Research Project Summaries
Climate Change Research Program
National Biochar Initiative
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Overview

The Climate Change Research Program (CCRP), which ended on 30 June 2012, funded research projects and on-farm demonstrations to help prepare Australia’s primary industries for climate change. Research focused on reducing greenhouse gas emissions, improving soil management and climate change adaptation, and involved projects that will lead to practical management solutions for farmers and industries.

Over four years the Australian Government invested $46.2 million in over 50 large scale collaborative research, development and demonstration projects. Total investment under the program was over $130 million and included contributions from research providers, industry groups, universities and state governments. A breakdown of the allocated government funding is below:

- Reducing Emissions from Livestock Research Program—$11.3 million
- Nitrous Oxide Research Program—$4.7 million
- Soil Carbon Research Program—$9.6 million
- National Biochar Initiative—$1.4 million
- Adaptation Research Program—$11.5 million
- Demonstration on-farm or by food processors—$7.7 million.

Research through the CCRP has increased our understanding of the sources of agricultural emissions and the potential for emission reduction and carbon sequestration. This information has underpinned the development of the first approved methodology under the Carbon Farming Initiative and has contributed valuable data for a number of methodologies currently under consideration. This will enable farmers to generate additional on-farm income through selling carbon offsets into domestic and international carbon markets.

Filling the Research Gap, part of the $429 million Carbon Farming Futures Program under the $1.7 billion Land Sector Package, is building on research undertaken through the CCRP. Research projects are targeting current gaps around abatement technologies and practices identified through the CCRP, and will continue to support the development of offset methodologies that land managers can use to participate in the Carbon Farming Initiative.

The following summaries highlight the key findings from biochar research undertaken through the CCRP as well as related projects being funded through the Biochar Capacity Building Program and Round 1 of Filling the Research Gap. This information should be used by potential applicants to guide applications in climate change research for agriculture under Round 2 of Filling the Research Gap.

Potential applicants are advised to contact the lead organisations for each project for further information and are encouraged to refer to the Filling the Research Gap Research Strategy (July 2012-June 2017).
Climate Change Research Program

National Biochar Initiative
From Source to Sink: A National Initiative for Biochar Research

**Lead organisation**
Commonwealth Science and Industrial Research Organisation (CSIRO)

**Consortium member organisations**
NSW Department of Primary Industries
University of New England
The University of Sydney
The University of Western Australia

**Objectives**
- characterise the biochemical and physical composition of common feedstock materials and the chemical and physical nature of the biochar produced under different production temperatures.
- assess the carbon sequestration potential of biochar and its changing properties over time in different soil types and at different production temperatures.
- quantify greenhouse gas emissions following biochar application to soils with different chemical and physical properties to determine under what soil and climatic conditions a mitigating effect is possible.
- investigate the potential contaminants from biochars and the effects of biochar on the efficacy of fertilisers and pesticides.
- apply life cycle assessment methodology to determine climate change impact, linked with policy analysis pertaining to biochar application to soils.

**Location**
Laboratory based with the exception of research quantifying greenhouse gas fluxes with field trials at Wollongbar, New South Wales and Wongan Hills, Western Australia.

**Key activities**
Research gaps on biochar were assessed through five interconnected tasks:
- biochar characterisation, analyses of key chemical and physical properties and categorisation to determine biochar variability
- quantification of biochar stability in a range of soils under controlled conditions
- quantification of greenhouse gas fluxes with regard to nitrous oxide emissions in laboratory and field studies under different agricultural and climatic conditions
- assessment of biochar risk factors, including: production-inherent and feedstock-derived toxicants and application rates of biochar to soil (specifically with regard to pesticide efficacy)
- life cycle assessments of greenhouse gas mitigation potential benefits of different biochar production scenarios whereby a biochar system was compared to a reference system of biomass to landfill, including fossil fuel use.

**Findings/Conclusions**
Biochar can be highly variable in chemical and physical properties and should be characterised to ascertain suitability for purpose. Results indicated that wood, green-
waste and nutshell biochars are most likely to have a higher organic carbon content and a lower nutrient content than biochar produced from food waste, paper mill waste and poultry manure.

While it is now possible to advise which feedstock and production temperatures are necessary to either maximise carbon sequestration or agricultural benefit, the researchers noted that the differences within broadscale feedstock groupings needs further research to determine whether these differences impact on the behaviour of biochar in soils.

Biochars produced at higher temperatures (550°C) and from wood-derived materials tend to be more stable than lower temperature (450°C) or high-ash biochars, which tend to have a greater amount of agronomically available nutrients. As such, biochars produced at the higher temperature offer a promising option for the long-term sequestration of carbon in the landscape.

Biochar did not reduce nitrous oxide emissions under dryland agricultural conditions (typical of large parts of Western Australia). However, the same biochar source did decrease nitrous oxide emissions under moist pedoclimatic conditions (e.g. northern New South Wales). These results show that the same biochar source can have a markedly different response depending on soil type and climatic conditions.

Biochar has been shown to reduce herbicide efficacy in laboratory experiments but this effect and its longevity need to be verified under field conditions.

Most biochars produced in Australia had a low amount of organic and metal toxicants such as polycyclic aromatic hydrocarbons (PAHs) and dioxins. The researchers noted that caution should be exercised when importing biochars from overseas and recommended that guidelines detailing the minimum amount of chemical analysis should be put in place.

Life cycle assessment showed that most biochar scenarios examined led to a substantial reduction in greenhouse gas emissions. However, the assumptions applied to the reference use of the biomass means these findings are uncertain.

**Related projects funded under the Biochar Capacity Building Program**

- **Direct quantification of biochar that is stable on centennial timescales**—James Cook University—Michael Bird. Funding of $143 079 ex GST
- **The National Biochar Initiative II - A country wide approach to biochar systems**—CSIRO—Lynne Macdonald. Funding of $1 050 411 ex GST
- **Understanding and observing the benefits of biochar in the carbon cycle**—North East Catchment Authority—Chris Reid. Funding of $250 000 ex GST
- **The contribution of biochar in increasing soil carbon in native woody bioenergy crops and on-farm revegetation**—Monash University—Antonia Patti. Funding of $263 770 ex GST
- **Integrated riverine land management system using biochar**—South Australian No Till Farmers Association Inc—Greg Butler. Funding of $292 740 ex GST
Related projects funded under Round 1 of Filling the Research Gap

- **Trialing compost and biochar amendments to North Queensland tropical agricultural soils**—James Cook University—Michael Bird. Funding of $1 000 000 ex GST
- **An assessment of the carbon sequestration potential of organic soil amendments**—CSIRO—Mark Farrell. Funding of $802 797 ex GST

**Publications**


Further publications detailing the results of this research are in preparation and will be available.

More information on the National Biochar Initiative can be found on the CSIRO website at [www.csiro.au/science/Biochar-Overview](http://www.csiro.au/science/Biochar-Overview)
Biochar Capacity Building Program
Overview

The Biochar Capacity Building Program is part of the $45.6 million Carbon Farming Initiative and is funding research that determines and quantifies how biochars mitigate greenhouse gas emissions. It is also funding research that demonstrates different biochar systems in Australia.

This program complements and builds on research conducted under the Climate Change Research Program to help Australian farmers and other land holders understand how biochar can reduce Australia’s emissions. The research will also inform the development of offset methodologies for the Carbon Farming Initiative.

Five research projects are sharing the $2 million in Australian Government funding over the years 2011–12 to 30 June 2014. These projects focus on reducing greenhouse gas emissions, improving soil management and developing ways to adapt to and manage climate change.

Direct quantification of biochar that is stable on centennial timescales—James Cook University—Michael Bird. Funding of $143,079 ex GST

The objective of this project is to develop a matrix that relates common biochar feedstock types and pyrolysis conditions to the proportion of stable carbon in the resultant biochar. The outcomes of the project will be a simple means of predicting the stable carbon content of biochar from common feedstock types, leading to an offset methodology and better enabling land managers to participate in carbon markets.

The National Biochar Initiative II—A country wide approach to biochar systems—CSIRO—Lynne Macdonald. Funding of $1,050,411 ex GST

This project builds on the first National Biochar Initiative. There is a strong focus on further developing or establishing new demonstration sites around the country. Establishing a large number of high quality biochar demonstration sites will demonstrate the applicability of biochar in a broad range of agricultural and land management situations. There will also be research activities to underpin the development of Carbon Farming Initiative offset methodologies such as examining biochar stabilisation processes and effects.

Understanding and observing the benefits of biochar in the carbon cycle—North East Catchment Authority—Chris Reid. Funding of $250,000 ex GST

This project will produce biochar from woody weeds (willow) and establish a number of biochar field sites and trials. The project will communicate to farmers the benefits of biochar, conduct field days around trial sites and develop and distribute glove-box
manuals for the use of biochar. It will also monitor and evaluate changes in soil chemistry and establish base-line data on biochar use.

**The contribution of biochar in increasing soil carbon in native woody bioenergy crops and on-farm revegetation**—Monash University—Antonio Patti. Funding of $263,770 ex GST

This project will demonstrate the potential of biochar and biochar/compost blends to increase soil carbon in native woody bioenergy crops. The project will produce and characterise biochars from local sources. It will conduct germination, growth and survival trials of the native species under various soil conditions in both greenhouse and field and quantify changes to soil carbon content. The outcomes will assist land managers to make informed decisions about using biochars to establish native plants in a range of soils, improve compromised soils and increase soil carbon.

**Integrated riverine land management system using biochar**—South Australian No Till Farmers Association Inc—Greg Butler. Funding of $292,740 ex GST

This project will demonstrate how degraded dairy pastures in the Lower Murray can be transformed by integrating a biochar management system. Biochar derived from a native reed will be used to filter polluting river drains loaded with acid or nutrients. The loaded chars will then be applied in local dairy and cropping enterprises as a means of reducing nitrous oxide emissions and storing carbon. The project will assist in the development of methodologies and also focus on grower engagement though the publishing of case studies and detailed economic modelling.
Round 1 of Filling the Research Gap
Overview

*Filling the Research Gap* supports research into emerging abatement technologies, strategies and innovative management practices that reduce greenhouse gas emissions from the land sector, store soil carbon and enhance sustainable agricultural practices.

A total of 57 successful projects are being undertaken under Round 1 of the program. These projects share $47 million in Australian Government funding over the years 2011–12 to 30 June 2015 and are grouped into five sub-programs:

- National Livestock Methane Program
- National Agricultural Manure Management Program
- National Agricultural Nitrous Oxide Research Program
- National Soil Carbon Program
- National Agricultural Greenhouse Gas Modelling Program.


### National Soil Carbon Program

**Coordination of the National Soil Carbon Program / Soil carbon increase through rangeland restoration by facilitating native forest regrowth**—Department of Science, Information Technology, Innovation and the Arts—Ram Dalal. Funding of $1 500 000 ex GST

This project will coordinate and manage the soil carbon projects as a national program. In addition, it will also use standardised sampling and measurement methods in previously-cleared Queensland rangelands to quantify increases in carbon and carbon pools in soil and biomass under native forest regrowth up to 50 years old. Through modelling, the project will quantify the optimal soil carbon sequestration and pasture production for rangeland. The project will also contribute to developing a *Carbon Farming Initiative* methodology for managed forest regrowth for rangelands.

**Environmental plantings for soil carbon sequestration on farms**—CSIRO—Keryn Paul. Funding of $1 000 000 ex GST

This national project will support the extension of the *Carbon Farming Initiative* (CFI) methodology for mixed-species environmental plantings to include carbon in soil. It will target agricultural-environmental planting sites for diverse climates and soil types and study how management of farmland with low opportunity costs affects soil carbon. The project aims to give land managers the required knowledge for CFI reforestation participation on marginal farm land.
Native perennial vegetation: Building stable soil carbon and farm resilience—CSIRO—Jonathan Sanderman. Funding of $350 000 ex GST

This project will quantify changes in soil carbon stocks and composition with the re-establishment of native perennial grasslands through adoption of rotational grazing and include measurement of soil carbon and its allocation to major fractions. The project aims to deliver the knowledge and tools needed for these extensive grazing systems to participate in the Carbon Farming Initiative.

Soil carbon benefits through reforestation in sub-tropical and tropical Australia—Queensland Department of Agriculture, Fisheries and Forestry—Tim Smith. Funding of $1 677 632 ex GST

This project will assess soil carbon sequestration under reforestation to enable accounting of full mitigation benefits (biomass and soil) and assist land managers to participate in Carbon Farming Initiative reforestation projects with increased confidence. It also will collect soil and biomass carbon data across hardwood, softwood, savannah and rainforest ecosystems in sub-tropical and tropical Australia to develop relationships of changes in soil carbon pools over time following reforestation of agricultural land. Finally, it will refine sampling protocols for improved measurement of soil carbon, develop a decision support calculator and provide economic case studies, enabling land managers to determine the feasibility of carbon farming through reforestation.

EverCrop® Carbon Plus: Perennial forage plants in cropping systems to manage soil carbon—Future Farm Industries Cooperative Research Centre / NSW Department of Primary Industries—John McGrath. Funding of $1 000 000 ex GST

This project will assess the role of perennial forage plants in improving the management of soil carbon in major cropping regions of southern Australia, provide data to improve soil carbon models and enhance farmers’ decision making. It will use existing EverCrop® farming system and long term perennial forage trials to research if including deep rooted perennial forages into cropping systems can sustain or increase soil organic carbon relative to current annual based cropping systems.

Compost and biochar amendments for increased carbon sequestration, increased soil resilience and decreased greenhouse gas fluxes in tropical agricultural soils—James Cook University—Michael Bird. Funding of $1 000 000 ex GST

This project will trial compost, biochar and COMBI-mix (biochar mixed with organic waste prior to composting) soil amendments to North Queensland tropical agricultural soils. The trials will consist of business as usual, compost alone, biochar alone, COMBI-mix and compost mixed with biochar at a number of field sites. From the trials, the project will determine the impact of each on carbon sequestration, greenhouse gas fluxes and crop performance.
**An assessment of the carbon sequestration potential of organic soil amendments**—CSIRO—Mark Farrell. Funding of $802 797 ex GST

This project will quantify the relationship between the chemical composition of organic carbon and how it decomposes in a variety of potential soil organic amendments. Spectroscopic techniques will be used to measure carbon chemistry and long-term incubation experiments will quantify degradation dynamics. The data generated will be used to define the relationship between chemical composition and potential longevity / stability of different types of organic amendments in soil. The results of this analysis will be used within FullCAM (the model used to construct Australia’s national greenhouse gas emissions account for the land sector) to provide consistency with Australia’s national inventory and *Carbon Farming Initiative* methodologies.

**Quantifying temporal variability of soil carbon**—CSIRO—Jeff Baldock. Funding of $1 000 000 ex GST

This project will re-sample soil from 60 sites within the New South Wales Monitoring, Evaluation and Reporting (MER) program. Samples will also be collected from selected *National Agricultural Nitrous Oxide Research Program* field experiments to quantify the influence of applied management treatments on soil carbon stocks. Statistical analyses will quantify the magnitude and certainty of measured soil carbon stock changes. This project will support development of robust *Carbon Farming Initiative* methodologies.

**Improved measurement and understanding of soil carbon and its fractions**—CSIRO—Jonathan Sanderman. Funding of $150 000 ex GST

This project will build on the research started in the *Soil Carbon Research Program* focused on developing techniques for rapidly and routinely measuring numerous soil properties at a lower cost. This research is to provide proof of concept to measure soil carbon fractions using visible near-infrared (vis-NIR) spectroscopy.

**A method for efficient and accurate project level soil organic carbon determination using in situ spectrophotometry and advanced spatial analysis**—Geo Carbon Services Pty Ltd—James Schultz. Funding of $195 550 ex GST

This project aims to demonstrate a commercially cost-efficient method to measure rangeland soil organic carbon (SOC) content and composition. The pilot project will be undertaken on 65 000 hectares of central Australian rangeland. It will utilise remote and ground based spectrometry, geospatial modelling using satellite derived soil with vegetation and landform indices to improve the basis for spatially stratifying soil types or land management zones to further improve sampling efficiency and confidence in SOC estimates.
Maintenance of soil organic carbon levels supporting grain production systems: The influence of management and environment on carbon and nitrogen turnover—Department of Agriculture and Food, Western Australia—Frances Hoyle. Funding of $1 009 884 ex GST

This project will investigate the stability of soil carbon under variable climate and management practices. Established research sites with different (or altered) soil organic carbon contents will be used to determine maximum soil carbon storage, the influence of carbon on critical soil functions and long-term viability of sequestering carbon as an emissions management practice. This evidence based approach combines field-based research with database analysis to provide information to landholders on beneficial/perverse outcomes associated with changing soil carbon levels in grain production systems. This will enable landowners to determine the profitability and risk of managing carbon from a sequestration versus production perspective.

Increasing soil carbon in eastern Australian farming systems: Linking management, nitrogen and productivity—Department of Primary Industries, Victoria—Fiona Robertson. Funding of $2 782 312 ex GST

This project will determine the effectiveness of a range of management practices for increasing soil carbon in cropping and pasture systems across eastern Australia, focusing on enhancing carbon input and permanence in key soil types and climatic zones. Soil carbon will be measured in farm paddocks and field trials. Simulation models, validated with measurement data will be used to extend experimental findings across eastern Australia. The project will support development of Carbon Farming Initiative methodologies to help landholders increase soil carbon and reduce greenhouse gas emissions.

Increasing carbon storage in alkaline sodic soils through improved productivity and greater organic carbon retention—The University of Adelaide—Glenn McDonald. Funding of $1 068 022 ex GST

This project will increase the present understanding of organic carbon accumulation in alkaline soils and improve farmers’ capacity to store organic carbon. The project will identify options to increase storage of organic carbon in alkaline soils by studying the soil chemistry, surveying soil organic carbon on alkaline soils and conducting field experiments to ameliorate pH to improve carbon storage.

Understanding the influence of grazing pressure changes on soil organic carbon in the semi-arid rangelands of western NSW—NSW Department of Primary Industries—Graham Denney. Funding of $316 365 ex GST

This project will compare the carbon sink potential of alternative management activities in the southern semi-arid rangelands of southern Australia. A series of economic analyses of alternative grazing management strategies will be used to examine the relationships between agricultural productivity and profitability; soil organic carbon;
and natural resource change. With the cooperation of innovative landholders, case studies will provide a benchmark comparison for soil organic carbon (SOC) by contrasting the impacts of current best management practice against alternative (traditional) management practice. Current best management practice will be considered in terms of total grazing pressure, fencing and rotational grazing, while traditional management practice will be considered in terms of biodiversity, landscape function, and grazing intensity.

**The fate of aboveground carbon inputs: A key process that is poorly understood**—Queensland University of Technology—Richard Conant. Funding of $378 161 ex GST

This project aims to increase present understanding of surface carbon movement into the soil, improve soil carbon/nitrogen simulation models and work directly with soil carbon and nitrous oxide network modellers to provide greater certainty on the potential for reducing emissions. It will include site-based experimentation that complements other research on how management and climate affect carbon sequestration, nitrogen inputs to the soil and nitrous oxide emissions.

**National Agricultural Greenhouse Gas Modelling Program**

**Potential soil carbon sequestration in Australian grain regions and its impact on soil productivity and greenhouse gas emissions**—CSIRO—Enli Wang. Funding of $639 283 ex GST

This project will define soil organic carbon (SOC) sequestration potential and identify management practices that benefit both productivity and SOC stocks. It will use the farming systems model APSIM (Agricultural Production Systems Simulator), together with measurements to identify agricultural practices that increase SOC, quantify SOC sequestration potential across Australian grain regions, assess the vulnerability of sequestered carbon to subsequent changes in management and climate, and investigate the impacts of SOC change on carbon-nitrogen cycling, productivity and greenhouse gas emissions.

**Facilitation of improvement in systems modelling capacity for Carbon Farming Futures**—CSIRO—Andrew Moore. Funding of $629 816 ex GST

This project aims to eliminate any inconsistencies in modelling activities across *Filling the Research Gap* (FtRG). It will ensure that models are developed and applied consistently in FtRG, and that they embody the best scientific understanding of methane, nitrous oxide and soil carbon fluxes. A series of workshops and comparative studies will result in more robust and consistent abatement predictions and increased human capacity for modelling.
Whole farm systems analysis of greenhouse gas abatement options for the southern Australian grazing industries—The University of Melbourne—Richard Eckard. Funding of $537,902 ex GST

This project will conduct whole farm systems analysis of a range of nitrogen, carbon and energy efficiency and greenhouse gas abatement strategies for the dairy, sheep and southern beef industries. Each strategy will be analysed in a whole farm systems context, including methane, nitrous oxide, soil carbon, productivity plus the interactions between these. The outcomes from the project will be evaluated options: for reducing emissions intensity, improving farm profitability and/or further development into Carbon Farming Initiative offset methods.
The ‘Biosphere’ Graphic Element
The biosphere is relevant to the work we do and aligns with our mission—we work to sustain the way of life and prosperity for all Australians. We use this shape as a recognisable symbol across our collateral.

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