Vegetation carbon stock has doubled since 1788

The model estimates a doubling of the carbon stock in living vegetation since 1788, which leads to the conclusion that 200 years ago there was a more open, grassy type of vegetation cover.

The increased store of carbon in the living vegetation is mostly in woody stems, branches and roots. These woody parts may be bigger and/or there may be more of them per area of land surface, and/or the wood may have a higher density of dry matter (thus less void space). Sandy Berry

Researchers investigating how Australian vegetation has changed since European settlement, taking into account the rapid rise in atmospheric CO_2 concentration over the last two centuries, have found that the total carbon stock in the living vegetation may have doubled. The vegetation should also have become more drought tolerant as a result of the increasing CO_2.

When Captain Arthur Phillip stepped ashore at Sydney Cove in 1788 to initiate European settlement in Australia, the fresh colonial air he inhaled had a CO_2 concentration of just 280 parts per million (ppm) and the vegetation had not suffered the indignity of wholesale land clearing. By 1988, two hundred years on, the atmospheric CO_2 concentration had risen some 25 per cent to 350 ppm, and land management had brought about radical change.

Drs Sandra Berry and Michael Roderick, both with the CRC for Greenhouse Accounting at ANU, wondered how Australian vegetation had changed since 1788 and have been exploring this using recent satellite imagery and a 'functional' computer model that takes into account the effect on plant photosynthesis of rising CO_2 concentrations over time. Their work is unique internationally and was recently published in the *Australian Journal of Botany*.

'Using our theoretical model, and given certain assumptions, we have been able to estimate the total mass of carbon, in roots, stems and leaves, in the living vegetation across Australia in both 1788 and 1988,' says Berry.

'We have estimated this for three different scenarios: for vegetation in 1988, for "natural" vegetation in 1988 if there had been no land-use change, and for vegetation back in 1788. Then, calculating the differences has given us an indication of the effects of changing CO_2 and of land-use change on the storage of carbon in living vegetation in Australia, as well as the combined or total effect,' says Berry.

'Because carbon dioxide is unseen, its effects on vegetation tend to get little attention,' argues Berry, 'but vegetation is essentially CO_2 starved and plants generally respond positively to increased concentrations. CO_2 is the fuel of the photosynthetic process, and therefore plant growth.

'According to our model, Australian vegetation has changed a great deal since European settlement with the total carbon stock in all living vegetation increasing, on average, by 50 million tonnes (Mt) of carbon per year for the continent (approximately a 0.35 per cent per year increase, compounded annually). And that's despite land clearing.'

Of course, this depends on where you are looking. The model and resulting maps indicate that carbon stock has, not surprisingly, declined in regions where woody vegetation (trees and shrubs) has been cleared for agriculture, but increased in the forests and remained pretty well unchanged in arid parts of the country.

Overall, though, the model estimates a doubling of the carbon stock in living vegetation since 1788, which leads to the conclusion that 200 years ago there was a more open, grassy type of vegetation cover. This initial flora profile has been noted previously, and has often been attributed to the frequent use of fire by humans in the past. But Berry and Roderick argue that increasing CO_2 must also have made an important contribution to the increased woodiness of Australian vegetation over time.

And there are other implications. 'At higher CO_2 concentrations we know that plants have better water use efficiency,' says Berry. 'They need less water for photosynthesis and this suggests that both native vegetation and crops may have fared better during the recent severe droughts than they would have at lower concentrations of CO_2. They also have better nutrient and light use efficiencies and that allows for more plant growth on nutrient-poor soils and in low light situations.

'More generally, also, the increased productivity of crops that we tend to credit to plant breeders, fertilisers and pesticides could be partly due to plant responses to more CO_2.'

So does all this mean that Australia is acting as a big carbon sink – on balance taking carbon from the atmosphere and locking it away in eucalypts and other vegetation? Unfortunately, the scientists conclude that they can't make that claim because, as yet, nobody knows how carbon in soil has changed at a continental scale.

Their work, however, suggests that we need to modify our paradigm for the management of natural vegetation. The availability of CO_2 has increased relative to the availability of ingredients for plant growth (water, mineral nutrients and light), and these changed conditions have correspondingly altered the natural climax vegetation from that in 1788. Berry points out that we therefore have to manage the natural vegetation as it is today, not as we think it was 200 years ago.

● **Steve Davidson**

More information:
Berry SL and Roderick ML (2006) Changing vegetation from 1788 to 1988: effects of CO_2 and land-use change. *Australian Journal of Botany* **54**, 325–338.

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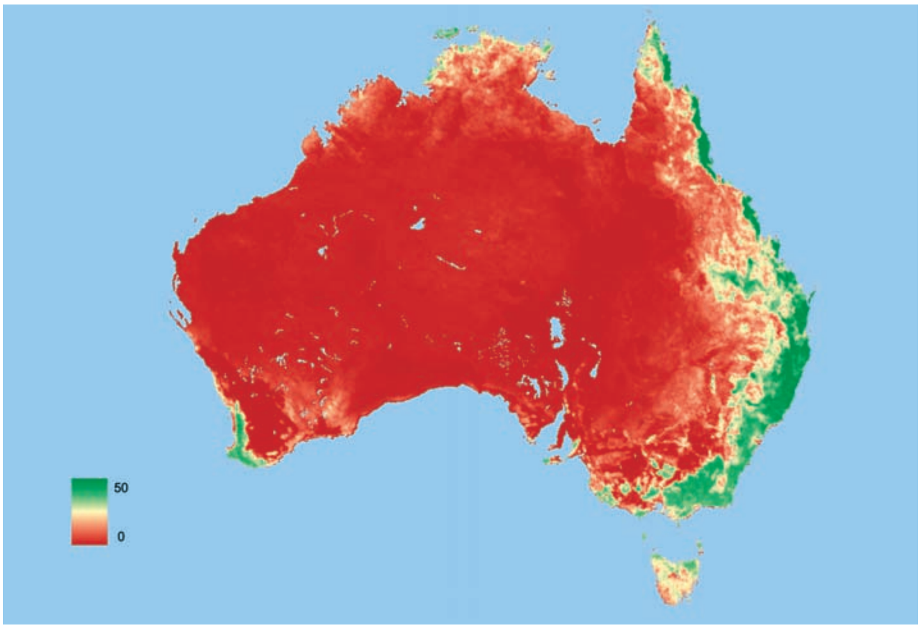

This map shows the estimated average annual increase in the carbon stock of the living vegetation across Australia. The units are grams of carbon per square metre per year. Over the arid interior and in the agricultural regions there has been little change (or even a decrease because of land clearing). The big increase (green areas) is in the forested regions. Sandy Berry