Case Study
Carbon in eastern Australian farming systems

Introduction

Despite considerable research, it remains difficult to predict how soil organic carbon in agricultural production systems will respond to alternative management practices. This is because soil carbon change occurs slowly and different sites often respond differently to the same management practices.

Carbon in eastern Australian farming systems was a collaborative project that assessed the impact on soil carbon and nitrogen of different farm management systems. It focused on enhancing carbon input and retention in key soil types and climatic zones in eastern Australia.

The researchers assessed practices that previous research or farmer experience suggested might have the potential to sequester carbon, such as including pastures in crop rotations and using alternative residue management and grazing systems.

Project leader Dr Fiona Robertson said, "We went looking for evidence of how carbon changes under different management in cropping and grazing systems. We used field and laboratory experimentation, data analysis and modelling."

The team also investigated the interactions between carbon and nitrogen in the soil-plant system to understand how soil carbon sequestration, greenhouse gas emissions and productivity are linked to nitrogen, soil type and climate.

The project supported the development of Emissions Reduction Fund methods to help landholders increase soil carbon and reduce greenhouse gas emissions.

Findings

Analysis of data collected from almost 1500 field sites across Queensland, New South Wales and Victoria showed that land use and management practices had relatively small influences on soil carbon. Climate and soil properties had considerably more impact.

"We found the effect of management, compared with climate and soil, was quite small," Dr Robertson said. "Previous work has shown that climate has a big effect in some places but not in others. This work showed that right across eastern Australia, climate is a very strong driver of soil carbon levels."

"Productive agriculture can be compatible with building soil carbon."

New crop growing in previous year's stubble.
Soil from the top 30cm.

Cultivation and cropping of pasture soils reduced soil carbon, and the losses increased the longer cropping was practised.

"Putting this land back to pasture can build soil carbon over the medium to long term," Dr Robertson said, "but the longer it has been cropped, the harder it becomes to restore it."

The restoration of carbon during the pasture phase was not accompanied by restoration of nitrogen availability, which is an important indicator of potential productivity.

Under cropping in Victoria and sugarcane in northern NSW, stubble retention and minimum tillage did not increase soil carbon.

"There's conflicting evidence about stubble retention and minimum tillage. We would expect that it would maintain or increase soil carbon, however we found no effect on soil carbon levels of these management practices, even over the long term (more than 15 years)," she said.

The inclusion of legumes in rotations with grain crops in Victorian cropping scenarios reduced soil carbon losses and increased soil nitrogen in some instances, but not in others. "We think that the variable responses we observed were due in part to differences in nitrogen and water availability, and also to other, unidentified, interactions," Dr Robertson said.

In the pastures of coastal NSW, soil carbon stocks increased as inputs of nutrients and irrigation increased, and the carbon stocks were positively associated with nitrogen availability. This demonstrates that productive agriculture can be compatible with building soil carbon.

Under grazing in southern Victoria, soil carbon was not significantly affected by a range of phosphorus fertiliser or stocking rate treatments over 35 years, despite extremely large responses in pasture and animal production due to the treatments. Farmers cannot assume that increased production above the ground equates to increased carbon storage in the soil.

Results suggested adding extra nitrogen in the form of fertiliser over and above normal crop requirements would not be an effective way to increase soil carbon sequestration unless the soil was nitrogen-limited and carbon inputs in the form of crop residue, manure and plants roots were high.

In southern Australia, soil carbon stocks were found to be lower in remnant native grassland than under agriculture. This contrasts to the common finding that conversion of native systems to agriculture usually reduces soil carbon.

"There are plenty of instances in Australia where areas of native vegetation have a lot more soil carbon than in agriculture, but in our experiments in Victoria, that wasn't the case," Dr Robertson said.

Testing the APSIM* model against data from three long-term field experiments showed that model performance was good, although simplifications in the model meant that it may not always capture trends at specific locations.

Sampling a pasture site for soil carbon and nitrogen analysis.

Next steps

The project findings will allow farmers and policymakers to make more informed decisions about soil carbon management. The practice with the most potential to increase soil carbon sequestration is the conversion of cropland to pasture, with increases in the order of 0.1 to 0.2 tonnes of carbon per hectare per year over about 20 years.

"This project was all about finding out what works and what doesn't," Dr Robertson said. "Conversion of long-term crop sites to pasture is likely to increase carbon in the long-to-medium term but the previous history of the site is going to be important, especially how long these sites have been cropped.

"We know that history of a cropping site is a big influence, but it's often neglected. We tend to measure the past 10 years but we know that the influence goes back a long way beyond that and often, we have no information."

The consequences of the transition from cropping to pasture for greenhouse gas emissions are also uncertain, as the project did not measure net carbon sequestration.

"If we are considering mitigation of greenhouse gas emissions, we need to look at the whole system," Dr Robertson said. "Putting in a pasture and introducing livestock changes the carbon and nitrogen dynamics in the system. Nitrous oxide and methane emissions need to be taken into account."

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** The Agricultural Production Systems Simulator (APSIM) software is a modular modelling framework developed to simulate biophysical processes in agricultural systems, particularly as it relates to the economic and ecological outcomes of management practices in the face of climate risk.*

Sampling a long-term field experiment in Victoria.