Towards a State Conservation Strategy

1. Planning to meet climatic changes

Department of Conservation and Environment,
Perth, Western Australia.

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Preface

As part of the process of preparing a definitive State Conservation Strategy for Western Australia, a wide range of subjects concerning our environment, natural resource usage and society's impacts are being considered. While some facets have been reviewed adequately in recent years to enable highlights to be summarised, others require reviewing to present necessary background information. These reviews do not constitute formal sections of a State Conservation Strategy, but rather are aimed at providing those having a concern for our future, with important source material.

The potential for increasing atmospheric carbon dioxide to affect world climate has been the subject of a number of recent reviews. However, as these have been concerned with larger scale effects (global or national), a need was felt to relate the processes to local impacts.

Introduction

After much careful research and evaluation, there can be little doubt that man has unwittingly set in train processes that will cause very significant changes to global climate. This is the co-called "greenhouse effect" of heat being trapped in the earth's atmosphere more effectively than in the past. The process is largely due to the rapid escalation in combustion of fossil fuels since early last century, freeing carbon dioxide that had been locked away over millions of years. Other gases such as the freons, methane and nitrous oxides (even water vapour) add to this effect, and are also increasing. During the 1970's the combined effect of these was comparable with that of carbon dioxide[1], though in the long-term carbon dioxide is expected to be the major determinant.

As there is no practical way that we can stop the train, we should see where it is taking us, how long before we begin to feel the effects, and what we can do to prepare ourselves for a changed environment.

Evidence of Change

There are several ways of tracking back on climate in the past, but the one that gives us the most direct measure of atmospheric carbon dioxide is by coring the annual layers of ice stored away in polar ice caps. Across Antarctica, domes of ice sometimes exceeding four kilometres thick, hold a stratified record going back over 200,000 years. Coring of this ice and analysis of layers has enabled us to track climate back 30-40,000 years so far, and just recently scientists of the USSR have cored back 160,000 years in Antarctic ice (to a depth of 2100 metres).

Climate records locked away in this manner show that although atmospheric carbon dioxide fell somewhat during the height of an ice age and rose immediately after, the concentration in the atmosphere today is higher than in any part of the historical record.

Soon after the last ice age, atmospheric carbon dioxide stabilised around 260-270 ppm and remained relatively constant about that level for 8,000 years until the middle of the 19th century. From about the time of the industrial revolution, atmospheric carbon dioxide increased, barely preceptibly at first, but gained in momentum during the 20th century.

From very precise, direct measurements of atmospheric carbon dioxide taken over various parts of the globe through the past 30 years, extrapolations predict a doubling of carbon dioxide by the middle of next century (Figure 1). The US National Academy of Sciences report of 1979 places this time of doubling of atmospheric carbon dioxide as early as about 2030 AD, but an economic downturn could delay it to about 2070 AD.

The models used in such forecasts take into account the dampening effect of the world's oceans absorbing a significant proportion of the increasing quantities of carbon dioxide being released into the earth's atmosphere by locking it into ocean depths. An important ocean sink for carbon dioxide occurs around the Antarctic continent where the sinking of cold, saline water carries dissolved carbon dioxide directly into the deep ocean. Also important here is the annual production of from 6.1 to 38 x 10^9 tonnes of phytoplankton in Antarctic Surface Water[2], representing a massive uptake of carbon dioxide, much of which sinks to deep waters as particulate oganic matter, either directly or through the death of consumers. This process is most evident from January to March each year, at which time atmospheric carbon dioxide at Mawson base has been shown to drop sharply[3].

Thus the oceans are playing a vital role in dampening the "greenhouse effect" by taking up part of the carbon dioxide being released. It has been calculated[1]

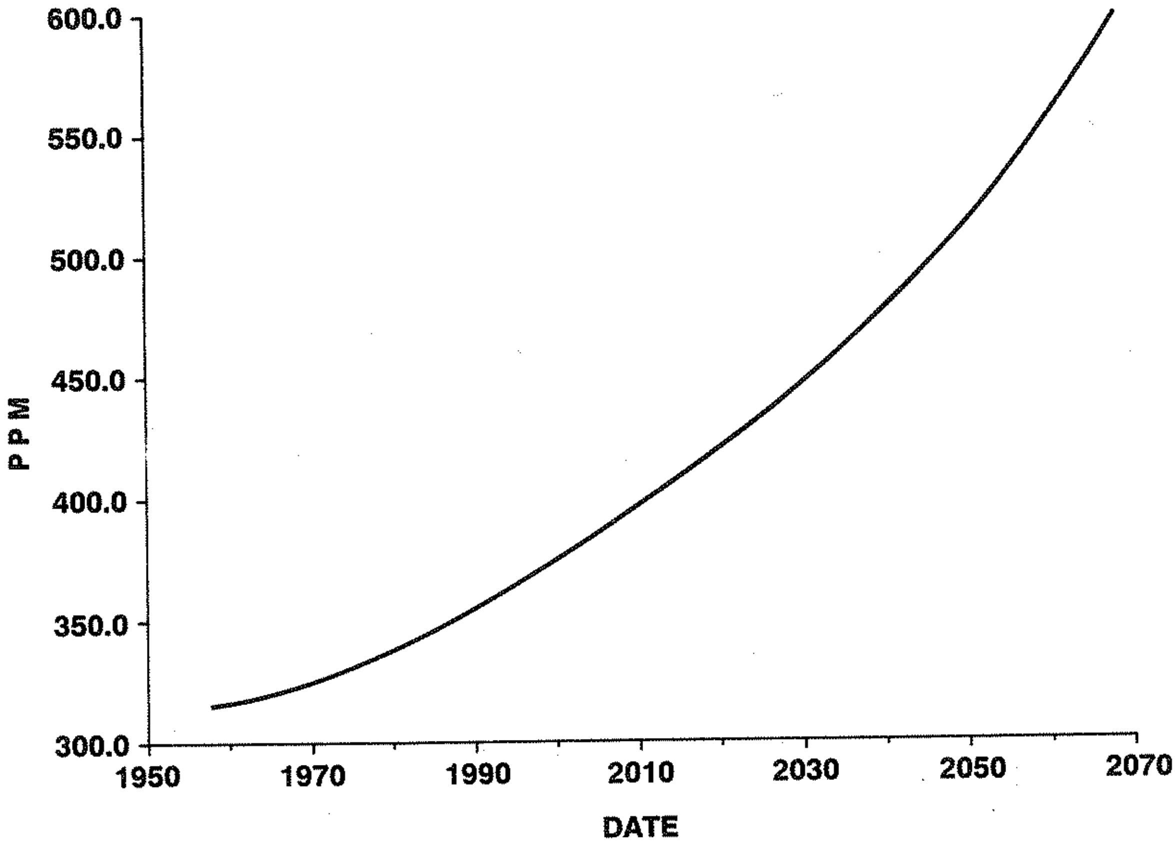

Figure 1: Atmospheric CO_2 as measured (at Mauna Loa since 1958) and predicted. (Rind, 1984).

that the increase of atmospheric carbon dioxide from 315 ppm in 1958 to 338 ppm in 1980 accounts for 50 per cent of the total carbon dioxide released by fossil fuel combustion during that period. As well as absorbing about half of the excess carbon dioxide, the oceans also act as a heat sink, delaying the onset of measurable increase in air temperature (but potentially hastening the melting of Antarctic ice shelves, as discussed below).

Effects

Although the overall features of a long-term carbon dioxide induced global warming are generally well accepted, the timing is less certain, depending on rates of future energy demands. Analysis by the US Council on Environmental Quality(4) indicate that a low growth rate (on a world-wide scale) over the next few decades in the use of fossil fuels, combined with more efficient use of energy, could delay the onset of climatic changes, allowing more time for development of alternative energy sources which do not create their own environmental problems.

However, the inescapable conclusion is that prevention on an international scale is unlikely to be effected(5), so that adapting to the changes is far more practical, especially as adaptive measures can be carried out regionally with effective results. Far too little attention has been given so far to the regional and socioeconomic effects of these climatic changes.

Direct effects on plants of raising the concentration of atmospheric carbon dioxide are fairly easily determined experimentally. These include increased photosynthesis, reduced evapo-transpiration, and therefore some improvement in drought resistance(6). All else being equal, the net effect of doubling the concentration of carbon dioxide could be to increase plant yields by an average of five per cent.

However, other things will not be equal. The indirect affects on vegetation through changes in climate will far outweigh the direct effects.

While the history and recent trends in atmospheric carbon dioxide are in no doubt, predicting the effect on climate is fraught with difficulties. This is partly because many other factors are involved in determining climate, and also because the processes are not understood completely. Nevertheless, the most recent computer models, when run with input of present atmospheric data, reproduce the current climate's temperature, rainfall and wind flow over the entire globe with reasonable accuracy.

When the models are run with increased amounts of atmospheric carbon dioxide, they produce a new simulation of climate; for example, that shown in Figure 2[1]. This indicates that a doubling of atmospheric carbon dioxide would raise the average annual air temperature by 4-5°C in mid-latitudes (e.g. much of Australia), and by 6-8°C in higher latitudes.

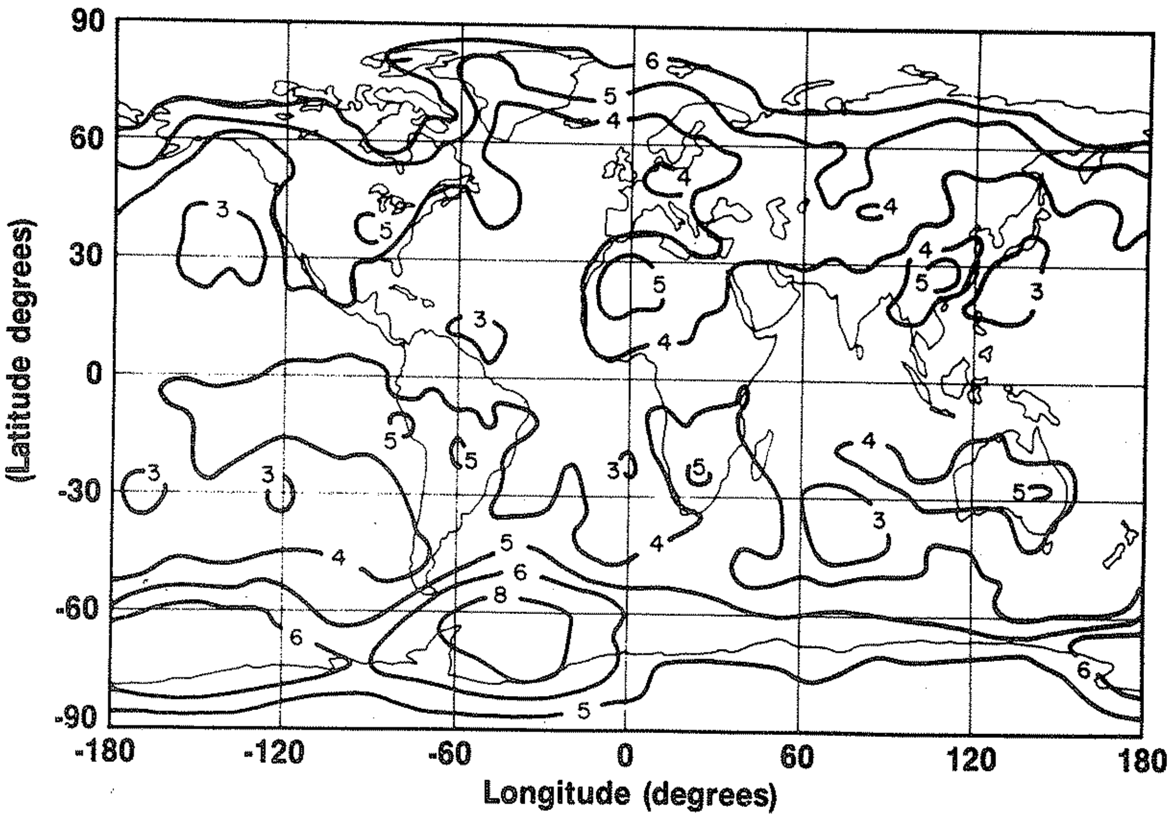

Figure 2: Annual average surface air temperature change (°C) predicted from a doubling of atmospheric CO_2. (Rind, 1984).

As the increase in air temperature will be greatest in high latitudes, then it would be logical to expect the effect to begin to show earlier around Antarctica. Examination of temperatures recorded over the 20 year period 1958-1978 shows that at sub-Antarctic islands the mean air temperature increase by 0.4°C and for Antarctic stations a net rise of 0.6°C[7]. While these changes are well within the variability of the long term means and so are not statistically significant, they are consistent with the predicted changes that could be expected from the actual increase in atmospheric carbon dioxide recorded over the same period.

With the warming effect, the models indicate a change in pattern of rainfall, with increases in lower latitudes and decreases in mid-latitudes. As a test of this, Pittock[8] selected eight years which were relatively warm at Antarctic weather stations and seven years recorded as relatively cool in Antarctica. For these two groups of years, he compared the percentage difference in mean annual rainfall at weather stations across Australia. Although the differences were significant in only two local areas, Figure 3 suggests that practically the whole of Australia north of 25°S. was appreciably wetter in years when Antarctica was warmer, but that a good deal of the southern mainland and Tasmania was drier.

Tucker and Stokes[9] used a slightly different approach. From numerical modelling of the effects of doubling atmospheric carbon dioxide, they considered that a ten per cent increase may **just** be sufficient in some areas for a signal to be detected above the noise level in actual climatic data. Noting that there had been a real increase of ten per cent in atmospheric carbon dioxide during the past 30 years, they analysed rainfall trends across Australia from 1950-1979, resulting in a pattern very similar to that in Figure 3.

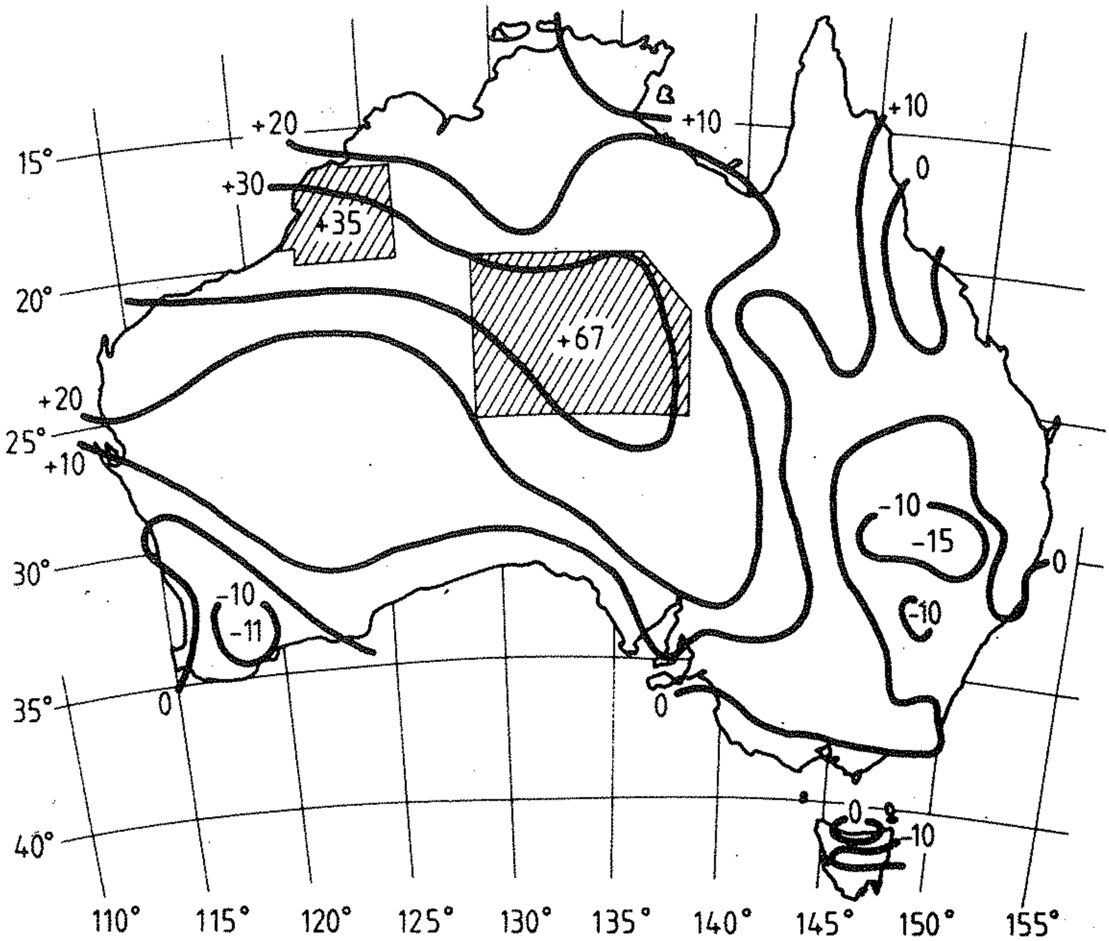

Figure 3: The percentage difference in mean annual precipitation over Australia between eight years which were relatively warm in Antarctica and seven years which were relatively cool in Antarctica. (Pittock, 1980).

Another effect of the warming might be to generate more hurricanes and tropical storms[10], and for these to extend further south down our coast than at present. As oceans warm, sea level will rise to some extent by thermal expansion alone (adding to the slight rise in sea level observed along our west coast in recent decades). The combined effect will be to increase storm erosion along our shores.

Predicting effects upon the oceans is more difficult as ocean modelling is at an earlier stage of development. Since the ocean acts as a heat sink, responses can be expected to be slower by a decade or two. In time, ocean current patterns may change, having considerable effects on living resources.

Predictions of climate change include a reduction in extent and thickness of Antarctic sea-ice[11]. Each winter, sea ice covers some 20 million km^{-2} of ocean around Antarctica. One of the potential impacts of clearing the sea-ice would be to remove an important sink of atmospheric carbon dioxide to deep ocean reservoirs, thus increasing the rate of gain of atmospheric carbon dioxide, accelerating the heating effect.

The potential for global warming on the scale predicted, to actually melt the polar ice caps is far less certain than other effects and any such trend would be on a much longer time scale. However, a partial melt involving only those parts of the ice dome which extend out over the ocean as floating ice is much more probable. The US Council on Environmental Quality[4] states that if the west Antarctic ice shelf melts, sea level would rise by five to eight metres, and that this would occur relatively rapidly (over several decades). From research upon southern icebergs, Orheim[12] concludes that the Antarctic ice store is now declining. Although the present rate of loss (melting minus gains from fresh snow) is calculated to be raising our sea level by only one millimetre per year, this can be expected to accelerate as the oceans absorb heat as a result of global warming.

To sum up, increasing atmospheric carbon dioxide concentrations are likely to cause widespread and pervasive changes in our climatic, economic, social and agricultural patterns, the effects beginning to be felt in one or two decades. In several decades, average annual air temperatures in southern Australia may be 4-5°C higher than now; most of Australia north of 25°S. will be significantly wetter, but the southwest will probably have lower rainfall than at present (particularly less winter rains). Increased storm frequency, together with a trend toward rising sea level, may accelerate coastal erosion, and ocean currents may become less reliable.

An important point to remember is that trends in this direction have probably commenced already, although natural variability in climate may mask the effects for a time. In fact, short term oscillations may even convince some that the predictions are invalid. The evidence should be convincing by the turn of the century, especially if self-generating processes have been set in motion. But we need to begin to adapt to meet the changes now, if hardships are to be minimised.

Planning to meet the changes

While the indirect consequences to Australia of global warming affecting the economies of other countries, should not be over-looked, let us consider now what might be done in Western Australia to plan to meet the direct effects. The extent of the impacts of the climate change will depend very much on the preparations made beforehand.

Given the long planning and implementation lead times involved in adapting to these changes, a strategy needs to be planned now if the process is to be orderly and manageable. There is an understandable tendency to postpone a response in the belief that there will be adequate time to act once climate changes are clearly evident. However, if responses are delayed one or two decades until a CO_2-caused global warming is actually measurable, the world will probably already have significantly increased its reliance on and use of fossil fuels. Economic factors would then make it even more difficult to slow the trend, and the impacts will be much more severe.

Once evident, the climatic changes might occur quickly[4]. Under conditions of rapid and substantial climate alteration, postponed societal responses would have to take place much more quickly than if orderly planning began now.

Local and regional strategies available for adapting to global climatic change include:

(i) Revision of land use policies
(ii) Developing and applying improved agrotechnology
(iii) Accelerating water management
(iv) Energy conservation
(v) Revision of coastal planning policies
(vi) Regional urban planning and decentralisation
(vii) Modification of fisheries practices.

(i) **Revision of land use policies:** Highest priority should be given to land systems already under greatest stress. This must include marginal lands being considered for clearing for agriculture. If it is debatable whether these lands can sustain agriculture today, the risks will be even greater as temperatures and evaporation increase and rainfall declines. Rather than face increasing claims for drought relief, alternative uses should be considered for these marginal lands.

The changing climate may require that some present land uses be changed greatly. The wheatbelt as we now know it, may gradually shrink as the southwest sector of the State has significantly less winter rainfall. Alternative uses may need to be found for the wheatbelt (e.g., deeper rooted perennials rather than annual grain crops).

On the other hand, increased monsoonal rains to the north of 25°S. may well widen options for land use here, if problems of erosion and soil fertility can be overcome.

(ii) **Developing and applying improved agrotechnology:** To a large extent, this means accelerating and widening activities already commenced. Of particular importance is the need to revegetate saline and eroded areas before the increasingly harsh conditions make this even more difficult. Minimum tillage techniques need to be extended, taking care that new technologies (including increasing reliance on pesticides) do not themselves create fresh problems.

(iii) **Accelerating water managment:** As the climate of our southwest region becomes warmer and drier, **per capita** consumption of water can be expected to rise, while rainfall over our water catchments declines and evaporation increases. Long-term action to arrest the spreading salinisation of our southwest streams thus becomes increasingly urgent. Water conservation promotion aimed at reducing **per capita** demand becomes even more important. New concepts for water storage and transport and for the inhibition of evaporation may be needed, including the developing of novel sources of fresh water such as large scale desalinisation or the mining of icebergs.

(iv) **Energy conservation:** Planning for climatic changes should include recognition of higher demand for electricity under hot weather conditions. As heat waves intensify and become more frequent, consumers may be required to make greater efforts to conserve energy demands. Pertinent here is the scenario presented by Rind[1] for Dallas in the 21st Century, with 70 days during a summer having temperatures above 38°C (100°F), compared with an average of eight days per summer during the period from 1930 to 1960. There will be increasing scope for thermally efficient architecture.

(v) **Revision of coastal planning policies:** With slowly rising sea level, and increasing frequency of cyclonic storms reaching our lower west coast, more severe coastal erosion will require more careful coastal planning in the long-term. Hard decisions may be needed to set development back from the foreshore rather than to rely on increasingly expensive coastal engineering. Housing on low lying land near the coast (including canal estates) may need to be phased out progressively, rather than accepting increasingly expensive claims for damages and/or protective works.

(vi) **Regional urban planning and decentralisation:** The impacts of changing climatic conditions may make Perth less attractive as the major population centre, even if water and energy conservation programs were relatively successful in accommodating rising demands. The present trend towards decentralising southwards might eventually become less attractive than options in a wetter (but no hotter) northern region of the State.

(vii) **Modification of fisheries practices:** In the longer term, changes to ocean currents off our west coast may change the patterns of our fisheries. For example, a strenghthening south of a warm current such as the Leeuwin Current might replace the western rock lobster on the Abrolhos Islands with tropical species. While the Abrolhos Islands might no longer yield $15 million of rock lobsters (1984 catch), the islands might then be opened up to tourism worth even more. If Melbourne or Sydney has such spectacular coral reefs less than 250 miles away, they would treasure such resources.

Conclusion

There is a need to begin adapting to the climatic changes forecast because of increasing atmospheric carbon dioxide (and other gases). This action should be incorporated into our planning processes as soon as possible to minimise hardships. If we postpone action for a significant time, it may not be possible to avoid substantial economic, social and environmental disruptions once a warming trend is detected.

It is noteworthy that many of the actions necessary to prepare for the anticipated changes to our climate would have long-term environmental, social or economic benefits if implemented even in the absence of the "greenhouse effect". Thus we have little excuse for deferring action. If the necessary steps were taken now, but some way found later to avert the climatic changes (unlikely as this appears at present), the restoration and better maintenance of our environment cannot fail to improve our options for the future.

Planning is required internationally, nationally, as well as locally. Canada is already taking this into account in planning its National Water Inquiry. The US Council on Environmental Quality recommended in January 1981 that a high priority be assigned to incorporating the carbon dioxide issue into US energy policy planning[4]. The US Department of Energy has committed $20 million in a five year research program on effects of the climatic change. The Australian Environment Council, at its meeting in July 1984 requested the Commonwealth to keep the issue under review. So far there has been little indication of planning for this on the local front.

Admittedly, there are still degrees of uncertainty; the budgets of carbon dioxide sinks are not well known, and the secondary effects on climate not yet predictable with absolute certainty. Yet in our planning process we can hardly afford to ignore the predicted changes: the economic and social costs could be very high. If we plan ahead and do not clear that marginal land, and do re-vegetate eroded and saline lands, then we will have wider options open next century instead of the present trend of narrowing options.

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