

## **King Billy pines and the world's carbon dioxide**

We often hear that the carbon dioxide content of the atmosphere is increasing. Before 1880, so the story goes, the pre-industrial level remained constant at about 290 parts per million (p.p.m.). Now the level is about 330 p.p.m. Some people blame much of this increase on Man's burning of fossil fuels.

Recent research has thrown this piece of conventional wisdom into doubt. It now appears that atmospheric levels of the gas might have been neither constant before the industrial revolution nor rising steadily during the last 90 years. Instead, they may

well have been passing through periods of higher and lower concentrations every 20–30 years.

The problem with looking at atmospheric carbon dioxide levels is that no reliable measurements were taken before 1958. Since then these levels have been increasing to be sure—by about 1 p.p.m. each year—but 20 years is a short time when measuring atmospheric phenomena. Investigations into what happened before 1958 depend on unreliable indirect methods.

One indirect way is to analyse the carbon in trees. They live a long time and their annual rings make it

easy to correctly date past natural events. With the right technique, it should be possible to glean from trees what has been happening to the atmospheric carbon dioxide for several centuries back.

Carbon, the building block of life, comes in three forms—as the common carbon 12, and as the much rarer 13 and 14 isotopes. Carbons 12 and 13 are very stable. Up to now the somewhat erratic evidence that carbon dioxide derived from fossil fuel is accumulating in the atmosphere has come from studies of unstable carbon 14.

The very stable carbon 13 makes up 1.1% of the element in nature. It is less abundant in plants—or in their fossil remains that we use as fuel—than in the atmosphere. Thus any build-up of carbon dioxide resulting from burning fossil fuels must cause the atmospheric carbon 13 to be diluted with carbon 12. Changes in the ratios of these two isotopes should then be recorded in the annual rings

of trees, since the carbon in their cellulose and lignin comes directly from the atmosphere.

During the last few years, several European researchers have analysed the ratios of carbon 13 to carbon 12 in pieces of wood of known ages taken from living trees. Essentially, the technique used involves burning the wood and measuring the amounts of the two isotopes in the carbon dioxide given off.

At the University of Glasgow, J. G. Farmer and M. S. Baxter obtained the following results: between 1900 and 1935 the proportion of carbon 13 fell steadily, which suggests that more carbon dioxide from plants was entering the atmosphere. However, during the next 20 years to 1955, the proportion of carbon 13 rose again. Since then it has dropped once more, which agrees with the accurate carbon dioxide measurements taken since 1958.

These results are hard to interpret, but they have



Wood samples came from this King Billy pine. The scientists cut a disc off the top of the stump that remained after the tree was logged some years ago.

been obtained by two separate research groups—the one in the United Kingdom, and another using trees from near the western coast of France.

In heavily industrialized Europe it's hard to be sure that local pollution hasn't affected the wood samples. Partly for this reason, Dr Graeme Pearman, Dr Roger Francey, and Dr Paul Fraser, of the CSIRO Division of Atmospheric Physics at Aspendale near Melbourne, recently carried out similar analyses on the wood of three ancient King Billy pines obtained from remote country at Swift Creek in north-western Tasmania. Industrial pollution in the vicinity of these native trees would have been minimal.

Ratios of the two carbon isotopes in the annual rings of the pines seemed to vary in much the same way as those of the Northern Hemisphere trees—implying that since 1900 Tasmanian carbon dioxide levels have risen and fallen in concert with those of western Europe. In addition, the researchers found that in Tasmania the isotope ratio variations seemed to correlate closely with maximum temperatures in February, when growth would be greatest. Thus during periods

with warm summers the proportion of carbon 13 increased, while in periods when summers were cooler it decreased.

A study of temperature records from south-eastern Australia and New Zealand confirmed that Tasmanian climatic trends coincided with those of the rest of the region. It would be most illuminating to find out if this also applies for the higher latitudes of the whole of the Southern Hemisphere, but records for these are hard to come by.

In theory, the climate is linked with atmospheric carbon dioxide concentrations (see *Ecos* 7). But why should the carbon isotope ratio rise and fall with climatic temperature variations? One possibility is that the temperature directly affected the amounts of the two isotopes that the King Billy pines took up during photosynthesis. The Aspendale scientists found this unlikely. They had seedlings of two commercial pine species grown under controlled conditions in the phytotron at Canberra. Their analysis of the seedlings revealed little direct effect.

Dr Pearman and his colleagues suggest that it's more likely that the oceans



An old King Billy pine in north-western Tasmania.

are indirectly responsible. Many scientists have for years thought that the world's oceans must considerably affect carbon dioxide levels in the atmosphere. The gas dissolves in the sea, so such a large area of water as an ocean must have some buffering effect. There's little agreement on how great this effect may be.

Carbon dioxide in the oceans contains more carbon 13 than that in the atmosphere. If the sea becomes warmer it will probably give off some of the dissolved gas, or at least dissolve less from the air. Either way the effect should be to increase the proportion of carbon 13 in the atmosphere, as should burning fossil fuels. If the oceans cool, the reverse should happen.

The few records available suggest that sea temperatures off eastern Tasmania have risen since 1940 in sympathy

with the climate. If this situation applies for the rest of the Southern Hemisphere, then the proportion of carbon 13 in the atmosphere of the whole world must rise as the oceans and climate of the Southern Hemisphere become warmer, and fall as they cool down.

In fact it's not such a far-fetched idea that events in the southern oceans control carbon dioxide levels over the whole globe. This Hemisphere contains much the larger part of the world's ocean surface, and it now seems that considerable mixing occurs between the gases on either side of the equator.

Such a mechanism could explain why climatic trends in Australia and New Zealand, and perhaps the rest of the Southern Hemisphere, seem to oppose those north of the equator—a hard fact to reconcile with the assumption

that increasing carbon dioxide levels are raising world temperatures through the 'greenhouse effect'. Thus the Northern Hemisphere trend toward increasingly warm summers between about 1910 and 1940 coincided with cooler summers here. Between 1940 and the early 1970s, northern summers became cooler and ours slightly warmer.

The Aspendale group points out that if the southern oceans really are exerting this sort of effect on world carbon dioxide levels then the chances are that any produced by burning fossil fuels will be swamped by the far greater natural cycles.

But all this has still to be proved. We know practically nothing about ocean temperature trends, and the Tasmanian information about carbon isotopes has come from three trees growing within a stone's

throw of one another. The tests need to be done again on trees coming from many more places.

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