and city power, nuclear reactors are the best bet for replacing coal and oil. The problems to solve are cost, safety, waste disposal, and security of reprocessing systems, all of which are feasible in the next decade. If a tax on carbon emissions were made, nuclear power would be economic and acceptable quickly. See their website: http://www.mit.edu/afs/athena/org/n/nuclearpower

Goldstein, D. 2005. Out of Gas: the End of the Age of Oil. W. W. Norton, New York, 140 pp. David Goldstein is Vice Provost of the California Institute of Technology, who thinks we are now in a downward spiral into carbon fuel resource exhaustion. He thinks nuclear energy will have to become a main player, until fusion power can be made economic. Nuclear power plants and uranium mining have lower fatalities than the coal and oil industry.

Guinnessy, P. 2006. Stronger future for nuclear power. Physics Today 59(2):19-20. At present, 16% of global electricity supply comes from nuclear power from 441 commercial reactors, 80% of which are over 15 years old. In the next 5 years, 14 new plants are scheduled for completion in Canada, USA, China, EU, Finnland, India, Iran, Pakistan, Russia, and South Africa. Most of the new plants will be pressurized water reactors, but there are a few gas-pebble-bed reactors in China, South Africa, and France. Russia is trying to build a fast neutron reactor. A surprisingly large number of nuclear plants were 90% completed in the 80s, but not finished, due to public distrust and activist protest. Japan and China are the most ambitious, with plans to build 30 new plants by 2020. If the nuclear power industry is to meet the demand for increasing power without CO_2 emissions, then government support is needed for massive construction efforts beginning now.

Ion, Sue. 2007. Nuclear energy: current situation and prospects to 2020. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 365(1853):935-944. [This whole issue is about alternate energy sources and greenhouse gas reduction.] For close to half a century nuclear fission has been providing reliable supplies of electricity to the UK, with virtually no emissions of carbon dioxide. Over that period, the UK nuclear industry has avoided the emission of over one and a half billion tonnes of CO_2. Globally, capacity factors for nuclear plants are higher than they have ever been, averaging around 85% and with the best stations achieving well over 90%. Lifetime can be 60 years. That the economics of such stations compete well with other technologies is well founded and easily verifiable—especially in the face of rising fossil fuel prices and the pricing in of costs for CO_2 emissions—both of which stand to improve the economics of nuclear energy still further. Waste volumes arising from modern plants are just a fraction of those of some earlier stations, and the technologies are in place to deal with them safely and effectively.

Appendix E.

http://www.aph.gov.au/house/committee/scin/geosequestration/report.htm, On Monday 13 August 2007, the House Standing Committee on Science and Innovation tabled its report on the inquiry into Geosequestration Technology entitled *Between a Rock and a Hard Place the science of geosequestration*. The majority report recommends the Government pay for at least one large-scale demonstration project of 500MW which demonstrates all stages in the process—from coal conversion, carbon capture, and transport, through to sequestration and long-term monitoring.

Kaplan, Karen H. 2007. EU hammers out pact to cut greenhouse emissions. Physics Today 60(5):26-28. This is a news article about German chancellor Angela Merkel (currently head of EU as well, and a trained in physics), who pushed through

significant future cuts in greenhouse gas emissions in Europe. They plan to reduce emissions by 1/5 of 1990 levels, and increase non-carbon energy sources by one fifth by 2020. They also supported the production of biofuels to reduce dependence upon petroleum.

Doniger, David D., Antonia Herezog, and Daniel A. Lashof. 2006. An ambitious, centrist approach to global warming legislation. Science 314(5800):764-765. These Washington DC think-tankers suggest that a delayed (decadal) action for reducing CO_2 emissions (to allow technology and the economic system to get ready) is not a good idea. Emission caps, reduction in emissions now, subsidies & tax breaks for non-carbon energy sources should be started now.

Gherardi, Fabrizio, Tianfu Xu and Karsten Pruess. 2007. Numerical modeling of self-limiting and self-enhancing caprock alteration induced by CO_2 storage in a depleted gas reservoir. Chemical Geology 244(1-2):103-129. This paper presents numerical simulations of reactive transport which may be induced in the caprock of an on-shore depleted gas reservoir by the geological sequestration of carbon dioxide. The objective is to verify that CO_2 geological disposal activities currently being planned for the study area are safe and do not induce any undesired environmental impact. In our model, fluid flow, mass transport and mineral alteration are induced in the caprock by penetration of high CO_2 concentrations from the underlying reservoir, where it was assumed that large amounts of CO_2 have already been injected at depth. The main focus is on the potential effect of precipitation and dissolution processes on the sealing efficiency of caprock formations. Concerns that some leakage may occur in the investigated system arise because the seal is made up of potentially highly-reactive rocks, consisting of carbonate-rich shales (calcite + dolomite averaging up to more than 30% of solid volume fraction). Batch simulations and multi-dimensional 1D and 2D modeling have been used to investigate multicomponent geochemical processes. Numerical simulations account for multiphase advection, aqueous diffusion, fracture–matrix interactions (advective and diffusive exchange of species between fractures and matrix rock), gas phase participation in multiphase fluid flow and geochemical reactions, and kinetics of fluid–rock interactions.
The sensitivity of CO_2 concentrations to geochemical processes and parameters is investigated by conceptualizing different mass transport mechanisms (i.e. diffusion and mixed advection + diffusion). The most relevant mineralogical transformations occurring in the caprock are described, and the feedback of these geochemical processes on physical properties such as porosity is examined to evaluate how the sealing capacity of the caprock could evolve in time.
The simulations demonstrate that the occurrence of some gas leakage from the reservoir may have a strong influence on the geochemical evolution of the caprock. In fact, when a free CO_2-dominated phase migrates into the caprock through pre-existing fractures, or through zones with high initial porosity acting as preferential flow paths for reservoir fluids, low pH values are predicted, accompanied by significant calcite dissolution and porosity enhancement. In contrast, when fluid–rock interactions occur under fully liquid-saturated conditions and a diffusion-controlled regime, pH will be buffered at higher values, and some calcite precipitation is predicted which leads to further sealing of the storage reservoir.

Klare, M. 2005. Blood and Oil. Penguin Books. Klare shows that war and oil/energy resources are linked. Unless we control our use of energy, oil demand will lead to more wars, poverty and loss of sustainable food production ability.

http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm
Nicholas Stern's economic study of the consequences of greenhouse gas climate warming. The Stern Review (31 Oct 06) on the economics of climate change,

suggesting that the next decades of climate warming will have economic downside effects similar to the world wars and the 1930s depression.
"If the world is waiting for a calm, reasonable, carefully argued approach to climate change, Nick Stern and his team have produced one. They outline a feasible adjustment policy at tolerable cost beginning now. Sooner is much better."- Robert M. Solow, Nobel Prize economist 1987. Sir Nicholas Stern is Head of the UK Government Economic Service, and a former Chief Economist of the World Bank.

Stern, Nicholas. 2007. The Economics of Climate Change: The Stern Review. Cambridge University Press, 712 pp. The basic message is to “pay now to fix global warming, or risk a worldwide economic depression later on…”.

Herzog, H. 2001. What Future for Carbon Capture and Sequestration? Environmental Science & Technology 35:148A. Transitioning away from fossil fuel use will be difficult, but Massachusetts Institute of Technology scientist Howard Herzog says that by reducing CO2 emissions, carbon capture and sequestration could allow fossil energy use to continue, while buying time to make the transition to other energy sources. He discusses storage options, commercial successes, costs, and the technology's possibilities and limitations.

Wilson, E. J., T. L. Johnson, and D. W. Keith. 2003. Regulating the ultimate sink: managing the risks of geologic CO_2 storage. Environmental Science & Technology 37:3476-3483. Injection of land-based CO_2 waste into drilled oil reservoirs in the North Sea costs US$15/tonne, and they put 30 Mt/yr down the hole. This could be done in the Gulf of Mexico, but regulations are not yet in place.

Wilson, Elizabeth J., S. Julio Friedmann, and Melisa F. Pollak. 2007. Research for Deployment: Incorporating Risk, Regulation, and Liability for Carbon Capture and Sequestration. ENVIRONMENTAL SCIENCE & TECHNOLOGY 41(17): 5945 -5952. Carbon capture and sequestration (CCS) has the potential to enable deep reductions in global carbon dioxide (CO_2) emissions, however this promise can only be fulfilled with large-scale deployment. For this to happen, CCS must be successfully embedded into a larger legal and regulatory context, and any potential risks must be effectively managed. We developed a list of outstanding research and technical questions driven by the demands of the regulatory and legal systems for the geologic sequestration (GS) component of CCS. We then looked at case studies that bound uncertainty within two of the research themes that emerge. These case studies, on surface leakage from abandoned wells and groundwater quality impacts from metals mobilization, illustrate how research can inform decision makers on issues of policy, regulatory need, and legal considerations. A central challenge is to ensure that the research program supports development of general regulatory and legal frameworks, and also the development of geological, geophysical, geochemical, and modeling methods necessary for effective GS site monitoring and verification (M&V) protocols, as well as mitigation and remediation plans. If large-scale deployment of GS is to occur in a manner that adequately protects human and ecological health and does not discourage private investment, strengthening the scientific underpinnings of regulatory and legal decision-making is crucial.

Kharaka, Yousif, and others. 2006. CO2 sequestration in Gulf of Mexico oil well holes. Geology 34:577-XXX. Experimental injection has begun in old brine-filled oil reservoirs on the Texas coast. Water and gas samples taken before and during the injection suggest that the carbonate cap on the reservoir is dissolving as carbonic acid accumulates in the brine. They worry that CO_2 rich brines will flow upward into the Gulf of Mexico, and geosequestration will not be accomplished in the long run.

Lackner, K. S. 2003. A guide to CO_2 sequestration. Science 300(5626):1677-1678. If technological carbon sequestration is to be relevant to significantly lowering carbon emissions to the atmosphere, it has to be multiterawatt scale, and sequester almost all technological carbon. In the 21st century, this means we have to find a storage

place for 600 Gt of carbon. World consumption of fossil fuel reserves is about 6 Gt C/yr, whereas total reserves are about 5000 Gt C.

Lewicki, Jennifer; Birkholzer, Jens; Tsang, Chin-Fu. 2007. Natural and industrial analogues for leakage of CO_2 from storage reservoirs: identification of features, events, and processes and lessons learned. Environmental Geology 52(3):457-467. Instances of gas leakage from naturally occurring CO_2 reservoirs and natural gas storage sites serve as analogues for the potential release of CO_2 from geologic storage sites. This paper summarizes and compares the features, events, and processes that can be identified from these analogues, which include both naturally occurring releases and those associated with industrial processes. The following conclusions are drawn: (1) carbon dioxide can accumulate beneath, and be released from, primary and secondary shallower reservoirs with capping units located at a wide range of depths; (2) many natural releases of CO_2 are correlated with a specific event that triggered the release; (3) unsealed fault and fracture zones may act as conduits for CO_2 flow from depth to the surface; (4) improperly constructed or abandoned wells can rapidly release large quantities of CO_2; (5) the types of CO_2 release at the surface vary widely between and within different leakage sites; (6) the hazard to human health was small in most cases, possibly because of implementation of post-leakage public education and monitoring programs; (7) while changes in groundwater chemistry were related to CO_2 leakage, waters often remained potable. Lessons learned for risk assessment associated with geologic carbon sequestration are discussed.

Lohmann, Larry (ed.). 2006. Carbon Trading: A critical conversation on climate change, privatization and power. Published by the Dag Hammarskjold Foundation, Durban Group of Climate Justice, and The Corner House. Lohman works for the UK-NGO the Corner House at http://www.thecornerhouse.org.uk. Part of his thesis is that carbon trading is not a good solution to reduce CO_2 emissions, but is an escape mechanism for the wealthy and biggest industries that does not reward the poor and the alternative energy industries. Government and industry need to get into a new paradigm that gradually excludes burning coal and oil.

Patiño-Echeverri, Dalia, Benoit Morel, Jay Apt, and Chao Chen. 2007. Should a Coal-Fired Power Plant be Replaced or Retrofitted? Environmental Science & Technology 41(23): 7980-7986. In a cap-and-trade system, a power plant operator can choose to operate while paying for the necessary emissions allowances, retrofit emissions controls to the plant, or replace the unit with a new plant. Allowance prices are uncertain, as are the timing and stringency of requirements for control of mercury and carbon emissions. We model the evolution of allowance prices for SO_2, NO_x, Hg, and CO_2 using geometric Brownian motion with drift, volatility, and jumps, and use an options-based analysis to find the value of the alternatives. In the absence of a carbon price, only if the owners have a planning horizon longer than 30 years would they replace a conventional coal-fired plant with a high-performance unit such as a supercritical plant; otherwise, they would install SO_2 and NO_x controls on the existing unit. An expectation that the CO_2 price will reach $50/t in 2020 makes the installation of an IGCC with carbon capture and sequestration attractive today, even for planning horizons as short as 20 years. A carbon price below $40/t is unlikely to produce investments in carbon capture for electric power.

Appendix F.

Pacala, S., and R. Socolow. 2004. Stabilization wedges: solving the climate problem for the next 50 years with current technologies. Science 305:968-972. All of the technology and tools are available to greatly decrease anthropogenic carbon

emissions on our planet, and some methods are already being used in industry. There is no excuse for lack of action to slow down greenhouse warming. See http://www.princeton.edu/~cmi for data and calculations.

Getting Ahead of the Curve: Corporate Strategies That Address Climate Change: Prepared for the Pew Center on Global Climate Change, October 2006 By: Andrew J. Hoffman, The University of Michigan. A pro-active business response to the threat of greenhouse gas warming and climate change. Alcoa, DuPont, Shell, Whirlpool, many mayors of cities in Europe and USA are involved in this operation. The complete 2 Mb report is at http://www.pewclimate.org/global-warming-in-depth/all_reports/corporate_strategies/index.cfm

Bradford, Travis. 2006. Solar Revolution**:** The Economic Transformation of the Global Energy Industry. MIT Press, Cambridge, Mass. An innovative analysis that shows how the shift to solar energy--in particular, the use of photovoltaic cells--is both economically advantageous and inevitable, and will rival the information and communication technologies revolution in its transformative effects.
ISBN 0-262-02604-X

Edenhofer, O., Michael Grubb, and others. 2006. The Innovation Modelling Comparison Project. The Energy Journal, special issue. This includes an economic and business model that estimates the cost and loss of GDP for developing non-carbon energy options, and large reductions in carbon emissions. The outcome is that the decrease in GDP is <1% for this century, with possibilities of stimulating economic growth. The hard part is to get industry to go in this direction. This report is at…
https://www.iaee.org/en/publications/ejsearch.aspx?entireIssue=true&id=2132

Weart, Spencer R. 2007. Reasons to be cheerful. New Scientist (14Apr07), p. 20. A wonderful short essay on the difficulty of making long-term plans in this rapidly changing world, but at the same time we have adequate resources, communication ability and intelligence to work directly on the big problems (climate change, poverty, over-population). There are adequate present-day and near future solutions to greatly reduce carbon emissions, but we now need the social and political will to execute these changes in our culture. Lack of action on this issue now, will result in more expensive and painful forced action in the distant future.

http://www.rega.com.au/, Renewable Energy Generators of Australia (REGA) is the peak national body representing the leading generators, equipment suppliers and industry specialists in the zero emission electricity supply industry.

McLennan, Magasanik, & Associates (Walter Gerardi & Sonja Ott). 2007. Increasing Australia's Low Emission Electricity Generation – An Analysis of Emissions Trading and a Complementary Measure. Report to REGA, Renewable Energy Generation of Australia, J1492 Report V8. 2 October 2007.
http://www.rega.com.au/Documents/Publications/MMAII-DRAFT%20report.PDF
Setting mandatory clean energy targets would have little impact on retail prices in Australia, and could help produce the optimal energy mix to deliver greenhouse cuts later in the century, according to a study by economic consultants McLennan Magasanik and Associates. The study, commissioned by the Renewable Energy Generators of Australia (REGA), models ten scenarios over the period between 2010 and 2050, being combinations of low, medium and high Clean Energy Targets (CETs) and a medium renewable energy only target operating in conjunction with a low and a medium carbon price against two base cases, a low and a moderate carbon price only. The report finds that for a number of scenarios the impact of a CET actually reduces the overall cost of delivering clean energy into the market.

http://www.hotdryrocks.com/, Hot Dry Rocks Pty Ltd is an Australian based geothermal exploration and development consultancy. Hot Dry Rocks specialises in locating and defining geothermal resources suitable to exploit for energy generation. Its strength lies in combining expertise in crustal heat flow measurement and modelling, engineered geothermal systems research and development, and petroleum and mineral exploration. Through its in-house expertise and strategic partnerships, Hot Dry Rocks offers a full range of services and advice from initial ground selection, exploration and resource assessment; through drilling, reservoir stimulation and appraisal; to economic resource modelling and full-scale development.

http://www.geodynamics.com.au/IRM/content/home.html, Geodynamics Limited is a Brisbane company exploring Hot Fractured Rock Geothermal Energy. They are building a Cooper Basin hot rock geothermal power plant to provide energy at $45-50/megawatt hour, which is lower than the projected cost of clean coal technology.

http://www.carnegiecorp.com.au/, since 1999, The Carnegie Corporation has invested in combined wave energy generators and desalination plants. A series of photos of the CETO machine (before deployment south of Fremantle) is saved in the ESD file, from their website above. The wave generator has been under development since 1999 by Carnegie Corporation and the Fremantle based marine engineering research and development company, Seapower Pty Ltd. Pacific Hydro will contribute its development and hydroelectric generation expertise to the joint venture. Wave energy is a renewable energy resource that is formed by the effect of wind blowing over the ocean surface. Wave energy devices absorb this energy and convert it into electricity. As well as providing clean renewable electricity the Seapower System will also produce substantial fresh water via reverse osmosis desalination.

http://www.pacifichydro.com.au/, Pacific Hydro Limited is Australia's leading renewable energy company, producing non-polluting electricity from wind and water. Based in Fremantle. Started CETO, an underwater wave energy harvester to be tested off Rotnest Island. They have also tried to generate non-carbon energy from the Ord River hydro and various other projects in the Philippines and Chile...see http://www.pacifichydro.com.au/projects.asp?articleZoneID=30. They recently sold the CETO (Seapower) project to REH (= Renewable Energy Holdings, a UK company). The man behind all of this is Alan Burns.
http://www.pacifichydro.com.au/projects.asp?articleZoneID=191>Ord River Hydro Project

http://www.suntech-power.com/, a Chinese corporation led by billionaire Shi Zhengrong, who was educated at Jilin University in NE China, Maisy's Café in Sydney, and the University of New South Wales (his mentor was Professor Martin Green). He is an Australian citizen & keeps 3 houses in Sydney, but he returned to China to establish a solar panel factory in Wuxi, because it was cheaper and the people work harder. He also is involved in education, climate change information, and environmental engineering. The website is mainly about solar power, but the corporation is involved in finance, education, and city planning as well. Near the top of the webpage is the "Sun Smart" motto: In just 1 hour, the Sun delivers more energy than the world uses in a whole year.

http://www.petratherm.com.au/. Petratherm LTD of South Australia, Geothermal energy is free from greenhouse gas emissions and capable of providing constant power to supply base-load electricity. The Company will explore for hot rock geothermal energy, one of the few renewable energy sources, with the ultimate objective of providing energy for producing electricity.

http://www.oceanlinx.com/, Oceanlinx is an international renewable energy company with a unique, commercially efficient system for extracting energy from ocean waves and converting it to electricity, or utilising that energy to produce clean, fresh water from brine. Oceanlinx's core patented technology is an Oscillating Water Column (OWC) device, based on the established science of wave energy, but one which – when compared to other OWC technologies – offers major improvements in the design of the system, the turbine, and in construction technique. This Australian company is currently building a wave energy source and water desalination plant off the coast of Cornwall in UK, at Port Kembla in NSW, at Portland in Victoria, one in Namibia, and two plants in coastal USA (Maine & Hawaii).

http://www.solarsystems.com.au/, Solar Systems is the world leader in high concentration solar photovoltaic applications. We deliver products that generate sustainable electricity in a way which is efficient, reliable and economic as well as seeking maximum value for all customers. This Australian company is building a solar-thermal power plant for Alice Springs.

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Special Issue: Clean energy in Australia

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Towards an Australian hydrogen economy
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Australia, uranium and nuclear power
<http://journalsonline.tandf.co.uk/link.asp?id=R64K182P30237496>
Jim Falk, Jim Green, Gavin Mudd pp. 845-857

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Martin Sevior pp. 859-872

Australia: host for a nuclear waste storage site?
<http://journalsonline.tandf.co.uk/link.asp?id=JG213616WP10R085>
Geoffrey N. Taylor pp. 873-881

Appendix G.

Crabtree, George W., and Nathan S. Lewis. 2007. Solar energy conversion. Physics Today 60(3):37-42 (March). A good physical evaluation of the various ways to make electrical energy and heat from solar radiation, including artificial photosynthesis mechanisms. The sun delivers 1.2 x 10^5 Terawatts of power to the earth, larger than any other energy source on earth. Human energy needs are about 13 Terawatts. Human energy needs are 4.6 x 10^{20} Joules/yr, and the sun provides this amount of energy in 1 hour. The big problem is the efficiency of collection (presently 1-30%) of this energy, and the storage & transmission of collected energy to the users. These technologies are not yet developed.

Edwards, R. 2002. Power Surge: renewable energy's latest contender is lurking by a coast near you. New Scientist 173 (2327):18 (26 January 02). Coastal Scotland tidal power generators could provide 50% of UK grid electricity supply.

Falnes, J. 2002. Ocean Waves and Oscillating Systems. Cambridge University Press, ISBN 0-521-78211-2.

Fanchi, J. R. 2004. Energy: Technology and Directions for the Future. Academic Press/Elsevier, Burlington, Massachusetts, 491 pp.

David Kerr, David. 2007. Marine Energy. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 365(1853):971-992. Marine energy is renewable and carbon free and has the potential to make a significant contribution to energy supplies in the future. In the UK, tidal power barrages and wave energy could make the largest contribution, and tidal stream energy could make a smaller but still a useful contribution. This paper provides an overview of the current status and prospects for electrical generation from marine energy. It concludes that a realistic potential contribution to UK electricity supplies is approximately 80TWh per year but that many years of development and investment will be required if this potential is to be realized.

http://www.enviromission.com.au/, EnviroMission is building a heat tower to harvest solar energy in Australia. They purchased a design from a German company that could provide complete electrical energy for 200,000 homes.

http://www.greenrock.com.au/, Green Rock Energy is another small company seeking geothermal energy resources in the southern parts of Australia.

http://www.torrensenergy.com/, Torrens has created an exceptional opportunity to generate sustainable, renewable, emissions-free geothermal energy and become a dominant player in efficient, reliable electricity generation. The Company has been granted a large geothermal tenement holding in areas close to Adelaide in South Australia.

http://www.geothermal-resources.com.au/, The principal objective of **Geothermal Resources** is to explore its tenement areas for hot rock geothermal energy resources that can be exploited for electricity generation purposes. The company's current projects in the **Curnamona Craton** and the **South East of South Australia** are well located with respect to existing infrastructure and power grids - a major strategic advantage over other more remotely located projects.

http://www.petratherm.com.au/. Petratherm LTD, Geothermal energy is free from greenhouse gas emissions and capable of providing constant power to supply base-load electricity. The Company will explore for hot rock geothermal energy, one of the few renewable energy sources, with the ultimate objective of providing energy for producing electricity.

http://www.energymarketreview.org.au/, Business Council for Sustainable Energy, an Australian lobby group representing commercial interests in renewable energy generation.

Renewable Energy Commercialisation Program (RECP) / Australian Greenhouse Office
http://www.greenhouse.gov.au/renewable/recp/

Tidal Power / Australian Greenhouse Office
http://www.greenhouse.gov.au/renewable/technologies/ocean/tidal.html

http://www.energetech.com.au/, wave power from Port Kembla

http://www.acre.murdoch.edu.au/ago/ocean/wave.html, an information page from Murdoch University, featuring wave, tidal, and thermal power generation from the ocean.

http://www.pacifichydro.com.au/, Pacific Hydro Limited is Australia's leading renewable energy company, producing non-polluting electricity from wind and water. Based in Fremantle. Started CETO, an underwater wave energy harvester to be tested off Rotnest Island. They have also tried to generate non-carbon energy from the Ord River hydro and various other projects in the Philippines and Chile...see http://www.pacifichydro.com.au/projects.asp?articleZoneID=30. They recently sold the CETO (Seapower) project to REH (= Renewable Energy Holdings, a UK company). The man behind all of this is Alan Burns.
http://www.pacifichydro.com.au/projects.asp?articleZoneID=191>Ord River Hydro Project

http://www.greenandgoldenergy.com.au/, South Australian man, Greg Watson, invented a solar collector dish that allows domestic consumers to produce 100% of their electricity needs from the sun at below-grid prices.

http://www.pinnaclevrb.com.au/, Pinnacle VRB Limited, a Melbourne company focused upon green energy storage, one avenue being vanadium flow storage (redox) batteries for massive capacity to store and release electrical energy from solar and wind energy sources. See New Scientist (13Jan07) for a review of this idea. Giant

70,000 liter vanadium sulfate flow batteries are now in use on King Island in Bass Strait, the power source being windmills.

http://www.solarsystems.com.au/, a Melbourne company led by John Lasich, building various wind, wave and solar power generators. One of them is in operation at Mildura, NSW, mainly testing solar focusing to generate steam.

http://www.suntech-power.com/, a Chinese corporation led by billionaire Shi Zhengrong, who was educated at Jilin University in NE China, Maisy's Café in Sydney, and the University of New South Wales (his mentor was Professor Martin Green). He is an Australian citizen & keeps 3 houses in Sydney, but he returned to China to establish a solar panel factory in Wuxi, because it was cheaper and the people work harder. He also is involved in education, climate change information, and environmental engineering. The website is mainly about solar power, but the corporation is involved in finance, education, and city planning as well. Near the top of the webpage is the "Sun Smart" motto: In just 1 hour, the Sun delivers more energy than the world uses in a whole year.

Appendix H.

Brandt, Adam R., and Alexander E. Farrell. 2007. Scraping the bottom of the barrel: greenhouse gas emission consequences of a transition to low-quality and synthetic petroleum resources. Climatic Change 84(3-4):241-263. We investigate uncertainties about conventional petroleum resources and substitutes for conventional petroleum, focusing on the impact of these uncertainties on future greenhouse gas (GHG) emissions. We use examples from the IPCC Special Report on Emissions Scenarios as a baseline for comparison. The studied uncertainties include, (1) uncertainty in emissions factors for petroleum substitutes, (2) uncertainties resulting from poor knowledge of the amount of remaining conventional petroleum, and (3) uncertainties about the amount of production of petroleum substitutes from natural gas and coal feedstocks. We find that the potential effects of a transition to petroleum substitutes on GHG emissions are significant. A transition to low-quality and synthetic petroleum resources such as tar sands or coal-to-liquids synfuels could raise upstream GHG emissions by several gigatonnes of carbon (GtC) per year by mid-century unless mitigation steps are taken.

Appendix I.

http://www.enviromission.com.au/faqs/faqs.htm

Appendix J.

Cullen, H. M., P. B. deMenocal, S. Hemming, G. Hemming, F. H. Brown, T. Guilderson, and F. Sirocko. 2000. Climate change and the collapse of the Akkadian empire: evidence from the deep sea. Geology 28:379-382. Gulf of Oman sediment cores show increases in dust inputs and changes in Sr and oxygen isotopic signals consistent with sudden aridification of Mesopotamia, which may be the reason for the collapse of the empire.

Diamond, J. 2005. Collapse: How Societies Choose to Fail or Survive. Allan Lane (Penguin Books), 575 pp.

Feynman, Joan, and Alexander Ruzmaikin. 2007. Climate stability and the development of agricultural societies. Climatic Change 84(3-4):295-311. Although Modern Man had developed long before the migration from Africa began ~

55,000 years ago no agricultural societies developed until about ~ 10,000 years ago. In the next 5,000 years agricultures developed independently in at least six regions of the world. It is virtually certain that it was not a chance occurrence that so many new agricultures appeared in the same 5,000 years. What inhibited agriculture world wide for 44,000 years and what changed ~ 10,000 years ago? Here we suggest that a major factor influencing the development of agricultural societies was climate stability. From the experience of four cultures we estimate that the development of agriculture needed ~ 2,000 years of climate free from significant climate variations on time scales of a few centuries. Using the Empirical Mode Decomposition technique specifically designed to exhibit the time history of the amplitude of variations in non-stationary time series such as climate proxy records, we find that between 50,000 years ago and the termination of the Younger Dryas ~ 11,600 years ago there was probably no time span as long as 2,000 years that was free of relatively large century scale variations. Furthermore variations on these time scales appear to have been relatively small since the Younger Dryas (YD) ended, supporting our proposition concerning the importance of climate stability in the history of human culture.

Pitman, A. J., G. T. Narisma, and J. McAneney. 2007. The impact of climate change on the risk of forest and grassland fires in Australia. Climatic Change 84(3-4):383-401. We explore the impact of future climate change on the risk of forest and grassland fires over Australia in January using a high resolution regional climate model, driven at the boundaries by data from a transitory coupled climate model. Two future emission scenarios (relatively high and relatively low) are used for 2050 and 2100 and four realizations for each time period and each emission scenario are run. Results show a consistent increase in regional-scale fire risk over Australia driven principally by warming and reductions in relative humidity in all simulations, under all emission scenarios and at all time periods. We calculate the probability density function for the fire risk for a single point in New South Wales and show that the probability of extreme fire risk increases by around 25% compared to the present day in 2050 under both relatively low and relatively high emissions, and that this increases by a further 20% under the relatively low emission scenario by 2100. The increase in the probability of extreme fire risk increases dramatically under the high emission scenario by 2100. Our results are broadly in-line with earlier analyses despite our use of a significantly different methodology and we therefore conclude that the likelihood of a significant increase in fire risk over Australia resulting from climate change is very high. While there is already substantial investment in fire-related management in Australia, our results indicate that this investment is likely to have to increase to maintain the present fire-related losses in Australia.

Kiple, Kenneth F. 2007. A Moveable Feast: Ten Millennia of Food Globalization. Cambridge University Press Australia, 384 pp. Ten thousand years of history of agriculture & food production is given here, from the Mesopotamian Fertile Crescent to the agribusiness megacorporations of today, fast food, obesity, and malnutrition.

Morton, John F. 2007. The impact of climate change on smallholder and subsistence agriculture. *Proc. Natl. Acad. Sci. USA*, 10.1073/pnas.0701855104. Some of the most important impacts of global climate change will be felt among the populations, predominantly in developing countries, referred to as "subsistence" or "smallholder" farmers. Their vulnerability to climate change comes both from being predominantly located in the tropics, and from various socioeconomic, demographic, and policy trends limiting their capacity to adapt to change. However, these impacts will be difficult to model or predict because of (*i*) the lack of standardised definitions of these sorts of farming system, and therefore of standard data above the national level, (*ii*) intrinsic characteristics of these systems, particularly their complexity, their location-specificity, and their integration of agricultural and nonagricultural livelihood strategies, and (*iii*) their vulnerability to a range of climate-related and other stressors. Some recent work relevant to these farming systems is reviewed, a

conceptual framework for understanding the diverse forms of impacts in an integrated manner is proposed, and future research needs are identified.

Shindell, D. T., G. Faluvegi, R. L. Miller, G. A. Schmidt, J. E. Hansen, and S. Sun (2006), Solar and anthropogenic forcing of tropical hydrology, *Geophys. Res. Lett.*, *33*, L24706, doi:10.1029/2006GL027468. Holocene climate proxies suggest substantial correlations between tropical meteorology and solar variations, but these have thus far not been explained. Using a coupled ocean-atmosphere-composition model forced by sustained multi-decadal irradiance increases, we show that greater tropical temperatures alter the hydrologic cycle, enhancing the climatological precipitation maxima in the tropics while drying the subtropical subsidence regions. The shift is enhanced by tropopause region ozone increases, and the model captures the pattern inferred from paleoclimate records. The physical process we describe likely affected past civilizations, including the Maya, Moche, and Ancestral Puebloans who experienced drought coincident with increased irradiance during the late medieval (~900–1250). Similarly, decreased irradiance may have affected cultures via a weakened monsoon during the Little Ice Age (~1400–1750). Projections of 21st-century climate change yield hydrologic cycle changes via similar processes, suggesting a strong likelihood of increased subtropical drought as climate warms.

Sivakumar, M. V. K., H. P. Das, and O. Brunini. 2005. Impacts of Present and Future Climate Variability and Change on Agriculture and Forestry in the Arid and Semi-Arid Tropics. Climate Change 70(1-2):31-72. The arid and semi-arid regions account for approximately 30% of the world total area and are inhabited by approximately 20% of the total world population. Issues of present and future climate variability and change on agriculture and forestry in the arid and semi-arid tropics of the world were examined and discussion under each of these issues had been presented separately for Asia, Africa and Latin America.
Several countries in tropical Asia have reported increasing surface temperature trends in recent decades. Although, there is no definite trend discernible in the long-term mean for precipitation for the tropical Asian region, many countries have shown a decreasing trend in rainfall in the past three decades. African rainfall has changed substantially over the last 60 yr and a number of theoretical, modelling and empirical analyses have suggested that noticeable changes in the frequency and intensity of extreme events, including floods may occur when there are only small changes in climate. Climate in Latin America is affected by the El Niño-southern oscillation (ENSO) phases and there is a close relationship between the increase and decrease of rainfall depending upon the warm or cold phases of the phenomenon. Over land regions of Asia, the projected area-averaged annual mean warming is likely to be 1.6 ± 0.2 °C in the 2020s, 3.1 ± 0.3 °C in the 2050s, and 4.6 ± 0.4 °C in the 2080s and the models show high uncertainty in projections of future winter and summer precipitation. Future annual warming across Africa is projected to range from 0.2 °C per decade to more than 0.5 °C per decade, while future changes in mean seasonal rainfall in Africa are less well defined. In Latin America, projections indicate a slight increase in temperature and changes in precipitation.
Impacts of climate variability and changes are discussed with suitable examples. Agricultural productivity in tropical Asia is sensitive not only to temperature increases, but also to changes in the nature and characteristics of monsoon. Simulations of the impacts of climate change using crop simulation models show that crop yield decreases due to climate change could have serious impacts on food security in tropical Asia. Climate change is likely to cause environmental and social stress in many of Asia's rangelands and drylands. In the arid and semi-arid tropics of Africa, which are already having difficulty coping with environmental stress, climate change resulting in increased frequencies of drought poses the greatest risk to agriculture. Impacts were described as those related to projected temperature increases, the possible consequences to water balance of the combination of enhanced temperatures and changes in precipitation and sensitivity of different

crops/cropping systems to projected changes. In Latin America, agriculture and water resources are most affected through the impact of extreme temperatures (excessive heat, frost) and the changes in rainfall (droughts, flooding). Adaptation potential in the arid and semi-arid tropics of Asia, Africa and Latin America was described using suitable examples. It is emphasized that approaches need to be prescriptive and dynamic, rather than descriptive and static.

Zhao, Y., C. Wang, S. Wang, and L. V. Tibig. 2005. Impacts of Present and Future Climate Variability On Agriculture and Forestry in the Humid and Sub-Humid Tropics. Climate Change. 70(1-2):73-116. Although there are different results from different studies, most assessments indicate that climate variability would have negative effects on agriculture and forestry in the humid and sub-humid tropics. Cereal crop yields would decrease generally with even minimal increases in temperature. For commercial crops, extreme events such as cyclones, droughts and floods lead to larger damages than only changes of mean climate. Impacts of climate variability on livestock mainly include two aspects; impacts on animals such as increase of heat and disease stress-related death, and impacts on pasture. As to forestry, climate variability would have negative as well as some positive impacts on forests of humid and sub-humid tropics. However, in most tropical regions, the impacts of human activities such as deforestation will be more important than climate variability and climate change in determining natural forest cover.

http://www.daff.gov.au/natural-resources/climate, Climate change poses challenges for all sectors of the Australian economy but particularly those sectors dependent on natural resources such as agriculture and forestry.The Council of Australian Governments and the Natural Resource Management Ministerial Council are focusing on climate change and its potential economic impacts. The National Agriculture and Climate Change Action Plan is an agreement by Australian governments to develop a coordinated framework for climate change policy in agriculture. It provides practical tools to develop effective and efficient policies to deal with climate change challenges. The plan aims to raise awareness about climate change issues among primary producers and rural communities and will provide a strategic framework for primary producers when decision-making and business planning. Four key areas identified for climate change management are:
1. adaptation strategies to build resilience into production systems
2. mitigation strategies to reduce or offset greenhouse gas emissions
3. research and development strategies to enhance the agricultural and forestry sectors capacity to respond to climate change
4. awareness and communication strategies to inform decision making by primary producers and rural communities.

Cowie, B. A., C. M. Thornton and B. J. Radford. 2007. The Brigalow Catchment Study: I. Overview of a 40-year study of the effects of land clearing in the brigalow bioregion of Australia. Australian Journal of Soil Research 45(7): 479–495. This paper describes a long-term, paired-catchment study, its broad findings, and considerations for future resource management of brigalow lands in north-eastern Australia. The Brigalow Catchment Study (BCS) commenced in 1965 with a pre-clearing calibration phase of 17 years to define the hydrology of 3 adjoining catchments (12–17 ha). After 2 catchments were cleared in 1982, 3 land uses (brigalow forest *Acacia harpophylla*, cropping, and grazed pasture) were monitored for water balance, resource condition and productivity, providing information for scientific understanding and resource management of the major land uses of the brigalow bioregion.
In addition, this paper draws upon several project reviews to highlight the value of the BCS as an 'outdoor laboratory', its data resource, and to reflect on the study's scientific rigor to support present and future value. An assessment of the BCS against national and international attributes of best practice for long-term studies showed the study to rate highly in aspects of design, implementation, monitoring, and data management, and moderately in formal publication, strategic

management, and networking. The literature shows that Brigalow Catchment Study is the longest paired-catchment study in Australia, and continues to sample the interactions between climate, soils, water, land use, and management.
Finally, this paper provides the context for component-specific papers on changes in hydrology, productivity, and salt balance. Results from the study to date include: a doubling of runoff after clearing, a reduction in wheat yield by more than 60% over 20 years, a halving of pasture availability 3 years after clearing, a decline in cattle liveweight gain of 4 kg/ha.year over an 8-year period with a constant stocking rate, and the leaching of 60% of the root-zone (0–1.5 m) chloride after clearing for cropping. Unanticipated applications of the data from the study include: (*i*) a crucial set of soil samples for calibration of the RothC soil carbon model used to estimate Australia's soil carbon emissions; and (*ii*) estimates of deep drainage as a basis for salinity risk assessment in the region.
Parts II and III, *Aust. J. Soil Res.* **45**(7), 496–511; 512–523. These papers by Thornton et al. and Radford et al. document changes in runoff and productivity for the control, cleared, cropped, and pasture catchments. Email: bruce.cowie@nrw.qld.gov.au, Queensland Department of Natural Resources and Water, PO Box 1762, Rockhampton, Qld 4700, Australia.

Radford, B. J., C. M. Thornton, B. A. Cowie and M. L. Stephens. 2007. The Brigalow Catchment Study: III. Productivity changes on brigalow land cleared for long-term cropping and for grazing. Australian Journal of Soil Research 45(7): 512–523. Productivity of grain crops and grazed pastures inevitably declines without soil nutrient replacement and may eventually make these enterprises unprofitable. We monitored these declines in north-eastern Australia during 23 years after clearing 2 of 3 adjacent brigalow catchments, in order to define the productivity levels of developed brigalow land over time. One catchment (11.7 ha) was used for grain production and another (12.7 ha) for beef production from a sown buffel grass pasture. There was no upward or downward trend in annual rainfall amounts throughout the study period. In the cropped catchment, grain yield from 14 winter crops without added nutrients declined significantly in 20 years from 2.9 to 1.1 t/ha.year on the upper-slope clay soil (92 kg/ha.year) and from 2.4 to 0.6 t/ha.year on the Sodosol (88 kg/ha.year). Crop production per year declined by 20% between 2 successive 10-year periods. Wheat grain protein content also declined with time, falling below the critical value for adequate soil N supply (11.5%) 12 years after clearing on the Sodosol and 16 years after clearing on the clay soil. Such declines in grain quantity and quality without applied fertiliser reduce profitability. The initial pasture dry matter on offer of 8 t/ha had halved 3 years after clearing, and a decline in cattle liveweight gain of 4 kg/ha.year was observed over an 8-year period with constant stocking of 0.59 head/ha. Due to fluctuating stocking rate levels of 0.3–0.7 head/ha over the trial period, liveweight productivity trends are attributed to the multiple effects of stocking rate changes and fertility decline. The amount of nitrogen exported from the cleared catchments was 36.1 kg/ha.year in grain but only 1.6 kg/ha.year in cattle (as liveweight gain). Total soil N at 0–0.3 m declined by 84 kg/ha.year under cropping but there was no significant decline under grazing. The soil nutrients removed during grain and beef production need to be replaced in order to avert productivity decline post-clearing. See also companion papers by Cowie et al. and Thornton et al. on this experimental catchment study.

Thornton, C. M., B. A. Cowie, D. M. Freebairn and C. L. Playford. 2007. The Brigalow Catchment Study: II. Clearing brigalow (*Acacia harpophylla*) for cropping or pasture increases runoff. Australian Journal of Soil Research 45(7): 496–511. The Brigalow Catchment Study (BCS) was established to determine the impact on hydrology when brigalow land is cleared for cropping and grazing. The paired catchment study was commenced in 1965 using catchments of approximately 15 ha, with natural vegetation dominated by brigalow scrub (*Acacia harpophylla*). Three contiguous catchments were selected near Theodore in central Queensland to

represent the extensive brigalow bioregion of central and southern Queensland and northern New South Wales (~40 Mha). The hydrology of the 3 catchments was characterised during a 17-year calibration period (1965–81). The catchments were considered hydrologically similar, with sufficient data available for an empirical comparison between catchments. In 1982, two of the catchments were cleared, with one developed for cropping and the other sown to improved pasture. The third catchment was used as an uncleared control. Hydrologic characteristics were then compared for the following 21 years. In their virgin state, the catchments behaved similarly, with average annual runoff being 5% of annual rainfall. Once cleared, total runoff from the cropping catchment increased to 11% of annual rainfall and total runoff from the pasture catchment increased to 9% of annual rainfall; however, timing of the individual runoff events varied between land uses. In order to confirm that changes in hydrology were a function of land use and not just seasonal variability or sampling error, several analytic techniques were used: a simple comparison of runoff totals, comparison of events, comparison of probability of exceedance for daily runoff, and comparison of predicted and observed runoff using a water balance modelling approach. See also papers by Cowie et al., and Radford et al. on this experimental catchment study.

Zhang, David D., Peter Brecke, Harry F. Lee, Yuan-Qing He, and Jane Zhang. 2007. Global climate change, war, and population decline in recent human history. *Proc. Natl. Acad. Sci. USA*, 10.1073/pnas.0703073104. Although scientists have warned of possible social perils resulting from climate change, the impacts of long-term climate change on social unrest and population collapse have not been quantitatively investigated. In this study, high-resolution paleo-climatic data have been used to explore at a macroscale the effects of climate change on the outbreak of war and population decline in the preindustrial era. We show that long-term fluctuations of war frequency and population changes followed the cycles of temperature change. Further analyses show that cooling impeded agricultural production, which brought about a series of serious social problems, including price inflation, then successively war outbreak, famine, and population decline successively. The findings suggest that worldwide and synchronistic war–peace, population, and price cycles in recent centuries have been driven mainly by long-term climate change. The findings also imply that social mechanisms that might mitigate the impact of climate change were not significantly effective during the study period. Climate change may thus have played a more important role and imposed a wider ranging effect on human civilization than has so far been suggested. Findings of this research may lend an additional dimension to the classic concepts of Malthusianism and Darwinism.

Appendix K.

Pigram, John. 2006. Australia's Water Resources: From use to management. CSIRO Publishing, 240 pp. [Revised paperback edition, 2007.] Can there be a just policy for sharing the small amount of water available in this country, for environmental flow, agriculture, heavy industry, and urban drinking water?

Rosa, L. P., Marco Aurelio dos Santos, Bohdan Matvienko, Ednaldo Oliveira dos Santos, Elizabeth Sikar. 2004. Greenhouse Gas Emissions from Hydroelectric Reservoirs in Tropical Regions. Climate Change 66(1-2):9-22. Most studied reservoirs are strong carbon sources to the atmosphere.

Somerville, C., and J. Briscoe. 2001. Genetic Engineering & Water. Science 292:2217. Powerful editorial about the water crisis looming for the population increase of 2.5 billion people in the next 25 years, the doubling of food requirements, the present decline in cereal production, the apparent lack of new land for agriculture. Many rivers no longer flow to the sea, and 50% of world wetlands have been drained. Over 70% of available freshwater is already used by agriculture, and 40% of world food production comes from irrigated land of declining fertility. Groundwater mining is depleting reservoirs by >1 m/yr in many highly populated areas. The production of one pound of cotton requires 17,000 lbs of water. Some genetic modification of crop plants might make food production better in arid regions with less water supply. The largest loss of food production is from pests and pathogens, for which research can supply partial solutions in rich countries.

Hyder Consulting. 2007. Assessment of the direct and indirect risks from human induced climate change to key ecosystems in Northern Australia. Synopsis. Published by WWF-Australia, Sydney, 7 pp. See http://www.wwf.org.au/publications/climatechangeriskassessmentsynposis/

Vance, D. J., and D. J. Staples. 1985. Factors affecting year-to-year variation in the catch of banana prawns (Penaeus merguiensis) in the Gulf of Carpentaria, Australia. J. Cons. Int. Explor. Mer. 42:83-97.

Vance, D. J., M. Haywood, D. Heales, R. Kenyon, and N. Loneragan. 1998. Seasonal and annual variation in abundance of post-larval and juvenile banana prawns Penaeus merguiensis and environmental variation in two estuaries in tropical northeastern Queensland: a six year study. Marine Ecology Progress Series 163:21-36.

Appendix L.

Hansen, J. E. 2007. Scientific reticence and sea level rise. Environ. Res. Lett. 2 024002 (6pp) doi:10.1088/1748-9326/2/2/024002. I suggest that a 'scientific reticence' is inhibiting the communication of a threat of a potentially large sea level rise. Delay is dangerous because of system inertias that could create a situation with future sea level changes out of our control. I argue for calling together a panel of scientific leaders to hear evidence and issue a prompt plain-written report on current understanding of the sea level change issue. See also plain language version of this in New Scientist, 28 July 07.

Shepherd, Andrew, and Duncan Wingham. 2007. Recent Sea-Level Contributions of the Antarctic and Greenland Ice Sheets. Science 315(5818):1529-1528. After a century of polar exploration, the past decade of satellite measurements has painted an altogether new picture of how Earth's ice sheets are changing. As global temperatures have risen, so have rates of snowfall, ice melting, and glacier flow. Although the balance between these opposing processes has varied considerably on a regional scale, data show that Antarctica and Greenland are each losing mass overall. Our best estimate of their combined imbalance is about 125 gigatons per year of ice, enough to raise sea level by 0.35 millimeters per year. This is only a modest contribution to the present rate of sea-level rise of 3.0 millimeters per year. However, much of the loss from Antarctica and Greenland is the result of the flow of

ice to the ocean from ice streams and glaciers, which has accelerated over the past decade. In both continents, there are suspected triggers for the accelerated ice discharge—surface and ocean warming, respectively—and, over the course of the 21st century, these processes could rapidly counteract the snowfall gains predicted by present coupled climate models.

http://www.greenhouse.gov.au/impacts/, suggestions for local and regional governments to get ready for the unavoidable impacts of climate warming, sea level rise, and ocean acidification.

Appendix M.

According to New Scientist, average per capita CO_2 emissions in UK are about 11.1 tonnes/yr.

Of this 11.1 tonnes/yr, 4.68 tonnes comes from manufactured goods & services, such as clothing, street lights, consumer durables, etc
3.25 tonnes comes from food production & transport
0.48 tonnes comes from household construction & maintenance
0.47 tonnes comes from household electricity consumption
1.03 tonnes comes from automobile travel
0.36 tonnes comes from airplane travel
1 tree planted in the rainy tropics could remove 22 kg/yr for about a century
1 energy efficient light bulb saves about 100 kg CO_2/8000 hrs of use.
1 m^2 of solar panel saves about 130 kg CO_2/yr

Durbin, Thomas D., J. Wayne Miller, Theodore Younglove, Tao Huai, and Kathalena Cocker. 2007. Effects of Fuel Ethanol Content and Volatility on Regulated and Unregulated Exhaust Emissions for the Latest Technology Gasoline Vehicles. ENVIRONMENTAL SCIENCE & TECHNOLOGY 41(11):4059-4064. Oxygenate content and fuel volatility (distillation) variables are important parameters affecting vehicle exhaust emissions, and data on their effects on the latest technology vehicles are quite limited. For this study, 12 California-certified LEV to SULEV vehicles were tested on a matrix of 12 fuels with varying levels of ethanol concentration (0, 5.7, and 10 vol %), T_{50} (195, 215, and 235 °F), and T_{90} (295, 330, and 355 °F). There were statistically significant interactions between ethanol and T_{90} for NMHC, ethanol, and T_{50} for CO and ethanol and T_{50} for NO_x. NMHC emissions increased with increasing ethanol content at the midpoint and high level of T_{90} but were unaffected at the low T_{90} level. CO emissions decreased as the ethanol content increased from the low to the midpoint level for all levels of T_{50}, but between the 5.7 and 10% ethanol levels, CO showed only an increase for the high level of T_{50}. NO_x emissions increased with ethanol content for some conditions. Non-methane organic gases (NMOG) and toxic emissions were examined for only a subset of fuels with the highest T_{90} level, with NMOG, acetaldehyde, benzene, and 1-,3-butadiene all found to increase with increasing ethanol content.

Hammar, Henrik, and Sverker C. Jagers. 2007. What is a fair CO_2 tax increase? On fair emission reductions in the transport sector. Ecological Economics 61(2-3):377-387. We examine how individual preferences for fair reductions of carbon dioxide (CO_2) emissions affect the support for increases in the CO_2 tax on gasoline and diesel. We assume that people not only care about their own material welfare, but also have preferences for fairness in policy design, and we explore the implications using original data from a mail questionnaire sent to a representative sample of the Swedish population. The main result is that fairness in policy design does matter. Those respondents who adhere to a fairness principle tend to be relatively more positive to increases in the CO_2 tax. One possible explanation for this result is that

there is a relatively high degree of reciprocity regarding the origin of emissions and the fairness regarding who should bear the burden of CO_2 reductions. Via a split sample analysis, we also find that the relative importance of fairness principles is dependent upon whether one uses a car often or not. This sheds light on the potential goal conflict between the importance of fairness principles and self-interest in the form of a need for private car transportation.

Jacobson, M. Z., W. G. Colella, and D. M. Golden. 2005. Cleaning the air and improving health with hydrogen fuel-cell vehicles. Science 308:1901-1905. Converting all road vehicles in USA to hydrogen fuel-cells would immediately benefit air quality, human health, and climate change worries. These fellows are from Stanford University's Energy Consortium.

Román-Leshkov, Yuriy, Christopher J. Barrett, Zhen Y. Liu & James A. Dumesic. 2007. Production of dimethylfuran for liquid fuels from biomass-derived carbohydrates. Nature 447(7147):982-985. doi:10.1038/nature05923. Diminishing fossil fuel reserves and growing concerns about global warming indicate that sustainable sources of energy are needed in the near future. For fuels to be useful in the transportation sector, they must have specific physical properties that allow for efficient distribution, storage and combustion; these properties are currently fulfilled by non-renewable petroleum-derived liquid fuels. Ethanol, the only renewable liquid fuel currently produced in large quantities, suffers from several limitations, including low energy density, high volatility, and contamination by the absorption of water from the atmosphere. Here we present a catalytic strategy for the production of 2,5-dimethylfuran from fructose (a carbohydrate obtained directly from biomass or by the isomerization of glucose) for use as a liquid transportation fuel. Compared to ethanol, 2,5-dimethylfuran has a higher energy density (by 40 per cent), a higher boiling point (by 20 K), and is not soluble in water. This catalytic strategy creates a route for transforming abundant renewable biomass resources into a liquid fuel suitable for the transportation sector, and may diminish our reliance on petroleum.

Appendix N.

Hammerschlag, Roel. 2006. Ethanol's energy return on investment: A survey of the literature 1990 to present. Environmental Science & Technology 40:1744-1750. He tries to cost the production of ethanol from corn and cellulose, and account for the non-renewable energy needed for this agriculture and manufacture. Some schemes appear to produce more available energy that is used to make it. This does not take into account the sacrifice of good agricultural land for energy production and not food production. http://www.eere.energy.gov/afdc/pdfs/estreviewofethanollca.pdf.

Hill, Jason, E. Nelson, D. Tilman, S. Polasky, and D. Tiffany. 2006. Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels. Proceedings of the National Academy of Science USA 103(30):11206-11210. Biodiesel made from soybeans would be energy saving, but even if they used all USA corn and soybean cropland for biofuels, it would only amount to 12% of gasoline and 6% of diesel demand in USA.

Righelato, Renton, and Dominick V. Spracklen. 2007. Carbon Mitigation by Biofuels or by Saving and Restoring Forests? Science 317(5840):902. The carbon sequestered by restoring forests is greater than the emissions avoided by the use of the liquid biofuels.

Appendix O.

Sampaio, G., C. Nobre, M. H. Costa, P. Satyamurty, B. S. Soares-Filho, and M. Cardoso (2007), Regional climate change over eastern Amazonia caused by pasture and soybean cropland expansion, *Geophys. Res. Lett.*, *34*, L17709, doi:10.1029/2007GL030612. Field observations and numerical studies revealed that large scale deforestation in Amazonia could alter the regional climate significantly, projecting a warmer and somewhat drier post-deforestation climate. In this study we employed the CPTEC-INPE AGCM to assess the effects of Amazonian deforestation on the regional climate, using simulated land cover maps from a business-as-usual scenario of future deforestation in which the rainforest was gradually replaced by degraded pasture or by soybean cropland. The results for eastern Amazonia, where changes in land cover are expected to be larger, show increase in near-surface air temperature, and decrease in evapotranspiration and precipitation, which occurs mainly during the dry season. The relationship between precipitation and deforestation shows an accelerating decrease of rainfall for increasing deforestation for both classes of land use conversions. Continued expansion of cropland in Amazonia is possible and may have important consequences for the sustainability of the region's remaining natural vegetation.

Weitz, A. M., E. Veldkamp, M. Keller et al. 1998. Nitrous oxide, nitric oxide, and methane fluxes from soils following clearing and burning of tropical secondary forest. Journal of Geophysical Research 103:28047-28058.

Werth, D., and R. Avissar (2005), The local and global effects of Southeast Asian deforestation, *Geophys. Res. Lett.*, *32*, L20702, doi:10.1029/2005GL022970. Using a global climate model (GCM), we simulate the effects of deforestation of Southeast Asia, looking at the local and remote precipitation effects of such a land-use change. We observe a strong local effect, with a reduction in Asian precipitation that persists throughout the year. The effect of this tropical rainforest deforestation extends throughout the Tropics, but it is weaker than that seen earlier in response to Amazonian and African deforestation. The remote effect is caused by the Asian geopotential changes being spread beyond the deforested area by the large-scale winds. The magnitude of the impact is proportional to the percentage of deforestation.

Williams, S. E., E. E. Bolitho, and S. Fox. 2003. Climate change in Australian tropical rainforests: an impending environmental catastrophe. Proceedings of the Royal Society of London B, doi: 10.1098/rspb.2003.2464. Increasing temperature alone will cause significant reduction in core habitat for 622 terrestrial vertebrate species in north Queensland, 65 species being endemic. They predict considerable extinction rates for birds, reptiles, amphibians, small mammals, and insects that require moist warm forests in the next few decades. This ignores add-on effects of changes in precipitation, deforestation, disease, weed species, fragmentation of habitat. Good references to other north Qld. terrestrial ecological studies on aspects of climate change.

Young, R., Brian R Wilson, Malem McLeod and Clair Alston. 2005. Carbon storage in the soils and vegetation of contrasting land uses in northern New South Wales, Australia. Australian Journal of Soil Research 43(1):21-31. The organic carbon stock in biomass and soil profiles sampled from nearby paddocks with different land-use histories was estimated at 7 sites in the upper Liverpool Plains catchment and the Manilla district of north-western New South Wales, Australia. The distribution of soil carbon concentrations over a depth of 2 m was significantly affected by site and land use. Continuous cultivation and cropping over ≥20 years significantly depleted carbon concentrations compared with grassy woodlands in the surface 0.20 m at all sites and to a depth of 0.60 m at 3 sites. Depth of sampling (0–0.20 *v.* 0–1.0 m) significantly affected the differences between land uses at most sites regarding estimates of the stock of soil carbon. These results show that differences in soil carbon concentrations and stock size do not remain constant with depth between contrasting land uses. However, comparisons between land uses of the total amount

of carbon stored were dominated by the number of trees per ha and the size of the trees in grassy woodlands. The implications of these results for carbon accounting are discussed.

Zhao, Y., C. Wang, S. Wang, and L. V. Tibig. 2005. Impacts of Present and Future Climate Variability On Agriculture and Forestry in the Humid and Sub-Humid Tropics. Climate Change. 70(1-2):73-116.

Abstract. Although there are different results from different studies, most assessments indicate that climate variability would have negative effects on agriculture and forestry in the humid and sub-humid tropics. Cereal crop yields would decrease generally with even minimal increases in temperature. For commercial crops, extreme events such as cyclones, droughts and floods lead to larger damages than only changes of mean climate. Impacts of climate variability on livestock mainly include two aspects; impacts on animals such as increase of heat and disease stress-related death, and impacts on pasture. As to forestry, climate variability would have negative as well as some positive impacts on forests of humid and sub-humid tropics. However, in most tropical regions, the impacts of human activities such as deforestation will be more important than climate variability and climate change in determining natural forest cover.