AGRICULTURAL

GREENHOUSE GAS EMISSIONS

AUDITS

Prepared for: **Private Forests Tasmania Project:**
"*Carbon Plantations – Extending R&D to best management practices for carbon sequestration, wood production and new investment opportunities on private land in Tasmania"*

Prepared by: **Ruth Hall**
Agricultural Consultant
AK Consultants
40 Tamar St
Launceston, Tas 7250

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AK Consultants
AGRICULTURAL & NATURAL RESOURCE MANAGEMENT CONSULTANTS

Tasmania
Explore the possibilities
Private Forests Tasmania

The *Carbon Plantations –Extending R&D to best management practices for carbon sequestration, wood production and new investment opportunities on private land in Tasmania project* is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry under the Forest Industries Climate Change Research Fund program.

Private Forests Tasmania is the Project Manager.

Project partners include:

CSIRO Forestry and Forest Products
Rural Development Services
Livingston Natural Resource Services
AK Consultants

EXECUTIVE SUMMARY

PURPOSE:

AK Consultants' role within this project is to conduct an audit of the existing agricultural enterprises on each of four demonstration farms to calculate current "*Kyoto-compliant"* greenhouse gas emissions and carbon sequestrations. This will then provide a base line to determine what level of carbon storage is required to offset emissions from the farming businesses.

SCOPE:

The demonstration farms consisted of a range of farming enterprises including:

- intensive irrigated cropping (with some livestock),
- mixed irrigated cropping and livestock,
- dryland grazing, and
- an irrigated dairy.

This mix was selected in order to gain an understanding of the emissions profiles from different agricultural operations.

The audits in this report cover only those emissions that Australia has agreed to report internationally under the Kyoto protocol. They have been compiled using publically available farm greenhouse gas calculators developed by Melbourne University in conjunction with the Victorian Department of Primary Industries. The accounting methodology used is detailed in the National Greenhouse Gas Inventory which has been approved by the Intergovernmental Panel on Climate Change (IPCC).

Emissions and sequestrations from farming enterprises are calculated under three different reporting sectors as shown in the table below:

Reporting Sector	**Substance measured**
Agriculture	Methane and nitrous oxide emissions
Energy (including Stationary and Transport)	Carbon dioxide emissions
Land Use, Land Use Change and Forestry	Carbon sequestration

RESULTS:

Key findings from the farm audits are:

1. On all farms, enteric methane (a natural by-product of ruminant digestion) was the main contributor to greenhouse gas emissions accounting for over 50% of emissions even on the intensive cropping farm. On the two properties running livestock only; namely the dryland grazing property and the irrigated dairy; enteric methane contributed 83% and 73% of the total GHG emissions respectively.

2. Only one farm sequestered enough carbon to fully offset all greenhouse gas emissions from the farming enterprise. This appears to be due to this farm achieving a balance of farming activities resulting in relatively fewer emissions (3.3 tCO2e / ha) combined with a significant proportion (12%) of the farm planted with eligible plantation trees

3. If emissions from the Agricultural Sector are excluded, as proposed in the Australian Government's Carbon Pollution Reduction Scheme, then all farms in this trial are able to offset all eligible carbon emissions (ie emissions from the Energy Sector) due to the amount of carbon sequestered by eligible tree plantings (ie the Land Use, Land Use Change and Forestry Sector).

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INTRODUCTION

This report forms part of a project titled "*Carbon Plantations – Extending R&D to best management practices for carbon sequestration, wood production and new investment opportunities on private land in Tasmania"* developed by Private Forests Tasmania. This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry under its Forest Industries Climate Change Research Fund program. The project is being implemented by a consortium of partners with specialist expertise in the various areas covered by the project. The project is managed by Private Forests Tasmania.

The project has three main components:

- A survey to determine landholder understanding, perceptions and willingness to participate in carbon off-set projects and trading schemes;
- Development of four existing farm forestry plantations as demonstrations to model carbon sequestration and wood production under future climate and economic conditions; and
- Development of a Carbon Plantations Tool Kit and "investment pathways" materials to facilitate landholder participation in the emerging "new carbon economy".

The demonstration sites will be located in northern Tasmania and will be used for four field days to inform landholders and the community about farm forestry options in the new carbon economy. The Carbon Tool kit will be published and available for all farmers.

AK Consultants role within this project is to conduct an audit of the existing agricultural enterprises on each of the four demonstration farms to calculate current "*Kyoto-compliant"* greenhouse gas emissions and sequestrations. This will provide a base line to determine what level of carbon storage is required to offset the emissions from the farming businesses.

BACKGROUND

Climate change is the result of changes in weather patterns due to an increase in the earth's average temperature. It has been scientifically demonstrated that this is caused by increases in greenhouse gases (GHGs) in the earth's atmosphere. These gases are released into the atmosphere via activities such as burning fossil fuels, land clearing and various agricultural activities. GHGs cause energy from the sun to be trapped on the earth rather than being radiated making the earth warmer (a similar function to that of a conventional greenhouse). This process is referred to as "global warming".

Changing climatic patterns mean that extreme weather events such as heat waves, floods, storms, droughts and bushfires are predicted to become more frequent, more widespread or more intense. Scientists have shown that climate change is already happening due to past and present emissions. The climate system will continue to adjust to the effects of these emissions for the next few decades at least.

While there has been debate and scepticism about climate change and the potential impacts of human activities, this project was developed assuming that climate change is real and anthropogenic (ie caused by man). The primary focus of this project is to identify and address knowledge gaps within industry, rural landholders and the community so as to ensure landholders can make well informed decisions about participating in carbon trading and/or providing offsets for agricultural enterprises as well as producing wood for the forest industry.

CARBON ACCOUNTING METHODOLOGY

The methodology for greenhouse gas accounting has been established though the United Nations Framework Convention on Climate Change and is based on the rules and approaches set out in the Kyoto Protocol. To facilitate the annual reporting of National Emissions countries must report on a total of six greenhouse gases:

- carbon dioxide,
- methane,
- nitrous oxide,
- perfluorocarbons,
- hexafluorocarbon, and
- sulphur hexafluoride

across seven sectors:

- Stationary Energy
- Transport;
- Industrial Processes;
- Solvent and Other Product Use (also known as 'Fugitive Emissions");
- Agriculture;
- Land Use, Land Use Change & Forestry; and
- Waste.

AUSTRALIAN CONTEXT

In Australia, the accounting methodology is detailed in the National Greenhouse Gas Inventory which has been approved by the Intergovernmental Panel on Climate Change (IPCC).

The Australian Government has an international commitment to:

- Annually report National Emissions to the United Nations Framework Convention on Climate Change; and
- Meet the emissions reduction target set under the Kyoto Protocol, which is to limit greenhouse gas emissions in Australia to 8% above 1990 levels during the period 2008-2012.

Stationary energy (dominated by emissions from electricity generation) is the major source of Australia's greenhouse gas emissions, representing 50% of our total annual emissions in 2008. Agriculture is the second most emissions-intensive sector representing 16% of the nation's annual emissions. Emissions from the Land Use, Land Use Change & Forestry Sector represent a further 7%.

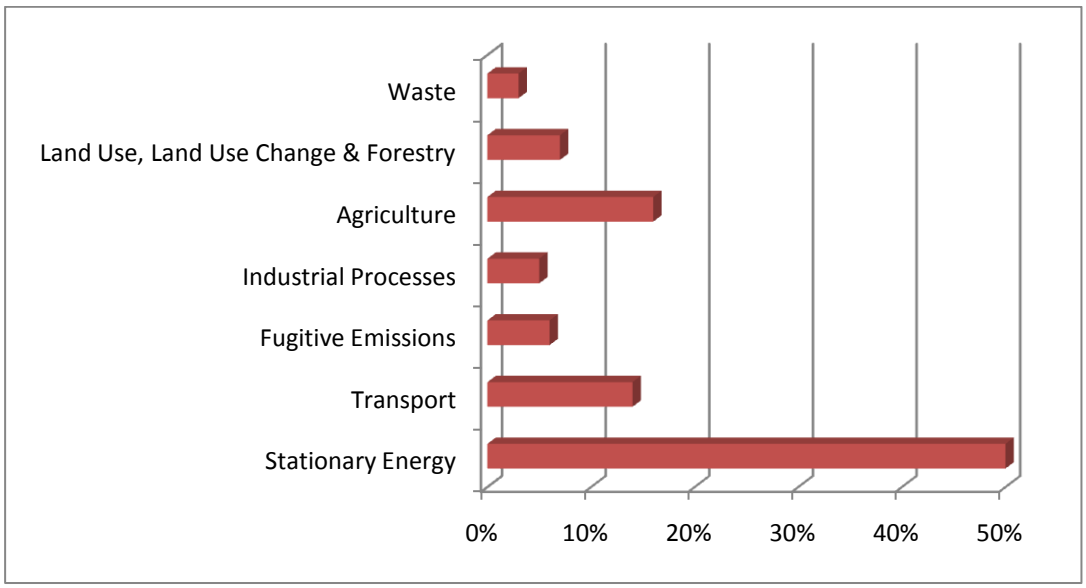


Figure 1: Australia's estimated greenhouse gas emissions in 2006, percentage contribution by sector (Source: NGGI 2008)

The audits in this report cover only those emissions that Australia has agreed to report internationally under the Kyoto protocol. There are other sources of carbon on-farm which have not been included; namely soil carbon which falls under Article 3.4 of the Kyoto protocol.

Article 3.4 of the Kyoto Protocol allows countries to elect to account for greenhouse gas emissions from any or all of the following activities:

- forest management (a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological, economic and social functions in a sustainable manner)
- revegetation (a direct human-induced activity to increase carbon stocks through the establishment of vegetation that covers a minimum area of 0.05 hectares and does not satisfy the definition of afforestation or reforestation)
- grazing land management (the system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced)
- cropland management (the system of practices on land on which agricultural crops are grown and on land that is set aside or temporarily not being used for crop production).

Australia accounts for soil carbon from afforestation, reforestation and deforestation as these activities fall under Article 3.3 of the Kyoto protocol which is mandatory. However, because Australia did not elect to account for any Article 3.4 activities, it does not account for soil carbon from forest management, cropland management, grazing land management or revegetation. There are likely to be important opportunities to increase the carbon stored in agricultural soils. However, scientific research conducted in Australia suggests that while there are opportunities for increasing and retaining agricultural soil carbon, there is significant risk of loss of soil carbon in times of drought or resulting from changed management practices.

If a country chooses to account for any Article 3.4 activities, it must include, and report on, all emissions from all land nationwide on which those activities are undertaken. Australia has elected not to include any such activities because of the risk that random natural events, such as drought or bushfire that could result in significant emissions from those sources during a commitment period.

TASMANIAN CONTEXT

The Tasmanian Government has introduced legislation to reduce the state's emissions of greenhouse gases to at least 60 per cent below 1990 levels by 2050. This represents a target of 4.6 Mt CO2e,[1] or around 49% below Tasmania's emissions in 2007. In order to inform its approach to the formulation of policies required to meet the State's emissions reduction target, the Government commissioned the following report: *Tasmanian Greenhouse Gas Emission Reduction Project - Understanding the Potential for Reducing Tasmania's Greenhouse Gas Emissions* (commonly referred to as the Tasmanian Wedges Report).

The Wedges Report found that the agricultural sector currently accounts for 25% of Tasmania's emissions which is the second largest source of the State's emissions. Livestock emissions dominate, accounting for 75% of agricultural emissions and 19% of Tasmania's total emissions. The report suggests that abatement opportunities in the agricultural sector are limited, highly uncertain and very dependent on environmental and climatic conditions. The major opportunity highlighted is the sequestration of carbon by converting agricultural land to forests. The Wedges Report indicated that up to 20% of Tasmania's arable land is considered open to conversion to forest plantations.

The Tasmanian Climate Action Council, in its advice to the Tasmanian Government on the Wedges Report[2] identified that a key priority for the agricultural sector is to develop a policy framework for farm-based reforestation of agricultural land including promoting environmentally appropriate reforestation activities by farm businesses. It is also critical to ensure that any policies to actively promote farm-based forest replanting are balanced with policies that adequately protect existing and future farming.

Additional priorities for the agricultural sector identified by the Tasmanian Climate Action Council included the implementation of more holistic and sustainable farming systems - including optimal feed mix, fertilizer usage, minimum tillage, and other landcare strategies. Sustainable farming provides a number of important abatement opportunities and long-term productivity gains for Tasmanian agriculture, particularly in the high emission livestock (sheep and cattle) farming sectors. The Council also believes that the Tasmanian agricultural sector has an opportunity to be a "fast follower" in the adoption of alternative fuel sources such as biofuels and the production and application of alternative fertilizers such as seaweeds and compost solutions.

[1] carbon dioxide equivalent

[2] Tasmanian Climate Action Council"s advice to the Tasmanian Government on the Tasmanian Wedges Report "Opportunities to Reduce Tasmania's Greenhouse Gas Emissions" (n.d.)

EMISSIONS FROM AGRICULTURE IN AUSTRALIA

The three main greenhouse gases emitted through agricultural practices are carbon dioxide, methane and nitrous oxides. The relative contribution of each molecule to the greenhouse effect varies as shown below, hence the term "carbon dioxide equivalent, (CO2e)"

Greenhouse Gas (GHG)	Carbon Dioxide equivalent (CO2e)
Carbon dioxide (CO2)	1
Methane (CH4)	21
Nitrous Oxides (NOx)	310

In the case of agricultural enterprises, accounting for emissions and sequestration is split between the Agriculture Sector, the Energy Sector, and the Land Use, Land Use Change and Forestry Sector. Methane and nitrous oxides are reported in the Agriculture Sector; carbon dioxide from fuel and power usage is reported in the Energy Sector; and carbon sequestration by trees is reported in the Land Use, Land Use Change and Forestry Sector.

AGRICULTURAL PRACTICES INCLUDED IN GREENHOUSE GAS ACCOUNTS

Australian agricultural sources of greenhouse gases are listed below.

Activity	GHG emitted
Enteric Fermentation (emissions from ruminant livestock)	Methane
Manure Management	Methane & Nitrous Oxide
Rice Cultivation	Methane
Agricultural Soils	Nitrous Oxide
Prescribed Burning of Savannas	Methane and Nitrous Oxide
Field Burning of Agricultural Residues	Methane, Nitrous Oxide and Carbon Dioxide

Enteric Fermentation

Around 75% of greenhouse gas emissions from a livestock grazing enterprise are enteric methane emissions derived from livestock.

Enteric fermentation is a digestive process whereby plant material consumed by the animal is broken down by bacteria in the gut under anaerobic (no oxygen) conditions. A major bi-product of this process is methane. The process is particularly pronounced in ruminant animals. Enteric fermentation is the major source of methane production in Australia. The proportion of feed intake converted to methane is dependent on the characteristics of the animal, the feed and the amount eaten. However, the more digestible the feed, the more easily it is converted to energy and the less methane is produced.

Manure Management

Methane

Methane is produced from the anaerobic decomposition of the organic matter remaining in the manure. This is likely to occur where high numbers of animals are managed in a confined area and the manure is stockpiled (eg feedlots), or accumulated under very wet conditions. In Australia, the

generally high temperatures, high solar radiation and low humidity environments cause the manure of free range animals to dry rapidly thus methane production from the manure of grazing animals is not considered significant in Australia.

Nitrous Oxides

Emissions of nitrous oxides from manure management systems can occur via nitrification-denitrification of ammonia compounds contained in the waste. The amount released depends on the system and duration of waste treatment.

Agricultural Soils

The chemical and microbial breakdown of nitrogen compounds (ammonium, nitrate & nitrite) in the soil produces nitrous oxides. These forms of nitrogen in the soil arise from: the application of inorganic fertilisers; the application of animal wastes to pastures; biological nitrogen fixation; the application and subsequent decomposition of crop residues; mineralisation due to cultivation of organic matter in soils; atmospheric nitrogen deposition; and leaching of inorganic nitrogen and subsequent denitrification in rivers and estuaries.

Burning Crop Residues

Incomplete burning of crop residues (due to their generally high moisture content) releases methane and nitrous oxide. Carbon dioxide is also released; however, carbon dioxide emissions from burning crop residue are not included as it is assumed that an equivalent amount of carbon dioxide is removed from the atmosphere by regrowing vegetation in the following year.

Electricity generation and use

This indirect emission is related to the emissions released from the generation of the electricity used on the farm. While it is often assumed that this is minimal in Tasmania since our electricity is hydro generated; in fact 25% of electricity consumed in this state last year (2009/10) was imported from Victoria via Basslink and was generated from the burning of brown coal[3].

Machinery and Vehicle Fuel Consumption

These emissions also do not form part of the agriculture sector, however they are calculated under the Transport Energy sector, thus they need to be included in a complete farm audit. These indirect emissions are released as a result of fuel use on-farm. The amount of emissions depends on the fuel source (diesel, petrol, LPG).

Land Use, Land Use Change and Forestry

Afforestation and reforestation refers to the establishment of a forest on land that was cleared of forest before the 1st January 1990. The amount of carbon dioxide removed from the atmosphere by tree growth is dependent on the tree species, climate and soil conditions as well as establishment considerations such as stocking rate and forest management such as thinning. Increases in carbon

[3] Hydro Tasmania Annual & Sustainability Report 2009: http://www.hydro.com.au/annual-reports/2009/contents/our_performance/assets_resource/page03.html

in the soil, litter and woody debris within a forest site may also be included when estimating the total carbon stock.

AGRICULTURAL GREENHOUSE GAS EMISSIONS CALCULATORS

There are a number of tools, models and approaches available for estimating emissions from farms. The science and practical use of such decision support tools for agriculture is still under development, however, there are two major tools developed for the Australian agricultural sector.

FARMGAS

This is an online calculator developed by the Australian Farm Institute that enables farmers to model the consequences of different farm enterprise and management decisions on both the amounts of GHG emitted and the financial performance of the business. The methodology is based on the Australian National Greenhouse Gas Inventory (NGGI) 2006. FarmGAS includes individual modules for livestock and cropping enterprises and any combination of these enterprises can be included to develop an individual farm business profile.

Advantages of this calculator are that it is easy to use and it enables emissions from individual farm enterprises to be easily identified. A disadvantage of this calculator is that it only calculates emissions reported in the Agricultural Sector. Thus farm emissions allocated to the Energy Sector and the Land Use, Land Use Change and Forestry Sector are not included (with the exception of a generalised section on carbon sequestration due to tree planting). Additionally, because it is only available online it has limited access for users in regional areas where internet speeds are poor.

DECISION SUPPORT FRAMEWORK FOR GREENHOUSE ACCOUNTING ON AUSTRALIAN DAIRY, SHEEP, BEEF OR GRAIN FARMS

These calculators have been developed by Dr Richard Eckard from the University of Melbourne in conjunction with the Victorian Department of Primary Industry. Again, they are enterprise specific and are also based on the NGGI method. They aim to calculate greenhouse gas emissions at a farm scale (including emissions from the Agricultural, Energy and Land Use, Land Use Change and Forestry Sectors); they identify the major sources of emissions; and they explore the impact of changed management options. They rely on the input of simple data that is easily available and provide an emissions profile for the farm. The calculators have been developed as Microsoft Excel files that can be readily saved and used on the user's own PC.

While each calculator has its merits, the Decision Support Framework for Greenhouse Accounting on Australian Dairy, Sheep, Beef or Grain Farms has been used for this project as it is the seen as the most user-friendly; it is portable, requires readily available farm data; and identifies the sources of emissions in a clear and concise manner. It is also easy to manipulate to conduct "What if" scenarios.

Note; for the dairy farm audited as part of this project the Dairy Greenhouse Gas Abatement Strategies (DGAS) calculator was used. This has been developed by the Tasmanian Institute of Agricultural Research (TIAR) and is based on the Decision Support Framework for Greenhouse Accounting on Australian Dairy Farms. DGAS allows for more detailed supplementary feed analysis as well as specifying the manure management system used.

FARM AUDIT RESULTS

Audits of greenhouse gas emissions from the farming enterprises on each of four trial properties were conducted. The scope of the audits is as follows:

- The boundary of each audit is defined as the property boundary as identified on maps provided by Private Forests Tasmania.
- The audit period is the 2009-2010 Financial Year.
- All "Kyoto compliant" greenhouse gas emissions were calculated; including from the Agricultural, Energy and Land Use, Land Use Change and Forestry Sectors.
- Greenhouse gases emitted due to the actions of third parties (eg crop contractors) have been included as they form part of the net emissions within the audit boundary as defined above. However, under current proposed national reporting requirements, these emissions would be reported by the third party and not the landholder.
- Electricity is assumed to be derived from 25% Victorian brown coal and 75% hydro. (This is based on the estimated percentage of power imported into Tasmania via Basslink in 2009)[4].
- Feed analyses were unavailable for pastures on any of the properties; therefore default values have been used. Note; for the dairy farm supplementary feed had been analysed and results have been used accordingly.
- Where hard data was not available (eg; third party diesel consumption) the landholder's best estimate has been used.

[4] Hydro Tasmania Annual and Sustainability Report 2009 sourced from: http://www.hydro.com.au/annual-reports/2009/contents/our_performance/assets_resource/page03.html

OVERVIEW OF PROPERTIES

The four trial properties participating in this project were chosen to represent a range of different agricultural enterprises.

Property 1:

This property is approximately 430 Ha in size and is run as an intensive mixed enterprise business consisting of cropping, sheep breeding (primarily for fat lambs) and some trade cattle. All crops are irrigated and in 2009-10 included seed cabbages, poppies, clover seed, pyrethrum, peas, grass seed, peppermint, fennel and lucerne. The property is located near Cressy and has an annual average rainfall of 500-550mm.

Table 1: General Characterisitcs of Property 1

Area Pasture:	121 Ha
Area Cropped:	153 Ha
Area Vegetation (planted post 1990):	Eucalyptus nitens 2 ha Pinus radiata 15 ha Mixed native 5 ha
Nitrogen Fertilizer on Crops:	7,043 kg
Nitrogen Fertilizer on Pasture:	44,800 kg (applied as 800 t of poppy meal at 5.6% N)
Diesel Usage:	Landholder 16,475 L Third parties 8,238 L
Electricity Usage:	125,958 kWh

Table 2: 2009/10 Crop Yields for Property 1

Crop	Area (ha)	Yield (t/ha)
Cabbages	6	0.4
Poppies	30	1.8
Clover	17	0.25
Pyrethrum	24	No harvest in 09/10
Peas	15	6.5
Grass Seed	11	2.3
Peppermint	9	0.07
Fennel	11	0.08
Lucerne	30	12

Table 3: 2009/10 Livestock Numbers for Property 1

Type	Opening Number	Closing Number	Average Wt (kg)
Yearling Steers	0	24	650
Total Cattle	**0**	**24**	
Rams	43	56	60
Wethers	100	140	50
Lambs/Hoggets	700	310	50
Replacement Ewes	220	290	48
Breeding Ewes	1083	1040	57
Total Sheep	**2146**	**1836**	

Property 2:

This is a 692 Ha mixed cropping and grazing property located at Westwood. Irrigated crops in 2009-10 included: peas, grass seed, potatoes, poppies, and beans. A further 15 ha of dryland barley and 44 ha of fodder crops were also grown. The grazing enterprises include sheep (fat lamb breeding) and cattle. The cattle enterprise has been converted from breeding to trading over the 2009-10 financial year with the result that the cattle herd now consists of a larger number of younger cattle compared to the start of the year. Annual rainfall is around 700mm on average.

Table 4: General Characterisitcs of Property 2

Area Pasture:	415 Ha
Area Cropped:	208 Ha
Area Vegetation (planted post 1990):	Eucalyptus nitens 49 ha Pinus radiata 16 ha Mixed native 4 ha
Nitrogen Fertilizer on Crops:	16,819 kg
Nitrogen Fertilizer on Pasture:	6,204 kg
Diesel Usage:	Landholder 26,200 L Third Parties 15,000 L
Electricity Usage:	167,954 kWh

Table 5: 2009/10 Crop Yields for Property 2

Crop	Area (ha)	Yield (t/ha)
Peas	47	7.5
Grass Seed	8	0.875
Barely	15	5
Potatoes	28	54.5
Poppies	57	1.34
Beans	9	11

Table 6: 2009/10 Livestock Numbers for Property 2

Type	Opening Number	Closing Number	Average Wt (kg)
Bulls	3	0	900
Yearling Steers	52	0	400
Steer Calves	34	144	350
Heifer Calves	33	118	330
Breeding Cows	64	4	500
Total Cattle	**186**	**266**	
Rams	47	39	80
Lambs/Hoggets	2140	0	25
Replacement Ewes	297	460	50
Breeding Ewes	2085	2020	60
Total Sheep	**4569**	**2519**	

Property 3:

This is a dryland grazing enterprise located near Bridport. The farm is approximately 1,700 Ha in size and has an annual average rainfall of 650 - 700mm. Livestock consist of breeding cattle and sheep for both wool and meat production. Note; this farm has a large forestry component, thus the area currently available for livestock production is approximately 670 Ha. It is also run in conjunction with another farm, thus rams are run off farm.

Table 7: General Characterisitcs of Property 3

Area Pasture:	486 Ha
Area Cropped:	16 Ha
Area Vegetation (planted post 1990):	Eucalyptus globulus 5 ha Pinus radiata 23 ha Mixed native 9 ha
Nitrogen Fertilizer on Crops:	0 kg
Nitrogen Fertilizer on Pasture:	1,800 kg
Diesel Usage:	Landholder 2,950 L Third Parties 1,320 L
Electricity Usage:	120 kWh

Table 8: 2009/10 Livestock Numbers for Property 3

Type	Opening Number	Closing Number	Average Wt (kg)
Bulls	5	5	800
Heifer Calves	180	20	185
Breeding Cows	190	170	550
Total Cattle	**375**	**195**	
Lambs/Hoggets	1900	0	26
Replacement Ewes	0	300	45
Breeding Ewes	1800	1200	72
Total Sheep	**3700**	**1500**	

Property 4:

This is a dairy located at Derby. It is approximately 280 Ha in size, 100 Ha of which is irrigated. The average annual rainfall is 1000mm. A small crop of potatoes (4 ha) was also harvested in 2009-10. Note; this farm is run in conjunction with others, thus replacement heifers are run off farm.

Table 9: General Characterisitcs of Property 4

Area Pasture:	250 Ha
Area Cropped:	4 Ha
Area Vegetation (planted post 1990):	Pinus radiata 11 ha
Nitrogen Fertilizer on Crops:	660 kg
Nitrogen Fertilizer on Pasture:	4,600 kg
Diesel Usage:	Landholder 5,000 L Third Parties 250 L
Electricity Usage:	298,422 kWh

Table 10: 2009/10 Livestock Numbers for Property 4

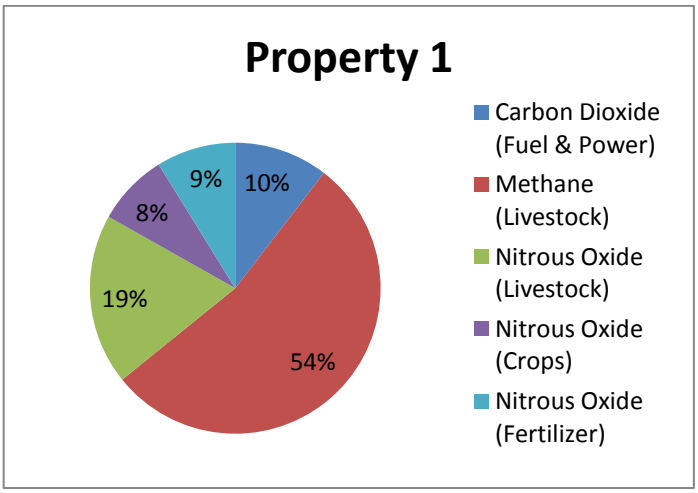
Type	Opening Number	Closing Number	Average Wt (kg)
Bulls	22	22	700
Heifer Calves	210	210	60
Milking Cows	615	615	520
Total Cattle	**847**	**847**	

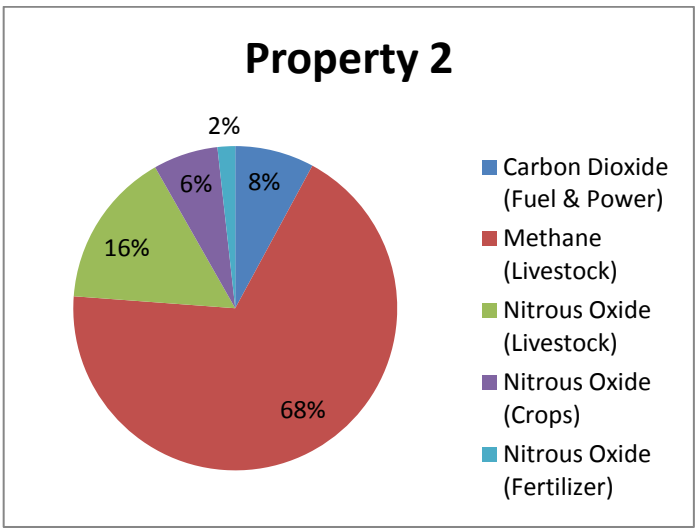
FARM GREENHOUSE GAS EMISSIONS SUMMARY

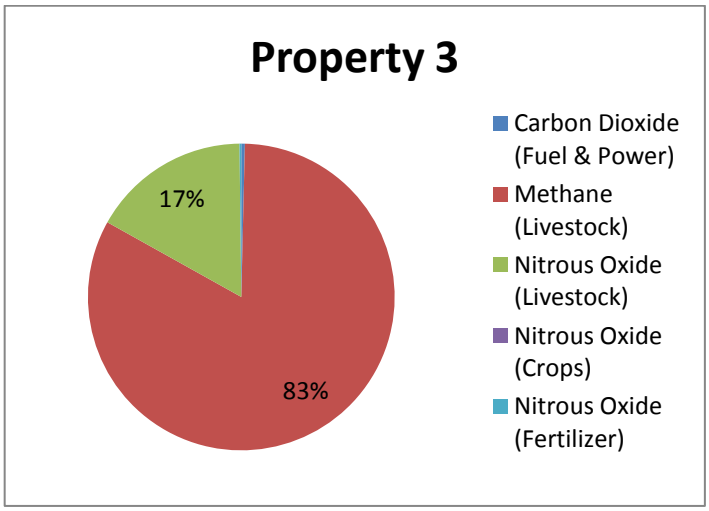
Outputs	Property 1 (tCO2e)	Property 2 (tCO2e)	Property 3 (tCO2e)	Property 4 (tCO2e)
Carbon Dioxide from Energy Use (Diesel & Power)	116	166	8	184
Enteric Methane from Cattle	56	242	459	1,839
Enteric Methane from Sheep	541	1,194	1,303	-
Nitrous Oxide from Nitrogen Fertiliser	98	37	4	10
Nitrous Oxide from Livestock Dung & Urine	43	137	178	234
Indirect Nitrous Oxides	168	191	178	269
Methane from Effluent (Dairy)	-	-	-	42
Nitrous Oxide from Effluent (Dairy)	-	-	-	2
Nitrous Oxide from Crop Residues	15	44	-	-
Nitrous Oxide from Nitrogen Fixation (crops)	74	92	-	-
TOTAL Greenhouse Gas Emissions:	**1,119**	**2,103**	**2,130**	**2,580**
Carbon Sequestration by trees planted post 1990	491	2422	845	263
Net Farm Greenhouse Gas Emissions:	**628**	**-319**	**1,285**	**2,317**

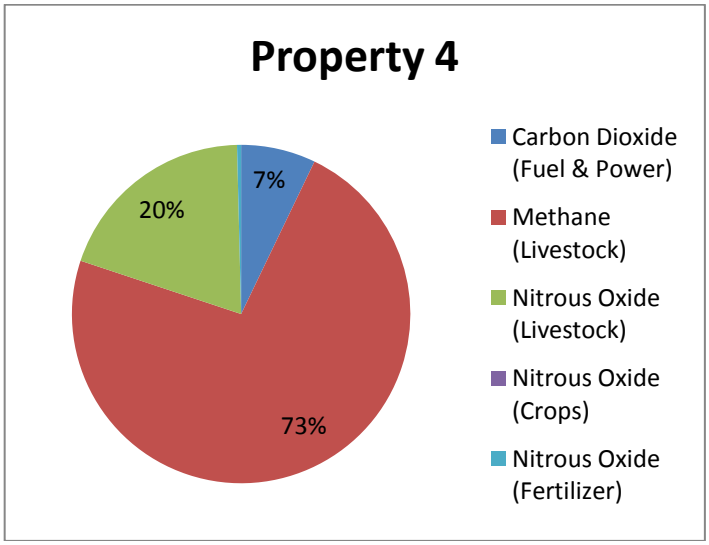
tCO2e = tonnes of carbon dioxide equivalent

The contribution of each emission source as a percentage of the total greenhouse gas emissions from each farm is shown in the charts below.




Property 2
2%
6%
8%
16%
68%
Carbon Dioxide (Fuel & Power)
Methane (Livestock)
Nitrous Oxide (Livestock)
Nitrous Oxide (Crops)
Nitrous Oxide (Fertilizer)


Property 3
17%
83%
Carbon Dioxide (Fuel & Power)
Methane (Livestock)
Nitrous Oxide (Livestock)
Nitrous Oxide (Crops)
Nitrous Oxide (Fertilizer)


Property 4
7%
20%
73%
Carbon Dioxide (Fuel & Power)
Methane (Livestock)
Nitrous Oxide (Livestock)
Nitrous Oxide (Crops)
Nitrous Oxide (Fertilizer)

DISCUSSION

The first and most obvious point to note from these results is that methane, specifically enteric methane is the main contributor to greenhouse gas emissions on farms. On the two properties running livestock only, Properties 3 and 4, enteric methane contributes 83% and 73% of the total GHG emissions respectively.

Nitrous oxides attributable to livestock are the second largest contributor to greenhouse gas emissions, accounting for an average 18% across all 4 farms. The main contribution to total emissions made by cropping enterprises is also nitrous oxide. These arise from nitrogenous fertiliser application and nitrogen fixation by leguminous crop and pasture species and accounted for less than 1% of emissions across all farms except Property 1 (7%) where more nitrogen was added to the pasture in the form of poppy meal (5.6% N).

Figure 2 shows emissions from each property per hectare farmed (excluding plantations and native forest). This demonstrates that intensive management of livestock in a dairy situation, as is the case for Property 4, results in significantly more emissions per hectare (10 tCO2e/ha) than either mixed cropping or low intensity, dryland livestock grazing. (3 - 4 tCO2e/ha)

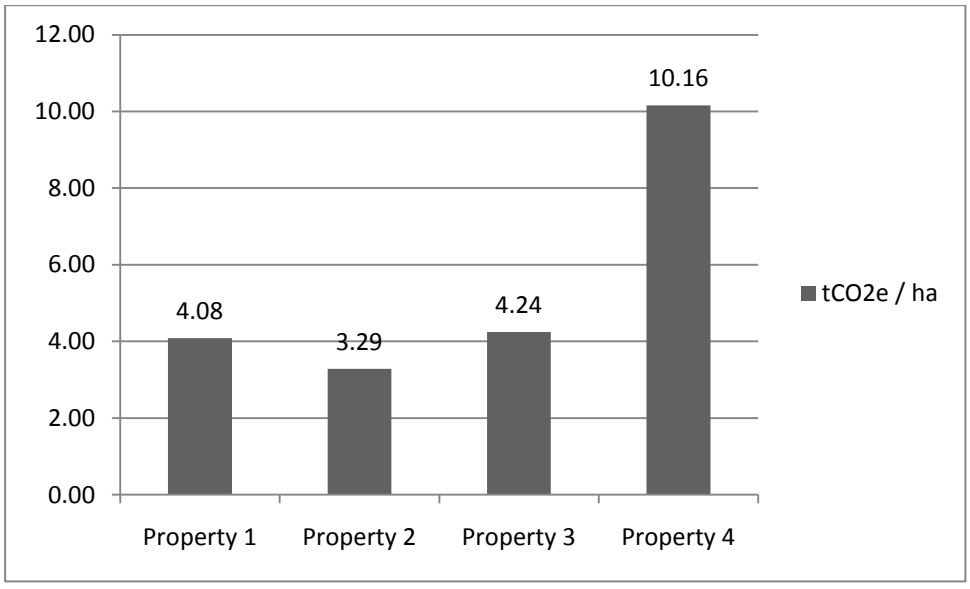


Figure 2: Greenhouse gas emissions per hectare farmed on each of the trial properties

It is interesting to note that Property 2 has slightly less total emissions than Property 3 despite running more livestock and conducting cropping activities. On a per hectare basis Property 2 also has fewer emissions than both Property 3 (dryland sheep only) and Property 1 (intensive irrigated cropping with some trade livestock).

Only one property (Property 2) sequesters enough carbon to fully offset all greenhouse gas emissions from the farming enterprise (including the Agriculture Sector). This is largely due to a 49 ha *Eucalyptus nitens* plantation on the property. However, for this plantation to be counted towards providing offsets for the farming enterprise, the carbon store needs to meet the permanence criteria. “Permanence” requires that the carbon must be stored for at least 100 years. To do this it will be necessary to ensure a “rolling stock” of carbon via successive plantings as the existing trees

are thinned and harvested. This aspect of trees on farms is being investigated in more detail by other members of the Consortium contributing to this project, namely Livingston Natural Resources and CSIRO.

At this stage emissions from the Agricultural Sector will not have a carbon price placed on them under the proposed Carbon Pollution Reduction Scheme. Therefore all methane and nitrous oxide emissions from farms will be excluded. The following figure shows the split of emissions from the four trial farms between the 3 reporting sectors represented.

Figure 3: Emissions from each property by reporting sector.

What is clear from this is that the 4 properties within this trial are offsetting all eligible carbon emissions (ie emissions from the Energy Sector) due to the amount of carbon sequestered by the eligible tree plantings (ie the LULUCF Sector). Note; this assumes the carbon stored in these trees is owned by the landholder and not by a third party eg; forestry company that owns the trees.

In summary, the results obtained from these 4 trial farms would suggest that the optimal enterprise mix to minimise greenhouse gas emissions is a mixed cropping farm with both sheep and cattle and significant areas of woody vegetation. Given that this mix most closely resembles the diversity of a natural system, this is perhaps not surprising.