THE EFFECT OF CHANGING CLIMATE ON AUSTRALIAN BIOMASS PRODUCTION — A PRELIMINARY STUDY

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Abstract. Increasing concentrations of carbon dioxide and other infrared absorbing gases are widely proposed as a mechanism for a global surface warming over the next several decades. Various methods have been used to anticipate the regional climatic changes which might result. In earlier papers Pittock has concluded that for Australia an increase in the extent of the summer rainfall regime is likely, with a decrease in winter rainfall. This is similar to a change which took place over much of Australia in the 1940's.

In this paper a climate scenario, roughly corresponding to the climate which might be expected to occur by about the middle of the twenty-first century, has been used as the input into the 'Miami Model' of net primary productivity due to Lieth. Results show that about half of Australia might experience productivity increases in excess of 20%. A small area in the extreme south-west of Australia shows a small decrease in productivity.

The direct response of plants to higher ambient carbon dioxide concentrations, and many other possible effects such as changes in the incidence of plant diseases, pests, and soil erosion have not been assessed.

Whether or not increasing carbon dioxide will lead to further climatic change in the next few decades, the results show that Australian primary productivity is quite sensitive to climatic variations within the range found in the historical records.

1. Introduction

Fluctuations in Australian climate, particularly in rainfall, have been noted since the earliest years of European settlement, but quantitative analysis based on instrumental observations is more recent. Gentilli (1971) found a shift to a more arid climate in southeastern Australia between 1881—1910 and 1911—1940. This change was almost completely reversed in the 30 yr after 1945 (Pittock, 1975). The latter change has been analysed in some detail by Cornish (1977), Russell (1981) and Pittock (1983). Coughlan (1979) also found a significant change in spring and summer temperatures over the same period.

Both Russell (1981) and Pittock (1981) have suggested that the westward shift in the margin of wheat-growing in eastern Australia in the decades following 1945 might be at least partially explained by increased spring, summer and autumn rainfalls, although improved technology, new strains of wheat, and market forces also undoubtedly played a part.

Given the natural variability of weather and climate, there is little reason to doubt that climatic fluctuations of the type and magnitude already experienced will occur again, although supplemented in the future by the effects of global pollution. The latter could

lead to more rapid and extreme climatic change than that experienced at any time since the end of the last glaciation.

The prime candidate for causing more rapid climatic change is the increase in the carbon dioxide content of the atmosphere due to deforestation and the burning of fossil fuels (Pittock et al., 1981; NRC, 1983). Another possibility is that of a 'nuclear winter' following a possible large-scale nuclear war (Turco et al., 1983; NAS, 1984, Pittock, 1984).

It is therefore of interest to develop and apply methods of assessing the likely impacts of climatic change, whatever the cause, on natural and managed eco-systems. In the present paper we make a preliminary assessment of the impact on Australian biomass productivity of a particular climatic change scenario, thought to be appropriate to about the middle of the 21st century due to increasing carbon dioxide and other infrared absorbing gases, with a view to future elaboration and application of the method to a variety of problems.

2. Towards a Method

Precise and detailed prediction of future climatic change over Australia is not possible. Not only do we lack a complete understanding of the effect of increasing carbon dioxide, or of smoke from a nuclear war, on the atmosphere, but we are not able to predict 'natural' influences such as those due to volcanic eruptions or internal fluctuations in the climate system (Frankignoul and Hasselmann, 1977; Pittock et al., 1978). Nevertheless, broad pictures or 'scenarios' predicated on other things remaining constant are possible, and may serve as useful guides to the sensitivity of the biomass to climatic change. Such scenarios may be varied to take into account a range of possibilities, and should be regarded as conditional estimates rather than as predictions of what will happen in the real world.

Four main components are necessary in endeavouring to assess the total impact on biomass or crop production of an increase in carbon dioxide concentration in the atmosphere:

1. A biomass or crop model which responds to climatic change.
2. A climatic change scenario providing all necessary climatic data for the biomass or crop model.
3. An understanding of the direct plant response to changing ambient carbon dioxide concentrations, and an ability to modify the biomass or crop model accordingly.

Biomass and crop productivity is affected by many aspects of climate, including the means, extremes, and seasonality of temperature and precipitation, and related changes in cloudiness, humidity, wind speed, potential evaporation and solar radiation. Such factors will vary from place to place, and are highly inter-related. Their detailed incorporation into a climatic impact model would be an extremely complex task, and would require both an elaborate climate scenario and a sophisticated productivity model.

An hierarchy of biomass and crop models exist. These range from empirical-statistical models of relationships between productivity and annual mean temperature and precipi-