Case Study
Environmental Plantings

Introduction

The *Environmental Plantings* project aimed to improve the predictive accuracy of soil carbon sequestration after reforestation. This would support model-based Emissions Reduction Fund (ERF) methods that include environmental plantings.

The CSIRO-led three-year study was highly collaborative, involving seven universities and state government agencies from NSW, Victoria, Queensland and South Australia.

Project leader Dr Keryn Paul from CSIRO said the excellent collaboration within the project made it highly efficient.

"We had 124 study sites across Australia," Dr Paul said. "We worked together to compile an unprecedented dataset showing changes in carbon in the soil, litter and live biomass that followed the targeted integration of environmental plantings into farmlands.

"We can see afforestation giving not just above and belowground carbon storage, and also benefits for soil carbon. It also affords a range of co-benefits, such as improved erosion control in riparian regions of the farm and the potential to increase farm profits when environmental plantings are established as shelterbelts."

Background

Many Australian farmers already integrate reforestation activities into their farming systems. These activities include shelterbelts, landscape remediation and plantings to increase biodiversity. The Australian Government's ERF provides standard methods by which land managers can obtain carbon credits for such reforestation activities.

There is already a modelling-based method available to obtain credits for carbon sequestration in biomass and debris from reforestation activities. The model used in this method, FullCAM, also underpins Australia's National Greenhouse Gas Inventory. Despite FullCAM's capacity to predict soil carbon, this pool is not included in reforestation ERF methods. The *Environmental Plantings* project aimed to obtain the data to undertake calibrations within this model framework. This was required to add a pool of carbon that farmers undertaking reforestation could get credit for via the ERF: the soil.

Dr Paul said the project's strength lay in the vast amount of data it collected. A network of researchers sampled above and belowground biomass and soil carbon at a huge number of sites across a wide range of geo-climatic regions across Australia.

"Having this powerful dataset to calibrate FullCAM gives us confidence that the model is robust in predicting changes in all pools of carbon following reforestation on farms," she said.

Findings

New and existing soil carbon data were collated from more than 120 paired environmental planting sites from across Australia. Researchers found that almost half the observed variation in change in soil carbon stock could be explained by climate, stand age and/or the initial soil carbon content at the time of reforestation.

The project also had three intensively measured sites. Results from these sites showed that many previous estimates of soil carbon were unreliable due to under-sampling (e.g. < 30 replicate cores sampled). Dr Paul

summarised the results from the 71 sites with adequate replication: "On ex-cropping sites, which tended to have low initial stocks of carbon, the carbon sequestered in the soil was fairly high, an average of 0.55 tonnes of carbon per hectare. In contrast, in the ex-pasture sites, where soil carbon tends to be relatively high, the carbon sequestered following reforestation was only half that of ex-cropping sites."

In addition to measuring total soil carbon stocks, the various fast and slow-turnover pools of soil carbon were measured, as was the litter and biomass carbon. As a result, FullCAM predictions of *total* carbon (biomass + debris + soil) sequestered following reforestation could be calibrated. This was done for different categories of environmental plantings. These categories were defined in terms of landscape position (e.g. riparian vs rainfed), planting configuration (e.g. belts vs blocks), stand density (e.g. sparse or densely planted), and species mix (e.g. proportion of trees to shrubs).

Modelling showed that including soil in addition to the biomass and debris pools already accounted for in the ERF methodology would increase credits obtained by an average of eight per cent. Scenario analysis confirmed that in spite of the clear trends, there was a significant amount of variation in the data. Dr Paul noted that this noise could be attributed to the huge variation present in the types of environmental plantings established.

"They vary not just in the species mix – some are quite tree-dominant, some are a mix of trees and shrubs – but also in their density," she said.

"Some are sparsely planted, some are very dense, some are in blocks and some are in belts, some are riparian, some of them are rainfed. There's a huge variety of environmental plantings causing that variation. In fact, another key finding from this project was that many environmental plantings established in riparian regions of the farm, such as in eroded gullies, had much higher rates of sequestration of carbon than the models initially predicted.

"They potentially provide a terrific opportunity for farmers to reduce erosion while also obtaining carbon credits: a win-win scenario."

Measurement of carbon stocks in soil (0–30cm), litter and biomass was undertaken in 120 environmental planting sites paired with adjacent agricultural land.

There was a wide range of different types of environmental plantings established. Riparian plantings such as this one offer some of the greatest benefits to both sequestration of carbon and other co-benefits such as decreased erosion and improved water quality.

Impact

Dr Paul said the major goal of the project was to improve the FullCAM model so it could support methods to encourage a wider group to engage in the ERF.

"We looked at a wide range of geo-climatic regions and we're increasing the area of applicability in those calibrations," she said. "By improving the model, we can encourage farmer participation in the ERF through reforestation projects."

The work will enable FullCAM-based ERF methods to be expanded to include credits from sequestration in the soil in addition to sequestration in biomass and debris, opening up new opportunities for farmers.

"There are only a limited number of grants available for natural resource management projects," Dr Paul said. "If these improvements are implemented in the ERF methods for reforestation, farmers may be able use the carbon market to help pay for the establishment and maintenance of environmental plantings."

Farmers can use environmental plantings as riparian plantings to decrease soil erosion, and in alley crop configurations to both manage the farm's water availability and mitigate salinity. Other co-benefits could be increased biodiversity and pollination services.

"There are also possible production benefits from environmental plantings, for example, when they are established as shelterbelts and for stock," Dr Paul said. "A recent land use policy paper showed that carbon sequestration from dense and tree-dominant shelterbelts was also the most efficient way to sequester carbon from reforestation with environmental plantings, with minimal impact on land available for agriculture."

Another key impact of the research was the development of guidelines for soil sampling.

"Sampling errors are a real thorn in the side of soil carbon researchers," Dr Paul said. "The work from the three intensive sites led to guidelines on how to sample soil organic carbon to minimise sampling errors. As a result of this work, we now know that many previous studies on soil carbon have unreliable results due to high sampling errors from under-sampling."

Researchers marking out plots for soil carbon sampling at one of the 120 paired environmental planting and adjacent agricultural sites where carbon in biomass, litter and soil were studied.

Next steps

"By linking with other projects under the Filling the Research Gap initiative that have measured soil carbon stocks under other woody systems such as regrowth, plantation forestry and fodder crops, it will be possible to undertake even more robust calibrations of FullCAM," Dr Paul said.

"We will be able to ensure the final calibrations are applicable to a wider range of woody systems across Australia, and to a wider range of geo-climatic regions.

"Now the hard work of collecting the data is done, we hope the FullCAM model can be validated with the datasets from not just this project, but also other Filling the Research Gap projects on woody systems. This will improve our understanding and confidence in the predictions of changes in soil carbon following natural regeneration, reforestation, or farm forestry.

"We hope the ERF methods based on FullCAM can be extended to credit carbon sequestered in soil, in addition to that sequestered in biomass and debris."

Further information: Keryn Paul
CSIRO, 0418 42 010
keryn.paul@csiro.au

Acknowledgements: Jacqui England, Dinesh Madhavan, Shaun Cunningham, Tom Baker, Simon Murphy, Zoe Read, Brian Wilson, Tom Lewis, Mike Perring, Jeff Baldock, Tim Cavagnaro, Tim Herman, Stephen Roxburgh, Richard Greene, Amanda Schapel et al.

For assistance with site selection, field work and soil preparation and analyses we thank John Larmour, Micah Davies, Melanie Bullock, Pandora Holliday, Gordon McLaughlin, Michael Davy, Tom Fairman, Harry Roberts, Trevor Hobbs, Geoff Minchin and Tony Patti. For supervision/guidance, we thank Richard Hobbs, Christopher Weston, Tim Smith, John Field and John Raison. We are also indebted to the farmers who gave us permission to sample on their properties, particularly those of our three 'intensive' study sites: John and Felicia Di Stefano, Glenn and Glenice Foster, and David Tepper.