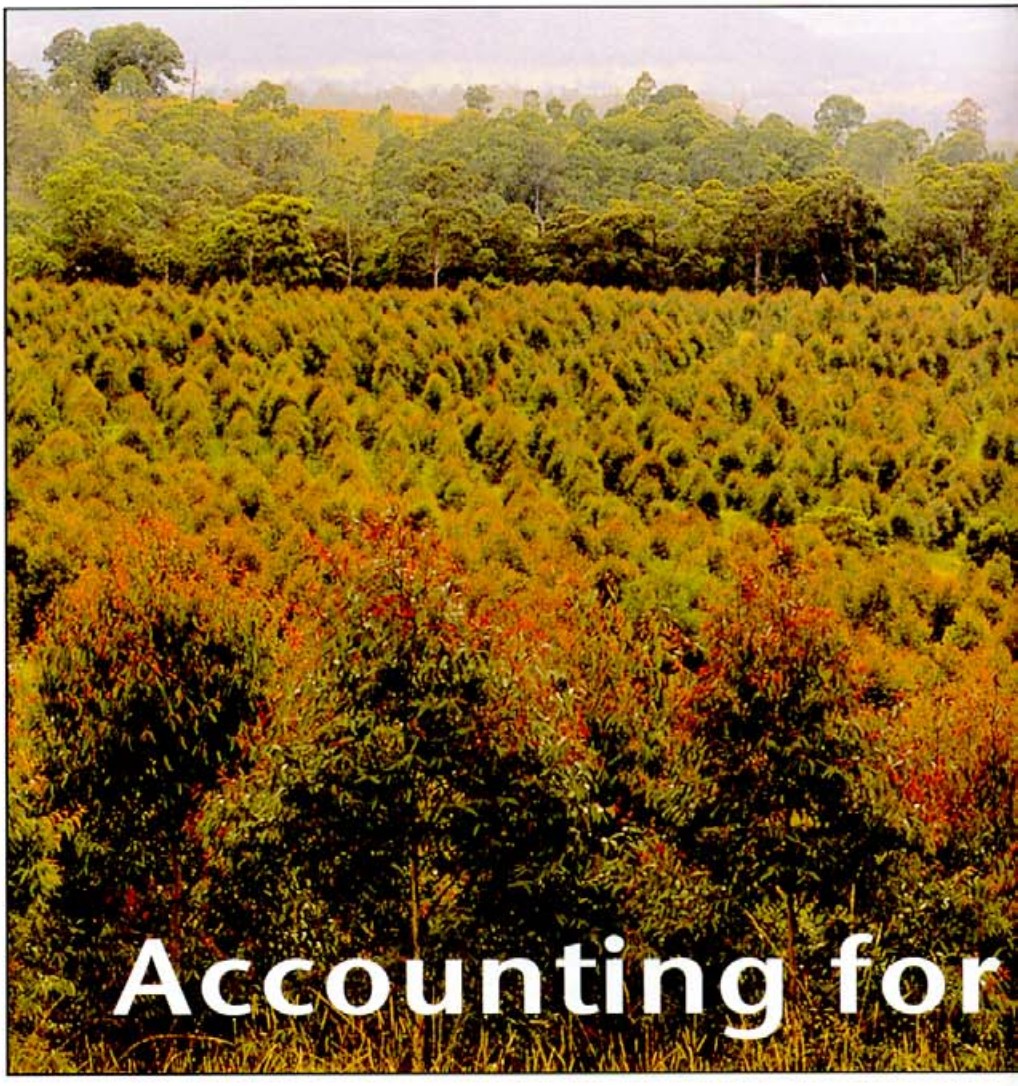
How much carbon is stored by a forest, on a farm, or in the soil? Australia has to tackle some complex mathematics before banking on the carbon trade to help meet its greenhouse obligations. **Graeme O'Neill** reports.



Accounting for

The Tokyo Power Company made a small piece of history earlier this year when it bought $A140 million worth of carbon credits from Australia. The deal commits the company to establish 40 000 hectares of eucalypt plantations in New South Wales to offset some of the carbon emissions from its Japanese power stations.

Australia stands to be a big winner in the international carbon credits trade as industrialised nations seek to fulfil their commitments under the Framework Convention on Climate Change and the Kyoto Protocol. Exploiting the trade would enable Australia to offset some of its own and other nations' excess carbon emissions through revegetation.

Under an emissions trading system, Australia could earn credits for the amount of carbon it sequestered (stored in plants and soil). This could provide immediate benefits, allowing time for substantial restructuring measures to reduce industrial, urban and transport emissions, which otherwise might yield only small reductions at a substantial social and economic cost.

Before claiming official credit for its carbon 'sinks', however, Australia must develop a scientifically defensible way of estimating carbon dioxide flux from farms, forests and land-clearing operations.

The Cooperative Research Centre for Greenhouse Accounting has been established to meet this challenge. Its partners are the Australian Greenhouse Office, the Australian National University, the Bureau of Rural Sciences, CSIRO, Queensland's departments of Natural Resources and Primary Industries, State Forests of NSW and Western Australia's Department of Conservation and Land Management.

Heading the new CRC is the ANU's Professor Ian Noble who co-chairs an expert group of the Intergovernmental Panel on Climate Change that is reporting on global carbon sources and sinks.

Noble says Australia has an unrivalled opportunity to meet its greenhouse commitments – to contain emissions to 108% of 1990 levels by 2008–2012 – by focussing on the 'sinks' side of the equation. But there is a long way to go before it starts sinking carbon in a serious way.

Australia has 160 million hectares of forests: 40 million hectares of tall forest and 120 million hectares of more open woodlands including mallee woodlands and brigalow scrubs. It also has about one million hectares of softwood and hardwood plantations which are increasing by 50 000–100 000 hectares annually. But this rate of planting offsets less than one fifth of the forest and woodland still being cleared in Australia every year.

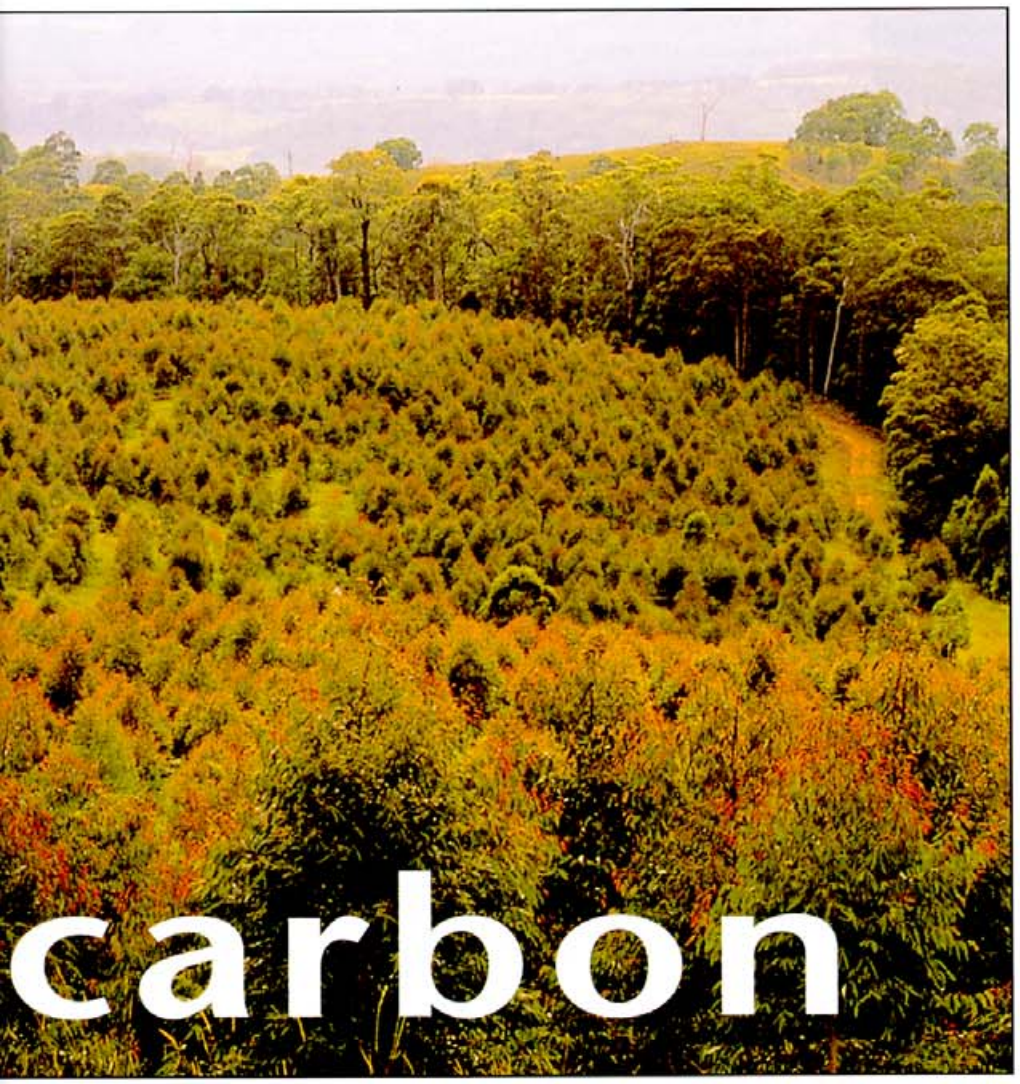
Noble says that, almost uniquely among Kyoto's so-called Annexe 1 nations, – industrialised nations and the transition economies of the former Soviet Union – Australia was still rapidly clearing its forests and woodlands in 1990, at an annual rate of some 550 000 hectares. The rate still hovers at 400 000 hectares.

Despite gains from tree-planting and natural regeneration in the wake of forest harvesting, rural Australia features on the red side of the emissions ledger: as a net source, not a sink. In fact it accounts for 20–30% of the nation's anthropogenic carbon emissions. In most Annexe 1 nations the contribution is below 10%, with some closer to 5%. 'North America went through its major land clearance phase last century. For Denmark, it was closer to a millenium ago,' Noble says.

In search of surprises

The CRC is pursuing four main research programs, plus an education/outreach program.

Noble says one program will look at how biophysical systems are likely to



respond to rising levels of greenhouse gases in the atmosphere. He calls it 'a search for surprises' – as-yet undiscovered aspects of the carbon cycle that need to be factored into models.

One of his ANU colleagues, Dr Marilyn Ball, recently uncovered an unpleasant surprise while investigating factors affecting the distribution of high-altitude snowgums (*Eucalyptus pauciflora*) in the Australian Alps.

Ball found that seedlings grown in a doubled-CO_2 atmosphere are severely damaged by early or late-season frosts. If other native species are as vulnerable as the most cold-tolerant of Australian eucalypts, it could affect the success of natural regeneration or tree-planting programs to sequester carbon.

A research program led by Professor Snow Barlow from the Bureau of Rural Sciences aims to provide support for Australia's negotiating position when nations meet to ratify the Kyoto Protocol. Many nations are likely to seek changes in their allowances, in light of an improved understanding of the state of their carbon emissions and sinks in 1990. The CRC will use a set of models to ask 'what if' questions about the effects of different policy options on its carbon sources and sinks.

Noble says that Australia, with its large land area, reliance on primary production, small population and long transport routes, is not unlike many Third World Nations. Its scientists, and the resources available for research and monitoring to underpin revegetation and rehabilitation, are far more thinly spread than in Europe or North America.

'We have to find methodologies that work for us, and some of them are going to be more relevant to developing than to industrialised nations,' he says.

Europe, the United States and Canada cannot undertake large-scale reforestation because of intense competition for land, but much of Australia is sparsely-settled rangelands, or regions where agriculture has become marginally economic.

'If we could increase soil carbon levels by just a few per cent, it would make an enormous contribution to our carbon balance,' he says.

Dr John Raison from CSIRO Forestry and Forest Products will lead a program to develop reliable methods for measuring carbon fluxes associated with biomass above and below ground. Woody biomass has a high carbon content and therefore a high potential to either release carbon (during clearing or burning) or sequester it (in new tree plantings). John Carter from Queensland's Department of Natural Resources will lead a matching program with the exacting task of developing effective measurements of soil organic carbon.

Raison says that if emissions resulting from Australia's rapid land clearing in 1990 can be accurately quantified, then reductions during the 2008–12 period will be reflected as an important carbon credit.

But two factors complicate the task of establishing the 1990 baseline figure.

'The soil has a "memory",' Raison says. 'Carbon leaks out in an exponentially decreasing manner after vegetation is cleared. This delay factor means that land cleared before 1990 was still contributing to carbon emissions in the baseline year.

'Regrowth is the other complication. Some of the areas cleared were not virgin forest, but regrowth from earlier clearing, so its biomass was less than for mature woodland. We have to work out how much of each was cleared.'

To help assess the actual biomass of mature forest and forests in various stages of regrowth, Raison and his colleagues will have to develop allometric equations that relate certain dimensions of the forest to the amount of carbon stored above and below ground. The equations must take soil fertility into account, and differences in the way tree species partition carbon between their root systems and above-ground growth.

On richer soils, about 30% of a tree's biomass is in its roots. Trees growing on less fertile soils need more extensive root systems, so the figure will probably be greater. Raison's team will have to carry out detailed ground-truthing studies in selected ecosystems to determine what that percentage is. The next challenge will lie in determining how rapidly the soil microflora decomposes the roots left behind after land clearing.

On richer soils, about 30% of a tree's biomass is in its roots. Trees growing on less fertile soils need more extensive root systems. Equations that relate certain dimensions of the forest to the amount of carbon stored above and below ground are needed to help assess the actual biomass of forests, and their potential for storing carbon.

Amid talk, the **deals** begin

EARLY in 2000, the Australian Greenhouse Office (AGO) will advise the Federal Government on the feasibility of establishing a national emissions-trading system to help Australia meet its commitments under the Kyoto Protocol.

The system, if introduced, would be based on a finite number of Government issued permits that authorise the owner to emit a specified amount of carbon dioxide-equivalent greenhouse gas. Once used by an emitting source to authorise their emissions, the permit would be retired from the trading system. The maximum number of Australian permits available in the trading system would equal the national target for greenhouse gas reduction (108% of 1990 levels for the years 2008–2012).

The incorporation of carbon sinks in an emissions-trading system would in effect provide supplementary emissions permits, or carbon credits. Emitters of greenhouse gases would be able to offset their emissions buy buying carbon credits from the operators of Kyoto-eligible, forest-related activities. The amount of domestically generated carbon credits available would be limited only by Australia's capacity to provide Kyoto-eligible carbon sinks.

To enable carbon credits to be traded internationally, issues relating to carbon measurement techniques, and the definition of terms such as afforestation, reforestation and deforestation, are being addressed by the Intergovernmental Panel on Climate Change. A deadline for finalising this work has been set the Sixth Conference of the Parties, scheduled for the end of 2000 or early 2001.

But carbon will not be a commodity to be traded in an international sense until the Kyoto Protocol is ratified, according to Professor Ian Noble. 'Only when legal limits are agreed to can a trading system have any rationale at all,' he says. 'And that won't be for many years yet.'

The signing in July of a letter of intent between the Tokyo Electric Power Company and State Forests of NSW to establish between 10 000 and 40 000 hectares of new forest in the next 10 years offers an example of the potential of carbon trading in Australia. State Forests of NSW has also signed a Memorandum of Understanding with the Sydney Futures Exchange and its subsidiary the New Zealand Futures and Options Exchange to develop the world's first exchange-traded market for carbon credits. Forward trading of these carbon credits is expected to begin in mid 2000. Trading is expected to be consistent with the Kyoto Protocol.

According to the AGO, traders who speculate in carbon credits are taking significant risks, given there are no formal mechanisms for recognising or crediting their trades internationally. At the same time, businesses are being urged to avoid being left behind in a world where emissions reductions permits can be traded.

A discussion of how carbon sinks might be incorporated in an emissions-trading system can be found in the report, Crediting the carbon, *at the AGO website http://www.greenhouse.gov.au/.*

Land use after clearing adds another layer of complexity.

'If it goes to cropping, the soil carbon rundown is more rapid than if it is converted to grazing, and on improved pastures, soil carbon levels may not drop much at all,' Raison says.

In the rangelands, stocking rates for livestock have a major effect on soil carbon storage. Heavy stocking, by consuming much of the herbage production, reduces the amount of carbon going into the soil.

'One issue we will look at is how much we could increase soil biomass and carbon levels if Australia destocked large areas of its rangelands,' Raison says. 'Small changes per unit area, over a large area, could add up to very large amounts of carbon.'

One of the CRC's first priorities is to help deliver the 1990 baseline figure, due in about two years time; there will be more time to develop tools to facilitate trading in carbon.

Remote sensing satellites make large-scale assessments possible; they will be an important tool for monitoring changes in vegetation cover and biomass in the next decade as tree planting and ecosystem rehabilitation gather pace. And ground-penetrating radar can 'see' several metres into the soil to help assess root biomass.

'But the overriding question is whether we can cost-effectively measure or estimate changes in carbon in variable environments in a scientifically defensible way,' Raison says. 'The primary goal of the CRC is to address this question.'

Abstract: The CRC for Greenhouse Accounting has been established to determine cost-effective ways of estimating carbon dioxide flux from farms, forests and land-clearing operations. These are needed so that Australia can claim official credit for its carbon 'sinks' and offset some of its own and other nations' excess carbon emissions through revegetation. CRC research programs will investigate the response of biophysical systems to rising levels of greenhouse gases in the atmosphere, will create 'what if' models to asses the effects of different policy options on carbon sources and sinks, and develop methods for measuring carbon fluxes associated with biomass above and below ground.

Keywords: carbon emissions, carbon credits, carbon sinks, carbon trading, forests, plantations.