Australian Government

Department of Agriculture, Fisheries and Forestry

Research Project Summaries

Climate Change Research Program

Demonstration on-farm or by food processors

Internet

Research Project Summaries is available at: daff.gov.au/climatechange/australias-farming-future/climate-change-and-productivity-research

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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 the demonstration activities undertaken through the CCRP as well as related projects being funded through 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

Demonstration on-farm or by food processors

National Adaptation and Mitigation Initiative

Lead organisation
Grains Research and Development Corporation

Consortium member organisations
Queensland Department of Agriculture, Food and Forestry
Department of Primary Industries, Victoria
Birchip Cropping Group
Department of Agriculture and Food, Western Australia

Objectives
- to assess the emission implications of demonstrated adaptations using existing National Greenhouse Gas Inventory methods (or similar) so as to identify possible maladaptation in terms of greenhouse gas (GHG) emissions
- to demonstrate the practices that can reduce net GHG emissions from nitrous oxide (N_2O) and methane; and increase soil carbon sequestration
- to increase farmers awareness and understanding of the viability of mitigation strategies and practices to manage them
- to provide farmers and advisers with direct access to, and learning from, on-ground demonstration of new and existing, locally-relevant adaptations to climate change to maintain or enhance farm viability
- to rapidly disseminate messages on adapting to climate change in their local communities.

Location
The work was conducted at a national grains industry scale, with demonstration sites located throughout the eastern, western and southern grain growing regions.

Key activities
- establishment of a network of demonstration sites (over two seasons) throughout the major grain growing regions in Australia in collaboration with key farm grower groups
- demonstration sites trialled a range of locally applicable climate change adaptation strategies for grain farming systems and practices aimed at reducing GHG emissions
- sites investigated the effect of various management practices and their impact on GHG emissions, soil carbon levels and productivity. Management practices included tactical fertiliser application (including nitrification inhibitors), variety choice, time of sowing, pulse sourced nitrogen (N) vs. fertiliser N, dry seeding, long-term fallow and so on. N_2O emissions from these sites were monitored using static chambers
- implementation of a series of climate smart workshops to provide growers with an opportunity to explore the impact of various farm management strategies in a low risk, virtual environment
- a range of extension activities including field days/paddock walks, newsletters, forums, trade displays, case studies and fact sheets were undertaken to communicate key findings.

Findings/Conclusions

Nitrous oxide (N_2O)

- Split applications and formulations with nitrification inhibitors (Entec®, Agrotain®) reduced daily N_2O losses by up to 90 per cent. The effects were most dramatic in summer crops and later in the winter season. This trend was consistent across the trials.
- Split applications and formulations with nitrification inhibitors produced lower daily N_2O emissions than applying N as fertiliser. However, fertiliser N applied after pasture led to very high losses due to high availability of nitrate and labile carbon.
- Pasture on old crop land has great potential to rebuild soil organic carbon and nutrients for future grain production in Queensland and northern New South Wales. However, pasture production and sequestration is variable and depends on nutrients being maintained by the cropping phase so that pasture legumes grow properly and support continued dry matter production. Failure to maintain background soil nutrients (e.g. phosphorus) after one or two generations of cropping could result in permanently poor pastures with low dry matter production, little carbon sequestration and poor returns.
- In Victoria, the application of the nitrate inhibitor dicyandiamide (DCD) reduced N_2O emissions by up to 84 per cent, but its impact was short lived (four to five weeks) as the chemical compound degraded under increasing soil temperatures during spring. Further, the application of DCD did not translate into higher grain yields and therefore remains an uneconomical option for mitigating N_2O losses.
- Pulse sourced N reduced N_2O losses and increased wheat yields by up to 3.22 t/ha in the Victorian medium rainfall zone (compared to wheat that received N fertiliser following a previous wheat crop). Tillage practice (conventional vs. no-till) was not found to have an effect on N_2O losses.
- Improved drainage from raised beds may mitigate against crop productivity losses from waterlogging, and also reduce N_2O emissions by maintaining drier topsoils.
- The decision support tool, Yield Prophet® was demonstrated across several sites. Importantly, a methodology was developed whereby farmers can link decision support tools like Yield Prophet® to Predictive Ocean Atmosphere Model for Australia (POAMA) seasonal forecasts to make decisions on how much extra N fertiliser is required to optimise yield within particular risk parameters.
- A large scale site in Western Australia demonstrated the benefits of Precision Agriculture (PA) technology in making in-paddock decisions (using Yield Prophet) to reduce overall paddock costs whilst optimising production from different zones in the paddock. This technology has wide applications across the grain industry.

Department of Agriculture and Food, Western Australia

- Crop rotations: Soil N_2O emissions are relatively low in the winter growing season, but increase markedly following summer rain. Different crop rotations can have a significant impact on N_2O emissions following rainfall in summer and the effect is also likely to be influenced by factors such as soil type, rainfall amount and timing.
- Early seeding canola: Sow canola early only if sufficient moisture is available to offset greater evaporation losses till the season breaks. The 20 mm rainfall rule of thumb is not adequate for early sowing. Yield response followed plant establishment response. Crop establishment increased sharply with increasing amount of post

sowing irrigation to about 25 mm at one site and to about 35 mm at another. It is important that there is sufficient moisture in the seedbed (0-10 cm) to achieve good plant numbers and then to sustain them, at the time of seeding.

- Early seeding canola: Follow the best practices of using big seeds for early vigour, retaining stubble to reduce sand blasting, evaporation and temperature. Use press wheels on sandy and non-wetting soils to increase seed-soil contact, place fertiliser away from the seed and have loose soil above the seed to reduce evaporation.
- Dry seeded wheat (variety Mace) yielded 230 kg/ha less than wet/common sown treatments for a high-rainfall farm demonstration site at Pingelly for the 2011 season. This indicates that a yield penalty may be associated with dry seeding compared with wheat sown at a late May "wet sowing" opportunity. Nevertheless, utilising the 2011 wheat prices for December 2011 the Dry Sown plots provided greater return per hectare, based on final yield, grade and price alone (difference in price range per hectare between the average yield of the Dry Sown and Wet Sown Plots was $19 - $44. In December 2011 the difference in price between Australian Premium White 2 (APW2) and (General Purpose 1) GP1 was approximately $10/t in comparison to long term trends where APW2 is generally $30 - $40/t higher in price than that of GP1); a full economic analysis of all inputs etc for the season would need to be completed to identify whether there was any significant difference in sowing times on end profit.
- Intervention through stubble rolling is an effective way of achieving weed seed emergence after pre-season rains but the level of benefit may vary with soil type.
- Under heavier soil types trifluralin may not be properly incorporated in dry soil reducing its efficacy.
- Boxer Gold and Sakura are both suitable pre emergents for annual ryegrass control in a dry seeding environment, although there are plenty of alternatives.
- Crop competition can play a key role in both yield and herbicide performance.
- Weed seed set control at harvest is not a magic bullet in all seasons and must be carefully managed to collect as much weed seed as possible.

Related projects funded under Round 1 of Filling the Research Gap

N/A

Publications

Queensland Department of Agriculture, Food and Forestry

1. Argent, S, Lawrence, D, Routley, R & Singh, J 2011, 'Can market research successfully improve communication and extension of climate change issues?', In *Hitting a Moving Target - Sustaining landscapes, livelihoods and lifestyles in a changing world. Proceedings of the 2011 APEN National Forum*, Armidale, NSW, 29-30 November.
2. Lester, W, O'Connor, R, Johnson, B, Lawrence, D & Grace, P 2011, 'Nitrification inhibitor lowers relative nitrous oxide flux compared to untreated urea and urease inhibitors applied to urea during winter 2011'. *Soil Science Society of Australia's Conference*.

Department of Primary Industries, Victoria

3. Draft conference paper submitted to the *16th Australian Society of Agronomy Conference*, summarising findings from the N source experiment and the N fertiliser experiment.

4. A webinar presented on 3 April 2012 summarising preliminary findings from all Victorian NAMI sites is available at www.dpi.vic.gov.au/agriculture/farming-management/weather-climate/webinar/webinar-playlist.

Department of Agriculture and Food, Western Australia

5. Fisher, J, Farre, I, Dray, A, Khimashia, N & Perez, P 2012, 'Using game workshops to explore and discuss farm adaptation, *National Climate Adaptation Conference*, 26-28 June.
6. Gray, D 2011, 'Western Australian farm businesses build resilience', *Conference proceedings, 5th World Congress on Conservation Agriculture,* Brisbane, 25-29 September.
7. Sharma, D, Riethmuller, G, Peek, C, Abrecht, D & Pasqual, G 2012, 'Scoping early sown canola in Western Australia', In C*apturing opportunities and overcoming obstacles in Australian agronomy*. *Proceedings of 16th Agronomy Conference 2012* (Australian Society of Agronomy).

Birchip Cropping Group

8. Related reports and media can be found at www.bcg.org.au.

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

Mitigation and Adaptation in the Australian Dairy Industry (MAADI)

Lead organisation

Dairy Australia

Consortium member organisations

The University of Melbourne
Department of Primary Industries, Victoria
Commonwealth Science and Industrial Research Organisation (CSIRO) Sustainable Ecosystems
NSW Department of Primary Industries
Regional Dairy Programs (Sub-Tropical Dairy, Dairy NSW, Murray Dairy, GippsDairy, DairyTas, WestVic Dairy, Dairy SA, Western Dairy)

Objectives

- to provide the dairy supply chain, including service providers and policy makers, with the confidence and capacity to capture the opportunities and deal with the uncertainties associated with a changing climate
- communication of MAADI activities and outputs via field days, workshops, scientific papers, conferences and industry publications
- validation of farming system and greenhouse gas (GHG) models and model assumptions using data from across all demonstration sites
- scientific evaluation of the impact of 'near-farm-ready' adaptation and mitigation options on a community owned demonstration farm.

Location

All eight Australian dairy regions (Sub-Tropical/Queensland, New South Wales, Murray, Gippsland, WestVic, Tasmania, South Australia and Western Australia)

DemoDAIRY (Terang, Victoria)
Parkville (The University of Melbourne)
Burnie (Tasmanian Institute of Agriculture)

Key activities

MAADI operated as two components: **Future Ready Dairy Systems** (delivering adaptation and mitigation information and strategies to dairy farmers and service providers across all eight dairy regions) and the **Validation Farm Project** (researching on-farm emissions reduction strategies for dairy farms in southern Victoria).

Future Ready Dairy Systems

Through this component, 15 on-farm demonstration sites were established to show adaptation and mitigation strategies in action. A reference group and coordinator were also established in each dairy region to customise activities to their needs.

Over 150 events were delivered to 4600 participants and included field days, dairy greenhouse abatement strategies (DGAS) model demonstrations, workshops, professional development days, dairy expos, and study tours. Case studies and factsheets were also developed to document individual dairy farmer actions and outcomes that demonstrate climate change preparedness or reductions in GHG emissions.

Further information on some of the events and all of the supporting information (case studies, fact sheets etc) has been collated into a major legacy product, hosted on the Dairy Australia website at http://frds.dairyaustralia.com.au.

Validation Farm Project

A series of studies were undertaken over the course of MAADI to evaluate methods to measure GHG emissions, evaluate different forages for their potential to reduce methane (CH_4) emissions and to evaluate the impact of different nitrogen products (fertiliser and dairy sludge) on nitrous oxide emissions.
The key areas of work were:

In vitro studies

In vitro herbage digestions were conducted at the University of Melbourne on forages collected primarily from DemoDAIRY (as well as other MAADI sites). These were digested in ruminant fluid collected from within the DPI Vic Ellinbank herd, and methane, ammonia, volatile fatty acids and carbon dioxide were measured. Herbage was also analysed for *in vitro* dry matter digestibility, crude protein, acid detergent fibre, neutral detergent fibre and water soluble carbohydrate content.

This study also compared the effect of oven drying and freeze drying of samples for analyses.

Methane measurements

Methane emissions from dairy cows as they grazed were measured using open path tuneable diode laser (OPL) instruments and a LiCor methane analyser to measure methane emissions from a herd of approximately 120 cows.

Nitrous oxide measurements

An experiment was undertaken to determine the nitrous oxide emissions from strategic fertiliser nitrogen applications, the incorporation of dairy sludge or no addition of nitrogen. Sampling was undertaken using manual chambers (50 cm x 50 cm x 50 cm (2500 cm^2) fitted with internal fans to ensure even distribution of gases during sampling periods. Soil samples were also taken at key times to measure soil ammonium and nitrate content. In addition, soil moisture and temperature were monitored throughout the measurement period.

The Validation Farm Project also included communication activities to inform stakeholders about the research being conducted and on broader climate/emissions management issues. Key resources were developed for the Future Ready Dairy Systems (FRDS) groups (case studies, booklets, information notes), participation and guest speakers were provided for FRDS events and 'milking the weather' newsletters were issued (479 subscribers).

Findings/Conclusions

Future Ready Dairy Systems

- There is substantial support for this delivery model. An independent evaluation showed it provided a high level of support to co-ordinators while its flexibility allowed them to readily adapt and respond to local needs so information and activities were relevant and filled knowledge gaps for farmers and service providers.
- Cost savings are a major incentive for dairy farmer attendance. Dairy farmers were more likely to attend events to learn about potential input cost savings than about reduced use of resources.
- On-farm events add significant credibility. Comments validated the premise that farmers are interested in learning about what their peers have done on site and the evaluation results confirm that dairy farmers do benefit through learning from their peers.
- Industry stakeholders do want to increase their base level understanding and have realised the need for the industry to learn more about GHG emissions and how they can be reduced on dairy farms, particularly how to capture emissions and use them as a potential power source.
- Electronic communication is increasingly relevant for dairy farmers.
- Good quality supporting information is important. The case studies prepared for MAADI events are highly regarded due to the appropriateness of the technical information as well as providing the farm 'story'.

Validation Farm Project

Modelling

APSIM can be used with confidence to explore the influence of crop management and environment on forage crop dry matter (DM) yield and in some cases crop development on dairy farms in south eastern Australia. However, herbage nutritive characteristics (DM digestibility and crude protein concentration) for all crop species were found to be poorly predicted.

APSIM was successfully modified to simulate the change in crop biomass yield with elevated atmospheric CO_2 conditions. Forage crops estimated in this study will continue to form an important component of the dairy feedbase in south eastern Australia under projected climate change.

APSIM was then used in conjunction with DairyMod to model the performance of perennial pastures and annual forage cropping options under historical and two possible future climate scenarios at the Dookie and Terang sites in Victoria and Elliot in Tasmania. The result showed that DM yields of the forage cropping options and the pasture systems at Dookie increased under both the future climate scenarios. At Terang, the forage cropping systems increased in DM yield under the future climate scenarios while the yield of the pasture decreased. At Elliott the response of the perennial forage options were inconsistent. This study has indicated that dryland and irrigated double cropping and irrigated pasture systems at all three locations appear resilient to projected future changes in climate. However, the systems implications of how a shift in the seasonality of supply within these forage options will impact on the farm system as a whole is suggested by project researchers as an area warranting further investigation.

The same scenarios were then used to determine financial performance and greenhouse gas emissions from the respective forage systems. Farm gross margin, percentage of home grown feed and GHG emissions per kg milk solids (MS) were estimated using a combination of biophysical models (DairyMod and APSIM), a forage planning tool (Dairy Predict) and GHG emissions calculator (DGAS). The results from the three sites indicate that it is possible to develop alternate dairy forage systems that will be adapted to meet the challenges associated with future warmer and drier climates and constrain GHG emissions per unit of production.

The project researchers suggest that further improvement to APSIM to allow estimation of the nutritive value of forage crops will assist producers to predict requirements for forages and supplements more accurately in the future.

Results indicated that the incorporation of alternate forage species into the feedbase can increase profitability of dairy systems in warmer and drier future climate scenarios. Deep-rooted forage species, such as lucerne, and double cropping systems, such as winter wheat followed by summer brassica, showed potential at the sites modelled.

In vitro studies

There were significant differences in methane concentration among the pasture/forage species/varieties and differences in the maximum gas production reflect differences in nutrient availability (i.e. more fermentable organic matter is positively related to maximum gas production) which suggest that the *in vitro* fermentation system is sensitive and able to differentiate between a range of important pasture and forage crops. Significant relationships were established between rates of fermentation and estimated metabolisable energy in forages. This data will be integral for the development of forage based feeding systems designed to mitigate methane emissions. The effect of the drying technique of freshly harvested plant material was consistent across all forages tested, with oven drying resulting in a slower rate of fermentation compared with freeze drying.

Methane measurements

Estimates of benchmark methane emissions from grazing cows are lower (16.8 to 17.7 g CH_4/kg DM intake) than the normally accepted 21 to 23 g CH_4/kg DM intake. These data need to be verified before the results can be reported to the National Greenhouse Gas Inventory.

Nitrous oxide measurements
Initial analyses of data has indicated higher emissions from the dairy sludge treatment than either the control or the strategic use of nitrogen fertiliser. Furthermore, there was little difference between the control and nitrogen treatment, indicating plant uptake of nitrogen was such that the production of nitrous oxide was minimised.

Related projects funded under Round 1 of Filling the Research Gap

N/A

Publications

Future Ready Dairy Systems

1. Due to the large amount of material produced for the program, a list is not provided here. All material can be found at http://frds.dairyaustralia.com.au.

Validation Farm Project

2. Seasonal and climate risk information for the dairy industry is available on the Department of Primary Industries, Victoria website at www.dpi.vic.gov.au/agriculture/about-agriculture/newsletters-and-updates/newsletters/milking-the-weather
3. Podcasts for the project are available on the Primary Industries Climate Challenges Centre website at www.piccc.org.au/resources

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

On-farm demonstration of best practice options for climate change mitigation and adaptation for beef producers across northern Australia

Lead organisation

Meat and Livestock Australia

Consortium member organisations

Queensland Department of Agriculture, Fisheries and Forestry (formerly Department of Employment, Economic Development and Innovation)
Northern Territory Department of Resources
Commonwealth Science and Industrial Research Organisation (CSIRO)

Objectives

- engage beef producers through on-farm demonstrations and equip them with the knowledge and tools to implement cost-effective mitigation and adaptation options
- help overcome constraints to adoption related to the perceived complexity and riskiness of new practices
- assist industry and other stakeholders to develop strategies and policies that account for the interactions between mitigation and adaptation options.

Location

Victoria River District (VRD) of Northern Territory, Queensland Gulf, Queensland Fitzroy Basin, Barkly region of Northern Territory, Queensland Mitchell grasslands

Key activities

Three regions (Queensland Gulf, Fitzroy Basin and VRD) explored both mitigation and adaptation options through a focal property approach, complemented by two demonstration sites per region, with the focal property in each region undertaking detailed benchmarking and options analysis. Two other regions (Queensland Mitchell grasslands and Barkly) explored adaptation options through two to three demonstration sites.

The likely conflicts and synergies between adaptation and mitigation options were evaluated through:

- a qualitative overview of trade-offs among various best management practices (BMPs)
- detailed quantitative analysis of three key practices (stocking rate management, improving land condition, increasing woody carbon stores) using simulation modelling.

Findings/Conclusions

The project engaged beef businesses across the five regions, stimulating practice change and enhancing their business resilience. Over 90 producers have already made significant practice changes consistent with cost-effective implementation of best practice options.

The impacts of changed practices and technologies on productivity, economic returns, adaptability and net emissions found wet season spelling to be effective in maintaining livestock carrying capacity, improving pasture condition, increasing profitability, and reducing greenhouse gas emissions. Stocking management and spelling around water bores (by turning them on and off) was found to spread grazing pressure more evenly across the paddock and reduce overgrazing and damage around bores.

The benchmarking and analysis approach provided a useful tool for identifying opportunities and risks in property management, taking account of natural resource condition, productivity, business performance and net greenhouse gas emissions.

A qualitative overview of trade-offs among various best management practices showed that recommended adaptation measures will have largely neutral implications for greenhouse gas emissions, and tend to reinforce many existing best practice recommendations aimed at improving productivity and sustainability.

Simulation modelling of three practices (adjusting stocking rates to maintain safe utilisation levels; improving land; and increasing woody carbon stores) show the effectiveness of mitigation measures in northern rangelands will be extremely sensitive to future changes in climate (and associated adaptation actions). For example, any gains in sequestering carbon would be threatened not only by drying climate scenarios but also by scenarios with warming alone. Sequestration through increased tree stocks can be a more significant and reliable option but comes with major costs to productivity.

Related projects funded under Round 1 of Filling the Research Gap

N/A

Publications

1. Bray, S, Walsh, D, Phelps, D & Stokes, C 2011, 'Climate Clever Beef. 1: Improving beef business resilience', poster presented at the *Northern Beef Research Update Conference*, Park Ridge.
2. Broad, K, Bray, S, English, B, Matthews, R & Rolfe, J 2011, 'Adapting to beef business pressures in the Gulf' poster presented at the *Northern Beef Research Update Conference*, Park Ridge.
3. Collier, C 2011, 'Climate Clever Beef. 2: A pasture spelling and stocking rate demonstration at Alexandria Station' poster presented at the *Northern Beef Research Update Conference*, Park Ridge.
4. Daniels, B & Bray, S 2011, 'Climate Clever Beef. 3: Soil health comparisons between remnant forest and cleared pasture in the Fitzroy catchment' poster presented at the *Northern Beef Research Update Conference*, Park Ridge.

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

Methane recovery and use in agriculture

Lead organisation

Rural Industries Research and Development Corporation

Consortium member organisations

Australian Meat Processor Corporation
Meat and Livestock Australia
JBS Australia Pty Ltd
Australian Lot Feeders' Association
Dairy Australia
Australian Pork Limited
The Australian Chicken Meat Federation
Queensland Natural Pork Holdings (Marketing Pty Ltd)
Queensland Department of Agriculture, Fisheries and Forestry (formerly Department of Employment, Economic Development and Innovation)

Objectives

- drive the uptake of waste water methane recovery and on-farm biogas technology in Australian agriculture and related processing industries by demonstrating two such technologies at a piggery and a meat processing plant
- communicate the benefits of methane recovery and use as a clean energy source through business case studies, reports and field days at the demonstration sites
- adapt technologies, quantify risks and collect data to facilitate improvement of economic assessment and emissions estimation through activities at two demonstration sites
- increase understanding of the benefits of recovering waste methane as a resource

- reduce the uncertainty, risk and cost of installing methane recovery and use systems.

Location

King Island, Tasmania and Grantham, Queensland

Key activities

Methane recovery and use at the King Island meat processing facility:

- document the covered anaerobic lagoon (CAL) design used at King Island
- collection and analysis of data on all inputs and outputs of the site operations to facilitate improvements in subsequent design and operation of CALs in the meat industry
- evaluate the economic benefits by completing an assessment of the design and an emissions estimation
- demonstrate waste water methane recovery and use at the JBS Australia abattoir and rendering plant on King Island in Bass Strait.

Methane recovery and use at the Grantham piggery:

- ongoing monitoring of biogas production, biogas quality, pond inflows, pond temperatures and air temperatures
- collation and analysis of relevant performance data
- development, fabrication, installation, operation and monitoring of a modified scrubber to remove hydrogen sulphide from the biogas prior to use (obtaining the necessary gas safety approvals)
- examining the feasibility of installing a cogeneration unit, producing both electrical power and heat
- seeking approval for all modifications made to the existing biogas system, in accordance with the relevant gas safety legislation
- communicating the benefits of methane recovery and use as a clean energy source.

Findings/Conclusions

Methane recovery and use in a King island meat processing plant

The covered anaerobic lagoon (CAL) began operation in December 2011 and reached stable operation after 25 weeks. It successfully operated for over six months.

Key project findings include:

- The CAL technology is suitable for red meat processing plants
- The King Island CAL was operating successfully and producing sizeable volumes of methane rich biogas
- The CAL delivered excellent biogas quality and quantity over six months of operation
- Gas flow was reasonably steady over the full seven days of a week despite the facility operating only five days of the week
- Crust build up occurred under the cover possibly due to the relatively low level of effluent pre-treatment used at King Island. This is not desirable for an efficient and effective operation of a CAL since the floating crust poses a risk to the integrity of the cover and the biogas capture system. Results indicate that crust build up in the initial phase may be more due to microbial foaming than oil and grease

accumulation. Crust build up showed signs of thinning in the rear half of the CAL as it achieved normal performance. The researchers recommend further attention to this area to avoid potential damage to infrastructure
- Sludge build up was noted in the CAL. Excessive amounts of sludge can affect the operation of the CALs. A significant volume was successfully extracted using sludge removal pipework after six months of CAL operation. The researchers noted design and management of sludge withdrawal systems is critical as a sludge management tool for CALs
- Stormwater removal from the cover is a persistent problem in industrial CAL operation and was noted in the King Island CAL
- The outcomes from this project provide valuable information and guidance on the effective and efficient establishment and operation of new and existing CALs at other meat processing sites.

Methane recovery and use at the Grantham piggery

The biogas extraction system at Grantham has now been upgraded to meet Queensland legislative requirements and standards.

Key project findings include:
- A major advance is the installation of a biogas reticulation pipeline to supply biogas from the extraction system to a water heating system which circulates hot water through copper pipes to underfloor heating pads in the piggery farrowing sheds. This biogas-fired water heating system has the potential to reduce on-farm energy costs by replacing a significant proportion of the Liquid Petroleum Gas (LPG) previously used for heating
- The relatively high thermal mass of the effluent stored in the pond resulted in more stable pond temperatures than the ambient air temperatures recorded at the site. This buffering effect increased with depth in the pond
- Analysis suggests that the costs incurred in establishing the biogas system at the Grantham piggery could be recouped over an eight year payback period, based on estimated reductions in LPG heating costs and revenue from carbon credits. This analysis has not considered ongoing operation and maintenance costs, depreciation and interest repayments
- It is anticipated that pig producers will be able to establish new biogas collection and use systems at lower costs than those incurred at the Grantham piggery for a number of reasons including:
  - the Grantham biogas system was installed as a demonstration system, incorporating technology that had not been previously used in the Australian pig industry
  - the cost of some system components has fallen since the Grantham system was originally installed
  - since the original installation in 2009, a number of Australian companies are now offering biogas system design and installation services, and have gained valuable experience in planning and installing a limited number of new systems
  - the costs incurred at the Grantham site included upgrading work which should not be required for properly designed commercial systems.

Related projects funded under Round 1 of Filling the Research Gap

- Mitigating the greenhouse gas potential of Australian soils amended with livestock manure—The University of Western Australia—Sasha Jenkins. Funding of $655 563 ex GST
- Advancing livestock waste as low emission-high efficiency fertilisers—Queensland Department of Agriculture, Fisheries and Forestry—Matt Redding. Funding of $996 124 ex GST
- Pork greenhouse gas mitigation—Feedlot Services Australia Pty Ltd (trading as FSA Consulting) —Eugene McGahan. Funding of $673 625 ex GST
- Poultry greenhouse gas mitigation—Feedlot Services Australia Pty Ltd (trading as FSA Consulting) —Stephen Wiedermann. Funding of $464 420 ex GST

Publications

1. Skerman, A 2010, 'Biogas production using livestock manure and greenhouse gas reduction in Australia', paper presented at the *International Symposium on Industrialization Plans of Biogas Production Using Livestock Manure, Agriculture Training Centre*, National Institute of Animal Science (NIAS), Suwon, Republic of Korea.
2. Skerman, A 2010, 'Methane recovery and use at a piggery near Grantham, Qld', paper presented at the *Bioenergy Australia Conference - Biomass for a clean energy future*, Manly, NSW, 8-10 December.
3. Whitby, J & Skerman, A 2010, 'Next generation energy - Biogas?' Presentation to visiting delegation from Jilin Agricultural University, People's Republic of China.

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

Carbon and sustainability—A demonstration on vegetable properties across Australia

Lead organisation

Horticulture Australia Limited

Consortium member organisations

Department of Primary Industries, Victoria
Queensland Department of Agriculture, Fisheries and Forestry (formerly Department of Employment, Economic Development and Innovation)
Growcom

Objectives

This demonstration project focused on three key objectives to increase the understanding by the vegetable supply chain of the market requirements for greenhouse gas (GHG) emissions management and sustainable vegetable production, and to provide information for industry to be able to address these market requirements. These three objectives were to:

- identify how soil carbon is an important part of the overall sustainability picture for the Australian vegetable industry

- understand GHG emissions and demonstrate their management in the vegetable supply and marketing chain
- develop information products for the vegetable farming community to help vegetable growers manage GHG emissions.

Location

Five demonstration sites were established on four vegetable production farms on the east coast of Australia. The four farms were located in the following regions:

- Melbourne (Boneo and Werribee), Victoria
- Granite Belt, Queensland
- Lockyer Valley, Queensland.

Key activities

This project used static sampling chambers to study greenhouse gas (GHG) emissions from various farming practices aimed at reducing emissions.

In Victoria three on-farm demonstration sites focused on the effect of fertiliser management on GHG emissions, productivity and profitability. Treatments included application rate, stabilised fertilisers (e.g. ENTEC® Nitrophoska, Alzon®, Perlka®), nitrification inhibitors and organic amendments (e.g. chicken manure). Treatments were applied to broccoli and lettuce crops on commercial farms over two years, where GHG emissions and crop yield were monitored.

Four trials were undertaken at Amiens in Queensland (Granite Belt) under overhead sprinklers on a Tenosol soil (Australian classification system). Experiments investigated the effect of controlled release fertilisers, stabilised fertilisers, fertigation, biochar, manure and minimum tillage on GHG emissions, yield and profitability. Crops included mini cos, celery and Chinese cabbage.

A fourth trial site was established on a heavy black soil at Forest Hill in the Lockyer Valley, Queensland. This site compared GHG emissions between standard urea (normal grower practice) and urea treated with a nitrification inhibitor.

The project also included desktop research and interviews with representatives from major retailers (Woolworths, Coles, and Metcash/IGA). This was done to build an understanding of the interests, directions and strategies of fresh produce retailers to help growers prepare for future requirements.

Findings/Conclusions

This project has demonstrated that nitrification inhibitors can effectively reduce nitrous oxide (N_2O) emissions in vegetable crop production.

In Victoria, stabilised fertilisers containing nitrification inhibitors (e.g. ENTEC, Perlka®) reduced N_2O emissions by up to 60 per cent. Importantly, stabilised fertilisers were shown to be cost effective as a result of improved nitrogen use efficiency and yield in the vegetable crops trialed. In broccoli, the stabilised fertiliser gave yield increases of between 8 to 59 per cent above the standard fertiliser (no inhibitor).

Stabilised fertilisers were also found to bring about a small reduction in the carbon footprint of farms in Victoria due to improved nitrogen use efficiency and a subsequent

reduction in the number of fertiliser applications required. Trial results from Victoria indicated that at least one fertiliser application could be dropped without a reduction in yield. It was estimated that this saved over $500/ha. Reduced fertiliser application rates for crop production also led to further reductions in N_2O emissions.
Results from the trials in Queensland showed that nitrification inhibitors are able to significantly reduce N_2O emissions under a range of crops.

The potential of a nitrification inhibitor to reduce N_2O emissions was heavily dependent on the inhibitor/fertiliser combination, soil type, crop grown, and whether organic amendments were also added to the production system.

The application of manure produced up to 20 times more N_2O than inorganic fertilisers. Trials conducted in Victoria demonstrated that nitrification inhibitors applied to manure can reduce the average N_2O emission flux by up to 60 per cent when the manure is incorporated into soil, and up to 16 per cent when the manure is left on the surface.

Chicken manures treated with nitrification inhibitors led to substantial increases in yield and profitability compared to the standard grower practice.

Related projects funded under Round 1 of Filling the Research Gap

N/A

Publications

A peer reviewed paper is currently being finalised for submission. Facts sheets have been produced and are being reviewed by the Department of Agriculture, Fisheries and Forestry. The fact sheets will be available on a website currently being developed.

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

Drought-hardy and carbon-conscious grazing systems: The use of forage shrubs to exploit a changing and variable climate whilst reducing methane emissions from livestock

Lead organisation

Future Farm Industries Cooperative Research Centre

Consortium member organisations

Commonwealth Science and Industrial Research Organisation (CSIRO)
The University of Western Australia
South Australian Research and Development Institute
NSW Department of Primary Industries

Objectives

- demonstrate the use of forage shrubs at the paddock scale
- demonstrate the use of the 'polytunnel' under paddock conditions to quantify methane production of grazing sheep

- determine whether animals grazing an 'improved' forage system that includes Australian native shrub species influences methane production and animal productivity compared with animals grazing a conventional 'unimproved' autumn pasture system
- determine whether using a diverse mixture of shrubs combined with grazing management based on animal behaviours influences the intake of shrubs by livestock compared with a monoculture shrub and conventional animal management
- determine the effect of water stress and defoliation stress on the anti-methanogenic properties of the forage shrubs

Location

Western Australia

A paddock-scale demonstration site in a medium-rainfall mixed farming zone was established at Ridgefield, the University of Western Australia's new 'future farm' at Pingelly. A grazing study was conducted at a partner site about 60 km from Ridgefield, on a commercial farm at Quairading.

South Australia

Effects of grazing management on feed intake of novel shrubs were investigated at Monarto (60 km east of Adelaide).

New South Wales

Effects of moisture availability and grazing eight anti-methanogenic shrubs and three others of interest were investigated at the Dareton Primary Industries Institute in far south western New South Wales (approximately three km west of Dareton and 10 km east of Wentworth).

Key activities

- A paddock-scale demonstration site (10 ha) was established at Ridgefield, the University of Western Australia's 'Future Farm'. Ten species of forage shrubs were planted at the site in a design that aims to show producers how the use of perennial shrubs can improve their whole-farm system.
- A semi-portable 'polytunnel' was used to measure methane production and a standard operating procedure for its use in the field developed and refined.
- Methane production and liveweight gain over an eight-week period in autumn (the time of year where pasture quality and quantity is typically limiting livestock production) were measured on 120 Merino sheep. Sheep were randomly allocated into two treatment groups, *improved shrub-pasture* (n = 60) or *unimproved pasture* (n = 60).
- Diet selection, feed intake and live-weight gain of sheep grazing a diverse shrub or monoculture shrub system over a seven-week period were measured on Suffolk ewe hoggets.
- Eight anti-methanogenic shrubs and three others of interest were grown at the Dareton Primary Industries Institute. The semi-arid irrigated site was chosen to compare treatments free from water stress (i.e. irrigated when required) with plants receiving periodic moisture stress from the long hot dry summers. Grazing was simulated by hand stripping the plants. Plants were sampled after the irrigation and

grazing treatments were imposed anti-methanogenic properties and the samples were measured by *in vitro fermentation technique.*

Findings/Conclusions

The project demonstrated that perennial forage shrubs that are native to Australia can provide a new addition to the feed base of livestock in Australia. In particular, their use coupled with a complementary pasture understory (or inter-row) can produce weight gain in autumn when feed quality and quantity typically limit livestock performance in southern Australia. The use of the perennial forage shrubs was able to replace hand-feeding with supplementary grain, reducing the annual cost of feeding livestock through an autumn 'feed gap' whilst adding long-lived, deep-rooted perennial shrubs into the grazing landscape.

Full analysis of methane production data is ongoing but, at the time of compiling this report, the data are encouraging by showing that the improved animal performance from the shrub-based system did not carry an extra cost in terms of methane production per unit of weight gain.

Preliminary data from Monarto suggest that the provision of a diverse mixture of shrubs is associated with higher weight gains of sheep than a monoculture of one species of shrub. Livestock incorporate a diverse mix of shrub species into their diet. Learnt behaviours contribute to their pattern of diet selection. This is important because (i) anti-methanogenic plants can become a regular part of the diet of grazing livestock and (ii) grazing management can help ensure that plants grown for their anti-methanogenic properties are consumed in adequate amounts to have the desired effect.

Water and defoliation stress do not affect the anti-methanogenic properties (plant fermentability and methane production) of the forage shrubs. The consistency of the methane production and gas production from rumen microbial fermentation in response to water stress or defoliation of the plants suggests that it is feasible to identify and use 'anti-methanogenic plants' in modified grazing systems.

A standard operating protocol for using the polytunnel to measure the methane production of grazing sheep was developed. This could be a very valuable technique to quantify methane production where other field techniques cannot be used (due to cost or logistical issues).

Related projects funded under Round 1 of Filling the Research Gap

N/A

Publications

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

Demonstrating the minimisation of methane and nitrous oxide emissions from food processing by-products by implementing best practice management of organic residues

Lead organisation

Gelita Australia

Consortium member organisations

New South Wales Sugar Cooperative
d'Arenberg Wines
SITA Environmental Solutions

Objectives

- to determine greenhouse gas (GHG) emissions methane [CH_4] and nitrous oxide [N_2O]) from food processing residues with different characteristics (moisture, nitrogen, carbon, bulk density) when stockpiled or composted in turned windrows or aerated piles
- demonstrate and promote the minimisation of methane and nitrous oxide emissions by implementing best practice management of organic food processing residues
- determine agronomic and environmental (GHG emissions) effects of applying raw and composted mill mud to land.

Location

Beaudesert and Ipswich, Queensland
Broadwater, New South Wales
McLaren Vale, South Australia

Key activities

- The project measured the GHG emissions from stockpiling and composting of organic residues generated during wine making, sugar milling, gelatine manufacturing, fruit and vegetable processing and beef packaging (abattoirs). All materials were composted in turned windrows and aerated piles, and GHG emissions were measured during four to thirteen week monitoring periods.
- A simplified life cycle assessment was used to compare the overall environmental performance of compost made from turned windrows or aerated piles.
- The effect on GHG emissions from using raw and composted mill mud as a soil amendment on both loam and clay soils was assessed in field and laboratory incubation trials.

Findings/Conclusions

A valid comparison between composting and stockpiling needs to account for the entire period needed for each material to reach the same level of stability, and/or the point at which it can be safely and beneficially used for land management purposes.

Some methane emission factors determined with flux chambers exceeded the likely future Australian default emission factor for composting (16 kg CO_2-e/t wet input), while nitrous oxide emissions were low, did not exceed the expected future default value for nitrous oxide (30 kg CO_2-e/t wet input) and ensured also that combined values (CH_4 + N_2O) did not exceed likely future default emission factors. However, measurements with a large gas capturing tent (flow-through wind tunnel) suggested that flux chamber measurements might underestimate emissions.

Use of a handheld methane detector showed promise for estimating methane emissions. Hence, it might be an operational tool for managing composting operations and reducing GHG emissions as methane represented more than 90 per cent of GHG emissions in most cases.

Stockpiled mill mud and grape marc showed low CH_4 + N_2O emissions, while CH_4 + N_2O emissions from stockpiled paunch and wastewater sludge were high. Emissions per tonne of wet feedstock as carbon dioxide equivalent (CO_2-e) were:

- stockpiled mill mud: CH_4 0.05 kg and N_2O 0.0 kg (11 weeks)
- stockpiled grape marc (fresh/old): CH_4 0.07/1.31 kg and N_2O 0.3/0.01 kg (13 weeks)
- stockpiled paunch: CH_4 11.04 kg and N_2O 1.16 kg (10 weeks)
- stockpiled wastewater sludge: CH_4 19.98 kg and N_2O 7.16 kg (8 weeks).

As stockpiled mill mud showed low GHG emissions, composting did not yield emission reductions. However, use of composted mill mud increased dry matter yield of silage corn significantly over yields achieved with raw mill mud. Both composted mill mud and raw mill mud have the capacity to increase methane emissions and reduce nitrous oxide emissions when applied to soil, but effects vary with soil type and moisture levels.

Use of aerated piles rather than turned windrows for composting reduced emissions markedly when composting paunch (62 per cent) and gelatine manufacturing residues. However, the use of aerated piles rather than turned windrows increased emissions when mill mud and corn residues were composted. Stockpiling of partially composted material (4 to 6 weeks) resulted in significant methane emissions over a 150 day storage period.

Composting of wastewater sludge from gelatine manufacturing (mixed with other materials) can reduce GHG emissions significantly compared to stockpiling, while that was not demonstrated for paunch in the given time frame.

Elevated GHG emissions from composting are primarily due to inappropriate composting conditions and process management. The best way of minimising GHG emissions from composting of food processing residues is to establish operational standards that represent 'good composting practices'. They not only help in minimising GHG emissions but they also ensure appropriate feedstock mixes, low odour and leachate, swift decomposition and high quality compost products.

Related projects funded under Round 1 of Filling the Research Gap

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

Publications

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

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.

The following projects are been funded under Round 1 of *Filling the Research Gap* to participate in the National Agricultural Manure Management Program, the National Soil Carbon Program and the National Agricultural Greenhouse Gas Modelling Program. Descriptions of all successful Round 1 projects are available at http://www.daff.gov.au/climatechange/carbonfarmingfutures/ftrg.

National Agricultural Manure Management Program

Coordination of the National Agricultural Manure Management Program—Australian Pork Limited—Darryl D'Souza. Funding of $185 196 ex GST

This project will coordinate and manage the *National Agricultural Manure Management Program*. The program will assist the intensive livestock industries to evaluate the agricultural greenhouse gas emissions abatement potential for various manure management systems. Information from the program will underpin the development of *Carbon Farming Initiative* methodologies.

Mitigating the greenhouse gas potential of Australian soils amended with livestock manure—The University of Western Australia—Sasha Jenkins. Funding of $655 563 ex GST

The aim of this project is to evaluate the effectiveness of different mitigation strategies at reducing greenhouse gas emissions following the application of piggery, poultry or feedlot manure to land by measuring carbon dioxide, nitrous oxide and methane fluxes from soils following amendment using laboratory and field studies.

Advancing livestock waste as low emission-high efficiency fertilisers—
Queensland Department of Agriculture, Fisheries and Forestry—Matt Redding. Funding of $996 124 ex GST

The project will develop know-how for reducing greenhouse gas emissions from intensive livestock production, increasing emission offsets through innovative managements for land-applied manures from intensive livestock production (egg, chicken meat, pork, beef) and fertiliser formulations.

Pork greenhouse gas mitigation—Feedlot Services Australia Pty Ltd (trading as FSA Consulting)—Eugene McGahan. Funding of $673 625 ex GST

This project will quantify differences in greenhouse gas from each system over a summer and winter period. Data will be made available to update the PIGBAL model. Quantification of mitigation potential from these systems will enable development of two additional *Carbon Farming Initiative* methodologies for the pig industry, enabling far broader participation.

Poultry greenhouse gas mitigation—Feedlot Services Australia Pty Ltd (trading as FSA Consulting)—Stephen Wiedermann. Funding of $464 420 ex GST

This project will address knowledge gaps in greenhouse gas estimation to allow development of two *Carbon Farming Initiative* methodologies based on changed feeding (dietary nitrogen) or manure management in the chicken meat and/or egg industries.

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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